United States House of Representatives
Select Committee on the Climate Crisis

Hearing on July 28, 2020
"Solving the Climate Crisis:
Building a Vibrant and Just Clean Energy Economy"

Questions for the Record

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<u>The Honorable Kathy Castor</u>

1. **As the United States moves toward a national, interconnected grid, what can the federal government and industry do to ensure that new transmission lines do not cause unintended environmental harm?**

A more nationally interconnected Macro Grid has multiple environmental benefits, starting with the connection of abundant, zero-emissions wind and solar resources in remote rural areas to population centers with high electricity demand. A nationwide, high-voltage direct current (HVDC) network, optimized for the nation's best wind and solar resources, could deliver 80% carbon emission reductions from the grid by 2030.[1] Furthermore, the decarbonization of our power sector enabled by expanded and enhanced transmission would greatly reduce co-pollutants like small particulate matter that lead to an estimated 21,000 deaths per year.[2]

We expect a very high percentage of future transmission expansion to utilize existing rights-of-way of various types. There are utility rights-of-way all over the country, which in many cases have old lines that are ready to be replaced. With new technology, including HVDC lines, far more power can be delivered over rights-of-way than in the past.

A critical point about transmission is that, at larger scales, less right-of-way is needed for a given amount of energy delivery. Therefore, it is important to plan ahead of time to build at the size that will be needed over the long term in order to reduce the amount of right-of-way needed.

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[1] MacDonald, Clack Et Al., "Future Cost-Competitive Electricity Systems and Their Impact on U.S. CO2 Emissions," January 25, 2016, https://www.vibrantcleanenergy.com/wp-content/uploads/2016/09/Future_cost-competitive_electricity_syst.pdf.
[2] Penn, Arunachalam Et Al., "Estimating State-Specific Contributions to PM2.5- and O3-Related Health Burden from Residential Combustion and Electricity Generating Unit Emissions in the United States", March 2017, https://ehp.niehs.nih.gov/doi/pdf/10.1289/EHP550.

Occasionally, new rights-of-way are needed. When new rights-of-way are required, local, state, and sometimes federal permitting processes require environmental review prior to being granted permits. The reviews are often very thorough. For example, in New York, Title 16, Part 86 of the New York Compilation of Codes, Rules, and Regulations outlines the several requirements for an interstate transmission line. An application is required to "submit detailed maps…[that] shall include" the location of a right-of-way and possible damage to the environment as well as historical areas.[3] Further, the applicant must "submit a statement explaining what consideration, if any, was given to: (1) any alternative route; (2) the expansion of any existing right-of-way…[and] (3) any alternate method which would fulfill the energy requirements with comparable costs" where the applicant may compare the benefits and drawbacks of the alternative.[4] When lines cross federal lands, Environmental Impact Statements are required prior to federal agency permitting. Of course, it is also the case that multiple agency processes without clear accountability can lead to delays, so efforts such as the FAST Act approach to rationalize the process can speed lengthy approval requirements while protecting the environment.

It is beneficial to proactively plan transmission to take renewable resource and sensitive habitat into account. For example, "Smart from the Start" transmission planning efforts in the west have engaged wildlife and lands experts along with renewable energy and transmission developers to identify corridors.

Better coordinated interregional and interstate planning can ensure we have the grid we need to power a clean and thriving economy, while minimizing cost and environmental impact. For example, as states seek to develop offshore wind, coordinated planning to create an offshore grid that collects electricity generated from multiple wind projects, along with a plan to upgrade onshore transmission, can lower overall costs for customers, and prevent major additional work on land. Fewer cables could also minimize impacts on traditional maritime interests, including shipping and fishing.[5]

2. **How can Congress support or require more efficient use of existing transmission infrastructure?**

Newly available grid-enhancing technologies such as dynamic line ratings, power flow control systems, storage-as-transmission, and topology optimization can reduce congestion and resource curtailment, raising the efficiency of existing transmission infrastructure. Many regions of the country are currently working to understand and incorporate the benefits of these technologies in RTO/ISO tariffs. The Energy Policy Act of 2005 directs FERC to incentivize the deployment and use of efficiency-improving transmission technologies for the benefit of electricity consumers. Unfortunately, FERC's recent Notice of Proposed Rulemaking on transmission incentive policy limits the ability of the aforementioned, lower-cost grid-enhancing technologies

[3] N.Y. Comp. Codes R. & Regs. tit. 16, § 86.3 (1970).

[4] N.Y. Comp. Codes. R. & Regs. tit. 16, § 86.4 (1970).

[5] Maldonado, Samantha and French, Marie J., "Offshore Grid Planning in the Wind," August 2020, https://www.politico.com/states/new-york/newsletters/weekly-new-york-new-jersey-energy/2020/08/24/offshore-wind-transmission-planning-338452.

to actually receive these incentives. FERC's proposal is based on a return-on-equity approach, which awards utilities greater incentives for the deployment of more expensive projects, such as power lines. Under the proposal, for example, a 100 basis point incentive on $1 million of equity invested yields only $50,000 in additional earnings.[6] It is hard to imagine senior utility management even having a meeting to discuss an action that could achieve only a $50,000 contribution to the bottom line, especially when 100 basis points on a $100 million transmission line with potentially similar system benefits would yield $5,000,000 in additional earnings. Congress should consider directing FERC to avoid using an incentive awards methodology that preferences high-cost projects, although new transmission will be needed in many parts of the country.

A major opportunity for efficient use of our limited rights of way is replacing aging assets with higher capacity lines so that we make maximum use of corridors. New transmission line conductor technologies are available that increase resilience and energy delivery capability over these paths.

Additionally, expanded wholesale energy markets can help better utilize existing transmission infrastructure by ensuring that generators are dispatched over the broadest area in the least-cost manner. A shared sense of Congress that wholesale energy market growth is beneficial may help encourage utilities and states to consider joining these markets.

Finally, transmission upgrades can vastly improve the efficiency of the entire electric system. This is because line losses increase significantly when power lines operate close to their maximum capacity, and the lines are hot. The Southwest Power Pool calculated that its transmission upgrades are saving consumers around $100 million from reduced transmission losses,[7] while the Midwest ISO estimates line loss savings of $200 million to $1 billion dollars in net present value due to upgrades.[8]

3. How can increasing transmission development at the "seams" between regions save consumers money and expedite renewable energy deployment?

Transmission that can stitch together the "seams" between regions could save consumers up to $47 billion annually[9] and return more than $2.50 for every dollar invested.[10]

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[6] Assuming 50% debt, tax of 27%, debt interest of 5%, target base ROE of 10%, O&M rate of 3% and discount rate of 7%.

[7] Southwest Power Pool, "The Value of Transmission," https://www.spp.org/documents/35297/the%20value%20of%20transmission%20report.pdf

[8] Midwest Independent System Operator, "MISO Value Proposition," https://www.misoenergy.org/about/miso-strategy-and-value-proposition/miso-value-proposition/

[9] MacDonald, Clack Et Al., "Future Cost-Competitive Electricity Systems and Their Impact on U.S. CO2 Emissions," January 25, 2016, https://www.vibrantcleanenergy.com/wp-content/uploads/2016/09/Future_cost-competitive_electricity_syst.pdf.

[10] National Renewable Energy Laboratory, Interconnections Seam Study, https://www.nrel.gov/analysis/seams.html.

While 15 states between the Rockies and the Mississippi River account for 88 percent of the nation's wind technical potential and 56 percent of solar technical potential, this region is home to only 30 percent of expected 2050 electricity demand.[11] Connecting centers of high renewable resources to high electric demand would expedite development of those resources and save consumers money.

Access to electricity over a large region allows locations with rich wind and solar resources to supply cheap power to distant markets. The key enabling technology for delivering these multiple benefits is a well-planned network of high-voltage direct-current (HVDC) transmission lines.

Currently, a lack of transmission is greatly constraining development of both wind and solar resources, as evidenced by interconnection queue backlogs. Access to consumers is paramount for zero-marginal-cost, location-constrained resources like wind and solar. At the end of 2017, over 188 GW of proposed solar projects and 180 GW of proposed wind projects were waiting in queues to connect to the grid after having applied for interconnection.[12] Historically, the vast majority of queue projects have failed to proceed to development, in many cases because of the costs and delays associated with interconnecting to the grid.

Finally, expanding access across the seams will help consumers by making the wholesale power markets more competitive, while promoting renewable development through expanded market opportunities. Consumers will also benefit from the improved reliability and resilience that comes from interregional transmission.

4. **Although renewable energy costs have fallen significantly, why does the renewable energy sector need continued federal support as the country confronts the climate crisis?**

The COVID-19 pandemic has had multiple adverse impacts on the renewable energy sector. Supply chain disruptions, construction and permitting delays, and a constrained tax equity market have all hit the renewable industry hard. Over 14% of renewable energy workers have lost their jobs since March.[13] Additionally, BloombergNEF is now projecting a $23 billion tax equity shortfall impacting more than 30 gigawatts of renewable projects over the next 18 months.[14]

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[11] Wind Solar Alliance, "Transmission Upgrades & Expansion: Keys to Meeting Large Customer Demand for Renewable Energy," January 2018, https://acore.org/transmission-upgrades-expansion-keys-to-meeting-large-customer-demand-for-renewable-energy/.

[12] American Wind Energy Association, "Grid Vision: The Electric Highway to a 21st Century Economy," May 2019, https://www.awea.org/Awea/media/Resources/Publications%20and%20Reports/White%20Papers/Grid-Vision-The-Electric-Highway-to-a-21st-Century-Economy.pdf.

[13] American Council on Renewable Energy, "Recovery Stalls as Few Clean Energy Employees Return to Work in July," August 12, 2020, https://acore.org/recovery-stalls-as-few-clean-energy-employees-return-to-work-in-july/.

[14] Bloomberg, "Covid Created a U.S. Clean Energy Shortfall of Up to $23 Billion," July 15, 2020, https://www.bloomberg.com/news/articles/2020-07-15/covid-likely-created-23-billion-shortfall-for-u-s-clean-energy/.

In order to get these hard-working Americans back on the job building America's clean energy future, the renewable sector needs commonsense emergency relief in the form of 1) temporary refundability for renewable credits to facilitate their continued monetization in an increasingly constrained tax equity market, and 2) delaying the scheduled phasedown of the PTC and the ITC in recognition of COVID-19's nationwide impact on renewable development this year. Enacting these two commonsense emergency relief measures into law would stem ongoing job losses in every state and enable the renewable industry to help power the nation's economic recovery.

As we look past the current downturn and towards a more sustainable economic recovery, there is a suite of complementary climate policies that Congress can consider to accelerate the deployment of emissions-free, renewable power: 1) a federal high-penetration renewable energy standard (RES) or clean energy standard (CES) to provide long-term market certainty and catalyze renewable energy investment and deployment; 2) a technology-neutral tax credit for zero- or low-carbon electricity generation to attract capital and lower the delivered cost of clean energy to consumers; 3) effective carbon pricing to internalize the cost of carbon pollution across all sectors of the economy; and 4) building a 21st century Macro Grid to deliver our nation's abundant renewable resources from where they are produced to where they are ultimately consumed.[15]

5. **How can adding clean energy to the electric generating mix increase electric system reliability and resilience?**

A diverse mix of resources is key to electric reliability and resilience. Clean energy provides an abundant source of domestic power that can be rapidly deployed and available even during extreme weather conditions. With zero reliance on global fuel supply, renewable energy sources are not subject to the vagaries of the global marketplace or unexpected changes to fuel availability. Renewable energy can even enhance power reliability under extreme weather conditions, not requiring fuel supplies that may be disrupted and bouncing back quickly from interruptions.

Moreover, as previously described, expanding and upgrading the transmission system with a 21st century Macro Grid would lower consumer costs and help prevent outages, thereby enhancing reliability and resilience.

Notably, the Department of Defense is increasingly relying on renewable energy and energy storage to improve its energy security, enhance readiness and ensure reliable and resilient power for critical domestic functions and forward operations. For example, the Fort Carson solar-plus-energy storage project supplies around-the-clock energy resilience to the 4th Infantry Division, the 10th Special Forces Group and 3,400 military family residences. By shifting energy between times of high and low demand, this system also saves taxpayers $500,000 per year on the

[15] American Council on Renewable Energy, "Advancing America's Climate Leadership," January 9, 2020, https://acore.org/advancing-americas-climate-leadership/.

installation's utility bill.[16]

6. **During the 2014 Polar Vortex and other severe winters, how did the cold weather affect on-site fuel for fossil-fueled power plants fare? How can electric utilities and regional organizations ensure the reliability and resilience of the grid in extreme temperatures?**

According to the North American Electric Reliability Corporation (NERC), fossil fuel facilities relying on natural gas and coal are susceptible to damages due to low temperatures, such as frozen coal stockpiles and disrupted natural gas pipelines, and are thus the largest sources of cold weather-related power outages.[17] According to NERC, coal and gas generators made up 81% of power outages during the 2014 Polar Vortex.[18] During the 2019 Polar Vortex in the Midwest, there was a fire in a gas plant in Michigan that forced it to shut down, along with gas delivery issues.

Last month, CAISO CEO Steve Berberich attributed California's rolling blackouts partially to a power plant that "tripped" in the high heat,[19] likely a natural gas plant that tripped offline during the heatwave,[20] as natural gas plants often struggle in extreme temperatures, further illustrating the importance of a diverse, fuel-free resource mix.

In FERC's resilience proceeding, grid operators were clear about the benefits of transmission for system resilience:

- NYISO said "…resiliency is closely linked to the importance of maintaining and expanding interregional interconnections, the building out of a robust transmission system…"[21]
- PJM said "Robust long-term planning, including developing and incorporating resilience criteria into the RTEP, can also help to protect the transmission system from threats to resilience."[22]
- SPP said "The transmission infrastructure requirements that are identified through the ITP process are intended to ensure that low cost generation is available to load, but the

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[16] Citizens for Responsible Energy Solutions, "Defense Spotlight: Fort Carson Optimizes Energy Storage," April 2020, https://www.citizensfor.com/defense-spotlight-fort-carson-optimizes-energy-storage/.
[17] Bade, Gavin, "Polar Vortex set to test Midwest grids amid FERC resilience debate," UtilityDive, January 30, 2019, https://www.utilitydive.com/news/polar-vortex-set-to-test-midwest-grids-amid-ferc-resilience-debate/547231/.
[18] Ibid.
[19] Kahn, Debra and Bermel, Colby, "California has first rolling blackouts in 19 years — and everyone faces blame," Politico, August 18, 2020, https://www.politico.com/states/california/story/2020/08/18/california-has-first-rolling-blackouts-in-19-years-and-everyone-faces-blame-1309757.
[20] Gilbert, Alex and Bazilian, Moran, "California power outages underscore challenge of maintaining reliability during climate change, the energy transition," UtilityDive, https://www.utilitydive.com/news/california-power-outages-underscore-challenge-of-maintaining-reliability-du/583727/.
[21] NYISO filing in FERC Docket No. AD18-7, p. 4.
[22] PJM filing in FERC Docket No. AD18-7, p. 49-50.

requirements also support resilience in that needs are identified beyond shorter term reliability needs. For example, the ITP identified the need for a number of 345 kV transmission lines connecting the panhandle of Texas to Oklahoma. These lines were identified as being economically beneficial for bringing low-cost, renewable energy to market, but their construction has also supported resilience by creating and strengthening alternate paths within SPP."[23]

As previously discussed, expanding transmission would increase reliability by enabling access to power in unaffected regions. In addition, modernizing the transmission system can also play a significant role in ensuring grid reliability and resilience in extreme temperatures and weather events. A smarter grid can respond to disruption by re-routing power or re-shaping load using demand response. These improvements include integrating storage and distributed energy technologies in wholesale power markets, using smart meters to detect grid outages, and expanding the nation's high-voltage transmission network to connect centers of supply with areas of demand.

The Honorable Garret Graves

1. **You stated that unsubsidized wind and solar (no ITC/PTC) are the cheapest forms of new energy. That is good news for the environment and for the taxpayers who have been subsidizing wind and solar either through tax credits, mandates or other market preferences. If, in fact, wind and solar are the cheapest forms of new energy, then the subsidies and mandates that have supported wind and solar are no longer necessary as market distortions (e.g.,, subsidies/mandates) are only necessary in those cases when the source is unable to compete without them.**

   a. **As a member of the MISO Advisory Committee can you identify any federal and/or state subsidies (tax credits/incentives, mandates or other preferences) for wind and solar in the MISO market that are no longer necessary in order for new wind and solar to successfully compete in the market?**

Policies in support of clean, low-cost, and reliable wind and solar deployment create numerous environmental, consumer and economic benefits, including over 350,000 jobs around the country.[24] For example, renewable energy standards help drive deployment of pollution-free renewable power by providing the long-term market certainty needed to catalyze investment in our communities. Policymakers have different preferences about how fast they would like to reduce emissions. Incentives can speed up deployment of clean energy beyond what the market would do on its own, and counteract the incentives that still exist for conventional, polluting resources.

[23] SPP filing in FERC Docket No. AD18-7, p. 8.

[24] NASEO and EFI, "2020 U.S. Energy and Employment Report," https://static1.squarespace.com/static/5a98cf80ec4eb7c5cd928c61/t/5ee78423c6fcc20e01b83896/1592230956175/USEER+2020+0615.pdf, p.40.

b. **When you made the statement that renewables are the cheapest form of energy, did your analysis include the cost of new transmission to move wind/solar generated power from the source to the consumer?**

When building new generation facilities, developers are responsible for connecting their plants to the nearest utility grid. Interconnection often requires construction of radial lines or other equipment such as substations. FERC Order 2003 stipulates that a generator seeking interconnection is responsible for the cost of all facilities, equipment, and all other transmission improvements between the point of interconnection and a public utility's system.[25]

Despite additional expenses associated with transmission upgrades needed to access remote resources, renewables still remain cost-competitive. A February 2020 report on the estimated levelized cost of electricity (LCOE) for new generation resources entering service in 2022 found that new wind and solar facilities would be substantially cheaper than fossil fuel units. When accounting for the levelized cost of new transmission, the LCOE of wind and solar were $27.71 and $28.88 per MWh, respectively, compared to $33.53 and $64.19 per MWh for combined cycle and combustion plants.[26]

Additionally, investment in large interregional transmission buildout to optimize the grid as a whole has broad economic benefits. In fact, efficiencies and access to cheap renewables facilitated by a nationwide power system would save U.S. consumers an estimated $47.2 billion annually.[27] The National Renewable Energy Laboratory also finds that stitching together the nation's electrical grid through a nationwide HDVC network would provide ratepayers $2.50 in benefits for each dollar invested.[28]

Finally, the package of transmission lines in the MISO Multi-Value Portfolio (MVP) approved by the MISO Board of Directors in 2011 provide reliability benefits, relieve congestion, create a well-functioning energy marketplace and deliver energy from renewable resources that benefit customers. In short, investing in transmission provides multiple benefits.

c. **With regard to transmission costs associated with renewables that are a large distance from the consumer, what are your thoughts on cost allocation for those transmission projects?**

Under FERC rules and court directives, costs should be allocated to those who benefit. Typically, there is some form of cost-sharing across different entities. Cost allocation policies should recognize the full regional benefits of significant interregional transmission, including reliability, effects on delivered energy costs, and access to low-cost resources. Many RTOs are

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[25] Norton Rose Fulbright, "Network Upgrades Controversy," October 2003, https://www.projectfinance.law/publications/network-upgrades-controversy.

[26] Energy Information Administration, "Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2020," https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf.

[27] MacDonald, Clack Et Al., "Future Cost-Competitive Electricity Systems and Their Impact on U.S. CO2 Emissions," January 25, 2016, https://www.vibrantcleanenergy.com/wp-content/uploads/2016/09/Future_cost-competitive_electricity_syst.pdf.

[28] National Renewable Energy Laboratory, Interconnections Seam Study, https://www.nrel.gov/analysis/seams.html.

currently discussing additional benefit metrics in the transmission planning process to recognize the full plethora of benefits transmission provides. The requisite portion of those costs should be allocated to reflect regional benefits to all beneficiaries in the region, regardless of their utility's or customers' contractual status with the new project. The number of benefits that accrue to customers from a robust transmission grid, or the harm that comes from the lack of one, can simply not be overstated.

2. **In his discussion with you, Mr. Casten noted that there are very few jobs associated with operating a wind and solar plant and because of that, operating costs were low.**

    a. **Do you agree with Mr. Casten that operational wind and solar generation provide few jobs?**

According to the 2020 U.S. Energy and Employment Report (USEER), solar and wind operations rank first and second, respectively, for employment in the U.S. electric power generation sector, each exceeding that of all other generator types.[29] Solar and wind plants employ over 350,000 Americans across the nation.[30]

There is no direct relationship between operating costs and total job growth in the solar and wind sectors. The growth of employment in the solar and wind sectors has been increasing even though O&M costs in both sectors have been decreasing. Solar and wind employment in the electric power generation sector increased by 2.4% and 3.2%,[31] respectively, in 2019 and was expected to continue to grow by 7% and 4% in 2020 prior to the pandemic.[32] According to the Bureau of Labor Statistics (BLS) Occupational Outlook Handbook, solar panel installers and wind turbine service technicians are expected to be the fastest growing jobs from 2018-2028.[33]

    b. **On average, how many employees, union and otherwise, are required to operate a fully constructed and functioning wind or solar powered generation unit in MISO?**

Jobs in the renewable sector span across the manufacturing, construction, wholesale trade, professional and business services, utility, and other industries. The utility-scale solar sector has high labor productivity with decreasing transaction costs per unit of capacity deployed.[34] The

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[29] NASEO and EFI, 2020 U.S. Energy and Employment Report, https://static1.squarespace.com/static/5a98cf80ec4eb7c5cd928c61/t/5ee78423c6fcc20e01b83896/1592230956175/USEER+2020+0615.pdf, p.40.

[30] Ibid.

[31] Ibid.

[32] Ibid, pp.58-61.

[33] U.S. Bureau of Labor Statistics, "Fastest Growing Occupations, Occupational Outlook Handbook," https://www.bls.gov/ooh/fastest-growing.htm, accessed August 24, 2020.

[34] The Solar Foundation, "Solar Jobs Census 2019," https://www.solarstates.org/#states/solar-jobs/2019.

MISO region employs about three[35] solar O&M jobs[36] per MW[37] of front-of-meter solar capacity. According to the National Renewable Energy Laboratory, a utility-scale wind farm requires about five to seven workers to maintain every 100 MW of a wind project with a lifecycle of 25 years.[38] Lower operational costs for renewable facilities translate to lower costs for ratepayers, compared to more employment-intensive or higher-risk generation technologies, like nuclear power.[39]

i. On average, how many employees, union and otherwise, work at a nuclear plant in MISO?

According to the Nuclear Energy Agency, each nuclear unit employs 400 to 700 direct workers.[40]

c. If wind and solar replaced all the nuclear plants in MISO, what would be the net impact on direct daily operating jobs at the generation unit (per your discussion with Mr. Casten)?

As noted above, operating nuclear power plants are more labor- and thus more cost-intensive than renewable energy facilities. However, replacing nuclear power plants with wind and solar facilities would result in new jobs outside of power plant operation in construction, wholesale trade, professional and business services and other industries.

i. If wind and solar replaced all the nuclear plants in MISO, what would be the net impact on emissions (including required back up power for renewables to ensure reliability)?

Because both renewable and nuclear energy generation yield zero emissions, there would be no difference in emissions. However, nuclear energy generation produces harmful, radioactive waste which requires extensive government regulation – a cost and environmental burden that is eliminated with the shift to renewable energy.

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[35] The Solar Foundation, "Solar Jobs Census 2019," https://www.solarstates.org/#states/solar-jobs/2019, accessed August 24, 2020, and Clean Energy Canada, "Clean energy opportunities are spread across the country," https://canwea.ca/wp-content/uploads/2019/05/Postcard_Opportunities-spread-across-the-country_20190521.jpg, accessed August 24, 2020.

[36] Number of jobs calculated by aggregating MISO state job numbers using The Solar Foundation State Map and Canadian Wind Energy's Manitoba webpage.

[37]MISO, "Planning Year 2020-2021 Wind & Solar Capacity Credit," https://cdn.misoenergy.org/2020%20Wind%20&%20Solar%20Capacity%20Credit%20Report408144.pdf, p.3, accessed August 24, 2020.

[38] Keyser, David, Tegen, Suzanne, The Wind Energy Workforce in the United States: Training, Hiring, and Future Needs, NREL, available at https://www.nrel.gov/docs/fy19osti/73908.pdf, p.5, accessed August 24, 2020.

[39] Davis, Lucas, "The High Cost of Nuclear Jobs," The Energy Institute at Haas, March 2020, https://energyathaas.wordpress.com/2020/03/09/the-high-cost-of-nuclear-jobs/.

[40] NEA and IAEA, "Measuring Employment Generated by the Nuclear Power Sector," https://www.oecd-nea.org/ndd/pubs/2018/7204-employment-nps.pdf, p.30, accessed August 24, 2020.

Renewables do not need to be paired with non-renewable or "backup" sources of energy to replace nuclear facilities and/or be integrated into the grid. Energy storage technology, demand response, large regional power markets, and a robust transmission network can ensure that electrons flow across the country at all hours of the day and night. Due to cost reductions, renewables have been steadily replacing other generation over the past few years[41] with a 19% share of total electricity generation in 2019, which is roughly equivalent to today's share of nuclear generation.[42] EIA's Annual Energy Outlook forecasts that solar PV will be less costly than natural gas to replace retiring coal and nuclear plants in the Southeast and Mid-Continent regions, where solar generation is growing.[43]

3. **In the hearing, you stated that renewables are not only the cheapest form of energy, but also the most reliable.**

    a. **Can you provide any facts or data that show wind and solar being more reliable than other competing forms of energy?**

Reliability is a system concept. A reliable system includes a diverse portfolio of resources that together meet load at all times. A high renewable energy portfolio can be part of a low-cost, low-carbon, reliable power system.

As the share of wind and solar power in the U.S. electricity mix has grown over time, official metrics indicate that system reliability has been stable or improved. According to a 2019 report to Congress, wind and solar power increased from 1% of generation in 2008 to 8% in 2018, while during the same period 9 of the 13 metrics the North American Electric Reliability Corporation uses to assess reliability were stable or improved.[44] In fact, wind and solar have increasingly provided the majority of generation in different regions without impacting reliability. At certain points in 2019, wind sources supplied 56% of electricity demand in ERCOT and 67.3% of demand in SPP, while solar supplied 59% of demand in CAISO – with bulk power system reliability being maintained during each of these periods.[45]

In addition to providing low-cost, pollution-free energy, renewables also deliver a suite of grid reliability services to help keep the lights on during disturbances, including ride-through capability, voltage and reactive power control, and flexibility, frequency regulation, and primary frequency response.[46] Wind and solar can also improve power system resilience during extreme

[41] Energy Information Administration, "Renewable energy explained," https://www.eia.gov/energyexplained/renewable-sources/, accessed August 24, 2020.
[42] Energy Information Administration, "Annual Energy Outlook 2020: Electricity," https://www.eia.gov/outlooks/aeo/pdf/AEO2020%20Electricity.pdf, p.2, accessed August 24, 2020.
[43] Ibid, p.20.
[44] Congressional Research Service, "Maintaining Electric Reliability with Wind and Solar Sources: Background and Issues for Congress," June 10, 2019, https://fas.org/sgp/crs/misc/R45764.pdf.
[45] Ibid.
[46] American Wind Energy Association, "Renewables on the grid: Market-based solutions support reliability," https://www.aweablog.org/renewables-grid-market-based-solutions-support-reliability/.

weather conditions. Wind's reliability was demonstrated during the 2014 Polar Vortex event, when turbines continued to turn even when freezing temperatures disrupted natural gas pipelines and froze coal piles, rendering many thermal plants inoperable. According to NERC, coal and gas generators made up 81% of power outages during the event.[47] Wind and solar also remain resilient during heat waves, occurrences that will only increase in frequency due to a changing climate. As described above, CAISO CEO Steve Berberich attributed California's rolling blackouts in part to a power plant that "tripped" in the high heat,[48] likely a natural gas plant that shut down during the heatwave,[49] as natural gas plants often struggle in extreme temperatures.

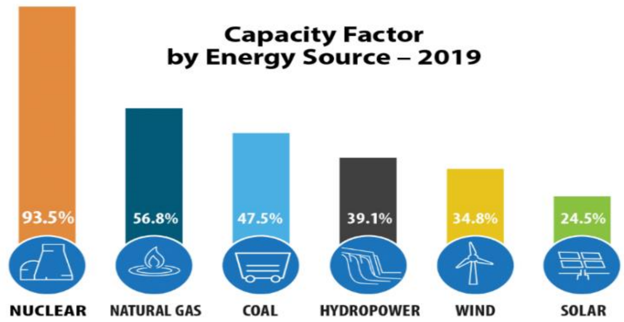
b. If MISO were to build wind and solar capacity equal to capacity needs and resource adequacy in MISO, how much back up natural gas generation would need to be on-line in order to ensure around the clock reliability?

If entities built wind and solar capacity equal to capacity needs and resource adequacy in MISO, then, by definition, no backup would be needed. As noted above, renewables do not necessarily need to be paired with non-renewable or "backup" sources of energy. Energy storage technology, demand response and a robust transmission network can ensure that electrons flow across the country at all hours of the day and night. A very low-carbon portfolio can also be achieved with natural gas included in the resource mix.

4. **Capacity factor is a measurement for an energy sources' reliability. According to the chart below (published by the Department of Energy based on EIA data), wind and solar are the least reliable forms of energy (https://www.energy.gov/ne/articles/what-generation-capacity). Do you disagree with EIA capacity factor data?**

[47] Bade, Gavin, "Polar Vortex set to test Midwest grids amid FERC resilience debate," UtilityDive, January 30, 2019, https://www.utilitydive.com/news/polar-vortex-set-to-test-midwest-grids-amid-ferc-resilience-debate/547231/.
[48] Kahn, Debra and Bermel, Colby, "California has first rolling blackouts in 19 years — and everyone faces blame," Politico, August 18, 2020, https://www.politico.com/states/california/story/2020/08/18/california-has-first-rolling-blackouts-in-19-years-and-everyone-faces-blame-1309757.
[49] Gilbert, Alex and Bazilian, Moran, "California power outages underscore challenge of maintaining reliability during climate change, the energy transition," UtilityDive, https://www.utilitydive.com/news/california-power-outages-underscore-challenge-of-maintaining-reliability-du/583727/.

The Capacity Factor



Source: U.S. Energy Information Administration

Capacity factors allow energy buffs to examine the reliability of various power plants. It basically measures how often a plant is running at maximum power. A plant with a capacity factor of 100% means it's producing power all of the time.

Nuclear has the highest capacity factor of any other energy source—producing reliable, carbon-free power more than 92% of the time in 2016. That's nearly twice as reliable as a coal (48%) or natural gas (57%) plant and almost 3 times more often than wind (35%) and solar (25%) plants.

Respectfully, capacity factor is not a measurement of an energy source's reliability. A capacity factor is a ratio of energy output relative to maximum potential output over a period of time. For example, a car with a top speed of 90 mph that typically cruises on the highway at a speed of 65 mph and only reaches 90 mph one day a month could be said to have a capacity factor of only 3%. This does not mean the car is unreliable. In fact, a typical wind turbine generates electricity 90% of the time.[50]

Additionally, the capacity factors listed in the chart are an aggregate of all wind and solar projects. As the technologies continue to improve, so do their capacity factors. For example, according to Lawrence Berkeley National Laboratory, "the average 2019 capacity factor among [wind] projects built from 2014 through 2018 was 41%, compared to an average of 31% among projects built from 2004 to 2012 and 25% among projects built from 1998 to 2001."[51]

Finally, most new utility-scale renewable development is not of single-resource projects, but rather hybrid multi-generator or generator-plus-energy storage projects that combine the unique benefits of multiple technologies to achieve reliability and economic gains rarely before seen in power generation.[52] The capacity factors of hybrid resources are absent from the EIA data presented here, but they are by definition higher than any single-resource renewable generator. A hybrid resource that includes energy storage can shift the electrons generated by a variable power resource from times of surplus to times of need. A hybrid resource with more than one generator

[50] American Wind Energy Association, "Basics of Wind Energy," https://www.awea.org/wind-101/basics-of-wind-energy/.
[51] Lawrence Berkley National Lab, "Wind Technologies Market Report," https://emp.lbl.gov/wind-technologies-market-report/.
[52] American Council on Renewable Energy, "Multi-Resource 'Hybrid' Power Plants are the Present and Future of Energy Generation," August 19, 2020, https://acore.org/multi-resource-hybrid-power-plants-are-the-present-and-future-of-energy-generation/.

can ensure that it is always producing power from the most available, least costly fuel of the day, be that sunlight, wind or water.

5. **According to the MISO MTEP18 report (https://cdn.misoenergy.org/MTEP18%20Book%202%20Resource%20Adequacy264875.pdf)**

   "MISO's ongoing goal is to support the achievement of Resource Adequacy — to ensure enough capacity is available to meet the needs of all consumers in the MISO footprint during all time frames and at just, reasonable rates."

   Resource Adequacy credits in MISO are determined by Module E-1 tariffs in MISO. This tariff determines the ability of the source to provide resource adequacy support in MISO. According to the MISO report titled "Planning Year 2020-2021 Wind and Solar Capacity Credit" published in December 2019 (https://cdn.misoenergy.org/2020%20Wind%20&%20Solar%20Capacity%20Credit%20Report408144.pdf), the system wide capacity credit for wind during the planning year is 16.6 percent. Can you explain how MISO calculated the 16.6 percent capacity credit and what it means in terms of winds capability to meet MISO resource adequacy?

This NREL fact sheet describes the terms. MISO and other operators use Effective Load Carrying Capability to determine capacity value. NERC has defined ELCC in this document.

6. **According to a recent MISO report, MISO has an installed wind capacity of 20,452MW, yet August 5, 2020 at 2:30pm CST– wind was providing only 3,891 MWs of power to the MISO grid.**

   a. **Why is over 80% of the wind capacity in MISO not providing power to customers?**

Very high penetrations of renewable energy are part of any low-cost, low-carbon, reliable portfolio. Natural gas, coal, nuclear, renewable, and all resources have planned and forced outages, and exogenous factors that affect their availability. That does not mean that any single resource or type of resource is available at all times, which is why all systems utilize diverse portfolios. States and grid operators need to assemble portfolios that work together to meet load at all times.

   b. **Is that normal for the majority of wind capacity in MISO not to be delivering power at any single point in time in the summer?**

Very high penetrations of renewable energy are part of any low cost, low carbon, reliable portfolio. Natural gas, coal, nuclear, renewable, and all resources have planned and forced outages, and exogenous factors that affect their availability. That does not mean that any single resource or type of resource is available at all times which is why all systems utilize diverse portfolios. States and grid operators need to assemble portfolios that work together to meet load at all times.

7. **At 2:30pm CST on August 5, 2020, the LMP in MISO was approximately $25.00. If according to the conversation between you and Mr. Casten the marginal cost of wind was $0 and therefore wind would be dispatching at any price over zero, can you explain why over 80% of the wind in MISO is not dispatching when the market was paying $25.00?**

Because of the free market, suppliers are not required to sell at any given price. Marginal cost therefore refers to the cost of the supplier to dispatch electricity, not the price at which the supplier must sell electricity. When wind dispatches at prices above $0, it earns a profit due to its zero-marginal cost.

Additionally, LMP refers to locational marginal price, a construct that exists because transmission constraints preclude the formation of any single market price for electricity in MISO at any given time. Prices vary across localized nodes, called LMPs. An expanded and updated transmission system would go a long way towards reducing this price variability and deliver the cleanest, lowest-cost power to consumers.

8. **An article published March 19, 2019, by the Institute for Energy Research (https://www.instituteforenergyresearch.org/the-grid/wind-generation-fails-in-midwest-due-to-weather-events-polar-vortex-and-el-nino/) analyzed the performance of wind generation during acute weather events and included the following statement,**

    "During the polar vortex, wind turbines shut off when temperatures dipped below minus 20 degrees Fahrenheit. There has been little focus on developing wind turbines to operate below minus 20 degrees Fahrenheit because at these temperatures, there is not much wind blowing. The economics of producing wind energy in such extreme conditions would not justify the additional cost, according to wind experts."

    a. **How did renewables perform (what percent of capacity was dispatched) during the polar vortex of 2014 and the polar vortex of 2019 in the regions impacted by each polar vortex?**

In January 2014, freezing temperatures descended upon the Midwest and Eastern regions of the United States, setting a winter peak demand record in MISO, SPP, ERCOT, PJM, and NYISO, along with most of the utilities in the Southeast.[53] During this event, cold temperatures disrupted natural gas pipelines and froze coal piles and mechanical components at generators, rendering

[53] Federal Energy Regulatory Commission, "Recent Weather Impacts on the Bulk Power System", January 16, 2014.

many inoperable.[54] Fortunately, wind energy output was well above expectations for its contribution during the peak demand period, helping to keep the lights on for millions of customers.[55]

For example, in an assessment of operational events and market performance, PJM highlighted that wind generation performed well above its capacity for the duration of the event, and performed at nearly 70% of its maximum capacity on January 6th.[56] Additionally, also on January 6, 2014, the Nebraska Public Power District (NPPD) met record winter electricity demand as wind provided about 13% of the utility's electricity. NPPD explained that "Nebraskans benefit from NPPD's diverse portfolio of generating resources. Using a combination of fuels means we deliver electricity using the lowest cost resources while maintaining high reliability for our customers." During the Polar Vortex, the utility also noted that "NPPD did not operate its natural gas generation because the fuel costs were up more than 300 percent over typical prices."[57]

During the 2019 Polar Vortex, freezing temperatures also impacted much of the Midwest and Eastern U.S. During the event, wind energy output was again consistently well above the level planned for by MISO and PJM during the period of highest electricity demand on January 30-31. Wind output was even higher on the evening of January 29 when the Midwest experienced very high demand.[58] This was in part driven by an intrusion of fast-moving, dense air which proportionally increased wind turbine output.

Wind energy worked especially well during the 2019 Polar Vortex, as wind output in MISO and PJM consistently outperformed grid operators' expectations as seen through the figure below.[59]

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[54] Bade, Gavin, "Polar Vortex set to test Midwest grids amid FERC resilience debate," Utility Dive, January 30, 2019, https://www.utilitydive.com/news/polar-vortex-set-to-test-midwest-grids-amid-ferc-resilience-debate/547231/.

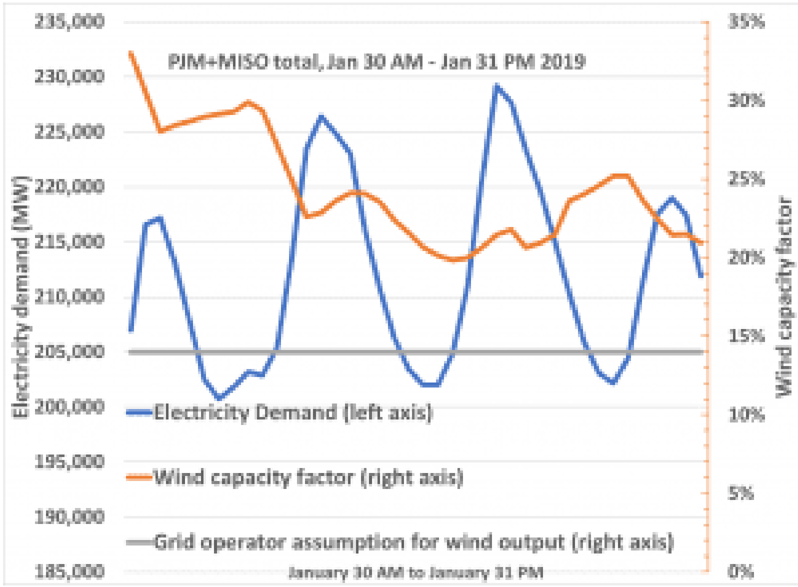
[55] Goggin, Michael, "Renewables on the grid: Market-based solutions support reliability," July 19, 2017, https://www.aweablog.org/renewables-grid-market-based-solutions-support-reliability/.

[56] PJM, "Operational Events and Market Impacts January 2014 Cold Weather." May 9, 2014, https://pjm.com/-/media/library/reports-notices/weather-related/20140509-presentation-of-january-2014-cold-weather-events.ashx?la=en.

[57] Nebraska Public Power District, "Nebraska Customers Set Winter Peak," accessed January 2015, http://www.nppd.com/2014/nebraska-customers-set-time-winter-peak-nppd/.

[58] Goggin, Michael, "How transmission helped keep the lights on during the Polar Vortex," February 14, 2019, https://www.aweablog.org/transmission-helped-keep-lights-polar-vortex/.

[59] American Wind Energy Association, "How transmission helped keep the lights on during the Polar Vortex," February 14, 2019, https://www.aweablog.org/transmission-helped-keep-lights-polar-vortex/.



During the 2019 Polar Vortex, Michigan utility DTE noted that its 277 wind turbines performed at full capacity for nearly the whole week.[60]

b. When people's health and safety depended on power during the polar vortex, what were the best performing sources of energy?

Coal and natural gas constituted the greatest proportion of forced outages in MISO from 2014 to 2019, the period of the two most recent polar vortices. By comparison, while wind plants in MISO experienced 4 GW of shutoffs, this figure pales in comparison to the nearly 14 GW of coal and natural gas facilities driven offline during the 2019 Polar Vortex.[61]

9. As renewable penetration increases, should we put in place requirements that ensure an "American Made" supply chain across the spectrum from extraction to assembly?

According to the Department of Energy, domestically manufactured content for recently installed wind projects in the U.S. was over 90% for nacelle assembly, between 75 and 90% for towers, and between 50% and 70% for blades and hubs.[62] Additionally, 95% of the wind power capacity

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[60] DTE Energy, "DTE's wind fleet weathers cold temperatures," February 1, 2019, https://empoweringmichigan.com/dtes-wind-fleet-weathers-cold-temperatures/.

[61] MISO, "MISO January 30-31 Maximum Generation Event Overview," February 27, 2019, available at HYPERLINK https://cdn.misoenergy.org/20190227%20RSC%20Item%2004%20Jan%2030%2031%20Max%20Gen%20Event322139.pdf, p.5, accessed August 24, 2020.

[62] Department of Energy, "2018 Wind Technologies Market Report," 2018, https://emp.lbl.gov/sites/default/files/wtmr_final_for_posting_8-9-19.pdf.

installed in the U.S. last year was built by wind turbine manufacturers with at least one American manufacturing facility.[63]

Although U.S. global market share for solar technology has declined in recent years, domestic solar photovoltaic manufacturing has expanded. An August 2017 International Trade Commission report found that, between 2012 and 2016, production capacity of U.S. PV module manufacturers rose 34%, and domestic production expanded by 24%.[64] Furthermore, a 2019 National Renewable Energy Laboratory report on U.S. infrastructure availability for PV manufacturing found that this growth in domestic demand could represent a significant catalyst for growth in upstream industries. The NREL report noted that the U.S. has significant steel and aluminum production capacity that could be utilized for manufacturing extruding racking and module frames, and further production capacity that could be adapted and scaled for other important components such as inverters, encapsulants, flat glass, and Tedlar.[65]

Today's renewable energy supply chain is a testament to the strength and diversity of American manufacturing, which plays a central role in the nation's renewable energy success story.

[63] American Wind Energy Association, "Wind Powers America Annual Report 2019," April 2020, https://www.awea.org/resources/publications-and-reports/market-reports/2019-u-s-wind-industry-market-reports.
[64] Congressional Research Service, "Domestic Solar Manufacturing and New U.S. Tariffs," February 2018, https://fas.org/sgp/crs/misc/IF10819.pdf.
[65] Smith, Brittany L., and Robert Margolis, "Expanding the Photovoltaic Supply Chain in the United States: Opportunities and Challenges," National Renewable Energy Laboratory, 2019, https://www.nrel.gov/docs/fy19osti/73363.pdf.