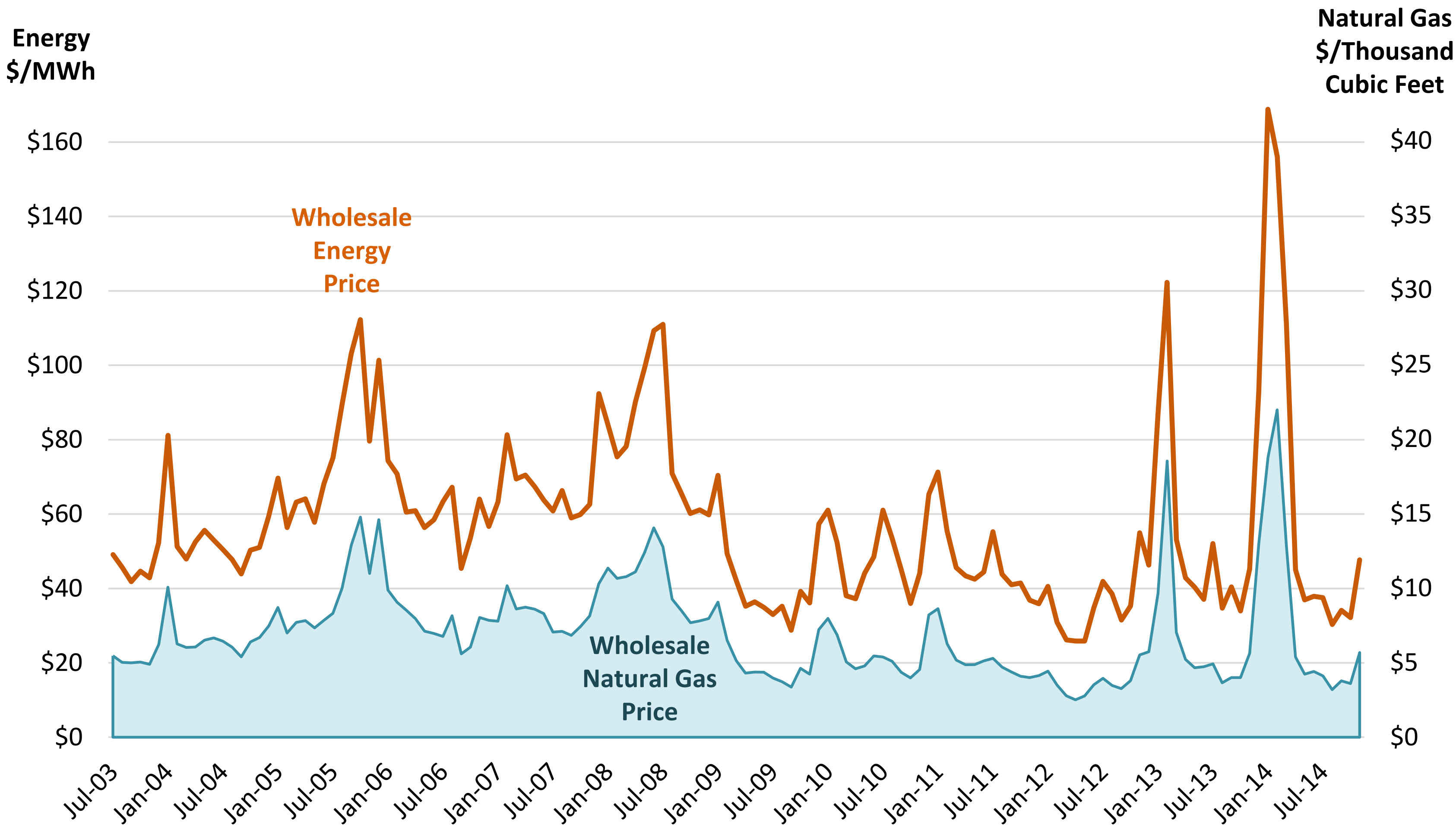
RENEW Northeast

Benefits of Long-Term Wind Contracts

July 1, 2015

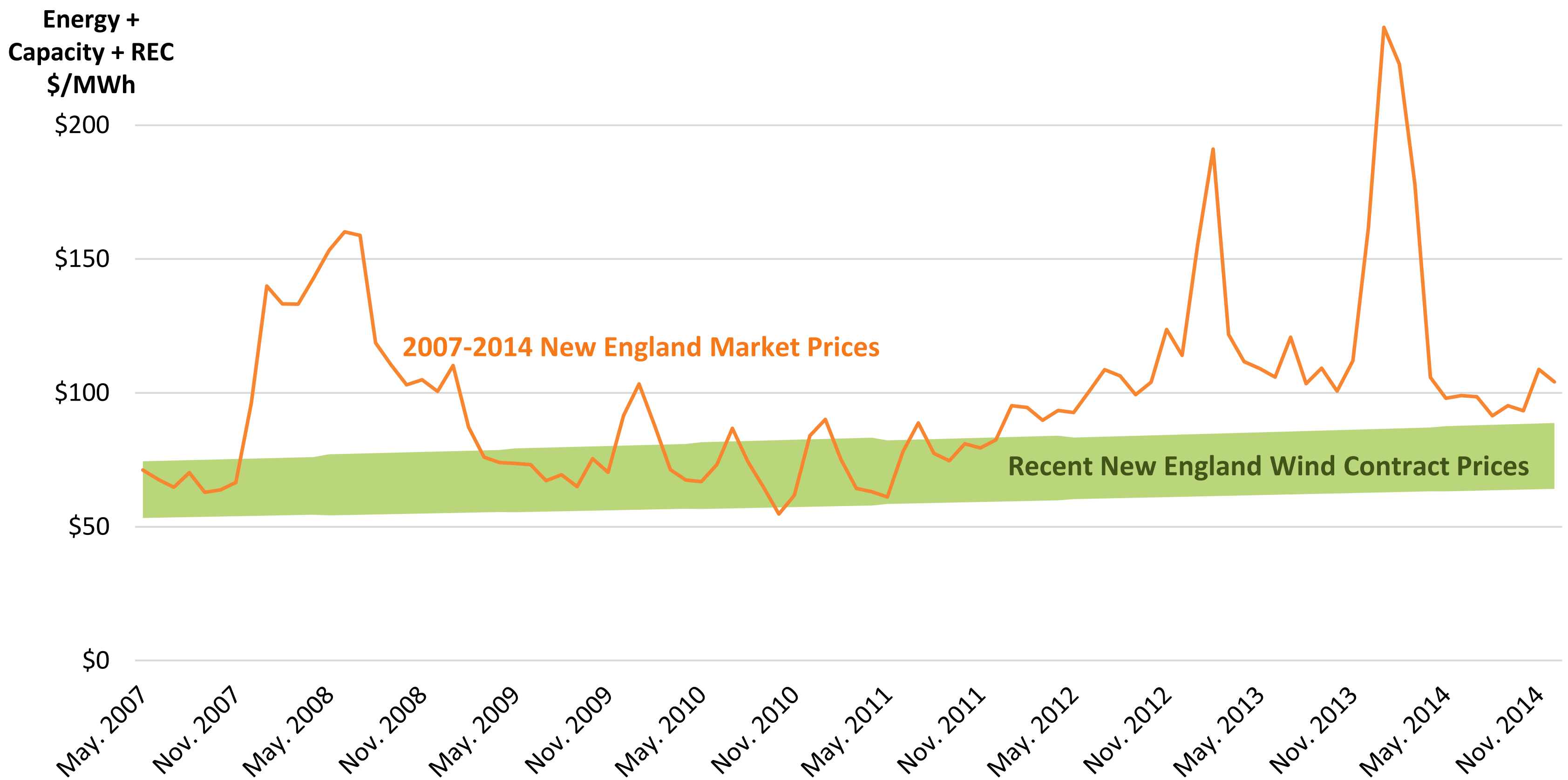
2. Value of Wind in Hedging Energy Prices

In New England, volatile natural gas prices generally set the price of electricity in the wholesale market. Long-term wind contracts can help to hedge this volatility.



3. Value of Wind in Hedging Energy Prices

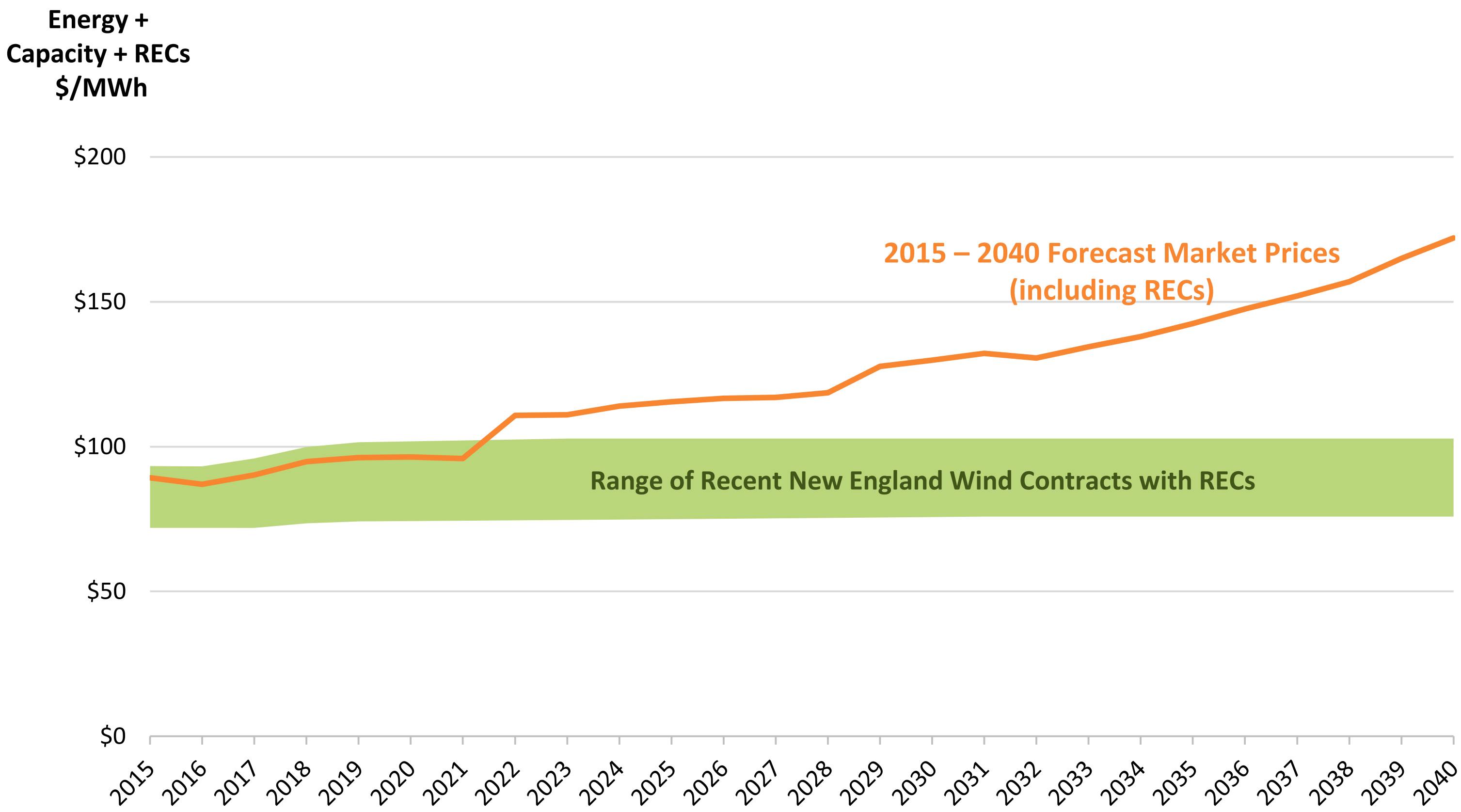
Renewable resources with their "free" fuel can provide an effective long term hedge, **like a 30 year fixed-rate mortgage,** against electricity market price volatility.



The orange line shows actual market prices from 2007-2014. The green shaded area shows the price of wind contracts, if you could have signed a contract in earlier years at today's wind prices. Of course, wind contract prices in 2007 would have been a bit higher, as technology has improved and costs have come down since then. Note that the wind contract prices have been adjusted for inflation.

4. Wind Contracts Offer Low Price and Provide Hedge Against Rising Costs

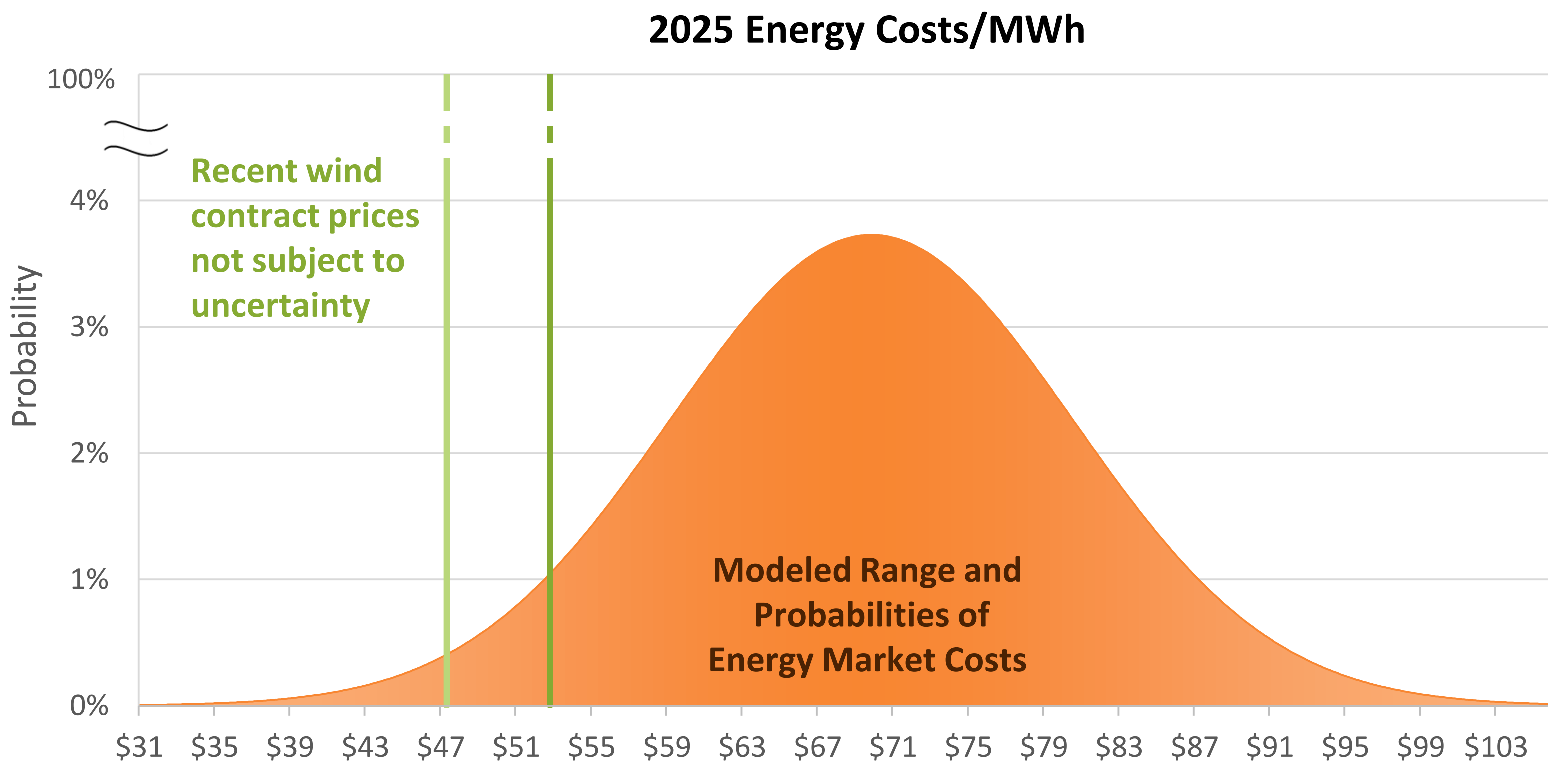
Bundled contracts include the price of energy and renewable energy certificates (RECs), providing a hedge against rising costs of energy and environmental compliance .



Energy price forecast based on EIA Annual Energy Outlook 2014. Capacity market price forecast based on recent auction results. REC price forecast based on 2015 AESC forecast

5. What is the hedge value of wind?

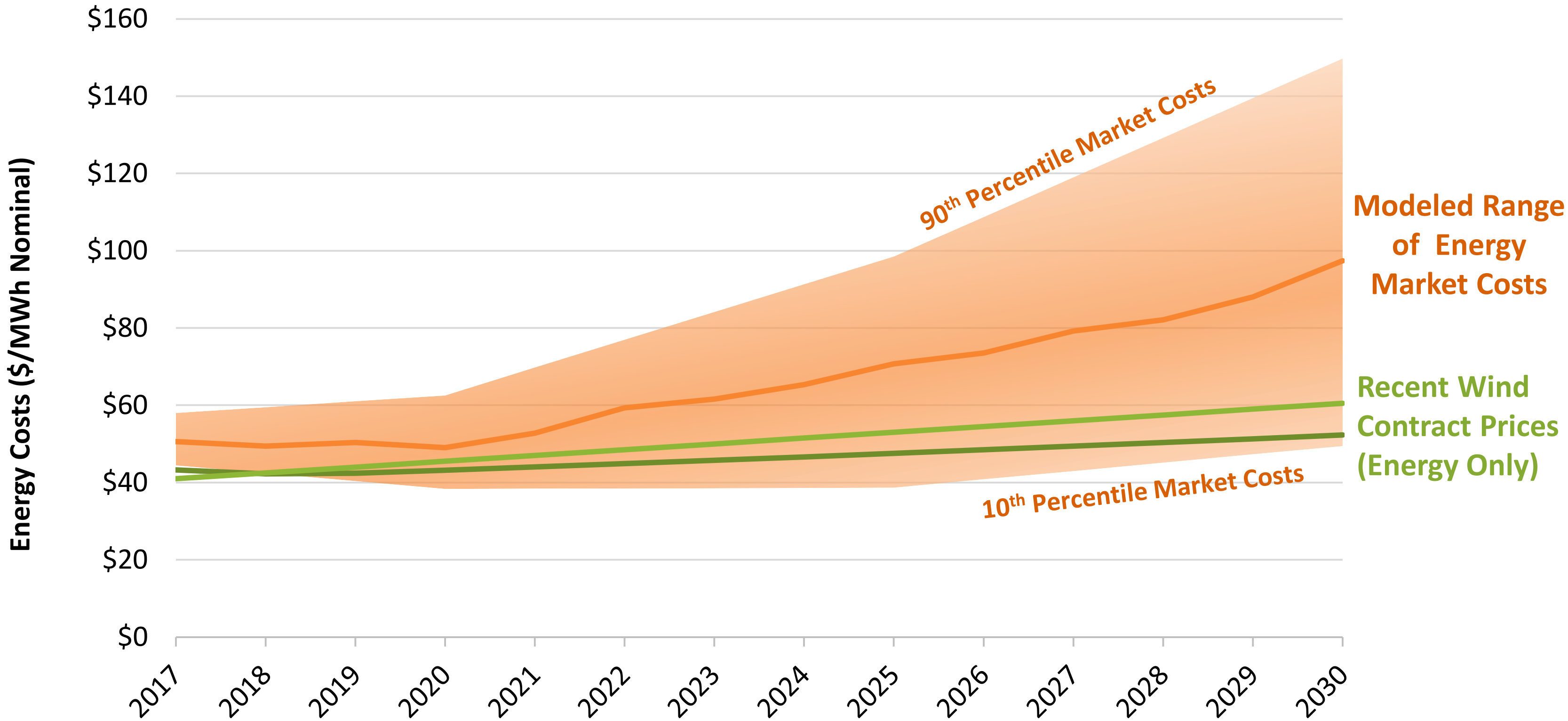
Future energy market prices are uncertain and can be represented using a probability distribution for each future year. In contrast, long-term wind contract prices are known with certainty. While energy market costs could be cheaper in the future, they are much more likely to be higher than wind contract costs.



Energy market costs are based on New England 2015 Avoided Energy Supply Costs under the scenario that energy efficiency programs continue. Probability assumes a normal distribution with a mean of 1 and a standard deviation of 0.15. Wind contract costs based on two recent Maine wind contracts, with capacity costs removed.

6. What is the hedge value of wind?

Uncertainty regarding future market prices increases over time, but wind contract prices do not. It is estimated that the levelized hedging benefit of wind is in the range of $13 - $16/MWh.



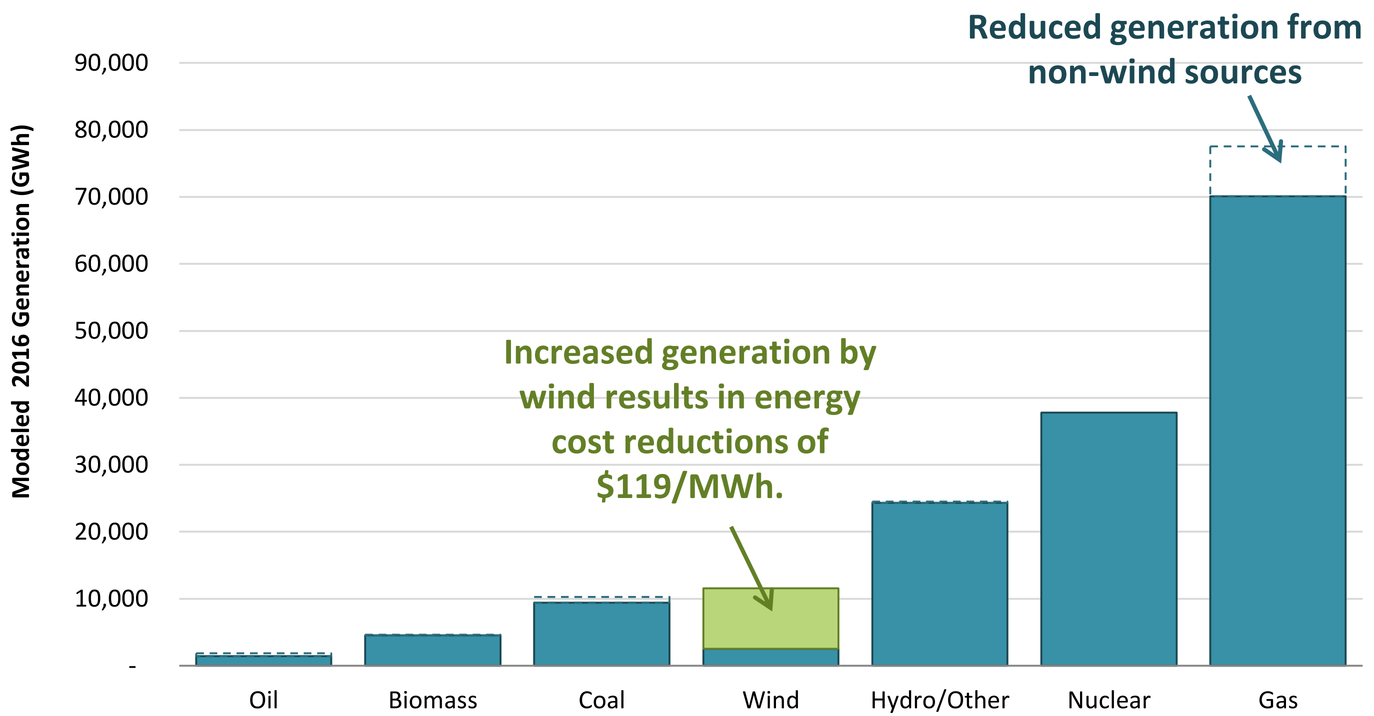
The prior slide compares wind contract prices with a range of possible market prices in one year, 2025. This slide shows the same idea, but for multiple years. The range of possible market prices increases further into the future. As this uncertainty in market prices grows, the wind contract price provides more value.

Energy market costs are based on New England 2015 Avoided Energy Supply Costs. Wind contract costs based on two recent Maine wind contracts, with capacity costs removed. Over the study period, the wind contracts provide a levelized benefit ranging from $13-$16/MWh, as compared to the higher energy market expected costs.

7. Wind Lowers Wholesale Energy Prices

ISO New England modeled a four-fold increase in wind (to 4 GW). The results indicate that annual wholesale energy costs would be reduced by over **$1 billion**, equivalent to $119 in savings per MWh of additional wind generation.

ISO New England Modeling Results from 2011 Economic Study



Graph based on ISO New England 2011 Economic Study, March 31, 2014 update, Case 5c, Expanded Wyman/Bigelow Contingencies, Table 6-11. Analysis assumed 4 GW of wind added to system in one year, with no retirements or deferred new entry, both of which would impact the results. The study year was 2016, but the price suppression effect is likely to continue for multiple years. Additional modeling would be required to quantify the amount and duration of this effect beyond 2016.

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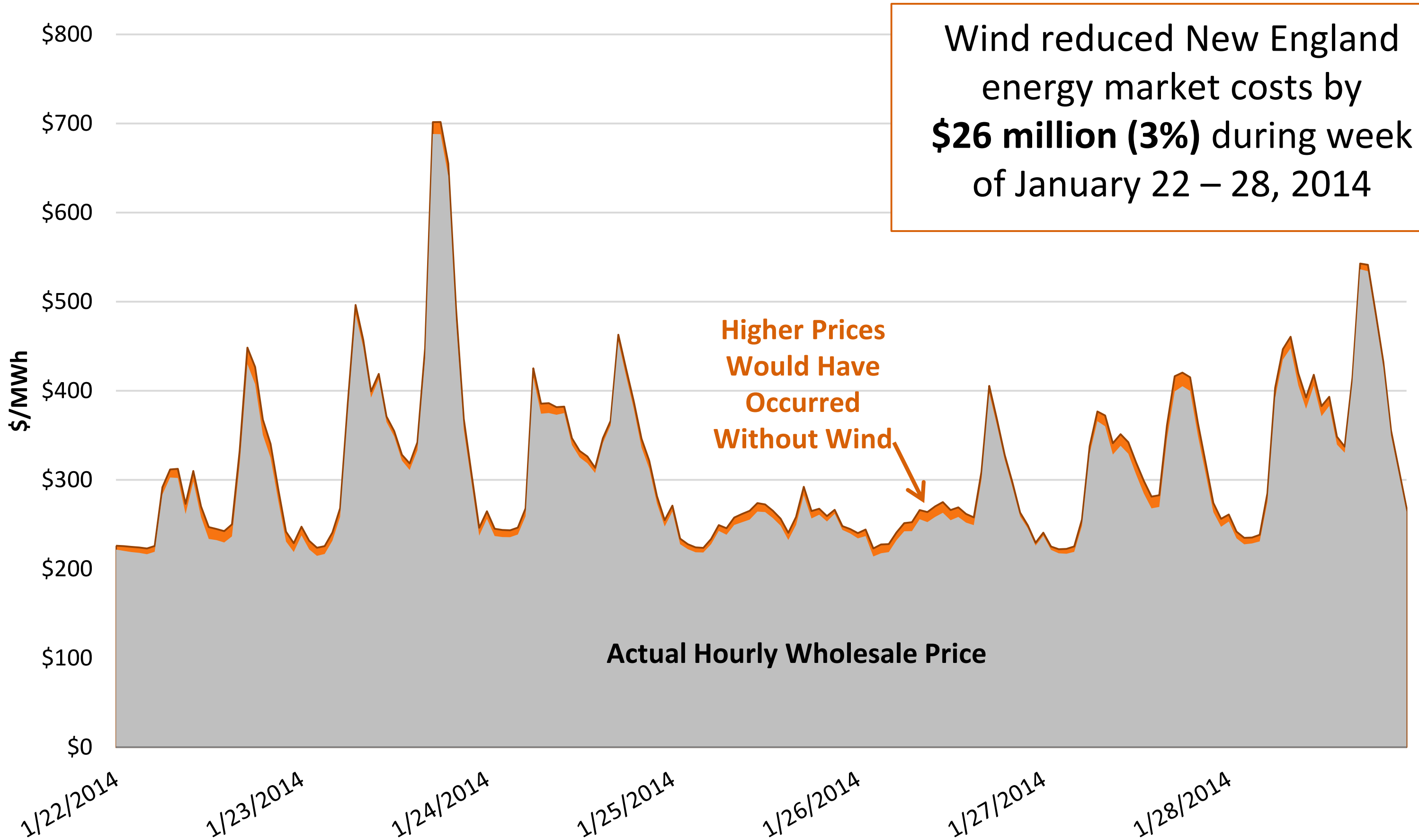
8. Value of Wind During Polar Vortex

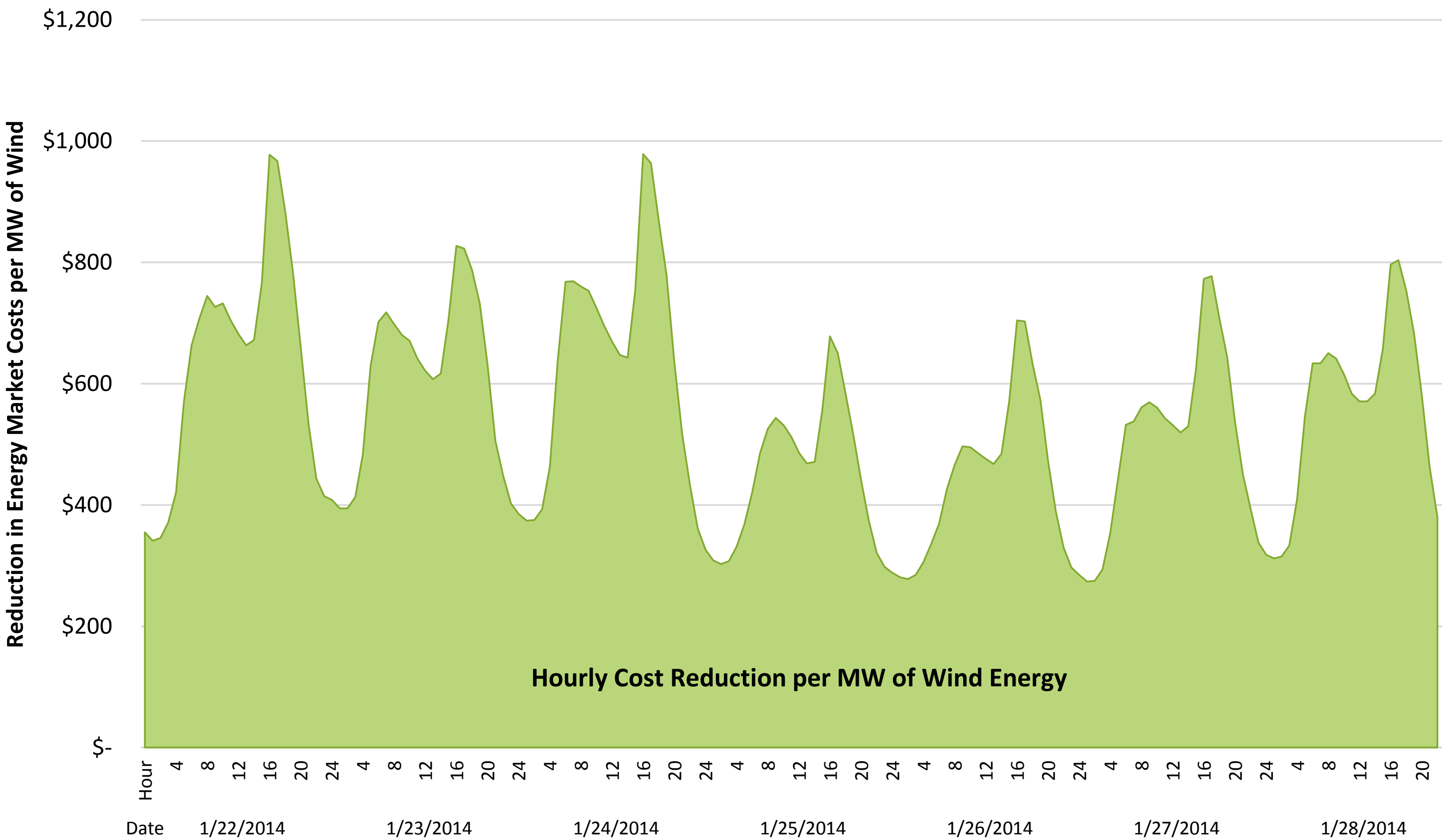
Wind helped to lower market prices during the polar vortex. Although it only constituted approximately 1% of energy, wind reduced total energy market costs by approximately 3% during the Polar Vortex.

Wind reduced New England energy market costs by **$26 million (3%)** during week of January 22 – 28, 2014



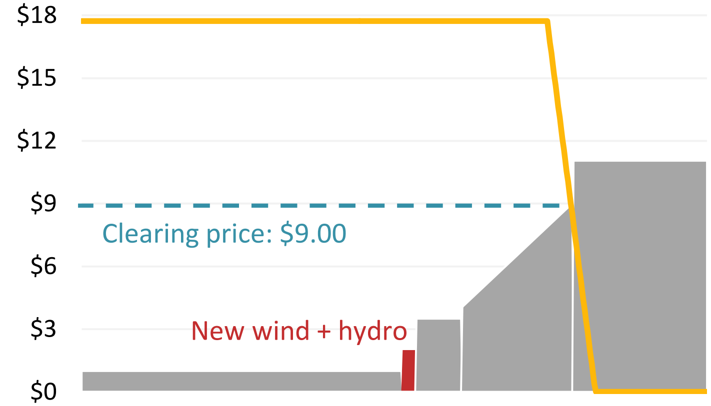
9. Hourly Cost Reduction During Polar Vortex

Each megawatt-hour of wind energy produced during the polar vortex reduced wholesale energy costs by an average of **$544**.



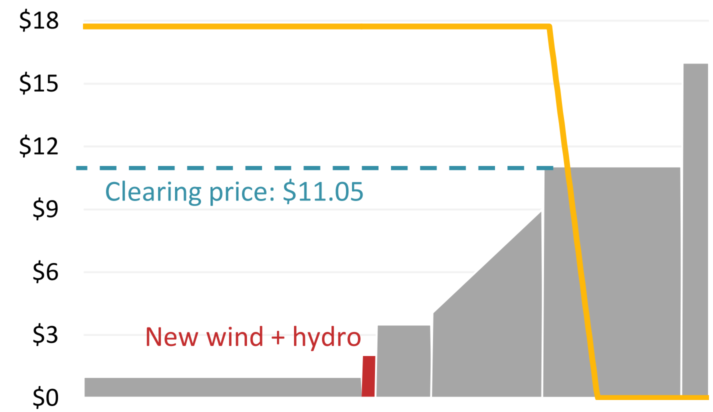
10. Reductions in Capacity

Potentially Large Impacts: Depending on supply and demand, in certain situations, adding 500 MW of wind and hydro could reduce capacity market costs by approximately **$900 million**.



Graphs are based on recent auction results and roughly approximate the current New England capacity market.
Savings estimates based on 35,000 MW of cleared capacity.

No Impacts: In other situations, adding 500 MW of wind and hydro will not alter the clearing price.



Graphs are based on recent auction results and roughly approximate the current New England capacity market.
Savings estimates based on 35,000 MW of cleared capacity.

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Sources and Notes

- **Slide 2:**
  - Wholesale energy price is the ISO-NE control area average day ahead LMP
  - Wholesale natural gas price is the Massachusetts Natural Gas Price Sold to Electric Power Consumers (Dollars per Thousand Cubic Feet), as reported by the EIA. Data released 2/27/2015, available at http://tonto.eia.gov/dnav/ng/hist/n3045ma3m.htm

- **Slide 3:**
  - New England Market Price = (Wholesale Energy Price) + (Wholesale Capacity Price) + (Actual REC Spot Market Price)
    - Where the wholesale energy price is the ISO-NE control area average day ahead LMP, the wholesale capacity price reflects the results of the New England Forward Capacity Market, and the REC spot market price is based on REC prices reported by the US Department of Energy (http://apps3.eere.energy.gov/greenpower/markets/certificates.shtml?page=5)
  - Recent Wind Contract Prices include:
    - Number Nine: (Energy price of $59) – (40% of the capacity market price)
    - Groton and Hoosac contracts for energy and RECs, plus the cost of capacity that a utility would be required to buy: (Energy + REC price range of $80-$89/MWh) + (100% of capacity market price)
    - Bull Hill contract for energy, RECs, and capacity: Bundled contract price range of $80-$89/MWh

    Note that these wind contract prices are then deflated to 2007 – 2014 dollars for this graph. The prices then increase over time due to inflation and varying capacity market prices.

- **Slide 4**
  - Energy market prices are Based on AEO 2014 Reference Case New England Natural Gas for Electric Generation Purposes (nominal) and an assumed heat rate of 7050, based on EIA forecast assumption (http://www.eia.gov/forecasts/aeo/assumptions/pdf/electricity.pdf)
  - Capacity market prices are based on recent auction results, and then escalated for inflation.
  - Recent Wind Contract Prices include:
    - Number Nine: (Energy price of $59) – (40% of the capacity market price)
    - Groton and Hoosac contracts for energy and RECs, plus the cost of capacity that a utility would be required to buy: (Energy + REC price range of $80-$89/MWh) + (100% of capacity market price)
    - Bull Hill contract for energy, RECs, and capacity: Bundled contract price range of $80-$89/MWh
  - REC prices for 2015 – 2030 are based on the REC forecast from the March 31, 2015 Avoided Energy Supply Component (AESC) Study Group report, Exhibit F-1 CT and MA Class 1 REC forecast through 2030 (http://ma-eeac.org/wordpress/wp-content/uploads/2015-Regional-Avoided-Cost-Study-Report1.pdf). 2031-2040 use 2030's forecast adjusted to nominal dollars.

Sources and Notes

- **Slide 5:**
  - Future energy market costs are based on the AESC 2015 Wholesale Energy Price Forecast for Massachusetts (Exhibit 6-3), which included energy efficiency effects in the forecast. Wind contract costs are for Weaver and Highland. All dollar values are in nominal terms.
  - There is no current consensus on the probability distribution of energy market prices, and we have therefore chosen to use a normal distribution with a mean of 1 and a steadily increasing standard deviation (ranging from 0.05 to 0.20).
  - This is but one of many ways to model the uncertainty regarding future energy market prices and hedge values. As stated by NREL in its 2012 Renewable Electricity Futures Study, "A variety of methods have been used to assess and sometimes quantify the benefits of fixed-price renewable energy contracts relative to variable-price fossil generation contracts, as well as the benefits of electricity supply diversity more generally. These methods have included risk-adjusted discount rates (e.g., Awerbuch 1993); Monte Carlo and decision analysis (e.g., Wiser and Bolinger 2006); portfolio theory (e.g., Bazilian and Roques 2008); market-based assessments of the cost of conventional fuel-price hedges (e.g., Bolinger et al. 2006); and various diversity indices (e.g., Stirling 1994, 2010). ***Many of these methods have proven controversial, and a single, standard benefit quantification has not emerged***." (emphasis added)

- **Slide 6:**
  - The "hedge value" of wind in this slide assumes a linear model with an expected value equivalent to the AESC 2015 Wholesale Energy Price Forecast for Massachusetts (Exhibit 6-3) compared with stable wind contracts (Weaver and Highland). The levelized benefit was calculated using a discount rate of 8 percent.

Sources and Notes

- **Slide 7:**
  - Graph based on ISO-New England 2011 Economic Study, March 31, 2014 update, Case 5c, Expanded Wyman/Bigelow Contingencies, Table 6-11.
  - The study year was 2016, but the price suppression effect is likely to continue for multiple years. Additional modeling would be required to quantify the amount and duration of this effect beyond 2016. Analysis assumed 4 GW of wind added to system in one year, with no retirements or deferred new entry, both of which would impact the results.
  - Results of ISO-NE study are not endorsed in any way by Synapse Energy Economics. A more complete study would
    - Phase in the 4 GW of wind over time;
    - Assess impacts on the energy and capacity markets from this new entry with low energy and capacity market bids;
    - Make realistic assumptions about the reaction of other market participants, i.e., resulting retirements and deferred new entry due to the entry of 4 GW of new wind;
    - Account for the supply curve impacts of such retirements and deferred new entry;
    - Model a longer study period in order to determine how long any price suppression impacts are likely to last; and
    - Make a realistic assumption about cost of transmission to integrate new wind and to handle retirements while still serving load reliably.

Sources and Notes

- **Slide 8:**
  - New England Energy Market Price is the ISO-NE control area hourly day ahead LMP for January 22 – January 28, 2014, which was the week with the greatest price spikes (averaging above $300/MWh on some days).
  - Hourly actual wind generation for January 22 – January 28 is from an ISO-NE data file located here: http://www.iso-ne.com/static-assets/documents/2014/11/hourly_wind_gen_2011_2014.xlsx
  - To determine the impact of wind generation, a regression analysis was performed to determine the relationship between load and price for the day ahead market. (A reduction in load shifts the demand curve to the left, which is equivalent to the effect produced by inserting wind in the supply stack, thereby shifting the supply curve to the right. Thus a 1 MWh reduction in load has the same effect as increasing wind output by 1 MWh.) This analysis produces predictions of what the higher prices might have been in the day ahead market without wind. The best fit was found to be an exponential curve, with an average savings of $9.1/MWh wind savings effect. In each hour, we took the change in price due to wind, and then multiplied this by the hourly load to get the DRIPE (Demand Reduction Induced Price Effect) for that hour. The sum of the DRIPE impacts for the week was found to be $26 million.

- **Slide 9:**
  - Slide 6 builds on Slide 5. First we calculate the hourly energy price without wind, using the results from the regression analysis described above, and then multiply this by the demand in that hour. This is what the day ahead wholesale energy costs would have been in that hour without wind. We then use actual prices multiplied by demand to determine the actual costs. The difference between these costs in each hour is then divided by the MW of wind output in that hour to determine the savings produced by wind per MWh for that hour. The weighted average is $544/hour of savings per MWh of wind for the period January 22- January 28, 2014.

- **Slide 10:**
  - Graphs show illustrative demand and supply curves, based on recent ISO-NE capacity market auction results. They are intended to roughly approximate the current New England capacity market.
  - Savings estimates are based on a plausible change in market clearing price due to the addition of 500 MW of low-cost resources, and assume 35,000 MW of cleared capacity. The savings are calculated as the product of the change in price and the 35,000 MW of cleared capacity.