Renewable Energy and Carbon Policy

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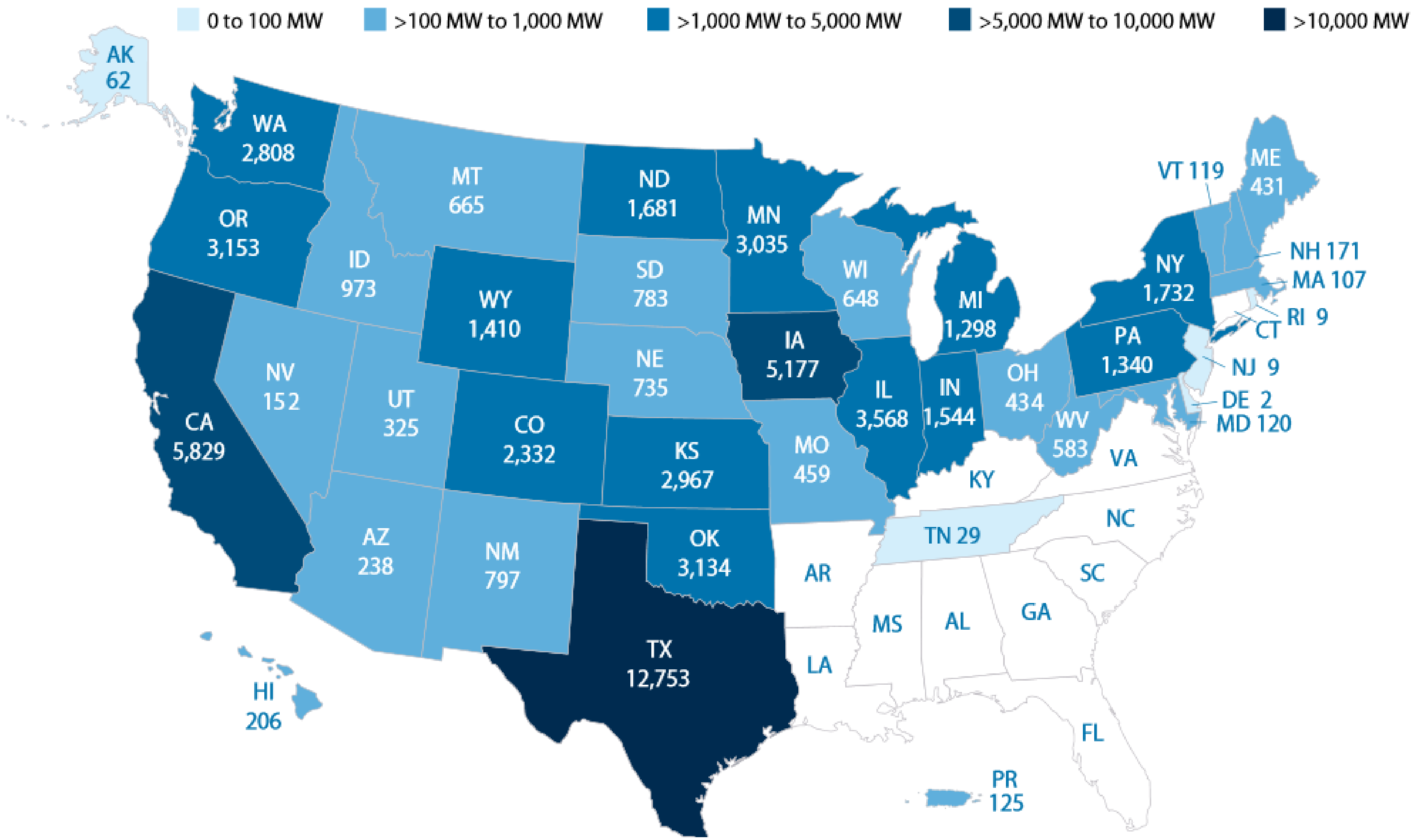
Harvard Electricity Policy Group panel discussion

Outline

- Wind energy significantly and cost-effectively reduces carbon emissions
- Papers by Frank and Schmalensee do not change the above statement, if one corrects some key inputs
- Clean energy tax credits are efficient carbon reduction policies in the absence of a carbon price

62 GW of wind capacity



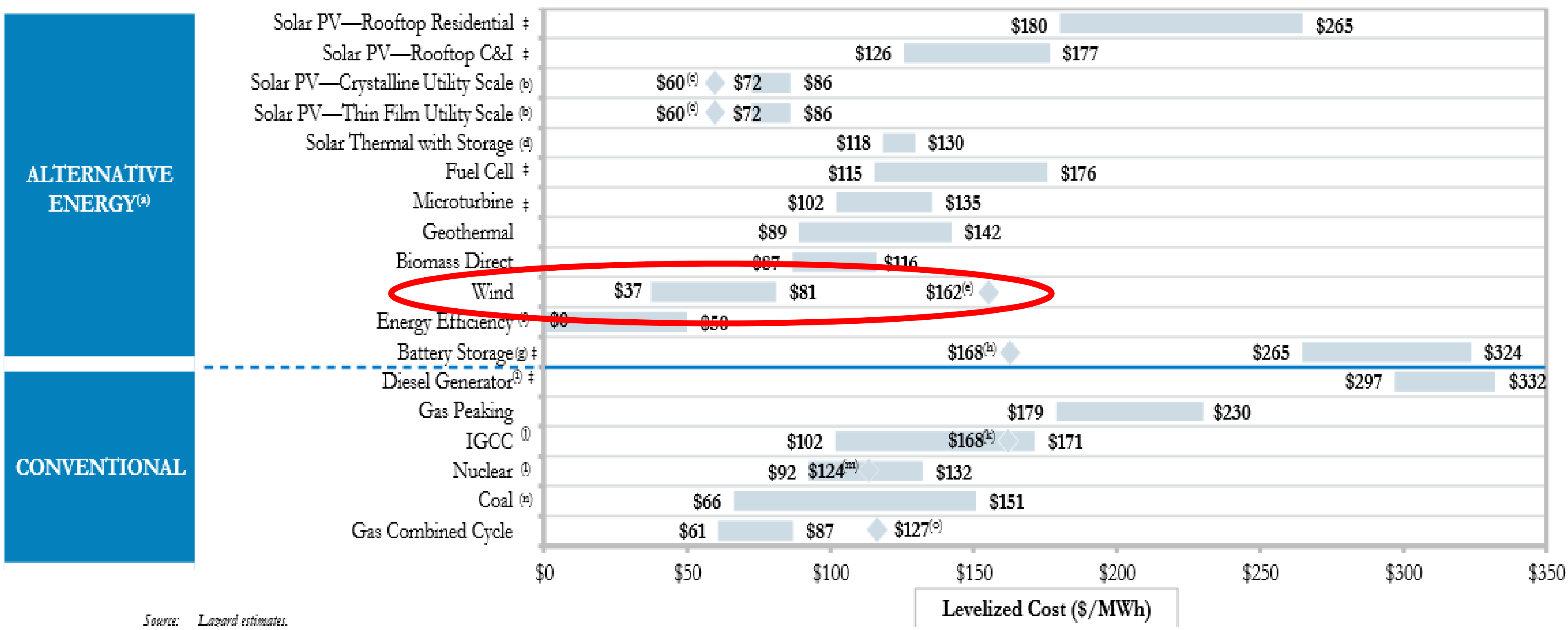
Installed wind capacity as of June 30, 2014, from AWEA 2014 2Q Market report

Wind cost trends

- DOE/LBNL Annual Wind Report: 60% decline in wind purchase prices over last four years (includes incentives):

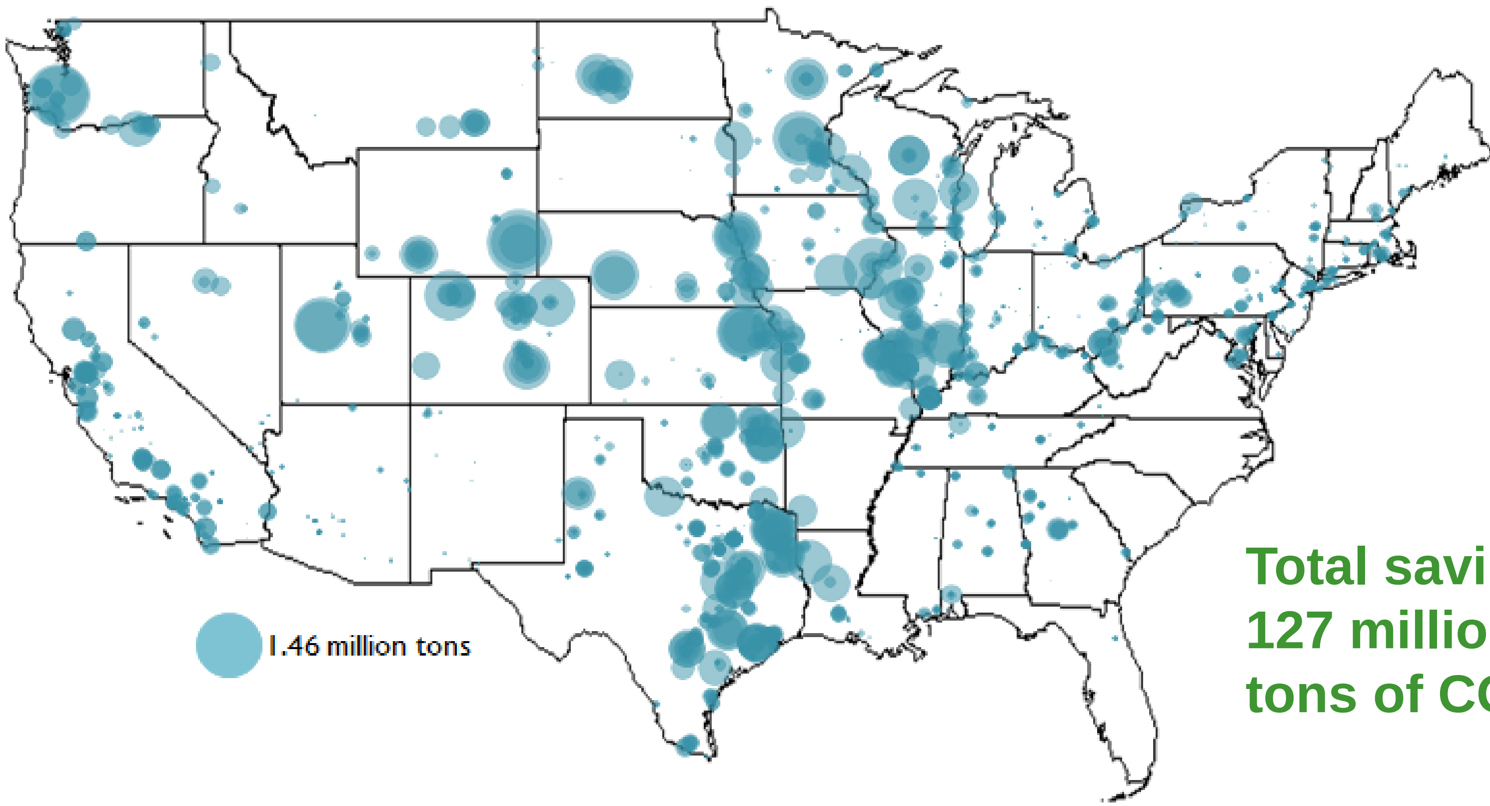
- Lazard 2014: Wind lowest cost energy source (excludes incentives)

Year	Average Wind Purchase Price, $/MWh
2009	$68.19
2010	$61.08
2011	$45.54
2012	$38.40
2013	$25.59



Wind's 2013 CO_2 savings, by fossil plant

EPA's AVERT tool or similar marginal emissions calculations are likely to be used by states for 111d planning and compliance to quantify the emissions reductions provided by various clean energy solutions, including wind, solar, nuclear, and energy efficiency. This is important for properly valuing the contributions of different solutions. In the map below, actual 2013 wind generation and the AVERT tool were used to calculate wind's emissions savings in 2013.



Total savings of 127 million short tons of CO2

Source: AWEA analysis using EPA AVERT tool,
EIA 2013 wind output data

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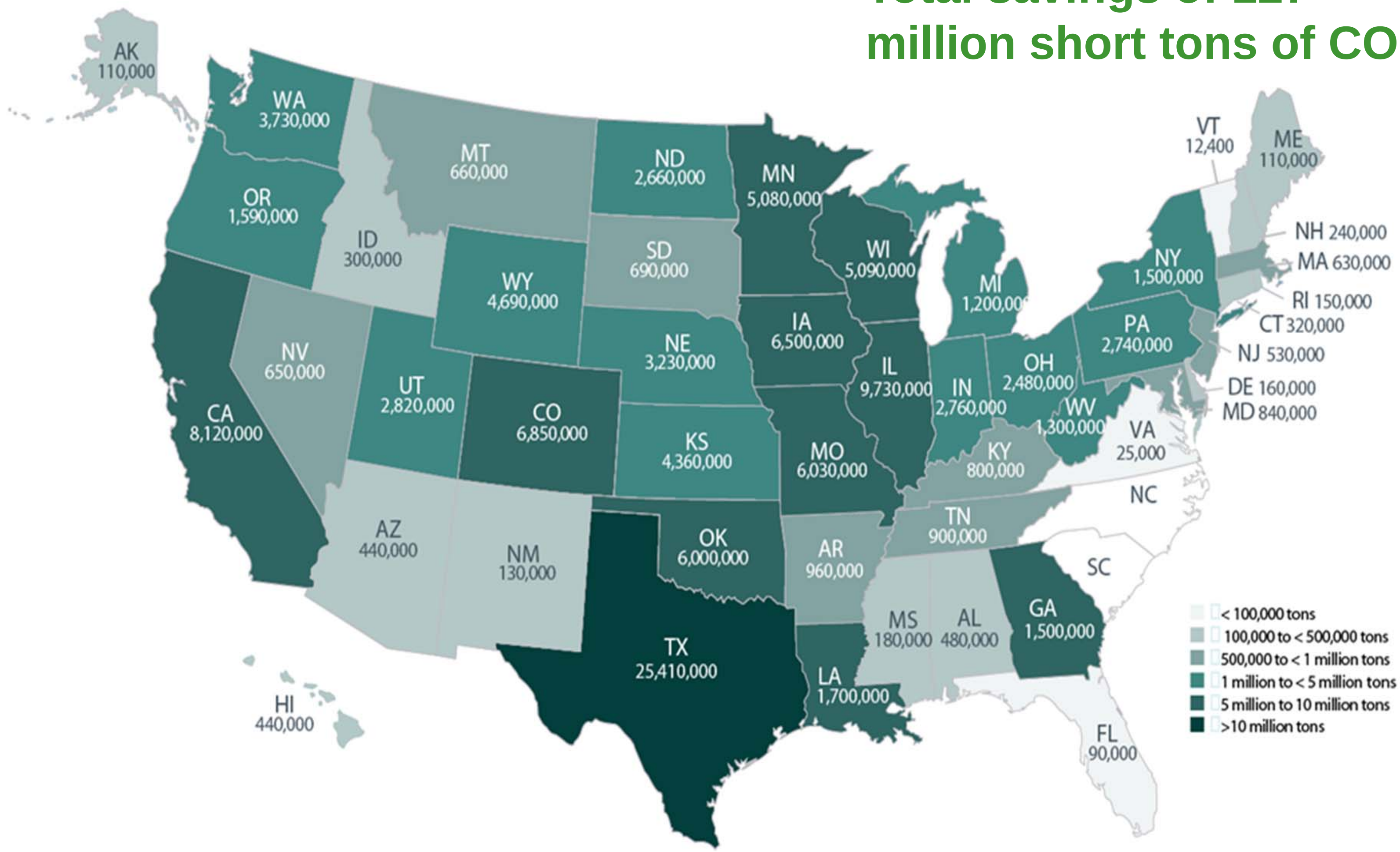
Wind's 2013 emission savings, by state

Total savings of 127 million short tons of CO2



Source: AWEA analysis using EPA AVERT tool, EIA 2013 wind output data

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Wind concentrated in carbon-heavy regions

- More than half of U.S. wind is in regions where wind has a 65+% coal displacement factor
- 54% of U.S. wind MWh displace coal

	Wind's 2013 savings, CO_2 (tons)	Wind's 2013 savings, SO_2 (tons)	Wind's 2013 savings, NOx (tons)	Wind CO_2 savings, lbs/MWh	% of wind MWh displacing coal in region	Wind MWh, share of national
MISO	34,344,200	56,391	30,042	1,834	85.4%	22.3%
Texas	22,235,300	29,681	11,998	1,341	38.2%	19.6%
SPP	19,099,400	26,544	18,772	1,675	67.1%	13.3%
PJM	13,906,200	33,281	12,238	1,545	66.4%	10.7%
California	10,044,500	900	7,532	985	10.0%	12.2%
CO+WY	10,242,200	7,878	10,057	1,771	70.8%	6.7%
Northwest and Interior West	9,005,700	5,805	9,976	1,404	41.8%	7.6%
Southeast	3,805,700	9,216	2,523	1,350	53.9%	3.4%
Northeast	2,948,600	2,564	1,925	1,109	14.2%	3.2%
Southwest	642,600	151	465	1,116	24.2%	0.7%
AK+HI	551,781	1,150	1,785	1,722	14.9%	0.4%
Total	126,826,000	172,300	105,500	1,500	54.1%	100%

Source: AWEA analysis using EPA AVERT tool,
EIA 2013 wind output data

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Europe: Very strong relationship between wind and electric sector carbon reductions

Country	Wind % 2001	Wind % 2011	Percentage share growth	CO_2/MWh % change
Ireland	1.4%	16.6%	15.2%	-36.1%
Portugal	0.6%	17.9%	17.4%	-32.4%
Denmark	11.9%	29.1%	17.2%	-28.9%
Spain	3.0%	15.2%	12.2%	-23.8%
Germany*	1.9%	8.5%	6.6%	-12.3%
All OECD Europe	0.8%	5.3%	4.4%	-11.0%

***Germany would have seen a far larger decline in carbon intensity had it not, for unrelated reasons, reduced the share of electricity it obtains from nuclear energy from 29.6 percent in 2001 to 17.7 percent in 2011.**

Source: IEA data

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Europe: Wind's emissions reductions continue

Spain

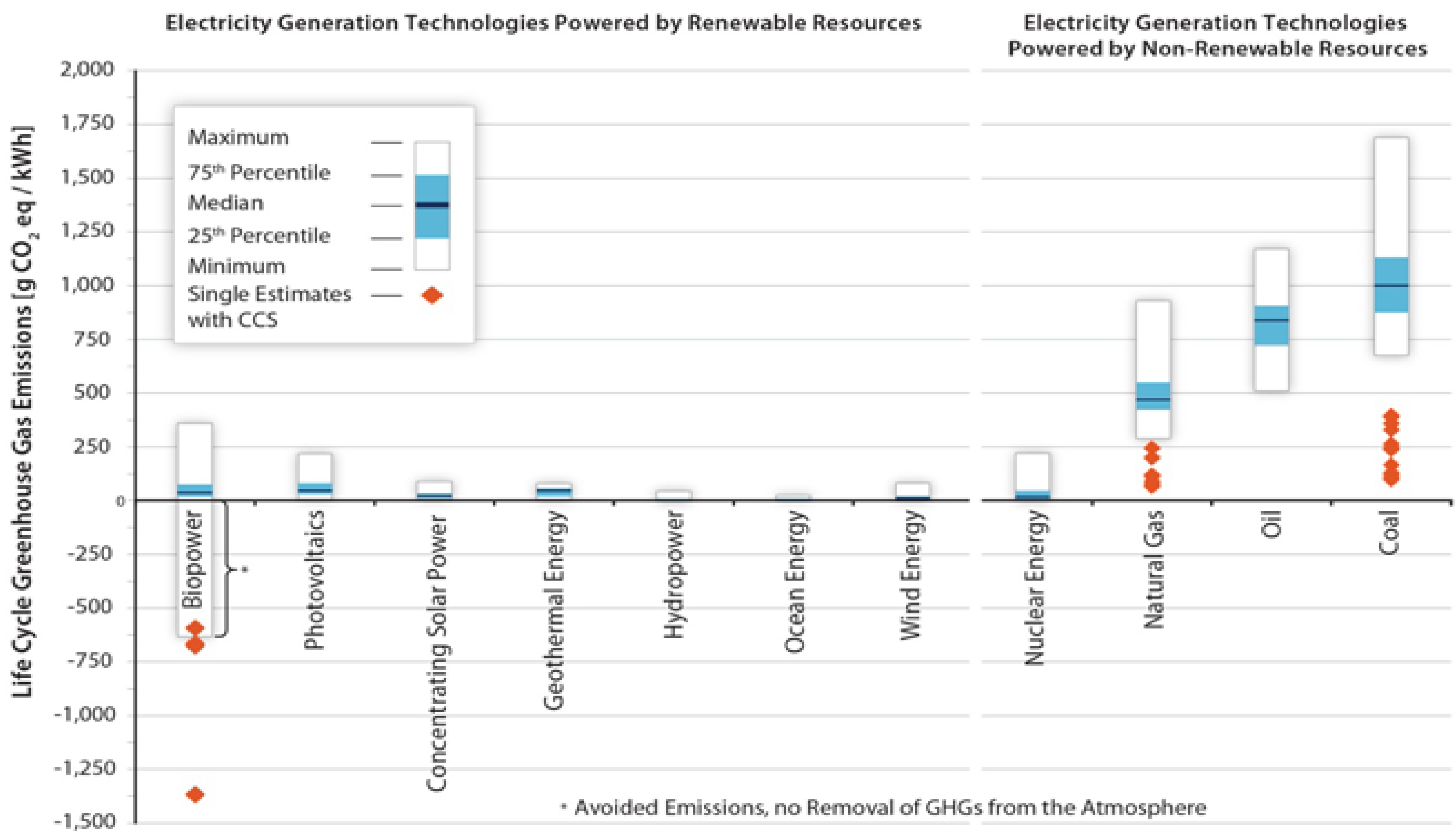
- Electric sector carbon dioxide emissions plummeted more than 23% in 2013 as wind energy grew to be Spain's largest single source of electricity at 21.1%.

- Gas power plant output dropped by 34.2% from 2012 and coal-fired generation fell by 27.3%, even though overall electricity use was relatively flat at a 2.1% decline. Other factors helping to reduce fossil generation and emissions were a weather-driven increase in hydro output, and a decrease in electricity exports.

Germany

- Electric sector CO2 emissions and coal use have increased by only a few percent, despite an accelerated reduction in nuclear generation since 2011. Other factors masking renewables' emissions reductions include an increase in coal use due to the completion of coal plants started more than 5 years ago and a shift away from gas due to price increases (doubling of Russian gas prices from 2009-2012) and recent geopolitical gas price risk.

Wind's lifecycle emissions among the lowest of non-emitting resources



Source: NREL/IPCC literature review and harmonization analysis, http://www.nrel.gov/analysis/sustain_lca_results.html

Myth of cycling emissions has been debunked

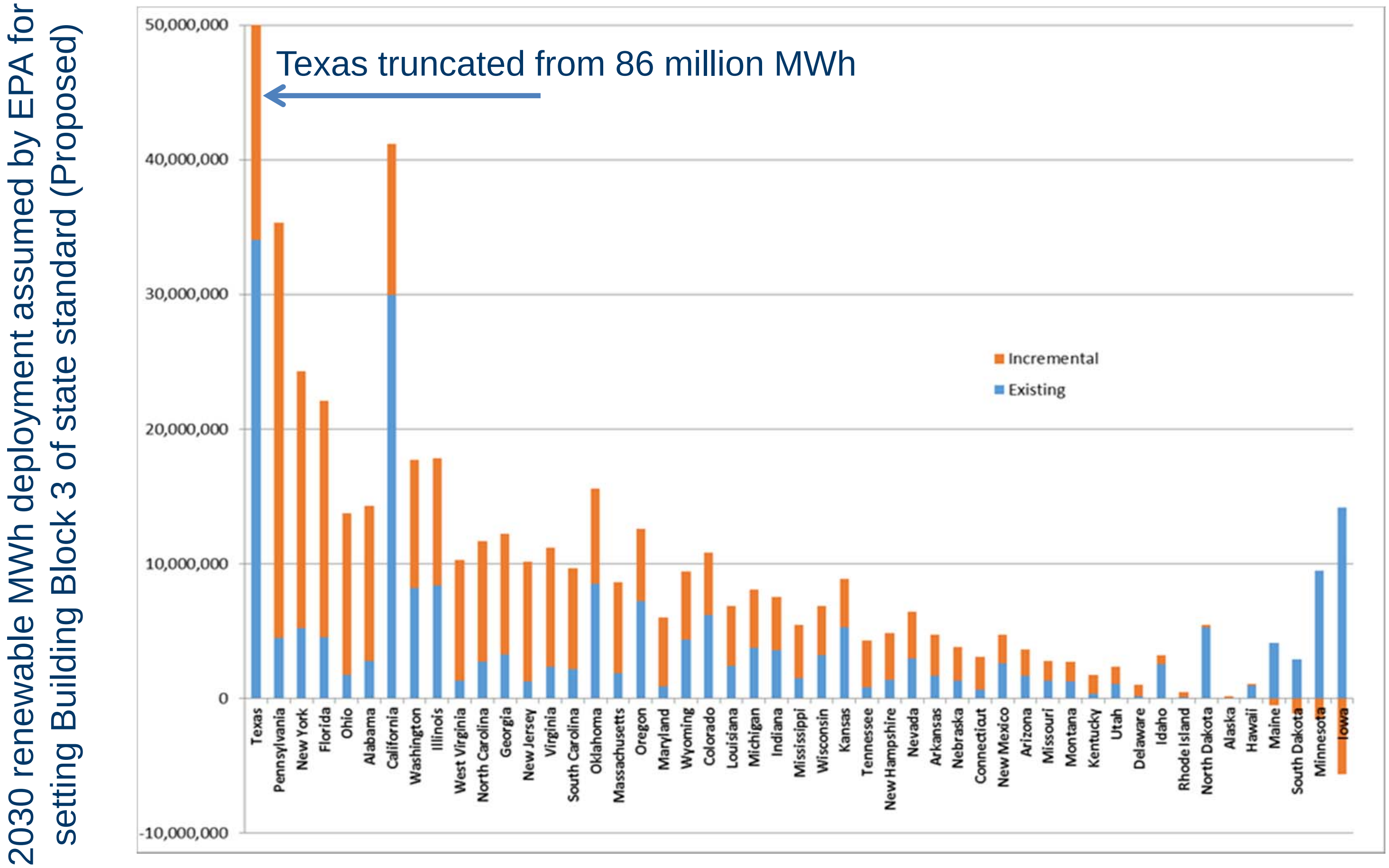
NREL: 33% renewables produces 99.8% of the expected CO2 emissions savings in the Western U.S., with wind saving 1190 lbs/MWh after cycling reduces that by 2.4 lbs

Emission Impacts of Cycling Are Relatively Small Compared to Emission Reductions Due to Renewables

	Emission Reduction Due to Renewables	Cycling Impact
CO_2	260–300 billion lbs 29%–34%	Negligible Impact
NO_x	170–230 million lbs 16%–22%	3–4 million lbs
SO_2	80–140 million lbs 14%–24%	3–4 million lbs

Source: http://www.nrel.gov/electricity/transmission/western_wind.html

EPA assumed renewables would play key role in 111d compliance

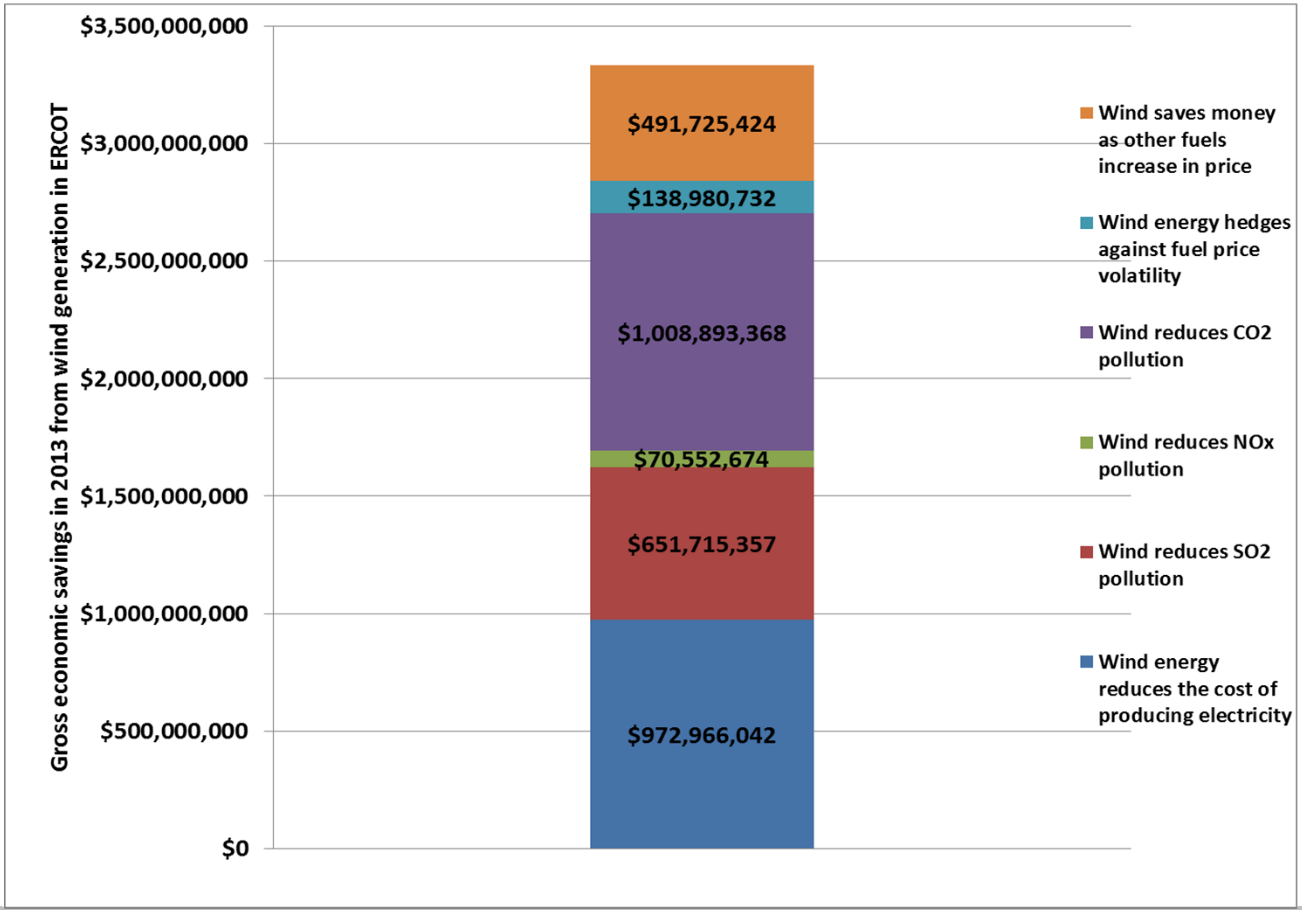


Wind saves billions annually on 111d compliance cost

AWEA economic optimization analysis for 111d compliance, using current wind costs, EIA data, EPA's Alternative method for setting state RE targets, and the assumption that ¾ of EPA's assumed EE and ½ of coal heat rate improvements occur.

Wind provides large societal benefits

AWEA analysis of ERCOT data shows gross benefits of $102/MWh of wind, half production cost savings and half environmental externalities, far greater than the current cost of wind energy.



Response to work by Frank, Schmalensee

Each has proposed innovative methods for important task of comparing net benefits of different energy options, but initial results are marred by inputs:

Dr. Charles Frank, Jr., "The Net Benefits of Low and No-Carbon Electricity Technologies," May 2014, Brookings Working Paper No. 73:

- Incorrect inputs for wind and gas capacity factors drastically alter the results, as capacity factor is the most important input into all three of the paper's calculations of economic value: energy, capacity, and emissions savings.
- Wind cost inputs are also too high.
- Assumed economic value of capacity is too high.
- Wind's integration costs are actually lower than conventional generators'.

Response to work by Schmalensee

Dr. Richard Schmalensee, "The Performance of U.S. Wind and Solar Generating Units," October 2013, NBER Working Paper No. 19509

- Results are skewed by using period (2011) with heavy wind curtailment and localized negative pricing, a problem that has since subsided thanks to grid upgrades (see below).
- Wind energy always significantly reduces fossil fuel use and power system production costs, regardless of when wind energy is produced; production cost savings are a more reliable indicator of societal value than market price.
- Once coal's far larger negative externalities are accounted for, what appeared to be wind's lower value of displacing off-peak coal relative to on-peak gas generation is likely reversed or brought close to parity.
- Wind's integration costs are lower than conventional generators'.

Frank - Input assumptions for wind and gas

	Wind plant capacity factor	Gas combined cycle capacity factor
DOE data (average 2008 – 2012)	31.0%	44.2%
Frank’s assumption	25.5%	92%

Data source	Installed wind project cost
Frank's assumption	$2,213/kW
DOE/LBNL data, 2012	$1,940/kW
DOE/LBNL data, 2013	$1,630/kW

Frank - Determining the value of capacity

In calculating the value of capacity, Frank makes two assumptions that are invalid in most U.S. electricity markets:

1. There is a demand for new capacity to meet system capacity needs, and

2. The construction of new power plants is always the lowest cost option for meeting capacity needs. Frank's analysis does not include demand response and other options that are supplying capacity at lower cost in many regions.

- Most U.S. electricity markets have excess generating capacity. In this case, the economic value of capacity is simply the fixed cost of maintaining existing power plants, not the cost of new capacity. Frank's paper provides data on fixed O&M costs, which are just 10-14 percent of his total calculated cost of capacity for gas and coal power plants.

- Even in those U.S. markets with incremental capacity needs, demand response, energy efficiency, and other innovative resources are meeting incremental capacity needs at a lower cost than installing a new conventional power plant. For example, the next slide shows that in PJM the value of capacity is well below the cost of new entry for a gas plant.

Frank and Schmalensee - Determining the value of capacity and dispatchability

- While wind does provide less capacity value than other resources, this has minimal impact on the economic value of wind.
- PJM Independent Market Monitor report (left) shows that the total value of the capacity market accounts for only 13% of the value of the total electricity market.
- DOE/LBNL (right) have developed Levelized Avoided Cost of Electricity (LACE) method to account for different capacity values and dispatchability of wind versus conventional resources, and found this only reduces the economic value of wind by around 10%.

Table 1-9 Total price per MWh by category: 2012[54] and 2013

Category	2012 $/MWh	2013 $/MWh	Percent Change Totals	2012 Percent of Total	2013 Percent of Total
Load Weighted Energy	$35.23	$38.66	9.7%	71.8%	71.7%
Capacity	$6.05	$7.13	17.8%	12.3%	13.2%
Transmission Service Charges	$4.78	$5.20	8.7%	9.7%	9.6%
Reactive	$0.43	$0.80	87.6%	0.9%	1.5%
Energy Uplift (Operating Reserves)	$0.79	$0.59	(25.5%)	1.6%	1.1%
PJM Administrative Fees	$0.44	$0.43	(2.0%)	0.9%	0.8%
Transmission Enhancement Cost Recovery	$0.34	$0.39	15.5%	0.7%	0.7%
Regulation	$0.26	$0.24	(5.3%)	0.5%	0.5%
Black Start	$0.03	$0.14	437.7%	0.1%	0.3%
Capacity (FRR)	$0.52	$0.11	(79.4%)	1.1%	0.2%
Transmission Owner (Schedule 1A)	$0.08	$0.08	(0.3%)	0.2%	0.2%
Emergency Load Response	$0.02	$0.06	209.0%	0.0%	0.1%
Day Ahead Scheduling Reserve (DASR)	$0.05	$0.06	21.9%	0.1%	0.1%
Synchronized Reserves	$0.04	$0.04	3.1%	0.1%	0.1%
NERC/RFC	$0.02	$0.02	(1.2%)	0.0%	0.0%
RTO Startup and Expansion	$0.01	$0.01	(1.4%)	0.0%	0.0%
Economic Load Response	$0.01	$0.01	41.6%	0.0%	0.0%
Non-Synchronized Reserves	$0.00	$0.00	127.3%	0.0%	0.0%
Transmission Facility Charges	$0.00	$0.00	17.2%	0.0%	0.0%
Emergency Energy	$0.00	$0.00		0.0%	0.0%
Total	$49.07	$53.92	9.9%	100.0%	100.0%

Fuel	LACE
Wind	$56/MWh
Gas	$62/MWh

Frank and Schmalensee - Wind's integration costs are lower than conventional generators'

AWEA analysis using ERCOT reserve pricing data and ERCOT's own analysis of wind's contribution to reserve needs: http://variablegen.org/wp-content/uploads/2012/12/Maggio-Reserve_Calculation_Methodology_Discussion.pdf

Factor	Total annual cost (million $)	% of total reserve cost	Cost per electric bill
Conventional plant failures	**$239.690**	**67%**	**76 cents**
Wind	**$13.740**	**4%**	**4.3 cents**
Conventional and demand deviations	**$103.359**	**29%**	**33 cents**

	Regulation down	Regulation up	Responsive reserves	Non-spinning reserves
Contingency reserves for conventional power plant failures (MW)			2,800	
Incremental reserves for wind (MW)	14	42		328
Electricity demand variability and deviations at conventional power plants (MW)	476	508		1,474
Cost of reserve ($/MW)	**$4.89**	**$8.57**	**$9.77**	**$3.47**
Annual reserve cost for conventional power plant failures (million $)			$239.690	
Annual reserve cost for wind (million $)	$0.585	$3.159		$9.996
Annual reserve cost for electricity demand variability and supply deviations at conventional power plants (million $)	$20.372	$38.126		$44.860

PTC is a cost-effective carbon policy

- \$23/MWh PTC cost discounted over 10 years PTC is provided, at 2.62% 10-year Treasury yield equals \$20/MWh
- \$20/MWh renewable production tax credit (PTC) divided by 2.5 (wind project provides emissions savings over ~25 year life, while PTC received for only 10 years) equals \$8/MWh
- 1 MWh of wind saves .75 short tons (.68 Metric tons) of CO_2 on average (from AVERT calculations), so cost to Treasury is \$12/Metric tonne of CO_2
- \$12/Metric tonne times 0.25 estimated deadweight loss/marginal excess burden of federal income taxation equals \$3/tonne societal cost for PTC

Energy policy in absence of a carbon price

- The power system should have a level playing field where all sources compete and carbon free electricity is appropriately valued.
- In a market without a carbon price, an alternative policy is needed in the interim. We should not let the perfect be the enemy of the good.
- Tax incentives can be efficient, and can be made technology neutral
- 2-year PTC extension needed immediately by the end of 2014 to avoid losing the manufacturing capacity in the US which brings short and long term cost reductions.