Wind energy saves consumers money during the polar vortex

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Introduction

Wind energy saved electricity users in the Mid-Atlantic and Great Lakes states at least $1 billion during the polar vortex event in early January 2014.

By diversifying America's energy mix, wind energy improves electric reliability and protects consumers from energy price spikes. While wind energy always provides these benefits, they can become particularly pronounced when the electric grid is stressed.

On January 6th and 7th, 2014, frigid Arctic air blanketed the Eastern U.S. when the "polar vortex" that normally holds cold air near the North Pole briefly weakened. The extreme cold snap, which became known as the "polar vortex" event, caused unusually high demand for electricity as well as for natural gas for both heating and electricity generation. In addition, extremely low temperatures contributed to unexpected failures at many power plants, due to equipment breaking and shortages of fuel.

Driven by high demand and low supply, electricity and natural gas prices rose to dozens of times their normal levels in many regions. The Mid-Atlantic and Great Lakes states were particularly hard hit by these abnormally cold temperatures and the resulting energy prices spikes.

There and in other regions, wind energy provided large quantities of critical electricity supply when it was needed most, keeping the lights on and reducing the impact of these price spikes. Our analysis quantified the savings wind energy provided to Mid-Atlantic and Great Lakes consumers on January 6th and 7th, 2014, by calculating how much more electricity prices would have increased had the region's wind generation not been online. Using hourly grid operator data, fuel price information, and a detailed representation of the characteristics of every power plant in the region, our analysis quantified how wind energy kept electricity price spikes in check.

Wind energy's consumer benefits stem from wind energy's fuel price stability. Wind is one of the few energy sources that offers perfect fuel price stability that can be locked in up front, as wind's fuel cost will always be zero. For all other major conventional sources of electricity, fuel prices cannot be locked in for the long term and are often set by the spot market. The costs of these fuel price increases and risk are passed directly on to consumers through their electric bills. In contrast, wind energy is more like a fixed-rate mortgage, locking in the fuel price for the life of the power plant.

As shown in the table below, wind energy creates these large consumer benefits by displacing the most expensive, least efficient, and most volatilely-priced power plants with a fixed-priced, zero-fuel-cost, zero-emission energy source. All of these benefits are purely market driven, occurring entirely because zero-fuel-cost wind energy is used to displace more expensive forms of energy.

	Wind energy	Power plant displaced by wind energy
Cost	Zero fuel cost	Highest fuel cost
Fuel price stability	Fixed price	

Results

Wind energy protected Mid-Atlantic and Great Lakes consumers from extreme price spikes during the polar vortex event in early January 2014, saving consumers over $1 billion on their electric bills. The black area in the following chart shows the actual power prices experienced in the electricity market that spreads across 13 Mid-Atlantic and Great Lakes states, known as PJM.[1] As indicated by the red line at the bottom, these prices greatly exceeded typical PJM power prices. However, the green area shows that power prices would have spiked much higher had PJM not had abundant supplies of wind energy throughout this critical time period.

The shaded green area in the chart above shows the amount by which wind energy reduced the electricity price spikes. These reduced electricity prices accrue to all of the electricity that was purchased by consumers in the market, not just the wind energy that was purchased. Because total electricity consumption was very high, wind's consumer savings for those two days alone total over $1 billion, as shown in the chart below.

The following table summarizes wind's consumer savings for those two days, and

changes occur far more slowly than the unexpected outages that frequently occur at large conventional power plants. Moreover, changes in wind energy output are predictable using weather forecasting, while conventional power plant failures are not, making them far more difficult and costly for grid operators to accommodate. [11]

Wind energy benefits consumers through at least six distinct mechanisms. While wind energy always provides these benefits, they can be particularly pronounced when electricity markets are facing shortages and price spikes.

The consumer benefits of wind energy

1. Wind reduces the cost of producing electricity. Zero-fuel cost wind energy directly displaces the output of the most expensive and least efficient power plants that are currently operating. Like the functioning of almost any market, electricity market operators rank power plants based on their cost of producing an incremental amount of electricity. They then start by using the least-cost power plants first, and then move up the supply curve until they have enough electricity to meet demand. The power plant rank order is based on the cost for that plant to produce an incremental amount of electricity, so only fuel costs and variable operations and maintenance costs are considered. As a result, wind energy and other low fuel cost resources are always used first, and they are used to displace the most expensive power plants that otherwise would have operated. Because that is almost always the least efficient fossil-fired power plant, adding wind energy greatly reduces fossil fuel energy costs and pollution.

2. Wind energy protects consumers by reducing the impact of electricity price spikes. The reduction in the need for conventional generation described above allows demand to be met by conventional generators with lower fuel cost, and therefore a lower cost of producing electricity. This reduces the market clearing price for all electricity purchased in the market. This is known as the "merit order" effect because it allows the market operator to move down the merit order, or supply curve, to use generators with a lower marginal production cost to meet demand, resulting in a lower market clearing price. Wind energy has a low marginal production cost because it has zero fuel costs. [12] This drives down the market price for all electricity that is being purchased in the market, not just the wind electricity, as the market price for all electricity purchasers is set by the last and most expensive power plant that was chosen to operate.

As an example, the following chart shows a hypothetical electricity supply curve for a fictitious grid operating area. [13] Adding low marginal cost generation like wind to the left side of the curve will push the supply curve out to the right, allowing electricity demand to be met by a lower cost power plant and therefore reducing the price of electricity. Because some parts of the generation supply curve can be quite steep, particularly during shortage periods like PJM and other areas experienced in early 2014, even a modest amount of additional supply can greatly benefit consumers.

[11] For analysis of the relative integration costs for wind generators versus conventional generators, using data from the Texas grid operator, see

3. Wind energy reduces pollution. Pollution from fossil -fired power plants harms public health and the

energy's costs are largely fixed at their current level for the life of the power purchase agreement and can even decrease due to inflation (as seen in the purple, teal and orange lines), while the cost o f natural gas generation grows over time as the price of natural gas increases (as seen in the black line with the grey uncertainty area). When evaluating the costs and benefits of fixed -price wind energy, one must factor in the costs and risks of future fuel price increases for the alternatives, just as one would when comparing fuel efficiency to determine which car to purchase.

6. Wind reduces consumer natural gas prices. Through the same supply and demand mechanism described above, wind energy also reduces prices in fossil fuel markets by reducing fossil fuel demand , providing savings for all fossil fuel users.

Methodology

Hourly wind generation, electricity demand data , and market price data for January 6 and 7, 2014, were obtained from PJM ; these data are reproduced in the Appendix .[18] PJM generation supply curve data, showing the marginal production cost and equivalent available capacity of every operational PJM generator, was obtained from industry data source SNL Energy. Mothballed, long -term out -of-service, retired, planned, and under construction generation was removed from SNL's supply curve. Wind capacity was also removed from the supply curve for this step, as actual hourly wind generation is incorporated into the model later in our analysis.

The normal PJM supply curve was adjusted to account for gas price changes and generator outages that occurred on January 6 and 7, 2014. A PJM Market Monitor report supplied gas price data in a graph showing the cost of delivered natural gas for Eastern and Western PJM power plants. [19] While Monitoring Analytics was unable to release the exact data, estimates of deliver ed gas prices were

To validate this method, we additionally used an alternate method of calculating wind's consumer benefits. The results of that analysis are very similar to the results obtained using the above methodology, providing additional support for the results of our method. In the alternate method, the observed impact of hourly changes in electricity demand on electricity market price was used to infer the slope of the generation supply curve in each hour. That slope was then used to calculate the consumer savings wind energy provided in each hour. This method was used because a decrease in electricity demand has the same impact on market prices as an identically-sized increase in wind generation. Using this method, wind's total consumer benefits in all hours in which the supply curve was found to slope upward were calculated at $801 million for the two day period.

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Appendix

PJM hourly wind, demand, and price data

Date/Time	PJM Average Power Price	PJM Electricity Demand	PJM Wind Generation
6-100	26.121081	85497	3976.965
6-200	25.765411	83511	3866.902
6-300	25.044994	82631	3648.733
6-400	20.770097	83277	3639.055
6-500	25.650717	85369	3427.755
6-600	27.63005	90884	3302.677
6-700	46.381305	99318	3210.341
6-800	49.226979	105679	3327.634
6-900	42.480832	107237	3364.96
6-1000	81.652214	108896	3387.159
6-1100	148.173373	110735	3405.508
6-1200	143.299272	111974	3326.078
6-1300	104.89542	112676	3358.304
6-1400	80.121071	112609	3423.495
6-1500	76.894722	112263	3437.564
6-1600	59.41488	113124	3352.604
6-1700	89.692063	117139	3234.667
6-1800	481.590549	125786	3213.113
6-1900	508.742267	130518	3034.43
6-2000	817.059974	131047	2863.939
6-2100	833.085769	130429	2810.607
6-2200	201.987208	128819	2777.03
6-2300	303.963846	125604	2710.043
6-2400	332.226435	121796	2629.612
7-100	315.110733	119916	2625.387
7-200	410.646619	119150	2521.256
7-300	417.298495	119232	2481.25
7-400	272.783955	120086	2345.867