Clean Energy Organizations
Exhibit ___________

STATE OF MINNESOTA

OFFICE OF ADMINISTRATIVE HEARINGS

FOR THE MINNESOTA PUBLIC UTILITIES COMMISSION

IN THE MATTER OF THE APPLICATION OF XCEL ENERGY AND ITC MIDWEST LLC FOR A CERTIFICATE OF NEED FOR THE HUNTLEY-WILMARTH 345 KV TRANSMISSION PROJECT	**DOCKET NO. E-002, ET-6675/CN-17-184** **OAH DOCKET NO. 82-2500-35157**

DIRECT TESTIMONY AND SCHEDULES

OF

MICHAEL GOGGIN

SUBMITTED ON BEHALF OF

WIND ON THE WIRES

MINNESOTA CENTER FOR ENVIRONMENTAL ADVOCACY

("CLEAN ENERGY ORGANIZATIONS")

SEPTEMBER 6, 2018

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I. INTRODUCTION

Q: Please state your name and job title.

A: My name is Michael Goggin, and I am the Vice President of Grid Strategies, LLC.

Q: For whom are you testifying?

A: I am testifying on behalf of Wind on the Wires and the Minnesota Center for Environmental Advocacy, collectively referred to as the Clean Energy Organizations or "CEOs".

Q: Have you testified in Utility Commission proceedings before?

A: Yes, in Minnesota Public Utilities Commission ("MPUC") Docket No. CN-12-1053 (the Minnesota-Iowa 345 kV Transmission Line Project), certificate of need cases for transmission lines in Illinois, Wisconsin, and Missouri, and Integrated Resource Planning cases in Oklahoma, Virginia, and Georgia.

Q: What is your background and educational experience?

A: I have worked on transmission and electricity market issues for over a decade. At Grid Strategies I serve as an expert on those topics for a range of clean energy clients, and before that I covered those issues for ten years at the American Wind Energy Association ("AWEA"), where I also oversaw the organization's analysis team for four years. Before that I worked for Sentech, Inc. and for two environmental advocacy groups. I have an undergraduate degree with honors from Harvard University.

Q: What is the purpose of your testimony?

A: I provide facts supporting the finding that the 345-kilovolt ("kV") transmission line between Xcel Energy's existing Wilmarth substation and ITC Midwest's existing Huntley substation ("Project" or "Huntley-Wilmarth Project") is needed to allow greater amounts of low-cost wind energy resources to reach Minnesota and regional consumers. I explain the economic factors driving growth in wind and solar generation, and why the Project is critical for the continued development of those resources. The Project—and the new wind and solar resources accessed by it—will lower the cost of electricity for Minnesota consumers, will improve the competitiveness of the region's electricity market, will enhance environmental quality and public health in Minnesota, and will improve the robustness of the transmission system so the state and region can reliably and affordably meet their electricity needs and state renewable energy standards.

Q: Please outline your testimony.

A: My testimony addresses some of the criteria for a certificate of need for a large energy facility, as described in Minnesota Statutes. First, I discuss the need for the Project and the benefits the state would forego if the application were to be denied, focusing on the consumer benefits from the Project and from the wind and solar development it will enable. Second, I explain that the wind and solar energy delivered by the project will enhance the environmental quality in Minnesota and the region.

II. THE NEED FOR THE HUNTLEY-WILMARTH TRANSMISSION PROJECT

Q: What is your understanding of the need for the Project?

A: The Project relieves transmission congestion to provide Minnesota consumers more access to low-cost energy, including from existing and new wind and solar resources.

With respect to existing congestion, analysis by the Midcontinent Independent System Operator ("MISO") as part of the MISO Transmission Expansion Plan for 2016 ("MTEP16") found that the Project would provide economic benefits to consumers by alleviating one of the most severely congested flowgates in the MISO transmission system while creating no additional reliability issues. MISO has noted transmission congestion in the area along the Minnesota-Iowa border since 2009. The Project alleviates that congestion by significantly increasing transfer capacity and also improving the efficiency of electricity transmission. MISO's analysis found that the Project removes all of the forecasted congestion in the Project area, and that the economic benefits from the Project reducing wholesale energy costs for consumers greatly exceed the cost of building the Project.

The Project alleviates congestion and curtailment that prevents existing and future wind and solar plants from delivering electricity to Minnesota. Reducing congestion and curtailment increases the amount of low-cost energy available to Minnesota consumers, increases environmental benefits, and enables the development of additional renewable resources.

With respect to future development, the Project is critical for the development of tens of thousands of Megawatts ("MW") of future wind and solar resources in Minnesota and the region, which will bring additional consumer, environmental, and economic benefits. MISO's analysis found the Project's benefit-to-cost ratio increased significantly with future wind capacity additions.

The Project will help meet even greater than anticipated growth in wind and solar generation in that area, driven by sustained reductions in the cost of renewable energy as well as public policy. 9,130 MW of additional wind generating capacity are currently under construction or in advanced development in Iowa, Minnesota, South Dakota, and North Dakota; none of that capacity was under construction when MISO's MTEP16 analysis found the project was already economic.[1] The amount of wind and solar

[1] http://www.awea.org/2q2018.

resources in the generation interconnection queue, which is a leading indicator for future wind and solar development, has also increased by several multiples since the Project was approved in MTEP16.

III. BENEFITS OF THE PROJECT FROM REDUCED CONGESTION AND CURTAILMENT

Q: What is transmission congestion and wind curtailment?

A: Transmission congestion occurs when there is insufficient transmission capacity to deliver low-cost electricity sources to customers. This increases electricity production costs and consumer costs because a higher-cost energy source closer to load must be used to replace the low-cost generation that could not be delivered due to the congestion.

Wind and solar energy are typically the lowest-cost resources available in the wholesale electricity market because they have zero fuel-cost and near-zero variable operating and maintenance costs. When wind and solar generation is delivered to customers it displaces an equivalent amount of output from the highest-cost generating resource that would have otherwise operated, which is typically the least efficient fossil-fired power plant.

Wind and solar energy curtailment occurs when the output of operating wind projects exceeds the transmission capacity that is locally available to deliver that energy to customers. When this occurs, the renewable generator receives a market signal or grid operator instruction to reduce their output to the level that can be carried on the transmission system. Wind turbines can rapidly reduce their output on command by pitching their blades out of the wind, while solar plants also have output controllers that respond quickly.

Q: What is the impact of congestion and curtailment?

A: MISO's analysis narrowly focused on how curtailment reduces the production cost savings provided by renewable generation, which is the appropriate focus for a market operator focused on societal welfare and not the impact of transmission congestion on consumers and producers. However, congestion also affects the price of all electricity purchased and sold in the wholesale market, not just the generation that is curtailed. This results in a much larger cost to consumers and harm to renewable development than is suggested by MISO's analysis.

Q: Before getting into MISO's analysis, please describe the other impacts of congestion and curtailment on consumers and renewable project development?

A: Transmission congestion results in lower Locational Marginal Prices ("LMPs") on the wind plant side of a transmission constraint and higher LMPs on the customer side of the constraint. The higher LMP on the consumer side reflects the higher marginal cost of the energy source closer to load that must be used to replace the low-cost generation that could not be delivered due to the congestion. The LMP on the wind plant side often drops to zero or even a negative price because the wind plant becomes the marginal generator in the congested area, reflecting the zero marginal cost of wind generation as well as federal and state incentives that are foregone if wind energy is not produced. Importantly, the local LMP clearing price applies to all Megawatt-hours ("MWh") sold into and procured from the market in those areas, not just the smaller quantity of MWh that are being curtailed. As a result, the cost of this congestion for consumers can be much higher than just the cost of generation lost to curtailment, particularly for utilities that are procuring a large amount of electricity in the wholesale market.

Q: What is the trend for congestion and curtailment in MISO?

A: Data collected by the MISO Independent Monitor shows that transmission congestion has continued to increase, from $1.4 billion in 2016 to $1.503 billion in 2017 for all of MISO. Wind curtailment in MISO remains high at 4.3%, significantly higher than all other ISOs.[2]

The Project Applicants calculated the reduction in regional wind curtailment that would be achieved with the Huntley-Wilmarth Project in service under MISO's Transmission Expansion Plan for 2017 ("MTEP17") scenarios, which are discussed in more detail later in my testimony. In the Existing Fleet case, the Project reduced wind curtailments by 16,308 MWh, or 22.7% of the expected curtailment in North Dakota, South Dakota, Iowa, and Minnesota in 2031.[3] In the Policy Regulation case curtailments were reduced by 203,348 MWh or 14.7%, and in the Advanced Alternative Technologies case curtailments were reduced by 1,676,482 MWH or 9.2%. Without the Project in place, under all scenarios the four states would see a large amount of curtailment in 2031.

Q: Are there alternatives to increased transmission capacity for reducing curtailment and increasing the deliverability of renewable energy?

A: Increasing renewable energy deliverability is an issue of moving energy across geographic space, which only transmission can do. Energy storage located on the same side of transmission congestion as renewable generation can store curtailed energy and move it in time, though batteries and most other storage devices are often constrained in their ability to reduce curtailment due to their limited energy storage capacity (most

[2] https://emp.lbl.gov/sites/default/files/2017_wind_technologies_market_report.pdf at 40.
[3] Northern States Power Company and ITC Midwest LLC Certificate of Need Application, January 17, 2018 ("Certificate of Need") at 94-95.

batteries are only designed to charge at full capacity for four hours, while many high wind output events last for days).[4] Analysis in Minnesota has shown that storage can work as a complement to transmission expansion by moving surplus energy to periods of lower wind output when more transmission capacity is available.[5] However, energy storage by itself cannot move energy across geographic space.

Demand response, energy efficiency, distributed storage, and other customer-sited resources are by definition located in electricity demand centers, which in Minnesota and elsewhere are far from where renewable resources are located. These distributed resources cannot alleviate transmission constraints limiting the delivery of renewable generation because they located on the demand side of the constraint and not the renewable resource side of the constraint. As explained in the Project Application, "Because the need for the Project is driven by increased amounts of wind generation along the Minnesota/Iowa border rather than increased demand, conservation and demand-side management programs are not effective alternatives to meet the identified need."[6]

Q: Does congestion and curtailment impede wind development?

A: Yes. Just as the market price for all MWh a utility procures in the market to meet its electricity demand is based on the LMP on the consumer side of the constraint, the market value of all wind energy generated behind the constraint is based on the LMP on the wind side of the constraint. As an example, assume 5,050 MW of wind generation is available on transmission lines that can only carry 5,000 MW to electricity demand

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[4] https://www.nrel.gov/docs/fy17osti/68960.pdf.
[5] http://www.vibrantcleanenergy.com/wp-content/uploads/2017/07/Modernizing_Minnesotas_Grid_ LR.pdf at 260.
[6] Certificate of Need at 122.

centers. While only 50 MW or 1% of wind generation would be curtailed, all 5,000 MW of wind generation sold into the market would receive a zero or negative electricity market clearing price that effectively reduces its profit margin to zero. This outsized effect on marginal pricing relative to average curtailment can be seen in real-life data showing that less than 2% of solar generation in California was curtailed in the first half of 2017, yet the electricity market marginal clearing prices received by solar generation had dropped by more than 50%.[7] Similarly, even though less than 3% of wind generation was curtailed in the Southwest Power Pool ("SPP") in 2017,[8] average market price across a wide swath of renewable-heavy western SPP fell to $12/MWh, half the SPP-wide average of $23/MWh.[9] Similarly large reductions in market clearing prices due to transmission congestion were found in recent modeling work by Lawrence Berkeley National Laboratory ("LBNL").[10]

When transmission congestion reduces LMPs in a wind generating area, or there is risk of that occurring over a prospective wind project's life, that significantly reduces the value of wind to customers and makes them less willing to sign a Power Purchase Agreement ("PPA") at pricing and other terms that are acceptable to wind developers. This inhibits wind development as long-term PPAs with customers, either utilities or corporations that use large amounts of electricity, are typically essential for obtaining the investment necessary to finance a renewable project.

When congestion is so extreme that it results in wind curtailment, there is an additional economic cost to wind owners, wind purchasers, consumers, and the environment from

[7] https://emp.lbl.gov/sites/default/files/utility-scale_solar_2016_report.pdf at 35.
[8] https://emp.lbl.gov/sites/default/files/2017_wind_technologies_market_report.pdf at 40.
[9] https://www.spp.org/documents/57928/spp_mmu_asom_2017.pdf at 134.
[10] https://emp.lbl.gov/publications/impacts-high-variable-renewable.

"throwing away" zero-fuel-cost, zero-emission energy that would have been used by consumers if sufficient transmission capacity were available.

While historically a large share of curtailment risk was borne by utilities purchasing wind energy, wind PPAs increasingly require wind project owners to shoulder a significant share of wind energy curtailment risk. The cost of this lost revenue, as well as the risk of experiencing this cost, significantly deters wind energy development and reduces the willingness of lenders or investors to finance wind energy development in constrained areas. As most PPAs pass some curtailment cost and risk to the customer, and the value of wind generation is reduced utilities are also hesitant to sign PPAs for wind projects that they expect will face significant congestion or curtailment.

An additional harm to additional deployment is that wind projects applying to interconnect in congested parts of the grid are often required to pay cost-prohibitive transmission upgrade costs as a condition of their interconnection. As was noted in the Project application, "134 interconnection requests amounting to over 21,000 MW are conditioned on, but not necessarily dependent on, the Huntley-Wilmarth Project." If the Huntley-Wilmarth Project is not built, many of these prospective wind projects would not be built because each of the wind project developers would be individually required to pay a large share of the total transmission upgrade cost. Developers have little incentive to pay for transmission through the generator interconnection process because under Federal Energy Regulatory Commission ("FERC")-mandated Open Access rules, any competing generator would be able to use the transmission once it was built. This is the classic "tragedy of the commons" that, per economic theory, exists for many "public goods." This market failure makes it efficient for grid operators and regulators to step in and broadly allocate the costs for Market Efficiency and Multi Value Projects.

Finally, transmission congestion, curtailment, and interconnection upgrade costs tend to force wind energy development into lower quality wind energy resource areas with lower wind capacity factors. Most directly, wind projects with lower output have smaller environmental benefits, and reduce electricity production costs and wholesale market LMPs less than more productive projects that displace more fossil fuel generation. Lower output also reduces the MWh of wind energy output over which the capital and other fixed costs of operating the plant must be recovered, increasing the per-MWh PPA price that the developer can offer and still make the project financially viable. That higher PPA price is directly passed on to the utility's customers, and also impedes renewable development by making it less attractive relative to other options.

Q: How does the quality of the wind resource in the area accessed by the Huntley-Wilmarth Project compare to that in other parts of Minnesota?

A: Southwestern Minnesota, northwestern Iowa, North Dakota, and South Dakota are known for having some of the highest quality wind resources in the nation. Clean Energy Organizations' Schedule 1 is a map prepared by National Renewable Energy Laboratory ("NREL") that shows wind speeds across the country. The output and cost difference between the 8.0-8.5 meter/second wind resources in northwest Iowa and southwest Minnesota (medium purple on the map) accessed by the Project and the 7.0-7.5 meter/second resources areas (orange) that covers much of the rest of Minnesota is actually quite significant. Specifically, the wind resources in the 8.0-8.5 meter/second area have about 47% more energy available in the wind than those in the 7.0-7.5

meter/second area. This is because the energy available for wind energy production is proportional to the cube of wind speed. As a result, the vast majority of utility-scale wind generation in Minnesota has been built in the southwest corner of the state. Due to their high output, new wind plants enabled by the Project offer low PPA prices to Minnesota customers. They also displace more fossil fuel generation, providing greater environmental benefits and electricity production cost and LMP savings for Minnesota consumers.

IV. BENEFITS OF ADDITIONAL WIND AND SOLAR DEVELOPMENT

Q: Does additional wind and solar development due to the addition of the Huntley-Wilmarth Project lower the cost of electricity for Minnesota consumers?

A: Yes. The new wind and solar resources that can be built and operated with minimal congestion and curtailment due to the Huntley-Wilmarth Project will help lower the cost of electricity in Minnesota. Adding wind and solar generation to the MISO wholesale electricity market always reduces the market clearing price. Wind and solar generation is the lowest-cost resource available in the market, due to its zero fuel and other variable costs. It therefore enters on the left side of the generation supply curve, pushing the supply curve out and displacing an equivalent amount of output from the most expensive generator that otherwise would have operated to meet electricity demand. The impact on market prices can be significant because the most expensive power plant that is needed to meet electricity demand sets the market clearing price for all generation bought and sold in the wholesale market.

Due to this effect, a May 2012 report by Synapse Energy Economics found that adding 20 to 40 gigawatts ("GW") of wind energy and the accompanying transmission in the

MISO region would save a typical household between $63 and $200 per year.[11] This report found that electricity market prices decrease drastically as more wind capacity is added to the MISO system. As the report explains, “Since wind energy “fuel” is free, once built, wind power plants displace fossil-fueled generation and lower the price of marginal supply—thus lowering the energy market clearing price.”[12]

A European literature review identified a number of studies that have found wind energy tends to drive electricity market prices downward.[13] As that report explains, “Wind power normally has a low marginal cost (zero fuel costs) and therefore enters near the bottom of the supply curve. Graphically, this shifts the supply curve to the right, resulting in a lower power price, depending on the price elasticity of the power demand. . . . When wind power reduces the spot power price, it has a significant influence on the price of power for consumers. When the spot price is lowered, this is beneficial to all power consumers, since the reduction in price applies to all electricity traded—not only to electricity generated by wind power.”

Q: Returning to MISO’s MTEP16 and MTEP17 results, what impact did MISO find the Huntley-Wilmarth Project would have on electricity production costs?

A: MISO tested the Huntley-Wilmarth Project under all five MTEP16 futures. As noted above, MISO’s analysis focused on electricity production cost savings to measure the benefits of transmission expansion options. Electricity production cost savings capture the additional low-cost generation that can be delivered across a transmission constraint

[11] http://cleanenergytransmission.org/wp-content/uploads/2012/05/Full-Report-The-Potential-Rate-Effects-of-Wind-Energy-and-Transmission-in-the-Midwest-ISO-Region.pdf at 3.
[12] *Id*.
[13] http://www.ewea.org/fileadmin/ewea_documents/documents/publications/reports/MeritOrder.pdf at 11-12.

to displace higher-cost generation on the other side of the constraint, due to transmission expansion that alleviates the constraint.[14]

The weighted benefit-to-cost ratio across the five MTEP16 scenarios was 1.87 to 1, indicating net present value benefits of $1.87 for every dollar invested. The High Demand, Regional Clean Power Plan ("CPP"), and Sub-Regional Clean Power Plan scenarios deployed the most renewable energy, with 10,400 MW, 26,100 MW, and 48,900 MW of deployment from 2015-2030, respectively. As I will explain further, because high levels of renewable deployment are continuing to occur in the area served by Huntley-Wilmarth, these scenarios are the most representative of the benefits the Project will provide. The benefit-cost ratios for these three scenarios were 1.22, 1.39, and 4.85, respectively.

Q: Did MISO evaluate the Huntley-Wilmarth Project's benefit-to-cost ratio under a scenario in which more wind generation is built in the area?

A: Yes. In MTEP16 MISO also performed a wind sensitivity analysis that evaluated what would happen if the wind generation expansion in Iowa and Minnesota that was forecasted in MTEP16 (which was just under 2,600 MW) was replaced with the wind resource capacity in the final stage of the MISO generation interconnection queue for those states. That wind sensitivity model increased the amount of wind generation expansion in Iowa and Minnesota from just under 2,600 MW to a range of values between 3,700 and 7,400 MW.[15] The Huntley-Wilmarth Project's benefit-to-cost ratio increased to between 1.86:1 and 2.28:1 as this wind was added to the area served by the

[14] Certificate of Need at 83.
[15] https://cdn.misoenergy.org/20160720%20PAC%20Item%2002h%20MCPS%20North%20Central%20Update89654.pdf at slide 6.

project, with benefit-to-cost ratios of 2:1 to 3:1 for the CPP scenarios.[16] Thus, the Project will provide large economic benefits if only a quarter of the wind and solar resources in the queue for Iowa and Minnesota are placed into service.

Q: Are recent wind and solar development trends in Minnesota and surrounding states consistent with this level of growth?

A: Wind and solar growth is on track to exceed even MISO's highest estimate. The American Wind Energy Association ("AWEA") tracks how many wind projects are under construction or in advanced development. AWEA defines a project as in advanced development if it has not yet started construction, but has signed a PPA, announced a firm turbine order, or been announced to proceed under utility ownership.

As of the end of the second quarter of 2018, 9,130 MW of additional wind generating capacity were under construction or in advanced development in Iowa, Minnesota, South Dakota, and North Dakota, with 6,003 MW of that wind capacity in Iowa and Minnesota. I checked the project list from AWEA's second quarter 2018 report against the project list from AWEA's second quarter 2016 report, and none of those 9,130 MW of projects were under construction when MISO's MTEP16 analysis found a large benefit-to-cost ratio for Huntley-Wilmarth. Essentially, all of that additional wind generation should be online by the time Huntley-Wilmarth is completed, increasing the benefit-to-cost ratio well beyond the MTEP16 results. In addition to the above figures, 343.37 MW of wind projects in Iowa were not under construction in the second quarter of 2016 but have since come online over the last two years.

[16] Certificate of Need at 86.

These additional 6,346 MW in Iowa and Minnesota are on the upper end of the 3,700-7,400 MW range for additional wind capacity that MISO evaluated in its queue sensitivity discussed above. The area served by the Project is on track to exceed wind levels that MISO projected for 2030 even before the Huntley-Wilmarth Project comes online in the early 2020s. Moreover, MISO's Generator Interconnection queue indicates that many more wind and solar projects are likely coming to Iowa and Minnesota beyond those currently under construction or in advanced development.

Q: Why is the MISO generation interconnection queue an indicator of future wind and solar development?

A: The wind resources in the generation interconnection queue indicate the degree of interest and approximate amount of capacity that could be developed in that area as demand for renewable energy resources continues. Historically not all of the generation projects in the queue have completed the interconnection process and been placed into service. However, the completion rate for queue projects has increased as MISO has increased deposit requirements for entering and remaining in the queue, and as MISO has built transmission to integrate additional renewable generation.

Projects in the generation interconnection queue are a strong indicator of future renewable development, as queue positions indicate the relative quality of the renewable resource in an area. Notably, MISO found it useful to use queued wind projects in its own analysis of the benefit-to-cost ratio for the Huntley-Wilmarth Project. Queued renewable projects have also been used as important inputs for other regions' transmission expansion plans, including the Competitive Renewable Energy Zone ("CREZ") lines in Texas and the Priority Projects in the SPP.

Q: How much wind and solar is in the MISO generation interconnection queue?

A: As of September 4, 2018, there were 78,155 MW of capacity in the MISO generation interconnection queue.[17] Of that amount, 42,425 MW are from wind energy resources and 35,730 MW are from solar energy resources. For comparison, MISO has 17,117 MW of wind in operation as of the end of June 2018.[18]

Q: How do wind and solar resources in the MISO generation interconnection queue compare to wind and solar resources MISO used to analyze Huntley-Wilmarth Project as part of MTEP16?

A: MISO has seen a rapid growth of wind and solar resources entering the generation interconnection queue since 2016.

	Wind (gigawatts)	Solar (gigawatts)
1/2017[19]	14.5	2.5
1/2018[20]	29.8	15.0
7/1/2018[21]	42.5	36.3

In the MISO West region, there is a total of 37,251 MW of generation in the generation interconnection queue for the MISO West region, of that, 26,094 MW is wind generation and 11,156 MW is solar generation.[22] Huntley-Wilmarth Project was analyzed using

[17] MISO Generator Interconnection" as of September 4, 2018; data available on webpage at https://www.misoenergy.org/planning/generator-interconnection/GI_Queue/.
[18] MISO, "Informational Forum" presentation, slide 39 (July 24, 2018) *available at* https://cdn.misoenergy.org/20180724%20Informational%20Forum%20Presentation257994.pdf.
[19] MISO, "Informational Forum" presentation, slide 47 (January 2017) *available at* https://cdn.misoenergy.org/20170124%20Informational%20Forum%20Presentation91728.pdf
[20] MISO, "Informational Forum" presentation, slide 50 (January 2018) *available at* https://cdn.misoenergy.org/20180123%20Informational%20Forum%20Presentation112642.pdf
[21] MISO, "Informational Forum" presentation, slide 39 (July 24, 2018).
[22] "MISO: West Region Generator Interconnection Studies", August 29, 2018; data from multiple slides of presentation *available at*

electric system forecasts prepared for MTEP16. The MTEP16 models forecasted a weighted average wind capacity expansion in southern Minnesota and northern Iowa of just under 2,600 MW by 2030.

In comparison, there currently is approximately 7,700 MW of wind capacity and 2,000 MW of solar capacity in the MISO generation interconnection queue in southern Minnesota and northern Iowa.[23] The wind capacity by itself is nearly 300% more than what was used in the MTEP16 analysis, and higher than the 3,700 to 7,400 MW assumed in the queue wind sensitivity that produced the 1.86:1 to 2.28:1 benefit-to-cost ratio. Most of the 6,003 MW of under construction and advanced development wind projects tracked by AWEA for all of Iowa and Minnesota should also be included in the 7,700 MW of queued wind projects. However, this still indicates that there are many wind projects, beyond those under construction or advanced development, being planned for southern Minnesota and northern Iowa.

MISO's Transmission Expansion Plan for 2018 ("MTEP18") also indicates increases in wind and solar capacity in the areas served by the Huntley-Wilmarth Project. In its MTEP, MISO predicts areas of likely expansion, called "zones," for wind and solar resources. In MTEP18, wind zones were selected by correlating wind quality in an area with location of wind projects that are in MISO's generation interconnection queue or have been withdrawn from MISO's generation interconnection queue. The wind zones in southern Minnesota and northern Iowa total approximately 13,700 MW of potential wind

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https://cdn.misoenergy.org/20180829%20WSPM%20Item%2005a%20Review%20of%20Generation%20Interconnection%20Study%20Plans269778.pdf.

[23] CEOs' Schedules 1.2 and 1.3.

capacity.[24] The MTEP18 forecasted weighted average wind capacity expansion in southern Minnesota and northern Iowa is just under 3,000 MW by 2032.

The Huntley-Wilmarth analysis did not evaluate solar resources, however, solar resources have expanded rapidly, since 2016, in MISO and in the area near the Huntley-Wilmarth Project. Approximately 1,000 MW of solar resources were included in MTEP18 for southern Minnesota and northern Iowa. The solar zones were developed in a manner similar to the wind zones.[25] The MTEP18 forecasted weighted average wind capacity expansion in southern Minnesota and northern Iowa is just approximately 850 MW by 2032.

Q: Returning to MISO's MTEP scenarios, as well as the wind queue sensitivity discussed above, which scenarios are the most representative of future trends in the region's generation mix?

A: As discussed above, wind and solar deployment continues to greatly exceed earlier expectations. This is primarily due to rapid reductions in the cost of wind and solar energy. Renewable deployment is meeting or exceeding the highest renewable deployment scenarios MISO studied, such as the MTEP16 wind queue sensitivity discussed earlier as well as the MTEP17 Accelerated Alternative Technologies scenario and the MTEP16 CPP scenarios, making these scenarios the most representative of the future generation mix in the Huntley-Wilmarth Project area. These scenarios yielded the highest benefit-to-cost ratios, indicating that the Project's benefit-to-cost ratio is likely to be even higher than expected because of the rapid growth of wind and solar generation.

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[24] CEOs' Schedule 1.4.
[25] CEOs' Schedule 1.5.

Specifically, the MTEP16 Regional and Sub-Regional Clean Power Plan cases achieved benefit-to-cost ratios of 1.39 and 4.85 with 26,100 MW, and 48,900 MW of deployment from 2015-2030, respectively. The MTEP17 Accelerated Advanced Technologies case deployed 51,600 MW of new renewable capacity by 2031, yielding a benefit-cost ratio between 4.93:1 and 6.43:1.

In MTEP16, MISO also ran a sensitivity in which Sherco coal units 1 and 2 were replaced with gas generation at the same site. This significantly increased the benefit-cost ratio for the Project because gas generation has a higher fuel cost than coal, making additional delivery of low-cost wind more valuable for reducing electricity production costs.

Q: What is the cost trend for wind and solar energy?

A: Strongly downward, which supports my conclusion that rapid deployment of renewable energy will continue. Since 2009, Wall Street firm Lazard reports that the levelized cost of wind energy has fallen by 67% while solar energy costs have fallen 86%.[26] Lazard notes that wind in the U.S. Midwest costs $30-50/MWh on a levelized unsubsidized basis, which is lower than any other energy source.

These cost reductions are expected to continue. In July 2018, the NREL released its updated cost projections for wind and solar energy.[27] In the low-cost case, which best tracks recently observed cost trends, NREL finds the unsubsidized levelized cost of wind energy could fall below $20/MWh by 2030 in strong wind resource areas like those accessed by the project. NREL also expects solar costs to continue their strong downward trend.

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[26] https://www.lazard.com/media/450337/lazard-levelized-cost-of-energy-version-110.pdf at 10.
[27] https://atb.nrel.gov/.

Other analysts agree. In 2016, Bloomberg New Energy Finance published a report that found renewable energy will dominate utility investment going forward, given its cost advantage against fossil generation.[28] Morgan Stanley published a report around the same time that which found the levelized cost of wind electricity is around $15-$25/MWh in the Interior region of the U.S. after accounting for the federal tax credit, far lower than the cost of a new natural gas combined-cycle facility at $55-$65/MWh in that region.

In a research note around the same time, Goldman Sachs concluded that "when compared to other incremental sources of power, wind provides the lowest cost source of new capacity."[29] The investment bank calculated the current levelized cost of wind electricity at $29/MWh, compared to $38/MWh for natural gas combined-cycle plants. As a result, Goldman predicts new wind and solar capacity of more than 200,000 MW in the U.S. by 2030, primarily driven by economics and not policy. Goldman also notes that the impact from the loss of tax credits will be small enough that it could be offset by either "a modest improvement in capacity factors from expected new-build levels of 40% currently to roughly 50%, or a 10% decline in capital costs."

A 2016 national laboratory study funded by the Department of Energy ("DOE") surveyed experts around the world and found they anticipated cost reductions for land-based wind of around 24% by 2030, driven by a 12% reduction in capital costs, a 9% reduction in fixed operating costs, and 10% increases in capacity factor and project life.[30] A similar

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[28] MacDonald, J, "Coal and gas to Stay Cheap, But Renewables Still Wind Race on Costs", Bloomberg New Energy Finance, June 12, 2016, *available at* http://about.bnef.com/press-releases/coal-and-gas-to-stay-cheap-but-renewables-still-win-race-on-costs/.
[29] Goldman Sachs, "The Low Carbon Economy: Part of the answer is blowing in the wind", June 30, 2016, *available at* http://pg.jrj.com.cn/acc/Res/CN_RES/INVEST/2016/6/30/8eef5771-4ac9-46b8-b03f-ec9c1d7f99c8.pdf.
[30] https://emp.lbl.gov/publications/forecasting-wind-energy-costs-and.

analysis by NREL in August 2017 concluded that a 50% reduction in the cost of wind energy was achievable by 2030 due to capital and operating cost reductions and capacity factor and plant life increases in excess of 20%.[31]

Cost projections from NextEra Energy, the largest renewable developer in the U.S. and the owner of several large utilities, are even more aggressive. Earlier this year NextEra said on a corporate earnings call that it expects wind and solar to be the lowest cost energy resource in the early 2020s on an unsubsidized basis, with wind at $20-25/MWh and solar at $30-40/MWh levelized costs.[32] "Over the past year, we've seen an approximate 30 percent reduction in turbine costs," NextEra's Chief Executive Officer noted. "Through the end of the decade, we expect another 10 percent decline per year on average."

Q: What about concerns that the phase down of the wind Production Tax Credit and solar Investment Tax Credit will reduce wind and solar deployment?

A: Interestingly, the DOE analysis found that the phase out of the wind Production Tax Credit ("PTC") would be mostly offset by developers shifting to a larger share of debt financing for wind project development, as they no longer need expensive tax equity financing to monetize the PTC. DOE found that moving to a greater debt share reduced the unsubsidized levelized cost of wind energy by $8-16/MWh at most wind sites.[33] LBNL found a similarly large reduction in wind's levelized cost if tax equity financing were replaced by lower-cost debt financing.[34]

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[31] https://www.nrel.gov/docs/fy17osti/68123.pdf.
[32] https://www.vox.com/energy-and-environment/2018/1/29/16944178/utility-ceo-renewables-cheaper.
[33] https://www.nrel.gov/docs/fy17osti/68123.pdf at 39.
[34] https://emp.lbl.gov/sites/all/files/lbnl-6610e.pdf.

Q: What does this lead you to conclude about the benefit-cost ratio for Huntley-Wilmarth?

A: All signs point to wind and solar growth outpacing MISO's most aggressive deployment assumptions. As a result, the benefit-to-cost ratio is likely even higher than MISO found in its most optimistic cases. As wind and solar continue their rapid growth, the Huntley-Wilmarth Project will become even more essential for allowing Minnesota customers to reap the benefits.

Q: Has there been experience with transmission driving wind development in MISO?

A: Yes. MISO's Multi-Value Projects ("MVPs") have driven significant expansion of wind generation across MISO. Thanks in part to the continued cost reductions and growth of renewable resources, MISO's periodic reviews of the net benefits of the MVPs show that they continue to exceed initial expectations, which already showed highly favorable benefit-to-cost ratios.[35]

The CapX2020 projects are another success story. The CapX2020 projects included five transmission lines that were placed in-service between 2012 and 2017. The lines addressed reliability issues in the region, but they were also intended to foster the growth of renewable energy resources. At the end of 2012 there were over 12,000 MW of renewable resources in MISO, more than 5,000 of which was in North Dakota, South Dakota and Minnesota.[36] The CapX2020 projects unlocked the wind potential in those states. By the end of 2017 there were 6,200 MW of wind and 162 MW of solar in operation in North Dakota, South Dakota and Minnesota, 4,626 MW of additional wind

[35] https://cdn.misoenergy.org/MTEP17%20MVP%20Triennial%20Review%20Report117065.pdf.
[36] https://www.potomaceconomics.com/wp-content/uploads/2017/02 /2012-State-of-the-Market-Analytical-Appendix.pdf at A-91.

under construction or in advanced development, and 14,250 MW of wind and 4,300 MW of solar in the generation interconnection queue.

Q: How much transmission capacity is needed?

A: As noted above, the growth of wind and solar continues to outpace even MISO's most aggressive assumptions. As a result, the risk and cost of under-sizing transmission is far greater than the risk and cost of over-sizing transmission.

There are also large economies of scale for transmission development, with higher voltage lines providing greater transfer capacity per dollar invested. Building higher-capacity transmission lines up front at minimal additional cost reduces the likelihood of having to later build additional upgrades, add lower voltage circuits, or reconductor at much greater expense. This is especially prudent in this area of the MISO system where the growth of wind and solar resources continues to exceed expectations.

In my experience around the country, from the CREZ upgrades in the Electric Reliability Council of Texas ("ERCOT") to the Tehachapi project in the California Independent System Operator to the Priority Projects in SPP, new transmission to wind-rich areas has quickly been fully subscribed. Similarly, wind developers are overbuilding the tie-lines that interconnect wind resources to existing transmission in anticipation of future wind resources being built nearby and needing to interconnect into the tie-line so they can cost effectively access the transmission system. In most instances, wind and solar developers that are independent power producers own the transmission assets (including the tie-line) from the wind or solar resource up to the step-up transformer that interconnects to the transmission system.[37] In certain areas of South Dakota and North Dakota, wind

[37] *See* illustrative depiction of the Electrical System at Certificate of Need, Fig. 5 at 43.

developers have long tie-lines interconnecting their project to the existing transmission system. Recently many have built higher-capacity lines, including building 345 kilovolt tie-lines, because the wind developer expects other developers to build additional wind capacity in the area.

As I mentioned earlier, the Project Applicants' analysis found that Huntley-Wilmarth alone will alleviate "between 9 percent and 24 percent of curtailments within Minnesota, Iowa, North Dakota, and South Dakota in 2031."[38] Even with the Project, there is still expected to be a large amount of curtailment in other parts of the region under all scenarios. The Project may enable some of the renewable development that would have happened in more transmission constrained areas to shift to the area served by Huntley-Wilmarth, further increasing the consumer and environmental benefits of the project by delivering even more renewable generation to Minnesota consumers. This would also increase the Project's economic development benefits for Minnesota.

V. OTHER BENEFITS

Q: What other benefits does the Huntley-Wilmarth Project provide?

A: In addition to the congestion relief and renewable development discussed above, the Project will increase wholesale electricity market competition, provide Minnesota consumers with resilience against reliability and economic risks, and provide environmental benefits. Transmission infrastructure is a powerful tool for increasing competition in wholesale power markets and reducing the potential for generators to harm consumers by exercising market power. Just as consumers who have access to one local retailer and lack high quality roads to easily access stores in other regions would be

[38] Certificate of Need at 95.

at the mercy of the prices charged by that retailer, a weak grid makes it possible for generation owners in constrained sections of the grid to exert market power and charge excessive prices. In any market, the more supply options that are available to an area, the less likely it is that any one of those suppliers will be in a position to exert market power. As an ERCOT Board member 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."[39]

Transmission also facilitates the integration of renewable energy by allowing greater aggregation of diverse renewable resources across a larger footprint. This results in a steadier output from the resources, reducing operating reserve needs and allowing a greater dependable contribution to meeting the system's peak demand needs.

When extreme events of any type affect any source of supply or demand on part of the grid, transmission capacity also protects consumers and reliability by enabling more electricity to be delivered to regions that are experiencing a shortage. As the New York grid operator noted in recent comments to FERC, "These interconnections support and bolster reliability and resilience by creating a larger and more diverse resource pool available to meet needs and address unexpected and/or disruptive events throughout an interconnected region."[40]

Over its multi-decade lifetime, transmission also protects consumers against the many types of uncertainty that affect the power system. Transmission allows greater flexibility in shifting from one form of generation to another as fuel prices fluctuate, power plant capacity is added and retired, and electricity demand changes.

[39] https://www.rtoinsider.com/ercot-board-rio-grande-valley-28040/.
[40] https://elibrary.ferc.gov/IDMWS/common/opennat.asp?fileID=14838205 at 10-12.

Q: What other studies have examined the consumer benefits of transmission?

A: Analysis conducted for MISO found that significant transmission expansion was economical under all future scenarios, with the largest transmission expansion needed in Minnesota, the Dakotas, and Iowa. In the carbon reduction case, transmission provided $3.8 billion in annual savings, reducing total power system costs by 5.3%.[41] Recent analysis using the same model for the state of Minnesota found that "the increased spending on transmission and sub-transmission (along with implicit distribution costs) was strongly outweighed by the decreased generation costs."[42] Specifically, expanded transmission connections to other states saved Minnesota consumers $86 million annually in a case without a limit on carbon. Those savings rose to $1.25 billion and $2.8 billion annually in cases in which Minnesota decarbonized.[43] The Great Plains Institute also recently analyzed future scenarios with very high levels of renewable generation, and concluded that "Efficient transmission expansion can also better integrate increases in renewable generation and avoid curtailments."[44]

Several analyses by Charles River Associates ("CRA"), International quantified the various benefits provided by transmission. CRA's analysis of the proposed Green Power Express, which would connect 17 GW of wind to the grid in MISO region, found that the transmission plan would yield benefits of $4.4 to $6.5 billion per year for the region (in

[41] http://www.vibrantcleanenergy.com/wp-content/uploads/2016/05/VCE_MISO_Study Report_04252016.pdf at 23.
[42] http://www.vibrantcleanenergy.com/wp-content/uploads/2018/07/MNSmarterGrid-VCE-FinalVersion-LR.pdf at 4.
[43] *Id.* at 18.
[44] http://roadmap.betterenergy.org/wp-content/uploads/2018/08/GPI_Roadmap_Web.pdf at 28.

2008 dollars), well above the annualized cost of the transmission, estimated to be between $1.2 billion and $1.44 billion.[45]

Another study looked at an investment in a high-voltage transmission overlay to access wind resources in SPP. It concluded the transmission investment would provide economic benefits of around $2 billion per year for the region, more than four times the $400-500 million annual cost of the transmission investment.[46] $900 million of these benefits would be in the form of direct consumer savings on their electric bills, with $100 million of these savings coming from the significantly higher efficiency of high-voltage transmission, which would reduce electricity losses by 1,600 gigawatt hours each year. The remainder would stem from reduced congestion on the grid allowing customers to obtain access to cheaper power.

Q: Does the statute require the consideration of environmental quality?

A: While I am not an attorney, the applicable statute and rule include language regarding consideration about how the energy facility "protect[s] or enhance[s] environmental quality."[47]

Q: Have you considered how the Project protects or enhances environmental quality?

A: Yes. As explained above, the Huntley-Wilmarth Project will allow for increased output from existing and future renewable projects by reducing curtailment, while also enabling additional deployment of renewable resources. Adding wind and solar generation displaces an equivalent amount of generation from the most expensive resources that

[45] http://elibrary.ferc.gov/idmws/common/opennat.asp?fileID=12111601.
[46]http://www.crai.com/uploadedFiles/RELATING_MATERIALS/Publications/BC/Energy_and_Environment/files/Southwest%20Power%20Pool%20Extra-High-Voltage%20Transmission%20Study.pdf.
[47] MINN. STAT. § 216B.243, subd. 3(5).

otherwise would have operated in the MISO market, which are almost always the least efficient fossil-fired power plants. Because the Project increases renewable output, it reduces air emissions and water withdrawal and consumption by displacing generation from fossil-fired power plants.

Huntley-Wilmarth will both reduce curtailment of renewable generation while also enabling deployment of additional renewable generation. As a low estimate of the Project's benefits for air emissions, I use the Applicants' calculations of how much the Project will reduce wind curtailment under the three primary MTEP17 scenarios.[48]

I input these MWh quantities into the Avoided Emissions and Generation Tool ("AVERT"), which was built by the U.S. Environmental Protection Agency to quantify the impact of renewable energy and other measures on air pollution emissions.[49] The tool statistically estimates which power plants in the region (AVERT's "Upper Midwest" region was used for this analysis) experience reduced emissions of sulfur dioxide, particulate matter ("$PM_{2.5}$"), nitrogen oxides, and carbon dioxide. The first three pollutants cause environmental degradation, including smog and acid rain, and contribute to cardiopulmonary health problems including asthma, bronchitis, heart attacks, and even death.[50] Carbon dioxide is a greenhouse gas that causes global warming and climate change, which has negative effects on human health and the environment.[51] The MPUC recently updated the environmental cost values associated with these emissions.[52]

[48] Certificate of Need at 95.
[49] https://www.epa.gov/statelocalenergy/avoided-emissions-and-generation-tool-avert.
[50] https://www.epa.gov/sites/production/files/2018-08/documents/utilities_ria_proposed_ace_2018-08.pdf at 4-18.
[51] http://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_SPM_FINAL.pdf.
[52] *See* Order Updating Environmental Cost Values, MPUC Docket No. E-999/CI-14-643 (Jan. 1, 2018).

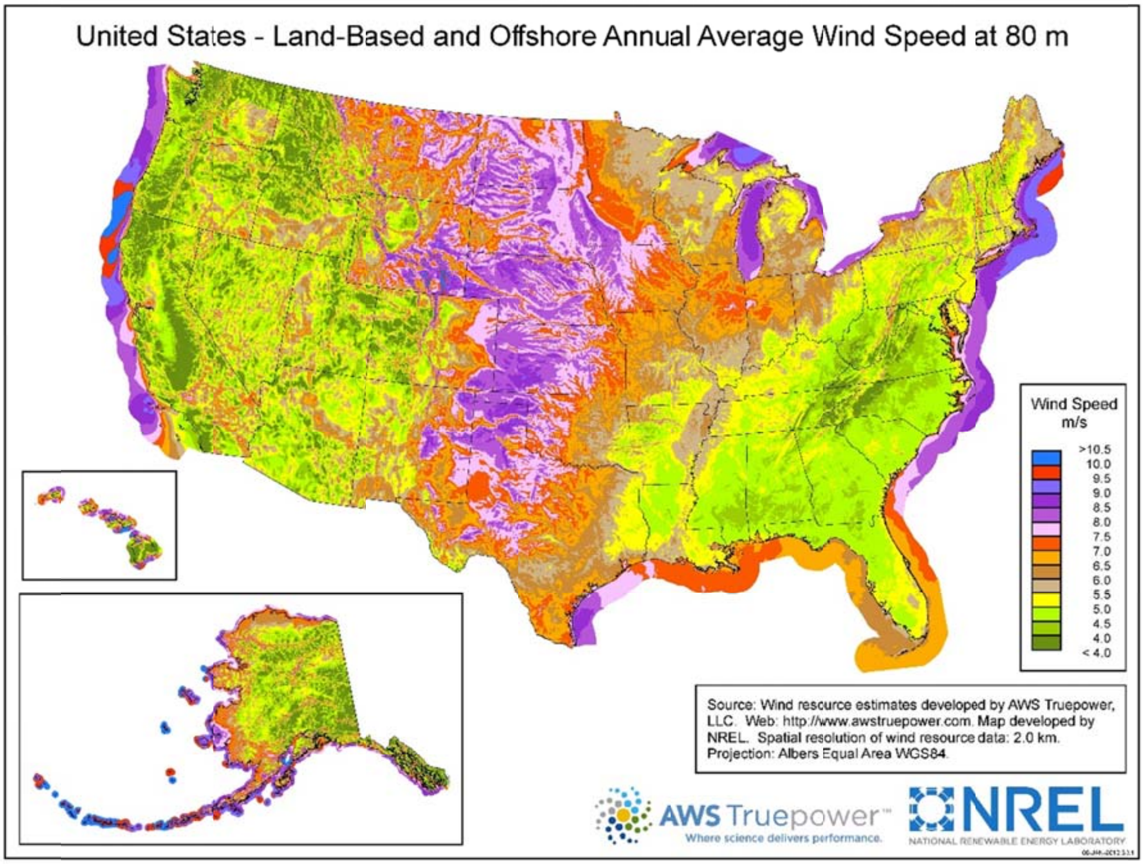
In MTEP17's Existing Fleet case, which greatly understates the region's future renewable energy generation, the Applicants found the Project would reduce wind curtailment by 16,308 MWh in 2031. According to AVERT, this additional delivery of wind generation would reduce sulfur dioxide emissions by 31,480 pounds, nitrogen oxide emissions by 21,220 pounds, carbon dioxide pollution by 15,280 short tons, and $PM_{2.5}$ emissions by 1,460 pounds. In MTEP17's Policy Regulation case, the Applicants found the Project would reduce wind curtailment by 203,348 MWh in 2031. According to AVERT, this additional delivery of wind generation would reduce sulfur dioxide emissions by 393,860 pounds, nitrogen oxide emissions by 265,480 pounds, carbon dioxide pollution by 191,230 short tons, and $PM_{2.5}$ emissions by 18,690 pounds.

In MTEP17's Advanced Alternative Technologies case, the Applicants found the Project would reduce wind curtailment by 1,676,482 MWh in 2031. According to AVERT, this additional delivery of wind generation would reduce sulfur dioxide emissions by 3,245,970 pounds, nitrogen oxide emissions by 2,192,220 pounds, carbon dioxide pollution by 1,575,250 short tons, and $PM_{2.5}$ emissions by 154,030 pounds.

Q: Does this conclude your testimony?

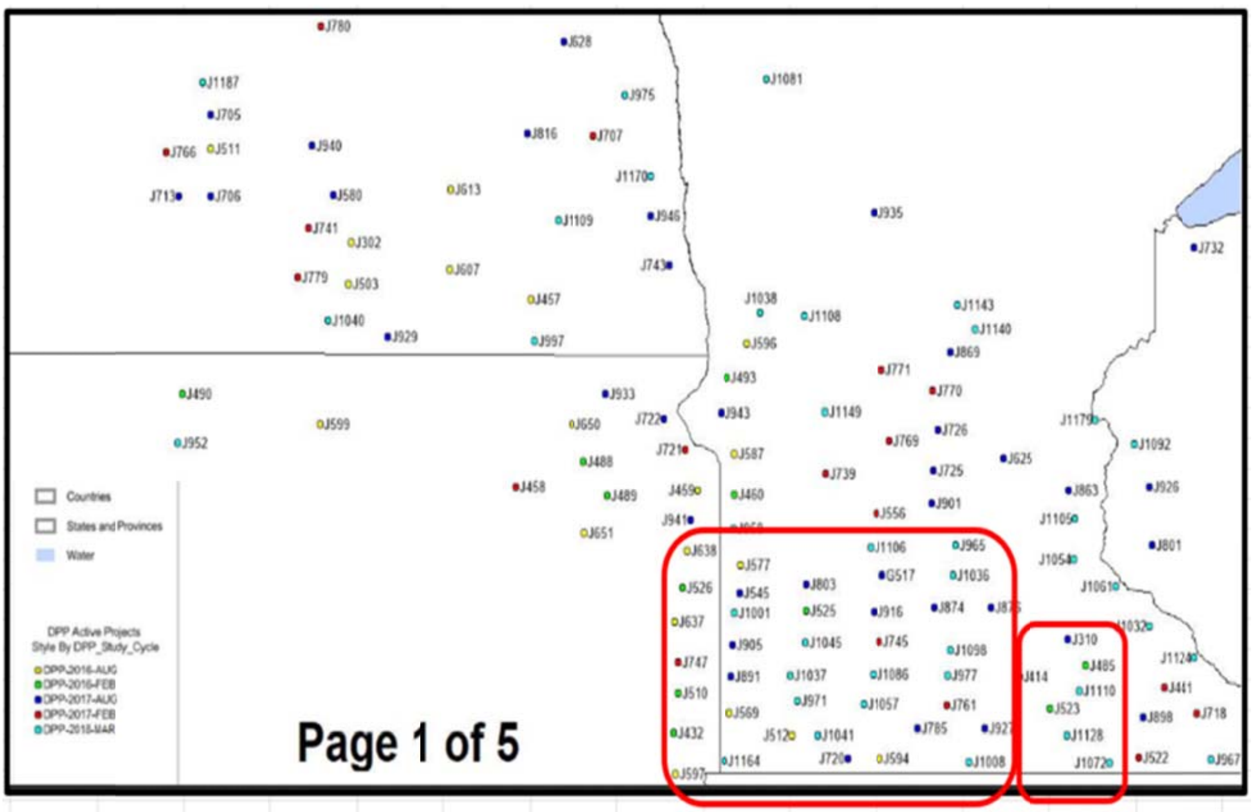
A: Yes.

Schedule 1.1: NREL wind resource assessment map of the U.S., *available at* http://www.nrel.gov/wind/resource_assessment.html as of March 26, 2013.



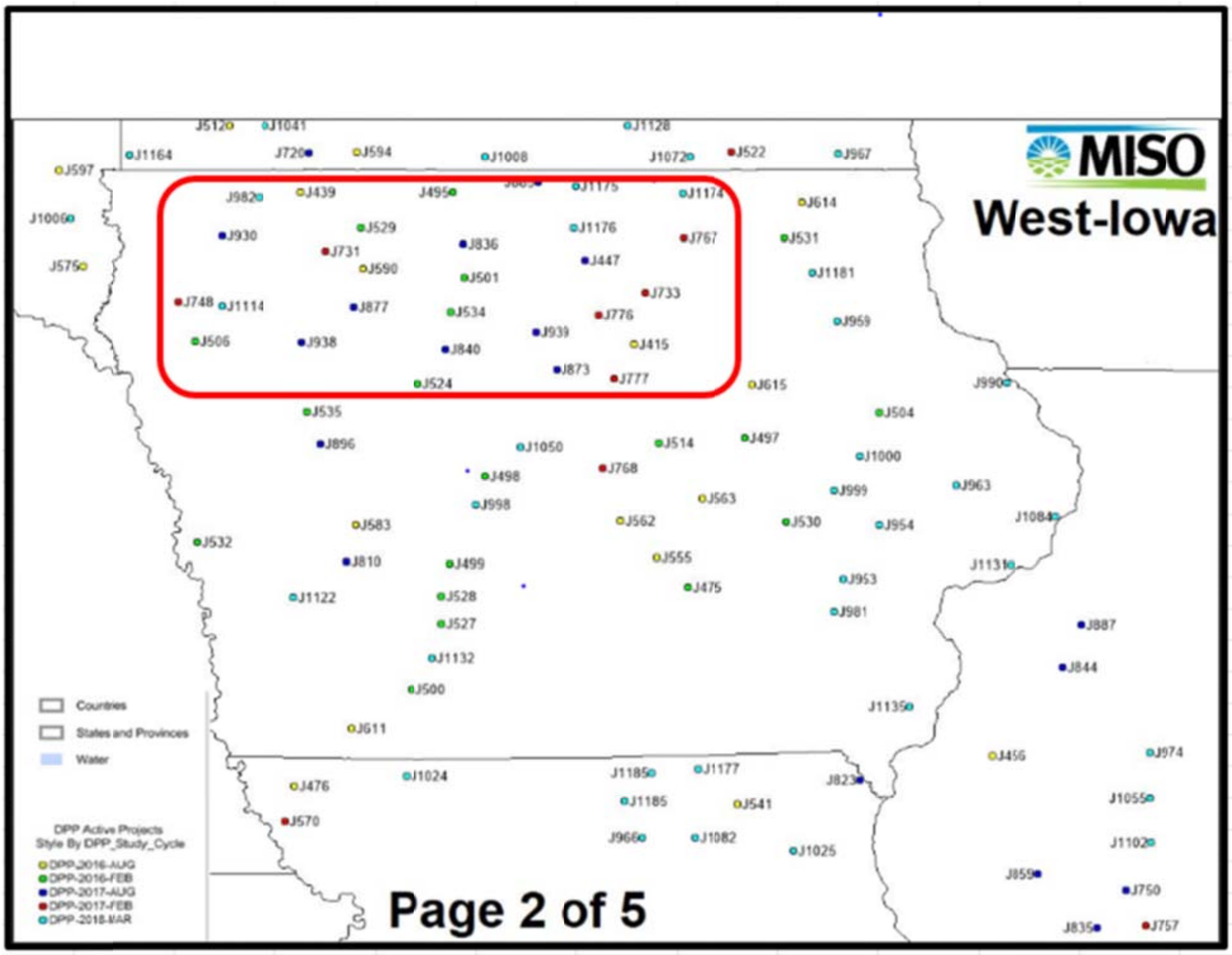
Schedule 1.2: MISO Generation Interconnection Active Queue Map for Minnesota, North Dakota and South Dakota, *available at* https://cdn.misoenergy.org/20180829%20WSPM%20Item%2005a%20Review%20of%20Generation%20Interconnection%20Study%20Plans269778.pdf

- Wind and Solar interconnection projects encircled in red form the basis of the calculated amount presented in the testimony.



Schedule 1.3: MISO Generation Interconnection Active Queue Map for Iowa, *available at* https://cdn.misoenergy.org/20180829%20WSPM%20Item%2005a%20Review%20of%20Generation%20Interconnection%20Study%20Plans269778.pdf

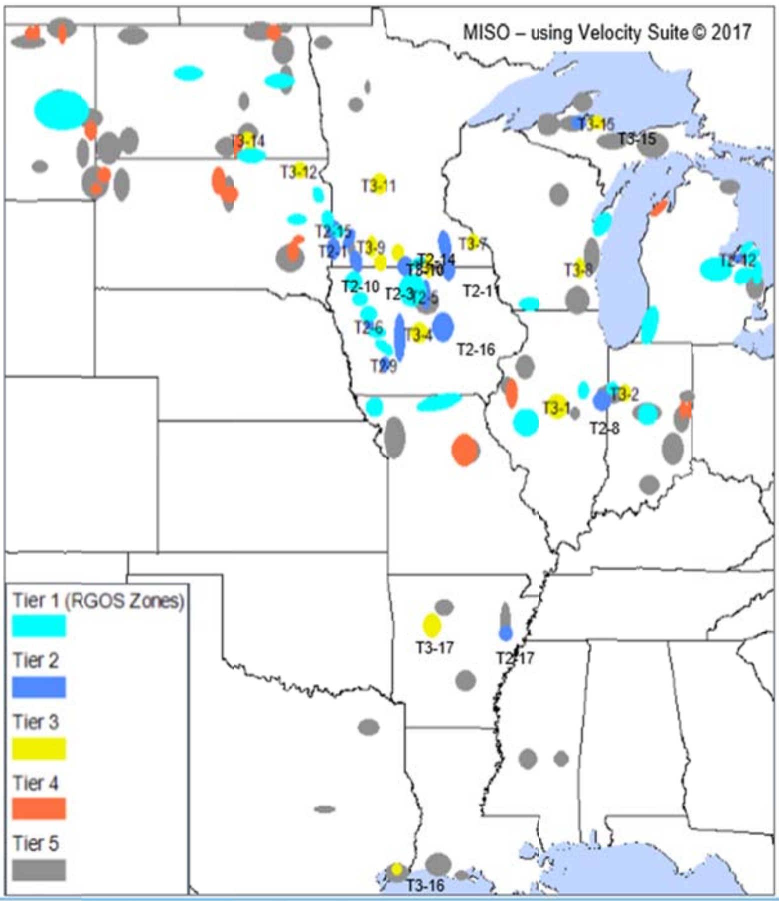
- Wind and Solar interconnection projects within the red rectangle form the basis of the calculated amount presented in the testimony.



Schedule 1.4: MISO MTEP18 Wind Zones, *available at* https://cdn.misoenergy.org/MTEP18%20Futures%20Summary111488.pdf

- Zones circled in red and orange are in southern Minnesota, northern Iowa or eastern South Dakota form the basis of the amount presented in testimony.

MTEP Tier 2 and 3 wind zones



Wind Zone	Size (MW)
T2-1	1,240
T2-2	2,074
T2-3	1,291
T2-5	1,240
T2-6	267
T2-8	1,399
T2-9	858
T2-10	813
T2-11	1,895
T2-12	720
T2-13	231
T2-14	1,154
T2-16	2,447
T2-17	100
T2-18	200
T2 Subtotal	15,729
T3-1	1,551
T3-2	820
T3-4	2,495
T3-5	592
T3-6	1,363
T3-7	1,636
T3-8	840
T3-9	1,001
T3-10	801
T3-11	1,858
T3-12	2,100
T3-13	1,080
T3-14	1,260
T3-15	1,000
T3-16	100
T3-17	500
T3 Subtotal	18,997

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Schedule 1.5: MISO MTEP18 Solar Zones, *available at*

https://cdn.misoenergy.org/MTEP18%20Futures%20Summary111488.pdf