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Chairman Upton, Ranking Member Rush, and other distinguished members of the Subcommittee, thank you for the opportunity to testify on behalf of the diverse membership of the American Wind Energy Association. The wind industry welcomes the focus on electric reliability and resilience, as modern wind energy facilities strongly support these objectives. Thanks to technological advances driven in part by the ingenuity of America's more than 100,000 wind industry employees, wind plants can now provide the grid reliability services traditionally provided by conventional power plants.

As NERC has noted, wind energy "offers ride-through capabilities and other essential reliability services."[1] Advanced power electronics and fast controls allow wind plants to regulate power system frequency and voltage, and ride through grid disturbances. Wind's resilience was demonstrated during the 2014 Polar Vortex event and a similar cold snap in Texas in 2011, when high wind output helped keep the lights on while many coal, nuclear and natural gas plants went offline.

[1] NERC, "2014 Long-Term Reliability Assessment," page 15, available at http://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/2014LTRA_ERATTA.pdf

Of course, no energy source cost-effectively provides all grid reliability services at all times, which is why markets are critical. Markets enable a division of labor among energy sources, with each delivering the services it can provide best at that point in time.

I offer four key recommendations regarding policy to promote electric reliability and resilience:

1) Rely on competitive markets: Wholesale electricity markets have performed well at providing affordable and reliable electricity. The RTOs, FERC, and NERC should continue to competitively procure services through markets without putting their thumbs on the scale for any generation source or technology.
2) Focus on reliability needs, not generation sources: Identify and compensate for the reliability services that are needed, not the fuel type of the generator or other resource characteristics that are not reliability services (e.g. having onsite fuel, being physically close to load).
3) Do not be distracted by perceived problems: As last month's DOE report notes,[2] negative prices "have had almost no impact on annual average day-ahead or real-time wholesale electricity prices," are often caused by fossil or nuclear power plants, and typically occur in remote parts of the grid where they have little to no impact on other power plants. As then-FERC Commissioner John Norris concluded after looking into the matter, focusing on negative prices is a "distraction," while "transmission development is the better, and more proactive, solution."[3]
4) Promote transmission infrastructure development: Building a more robust transmission system is the single most effective tool for improving resiliency and providing customers greater access to low-cost sources of energy, whether nuclear, renewable, or fossil.

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[2] U.S. Department of Energy, "Staff Report to the Secretary on Electricity Markets and Reliability," August 2017, page 114, available at https://energy.gov/sites/prod/files/2017/08/f36/Staff%20Report%20on%20Electricity%20Markets%20and%20Reliability_0.pdf

[3] FERC, "Commissioner John R. Norris Statement," May 2014, available at https://ferc.gov/media/statements-speeches/norris/2014/05-15-14-norris.asp

Wind contributes to electric reliability and resilience

Technological advances have reduced the cost of wind energy by two-thirds over the last 8 years, and have also enabled wind to compete in markets for grid reliability services. A 2016 Department of Energy report confirms that wind and solar plants contribute to the essential reliability services the grid needs.[4] The following table[5] documents how wind plants contribute to grid reliability services and resilience.

Reliability Service	Wind	Solar PV	Gas	Coal	Nuclear
Disturbance ride-through					
Note: For the following reliability services, yellow means the resource can provide the service but during many hours it may not be the most economic choice to do so.					
Reactive and voltage control					
Frequency regulation					
Flexibility					
Primary frequency response and inertial response to disturbances					
Resilience Service	Wind	Solar PV	Gas	Coal	Nuclear
Note: For the following resilience services, score reflects risk of common mode unavailability reducing fleetwide output below capacity value during challenging time period.					
Cold weather resilience					
Hot weather resilience					
Fuel delivery resilience					
Cooling water resilience					
Impact on System Variability	Wind	Solar PV	Gas	Coal	Nuclear
Impact on operating reserves and flexibility needs of other generators					
Key: **Green** is positive, **yellow** is medium value, **red** indicates that in most cases the resource does not offer that service.					

[4]DOE, "Maintaining Reliability in the Modern Power System," December 2016, available at https://www.energy.gov/sites/prod/files/2017/01/f34/Maintaining%20Reliability%20in%20the%20Modern%20Power%20System.pdf

[5]For larger table with linked citations:http://awea.files.cms-plus.com/FileDownloads/pdfs/Services%20Graphic.pdf

Recognizing that all mainstream energy sources must be good stewards of electricity reliability, the wind industry has consistently supported more rigorous reliability standards at FERC and NERC. Wind plants participate fully in electricity markets and abide by the same rules as other power plants.

Wind is not only capable of delivering reliability and resilience, but its track record is demonstrated. As NERC's CEO testified here last month, "Variable resources significantly diversify the generation portfolio and can contribute to reliability and resilience in important ways." Iowa and Kansas now produce more than 30% of their electricity from wind, with South Dakota and Oklahoma over 25%. The main Texas power system obtained 15% of its electricity from wind last year, and Colorado's main utility and the Southwest Power Pool are approaching 20%.

Electric reliability has greatly improved as wind has been added in Texas,[6] and NERC recently noted that power system frequency response is noticeably higher when wind output is high in the state.[7] Grid operators in Texas and Colorado now regularly dispatch the output of wind plants up and down to balance electricity supply and demand, with a degree of speed and accuracy not available from conventional power plants.

In addition to wind's resilience during the cold snap events in 2014 and 2011,[8] wind energy fared well during recent hurricanes. Most wind plants along the Texas coast continued producing at nearly full

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[6]ERCOT, "ERCOT Monthly Operational Overview," July 2017, page 6, available at http://www.ercot.com/content/wcm/key_documents_lists/27311/ERCOT_Monthly_Operational_Overview_201707.pdf

[7] NERC, "State or Reliability 2017," June 2017, page 163, available at http://www.nerc.com/pa/RAPA/PA/Performance%20Analysis%20DL/SOR_2017_MASTER_20170613.pdf

[8] Texas Tribune, "An Interview with the CEO of the Texas Grid," February 2011, available at https://www.texastribune.org/2011/02/04/an-interview-with-the-ceo-of-the-texas-grid/; ERCOT, "Review of February 2, 2011 Energy Emergency Alert Event, February 2011," available at http://www.ercot.com/content/meetings/board/keydocs/2011/0214/Review_of_February_2,_2011_EEA_Event.pdf; and PJM, "Analysis of Operational Events and Market Impacts During the January 2014 Cold Weather Events," May 2014, available at

output as Hurricane Harvey came ashore in August, and all large wind projects in the area came back online once the local power grid was restored. Recent analysis by PJM, the nation's largest grid operator, found that the scenarios in which wind energy provided the majority of electricity were some of the most resilient to unexpected weather events.[9]

Because no energy source cost-effectively provides all grid reliability services at all times, markets allow a valuable division of labor, with each delivering the services it can provide best at that point in time. This leads me to the following recommendations:

1. Rely on competitive markets

Wholesale electricity markets have performed well at providing affordable and reliable electricity. Since markets require open participation with low barriers to entry, any services needed can be competitively procured from all generation sources. The RTOs, FERC, and NERC should continue to competitively procure services through markets without putting their thumbs on the scale for any generation source or technology. We strongly support DOE's call for "creating fuel-neutral markets … that compensate grid participants for services that are necessary to support reliable grid operations."[10]

2. Focus on reliability needs, not generation sources

Identify and compensate for the reliability services that are needed—flexibility, disturbance ride-through, frequency and voltage support, as well as dependable capacity and energy generation—not the

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http://www.pjm.com/~/media/library/reports-notices/weather-related/20140509-analysis-of-operational-events-and-market-impacts-during-the-jan-2014-cold-weather-events.ashx

[9] PJM, "PJM's Evolving Resource Mix and System Reliability," March 2017, available at http://www.pjm.com/~/media/library/reports-notices/special-reports/20170330-pjms-evolving-resource-mix-and-system-reliability.ashx

[10] U.S. Department of Energy, "Staff Report to the Secretary on Electricity Markets and Reliability," August 2017, page 126, available at https://energy.gov/sites/prod/files/2017/08/f36/Staff%20Report%20on%20Electricity%20Markets%20and%20Reliability_0.pdf

fuel type of the generator or other characteristics that are not reliability services (e.g. having onsite fuel, being physically close to load).

As the Brattle Group explained in a June report, "As some of the coal and nuclear power plants face retirement decisions, focusing on their status as baseload generation is not a useful perspective for ensuring the cost-effective and reliable supply of electricity."[11] FERC, RTOs and NERC are well-equipped to define the services needed to keep the grid reliable and resilient. FERC Chairman Chatterjee correctly cautioned in testimony here last month that "states generally have jurisdiction over the resource mix in their individual states, and that FERC has generally remained resource- and fuel-neutral in fulfilling its core obligations...." To promote competition and innovation, all resources should be compensated for the reliability services they provide and all resources that can provide such services should be allowed to offer them.

3. Do not be distracted by negative prices

Last month's DOE report correctly notes that negative prices "have had almost no impact on annual average day-ahead or real-time wholesale electricity prices" and often occur in remote parts of the grid where they have little to no impact on other power plants.[12] DOE also accurately explains that many types of power plants occasionally cause negative prices, including nuclear and fossil plants, as "Conventional generators also face economic factors that lead them to submit negative bids. Existing

[11]Brattle Group, "Advancing Past "Baseload" to a Flexible Grid," June 2017, available at http://www.brattle.com/system/publications/pdfs/000/005/456/original/Advancing_Past_Baseload_to_a_Flexible_Grid.pdf?1498246224

[12] U.S. Department of Energy, "Staff Report to the Secretary on Electricity Markets and Reliability," August 2017, page 114, available at https://energy.gov/sites/prod/files/2017/08/f36/Staff%20Report%20on%20Electricity%20Markets%20and%20Reliability_0.pdf

nuclear plants in the United States, as well as some fossil units, may bid in during these periods to avoid costly start-ups and shutdowns."

AWEA recently released comprehensive analysis confirming that renewable energy accounts for an extremely small share of the already negligible occurrences of negative prices at retiring coal and nuclear power plants.[13] This data builds on analysis we released three years ago,[14] which demonstrated the trivially small frequency and impact of negative prices in Illinois, and was labeled by then-FERC Commissioner Norris as "compelling."

Our latest analysis examines full-year 2016 price data for all retiring power plants in the main wholesale electricity markets that have a large amount of wind generation: PJM, MISO, SPP, and ERCOT. Across more than 1.8 million data points, which cover all 2016 pricing intervals in the day-ahead electricity market for all retiring power plants in those regions, only 55 instances of negative prices were found (0.003% of prices) that could have been set by a wind project receiving the PTC. The analysis includes market price data for all power plants that have retired since 2012 or have announced plans to retire according to DOE.

Our analysis focused on the day-ahead electricity market (the results bolded below), as that is where nuclear and coal generators sell most if not all of their generation. However, the results show that wind plants almost never set prices in the real-time electricity market either. For more on electricity markets and how prices are set, see the last header under this section.

In PJM and MISO, which account for a large share of all power plants in wholesale markets that are retiring nationwide, only 0.003% of day-ahead market prices at retiring power plants were in a range

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[13] AWEA, "Putting the Negative Price Myth to Bed," July 2017, available at http://www.aweablog.org/renewables-grid-putting-negative-price-myth-bed/

[14] AWEA, "The Facts about Wind Energy's Impacts on Electricity Markets," March 2014, available at http://awea.files.cms-plus.com/FileDownloads/pdfs/AWEA%20white%20paper-Cutting%20through%20Exelon%27s%20claims.pdf

that could be set by a wind project receiving the federal Production Tax Credit (PTC), as shown on the left side of the table. Occurrences of negative prices that could be wind-related were even less frequent in SPP, at 0.0017% of day-ahead market price intervals. Those occurrences were slightly more common at retiring plants in ERCOT, at 0.06% of price intervals, but it should be noted that there is only one retiring coal power plant in ERCOT.

Market prices at retiring generators, by ISO	Real-Time or Day-Ahead Market	Share of prices that are negative	Prices between -$20 and -$40 /MWh (offer range for PTC + REC wind project)	Average market price	Average price if all -$20 to -$40/MWh prices were $0/MWh	Price change if wind offered $0/MWh
PJM	Real-Time	0.88%	0.12%	$26.41	$26.44	$0.03
	Day-Ahead	0.18%	**0.003%**	$26.8811	$26.8818	**$0.0007**
ERCOT	Real-Time	1.62%	0.03%	$21.7825	$21.7888	$0.0063
	Day-Ahead	0.08%	**0.06%**	$22.635	$22.649	**$0.014**
SPP	Real-Time	2.04%	0.54%	$21.32	$21.49	$0.17
	Day-Ahead	0.59%	**0.0017%**	$21.9965	$21.9969	**$0.0004**
MISO	Real-Time	1.20%	0.14%	$25.413	$25.451	$0.038
	Day-Ahead	0.22%	**0.003%**	$25.6803	$21.6810	**$0.0007**

To underscore the trivial impact of the PTC in setting market prices, the right side of the table shows how prices would change if wind projects receiving the PTC no longer received the credit. In PJM and MISO, conservatively assuming that all negative prices in that range were set by wind projects receiving the PTC, Day-Ahead Market prices at retiring power plants would increase by an average of $0.0007, or 1/13th of a penny per MWh, if operating wind projects no longer received the PTC. Retiring power plants in SPP saw an even smaller impact at 1/25th of a penny, while the one retiring coal power plant in ERCOT saw an impact of around one penny per MWh.

However, it is important to clarify that the PTC does directly reduce consumer electricity costs outside of the electricity market. The PTC and other incentives allow wind projects to offer lower long-term contract prices to customers and the utilities who serve them, which translates into lower electric bills for consumers on a 1:1 basis. However, those contract payments are outside of the wholesale electricity market, so they are not directly factored into the wholesale electricity market prices received by other generators.

In reality, market dynamics are driving retirements

Market changes are benefiting consumers by driving retirement of older, less efficient resources in favor of more efficient resources. The DOE report[15] agrees with a wide range of experts that the primary factors driving power plant retirements and economic challenges for generators of all types are cheap natural gas and flat electricity demand.[16]

Competition from lower-cost gas generation is the primary cause of the economic challenges facing many power plants. DOE's report notes that "The biggest contributor to coal and nuclear plant retirements has been the advantaged economics of natural gas-fired generation."[17] The DOE study also explicitly exonerates renewable generation as a primary cause of retirements, noting that "the data do

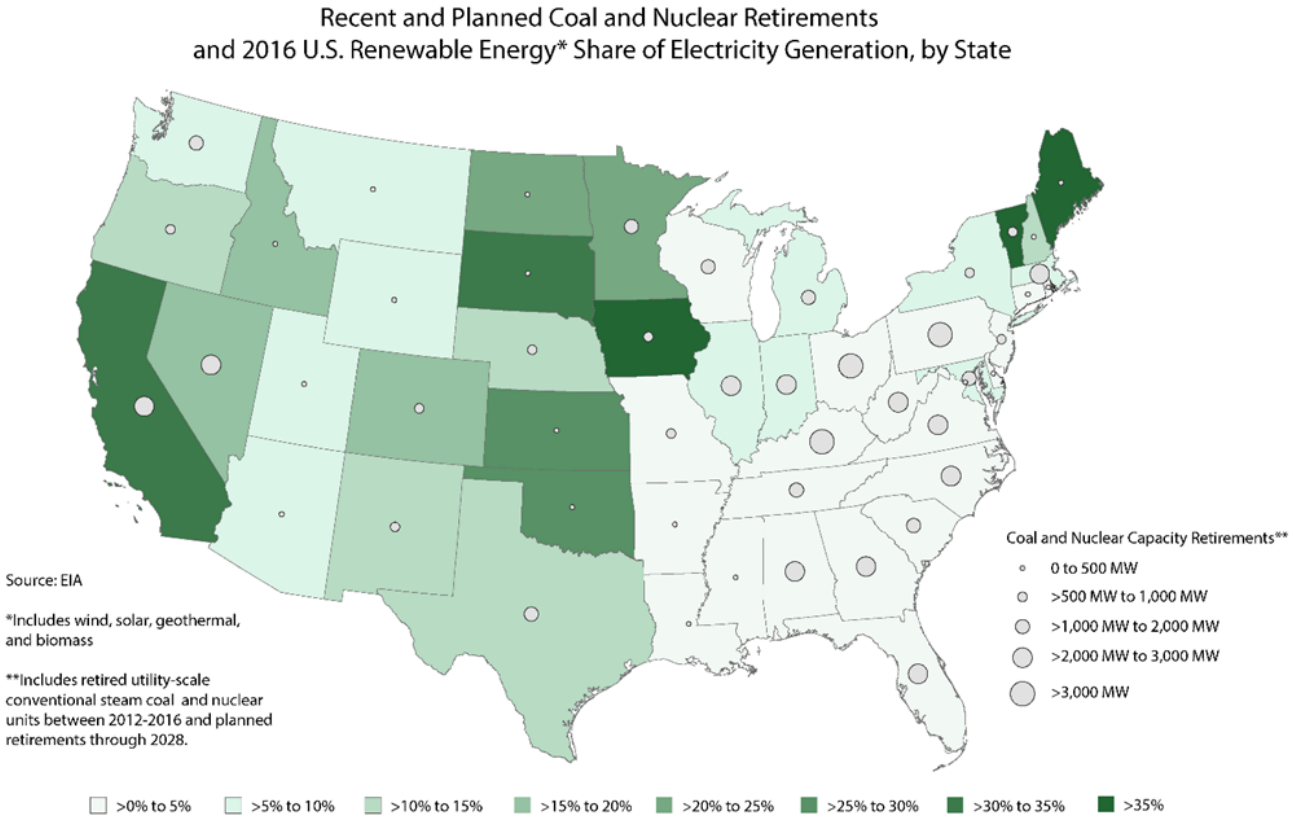
[15] U.S. Department of Energy, "Staff Report to the Secretary on Electricity Markets and Reliability," August 2017, page 113, available at https://energy.gov/sites/prod/files/2017/08/f36/Staff%20Report%20on%20Electricity%20Markets%20and%20Reliability_0.pdf

[16] See: Analysis Group, "Electricity Markets, Reliability and the Evolving U.S. Power System," June 2017 http://www.analysisgroup.com/uploadedfiles/content/insights/publishing/ag_markets_reliability_final_june_2017.pdf; R Street Institute, "Embracing Baseload Power Retirements," May 2017, available at http://www.rstreet.org/wp-content/uploads/2017/05/97.pdf; Rocky Mountain Institute, "The Grid Needs a Symphony, Not a Shouting Match," June 2017, available at https://rmi.org/news/grid-needs-symphony-not-shouting-match/; Utility Dive, "The state of US wholesale power markets: Is reliability at risk from low prices?," May 2017, available at http://www.utilitydive.com/news/the-state-of-us-wholesale-power-markets-is-reliability-at-risk-from-low-pr/443273/

[17] U.S. Department of Energy, "Staff Report to the Secretary on Electricity Markets and Reliability," August 2017, page 13, available at https://energy.gov/sites/prod/files/2017/08/f36/Staff%20Report%20on%20Electricity%20Markets%20and%20Reliability_0.pdf

not show a widespread relationship between [variable renewable energy] penetration and baseload retirements…While concerns exist about the impact of widespread deployment of renewable energy on the retirement of coal and nuclear power plants, the data do not suggest a correlation."[18]

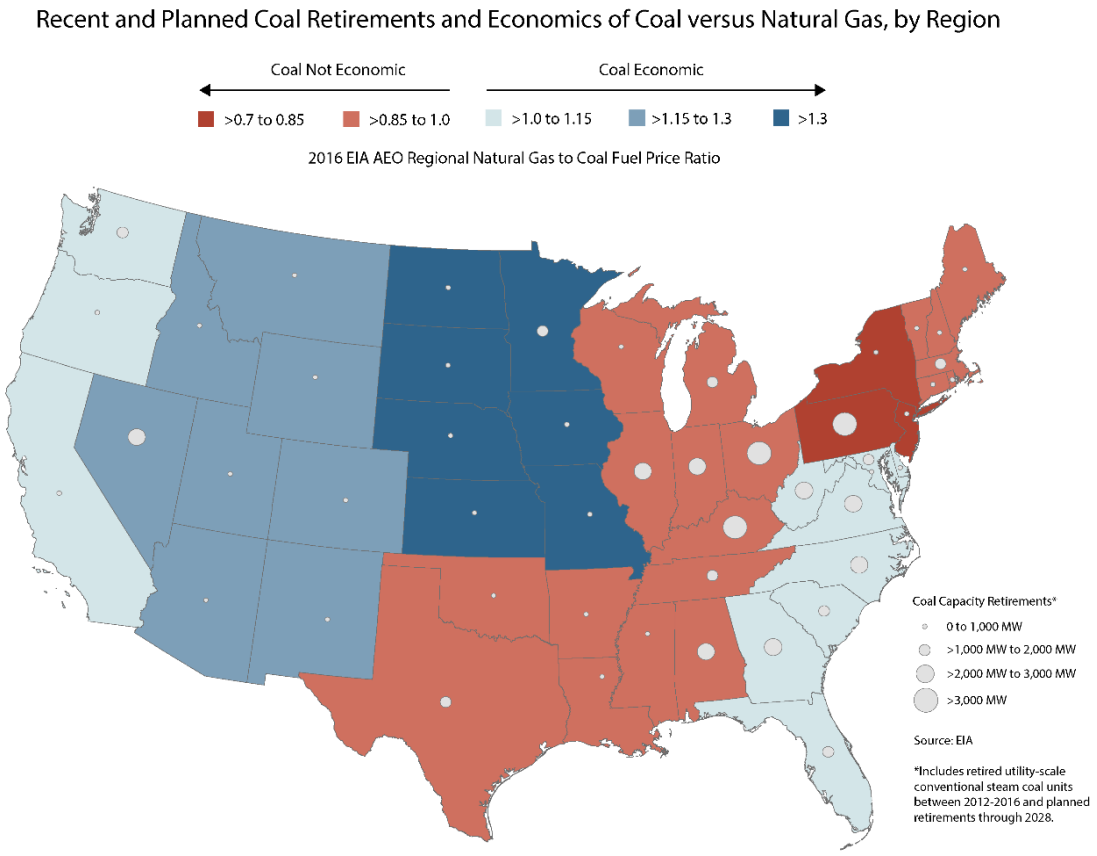
The following map, compiled from Department of Energy data, shows that most retiring coal and nuclear plants are in regions that have little to no renewable generation, confirming that renewable energy or pro-renewable policies cannot be the primary factor driving those retirements.



Rather, the primary factor driving power plant retirements appears to be low-cost shale gas production undercutting relatively high cost Appalachian and Illinois Basin coal in the Eastern U.S., as shown below. In the regions shaded red in the map, the fuel cost of producing electricity from natural gas is significantly lower than the fuel cost of coal power plants, explaining why utilities in those regions are

[18] *Ibid.,* page 50

moving from coal to natural gas generation.



In short, as then-FERC Commissioner John Norris concluded after looking into the matter, focusing on negative prices is a "distraction," while "transmission development is the better, and more proactive, solution."[19] This brings me to my fourth and final recommendation.

4. Promote transmission infrastructure investment

Building a more robust transmission system is the single most effective tool for improving resiliency and providing customers greater access to all low-cost sources of energy, whether nuclear, renewable, or fossil. NERC has noted that renewable integration is a primary driver for only 16 percent of planned

[19] Commissioner John R. Norris Statement, May 2014, available at https://ferc.gov/media/statements-speeches/norris/2014/05-15-14-norris.asp

transmission, demonstrating the range of benefits transmission provides.[20] A strong, integrated power grid would provide the same vast benefits as our interstate highway system: creating resilient infrastructure that is critical during emergencies, while on a daily basis allowing the most competitive businesses to deliver their low-cost goods to consumers. Unfortunately, in many regions today's grid is not a national network of four-lane highways but a balkanized tangle of dirt roads.

Transmission benefits all low-cost generation resources as it allows their low-cost power to reach customers. Like any market, electricity markets are more competitive when there are fewer barriers to entry, and a congested grid can be a barrier to competitive electricity markets. For this exact reason, Texas has always had some of the strongest pro-transmission policies in the country. As ERCOT board member Peter Cramton recently explained, "One thing in favor of strengthening transmission … is that it's pro market. It allows a larger set of generators to compete in a more robust marketplace. You don't always want to throw money at transmission, but at same time, you have to recognize it's transmission that's enabling the market."[21]

A more robust transmission system would prevent almost all occurrences of negative prices, whether caused by nuclear, coal, or renewables. The DOE report accurately notes that most instances of negative pricing have been observed at "constrained hubs that feature a relatively large amount of [variable renewable energy] and/or nuclear generation."[22] Any instances of wind-related negative prices are typically caused by transmission constraints on isolated parts of the grid. Because there are few if any

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[20] NERC, "Potential Reliability Impacts of EPA's Proposed Clean Power Plan," November 2014, page 20, available at http://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/Potential_Reliability_Impacts_of_EPA_Proposed_CPP_Final.pdf

[21] RTO Insider, "ERCOT Board OKs Rio Grande Valley Fixes," June 2016, available at https://www.rtoinsider.com/ercot-board-rio-grande-valley-28040/

[22] U.S. Department of Energy, "Staff Report to the Secretary on Electricity Markets and Reliability," August 2017, page 114, available at https://energy.gov/sites/prod/files/2017/08/f36/Staff%20Report%20on%20Electricity%20Markets%20and%20Reliability_0.pdf

conventional power plants on these remote parts of the grid, these events have little to no impact on other generators.

Grid operators have explained that transmission is a key solution for making electricity more reliable and affordable, and that investments in transmission pay for themselves many times over.[23] As DOE's report documents, "Transmission investments provide an array of benefits that include providing reliable electricity service to customers, relieving congestion, facilitating robust wholesale market competition, enabling a diverse and changing energy portfolio, and mitigating damage and limiting customer outages (resilience) during adverse conditions. Well-planned transmission investments also reduce total costs. SPP analyzed the costs and benefits of transmission projects from 2012–2014 and found that the planned $3.4 billion investment in transmission was expected to reduce customer cost by $12 billion. This yielded an estimated benefit of $3.50 for every dollar invested in the region."[24]

Among the DOE report's primary recommendations are that "DOE and related Federal agencies should accelerate and reduce costs for the licensing, relicensing, and permitting of grid infrastructure," and that "DOE should review regulatory burdens for siting and permitting for generation and gas and electricity transmission infrastructure and should take actions to accelerate the process and reduce costs."[25] As DOE notes, "natural gas pipelines can be built more quickly than electric transmission lines (in most states) because they have a comparatively streamlined permitting process."[26] Congress can greatly expedite infrastructure investment by applying the successful permitting policies used for natural gas

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[23] SPP, "The Value of Transmission," January 2016, available at https://www.spp.org/documents/35297/the%20value%20of%20transmission%20report.pdf; MISO, "MTEP14 MVP Triennial Review," September 2014, available at https://www.misoenergy.org/Library/Repository/Study/Candidate%20MVP%20Analysis/MTEP14%20MVP%20Triennial%20Review%20Report.pdf

[24] U.S. Department of Energy, "Staff Report to the Secretary on Electricity Markets and Reliability," August 2017, page 75, available at https://energy.gov/sites/prod/files/2017/08/f36/Staff%20Report%20on%20Electricity%20Markets%20and%20Reliability_0.pdf

[25] *Ibid.,* page 127

[26] *Ibid.,* page 37

pipelines to transmission infrastructure. NERC's CEO testified here last month that "policymakers should seek alternatives to streamline siting and permitting of transmission."

In sum, we support the objectives of maintaining reliability and resilience, and urge that they be promoted through free and open markets, with a focus on needed reliability services, not source, and a program to promote transmission infrastructure.