November 1, 2018

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U.S. Department of Energy
1000 Independence Avenue SW

RE: AWEA Comments on Procedures for Conducting Electric Transmission Congestion Studies

Submitted via email to: congestion.study2018@ hq.doe.gov

The American Wind Energy Association (AWEA)[1] respectfully submits these comments in response to the Notice of Procedures issued by the Department of Energy ("DOE" or "the Department") concerning its intention to conduct a triennial electric transmission congestion study, as required by §216(a)(1) of the Federal Power Act ("FPA"), to determine the state of congestion on the nation's electric transmission network. AWEA appreciates DOE moving forward with the 2019 study and seeking input about the scope and nature of the analysis that will be conducted in the study.

As discussed further herein, AWEA believes that this, the fourth, congestion study will help frame the challenges of the future adequacy of the nation's electric transmission infrastructure to meet the growing needs for electric reliability and resilience, energy diversity, new technologies in the electric sector, and more efficient wholesale power markets; and, in

[1] AWEA is the national trade association representing a broad range of entities with a common interest in encouraging the deployment and expansion of wind energy resources in the United States. AWEA members include wind turbine manufacturers, component suppliers, project developers, project owners, financiers, researchers, renewable energy supporters, utilities, marketers, customers and their advocates.

particular, how the siting of critical electric transmission infrastructure ought to be addressed as a policy and regulatory matter in order to facilitate these goals. With that end in mind, AWEA encourages DOE, as well as other interested Executive Branch departments and agencies, to ensure that the nation's electric transmission infrastructure is adequate to sustain the national energy policy goals that the Congress recognized in the Energy Policy Act of 2005[2] and more recently declared in the Presidential Executive Order on Promoting Energy Independence and Economic Growth ("Executive Order 13783").[3]

In sum, the 2019 congestion study represents an opportunity to improve the permitting of critical transmission infrastructure projects and, in turn, support national energy policy and security goals through a more robust and highly integrated national electric transmission network. Specifically, DOE can serve those ends by improving the metrics used in the 2019 study, proposing and designating national corridors on the basis of the study, and considering project-specific congestion studies and the designation of related corridors.

I. EXECUTIVE SUMMARY

The high-voltage bulk power transmission system must be further expanded, modernized, and integrated to enable the ongoing beneficial electrification of the U.S. economy and society in an optimally affordable, sustainable, reliable, and resilient manner. However, adding electric transmission capacity, especially with new rights-of-way, is extraordinarily costly, difficult and time-consuming among major energy-related actions. This difficulty comes from the divided regulatory authority governing transmission decisions, with various federal, state, and local

[2] Public Law 109-58 (2005).
[3] Executive Order 13783 states: "The prudent development of these natural resources is essential to ensuring the Nation's geopolitical security. It is further in the national interest to ensure that the Nation's electricity is affordable, reliable, safe, secure, and clean, and that it can be produced from . . . domestic sources, including renewable sources." 81 Fed. Reg. 51866 (August 5, 2016).

authorities approving or supervising key elements of transmission planning, construction, operation, and finance. In particular, while state siting is efficient at siting projects built by a single state utility to serve its customers, it has proved largely ineffective in siting interregional/interstate projects whose benefits (such as economic, reliability, and resilience) are national in nature. As a result, although there is generally sufficient private capital waiting in the wings to develop critical long-haul transmission infrastructure, this inefficient siting process has often proven to be a key barrier to unlocking such investment. In short, effective federal siting for interstate electric transmission facilities is critical, in certain circumstances, to ensure a more robust and secure grid that is able to meet the needs of the 21st century.

In recognition of the need to overcome the obstacles to further transmission expansion, modernization, and integration of the grid, in the Energy Policy Act of 2005, Congress gave DOE authority to conduct congestion studies and to identify and designate National Interest Electric Transmission Corridors ("NIETCs"), experiencing electric energy transmission constraints or congestion, to support a more robust electric grid. DOE should use this authority to support the expansion of long-haul electric transmission infrastructure to support our economy and the overall well-being of the United States. In fact, this would do more than any other action to ensure that our nation's energy grid is strong and secure and protects our national security, public safety, and economy from intentional attacks and natural disasters. Specifically, DOE should use its corridor designation authority and allow project-specific corridors that facilitate buildout of transmission that contributes to reducing constrains on the system, as well as enhancing the long-term reliability and resilience of the electric grid.

II. COMMENTS

A. Transmission Expansion Results in a Wide Range of Benefits

DOE should exercise its authority to designate corridors to secure the quantifiable, widespread, and long-lasting benefits produced by long-haul transmission.[4] Recent developments in transmission planning around the country show that the industry and regulators have reached a point where a more comprehensive and standardized catalogue of benefits and methodologies for estimating the benefits of transmission should be articulated and considered.[5] For further detail on the benefits of transmission, including those that should be included in the study please refer to Appendix A, Section III.

i. Resilience and reliability of the nation's electric grid are bolstered with investment in transmission system upgrades.

A significant benefit of reducing congestion, through the expansion of transmission, is that it allows the grid to operate equally reliably with fewer power plants, by allowing the sharing of planning and operating reserves among neighboring power systems. Reduced planning reserve needs are a significant benefit of transmission. New, strategically located transmission projects can allow grid operators to use imports and exports from neighboring power systems to help meet peak demand, saving billions in dollars per year by not having to build as many power plants for planning reserves.

Interregional transmission projects also provide geographic diversity, which contributes to resilience and reliability. Not all regions experience peak electricity demand at the same time, particularly with many northern regions experiencing peak demand in the winter and many

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[4] Available at https://www.wiresgroup.com/docs/reports/WIRES_LEI_MeasurableBenefits_FactSheet.pdf.
[5] Available at http://wiresgroup.com/docs/reports/WIRES%20Brattle%20Rpt%20Benefits%20Transmission%20July%202013.pdf, page iii.

southern regions experiencing peak demand in the summer due to the use of electricity for heating and cooling. Transmission connections among regions reduce the amount of extra power plant capacity each grid operator must hold as operating reserves to accommodate the seasonal peak demands.

Expansion of transmission provides benefits reliability and resilience benefits beyond reduced planning reserve and operating reserve needs. Kansas utility Westar has reported that transmission expansion has been associated with a 40 percent reduction in transmission-related customer outages.[6] There are also models that show that strengthening the grid by adding "backup" network paths significantly increases the system's resilience to damage and prevents power outages.[7]

In sum, focusing on investing in transmission infrastructure ensures that our grid can respond to all types of attacks or disasters that affect the power system (cyber or physical attacks, electromagnetic pulses, geomagnetic disturbances, gas supply disruptions, extreme weather, etc.). Section IV of Appendix A provides more detailed data on the benefits of resilience and reliability that transmission provides.

ii. Investments in expansion of electric transmission infrastructure result in pass through benefits to consumers in the form of lower costs of power.

Another benefit that results from transmission buildout is a lower cost of power for customers. Investments in transmission provide a high return on investment for customers, according to a report published by Southwest Power Pool, investments made in the region from 2012-2014 had, on average, a benefit-to-cost ratio of 3.5 to 1. This means that for every dollar invested in transmission, $3.50 in value is delivered to the region over the long lifespan of the

[6] Available at https://www.spp.org/documents/35297/the%20value%20of%20transmission%20report.pdf, page 15.
[7] Available at http://public.lanl.gov/rbent/pscc_resilience.pdf.

project.[8] While the benefits will vary across regions, studies have shown that these projects more than pay for themselves. In other words, even though the costs of these projects are high, they would reduce the cost of electricity, and in effect, ultimately pay for themselves

B. 2019 Triennial Congestion Study

i. How the term "congestion" is defined is critical to driving planning processes that result in effective transmission solutions.

Congestion, as defined by DOE, is "when a constraint within a given area's transmission network prevents the network from accommodating all transactions desired at a given time by authorized user." This definition echoes that congestion is a network phenomenon, one that affects the entire region covered by the network.

ii. The overwhelming majority of reliability and resilience problems and solutions are related to whether there is adequate transmission to get power to where it is needed.

As explained in more detail in Appendix A to these comments, electric transmission lines to do more than anything to bolster long-term resilience and reliability of the electric grid.[9] Physical and operational delivery assets are the key to strengthening the ability of the regional and interregional transmission grid to maintain operations when challenged by adverse events, and to aid the rapid restoration of service when damage and customer outages do occur.

While upgrades to transmission infrastructure are high-dollar projects, they are also high value and cost-effective solutions to address reliability and resilience concerns, without requiring a redesign or rethinking of the competitive generation markets, which have produced substantial

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[8] Available at https://www.spp.org/value-of-transmission/.

[9] Resilience of the electric power system is defined as "the ability of the nation's electricity infrastructure to prevent or diminish damage from high-impact, low-probability events without undue disruption and to rapidly restore service when such disruptions occur." The Brattle Group, Chupka & Donohoo-Vallett, *Recognizing the Role of Transmission in Electric System Resilience* at p. 3 (May 9, 2018) available at http://www.wiresgroup.com/docs/reports/Transmission_Resilience_WIRES_FINAL_05092018.pdf.

consumer benefits.[10] The larger the geographic "footprint" of the bulk power system (through bolstered transmission interconnection), the greater the ability for customers to capitalize on economies of scale and scope in energy, capacity, and reserves.[11] Further, strengthening the so-called "resilience" of an individual generator, or even the generation fleet as a whole, will not contribute to the overall resilience of the system if the power cannot be delivered into an intact distribution system to serve customer loads.[12] In contrast, the transmission network can absorb the damage potentially arising from multiple local generator outages, without customer service disruptions, by providing access to a network of technologically diverse and geographically dispersed set of power supplies. As such, when sufficiently robust to maintain the flow of power under stressful conditions, transmission systems are inherently resilient.[13]

iii. Additional metrics should be included in the criteria for designation of corridors, which goes beyond the traditional definitions of "congestion" or "constraint."

DOE should update criteria for the designation of NIETCs to reflect the current needs of the grid, including the ability to achieve public policy goals, bolster national security by supporting reliability and resilience, and reduce queue delays and curtailment.

Insufficient transmission capacity can make it difficult for utilities and other load serving entities to meet state or federal public policy goals to which they are otherwise subject. Without modernization or expansion of the grid, achievement of the various public policies, whether renewable energy portfolios, clean energy standards, or others governing greenhouse gas emission, will be difficult if not impossible. Access to new forms of generation therefore

[10] *Id.* at 19
[11] *Id.* at 2
[12] *Id.*
[13] *Id.* at ii.

becomes a public policy matter that, with identifiable exceptions, only robust transmission can address. DOE should identify and examine existing federal, state, and local policies, determine what those will require in terms or new supply resources, and determine the amount and general location of transmission capacity that will be needed to deliver output from those resources to customers.

Aging transmission facilities, outdated control technology, or infrastructure that is insufficient to deliver electric power from diverse resources and locations, as discussed above, heighten concerns about the reliability and resilience of the electric system and threatens national security in the face of extreme weather, physical attack, or other contingencies. These and other contingencies should also be part of the congestion analysis, considering how a lack of transmission capacity can dramatically limit the number and availability of remedies or defenses with which to meet such challenges when states and locales need them most.[14]

DOE should also consider the size and delays in generation interconnection queues, particularly MISO and SPP, as an indication of a lack of sufficient transmission capacity to promote economic outcomes. Delays in interconnection queues may also present resource diversity and resilience issues. In addition, curtailment across the various wholesale markets should be included in the study, examining how curtailment could be resolved with increasing transmission capacity in a region. Curtailment has far reaching impacts on the cost of electricity, ability to maintain a diverse resource portfolio mix, ability to meet public policy goals, and resilience of the overall system.

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[14] Available at thttp://www.wiresgroup.com/docs/AD18-7000%20Comments%20of%20WIRES.pdf; https://www.wiresgroup.com/docs/reports/WIRES%20Brattle%20Rpt_TransPlanning_042315.pdf.

C. Corridor Designation

i. Congress recognized the critical need for transmission and gave DOE corridor designation authority.

The federal siting process described in Energy Policy Act of 2005 is not playing out the way Congress envisioned. DOE has not established any new corridors since the first study, years ago, even though the need for transmission expansion has only grown since then. Indeed, long-haul interstate lines are currently being significantly delayed due to challenges in the permitting process at the state level. While the state permitting process is sufficient for smaller, regional projects, it has not been successful at effectively permitting interregional projects, largely due to the difficulty in capturing interregional benefits. Meanwhile, interregional transmission is sorely needed to meet new demand, changing generation resources, and public policy goals. A congested and obsolete power grid is denying consumers access to low cost power while increasing the risk of blackouts. Without the designation of NIETCs, projects with regional benefits and, therefore, the greatest national interest are not being constructed.

ii. DOE has the authority to designate corridors and should act on this authority.

If DOE were to use its designation authority, it would aid in enabling the buildout of valuable transmission investment necessary to maintain a robust and reliable electric grid. In acting on this designation authority, DOE should recognize the need in areas that are not only congested, but also constrained. DOE has recognized it has the authority to designate corridors in the absence of current congestion, so long as a constraint, including the absence of transmission capacity, is hindering the development of desirable generation, such as to meet public policy goals, or denying some transmission users the benefit of their preferred transactions, like the desire to purchase renewables.

The importance of these criteria were laid out above, and also in more detail in Appendix A, Section III. DOE has broad authority to examine a range of factors, including economic development, energy diversity and national defense and homeland security, when conducting the triennial study. Section 216 of the Federal Power Act enumerates several considerations that are becoming increasingly important and that should have been examined in previous studies and were not. We urge DOE to utilize this authority in a way that will enhance the knowledge base about the many benefits of greater sustained investment in transmission. Expanding the criteria and scope of the study would result in a more complete understanding of the impact of transmission and hopefully lead to more successful corridor designation.

iii. Allowing project-specific designation, with input from developers, results in more effective corridor designations.

DOE should also allow project-specific corridors that are more likely to help solve specific grid problems. Allowing transmission developers to request a corridor designation is not outside the scope of authority designated by section 216(a) of the Federal Power Act. Part of the ineffectiveness of corridor designation in the past has been the amount of land labeled as a "corridor." Narrowing the scope and having project-focused corridors would ultimately lead to more effective NIETCs (*i.e.*, developers themselves proposing the corridors).

Developers are best equipped to identify the areas that are most crucial to building transmission. Under such an approach, the developer should bear the burden of demonstrating that the proposed corridor meets the criteria in section 216(a)(4) of the Federal Power Act. The result of this amended process would be narrower corridors because developers would propose corridors that better align with the routes of specific projects. Not only could this create a more streamlined process for corridor designation (rather than waiting on triennial congestion studies), it could also reduce opposition due to the resulting narrower corridors, from a geographical perspective, and the due diligence private developers would have done prior to pursuing a project-specific designation.

III. CONCLUSION

For the foregoing reasons, AWEA strongly encourages DOE to complete the 2019 congestion study, propose and designate national corridors on the basis of the study and consider the designation of project-specific corridors based on studies performed by developers.

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APPENDIX A

What publicly-available data and information should be considered, and what types of analysis should be performed to identify and understand the significance and character of transmission congestion?

I. Data that should be used in DOE's Congestion Study

Independent System Operators (ISOs) and their Independent Market Monitors (IMMs) track transmission congestion data in their regular annual and quarterly market reports. As shown below, transmission congestion across the ISOs totaled $4 billion in 2016 and increased to nearly $4.5 billion in 2017.

Table 1: Congestion costs in IMM reports, in millions of dollars

	2017	2016
MISO	$1,503	$1,400
PJM	$698	$1,024
ERCOT	$967	$497
NYISO	$481	$529
SPP	$506	$280
CAISO	$180	$142
into CAISO	$114	$92
ISO-NE	$41	$39
Total	**$4,490**	**$4,003**

DOE's Congestion Study should also track how congestion costs have changed over time, particularly for regions that have invested in transmission. For example, the New England grid operator saw a large reduction in the congestion-related costs paid by consumers after it made significant investments in transmission upgrades. Specifically, system-wide congestion costs fell from in excess of $600 million per year in 2005 and 2006 to under $100 million annually, mostly as a result of transmission investment.[15] Similar reductions in congestion costs have been observed in other regions that have invested in transmission.

Data suggests that congestion costs are trending higher this year, in part because there was significant transmission congestion during the "Bomb Cyclone" cold weather event in early 2018, particularly between low prices in western PJM and high prices in eastern PJM. PJM's IMM found almost $900 million in congestion costs in the first half of 2018, up from $285 million in the first half of 2017.

Congestion costs have also increased substantially in regions with large amounts of renewable energy. A lack of transmission capacity out of wind-heavy western SPP pushed the annual

[15] Available at https://www.iso-ne.com/static-assets/documents/2017/01/20170130_stateofgrid2017_presentation_pr.pdf, pages 39-40.

average market price as low as $12/MWh across a large area in 2017, half the SPP-wide average of $23/MWh, as shown below.[16] Consumers in central Oklahoma who are paying as much as $42/MWh for electricity generation would greatly benefit from greater access to the low-cost wind resources just a short distance to the west.

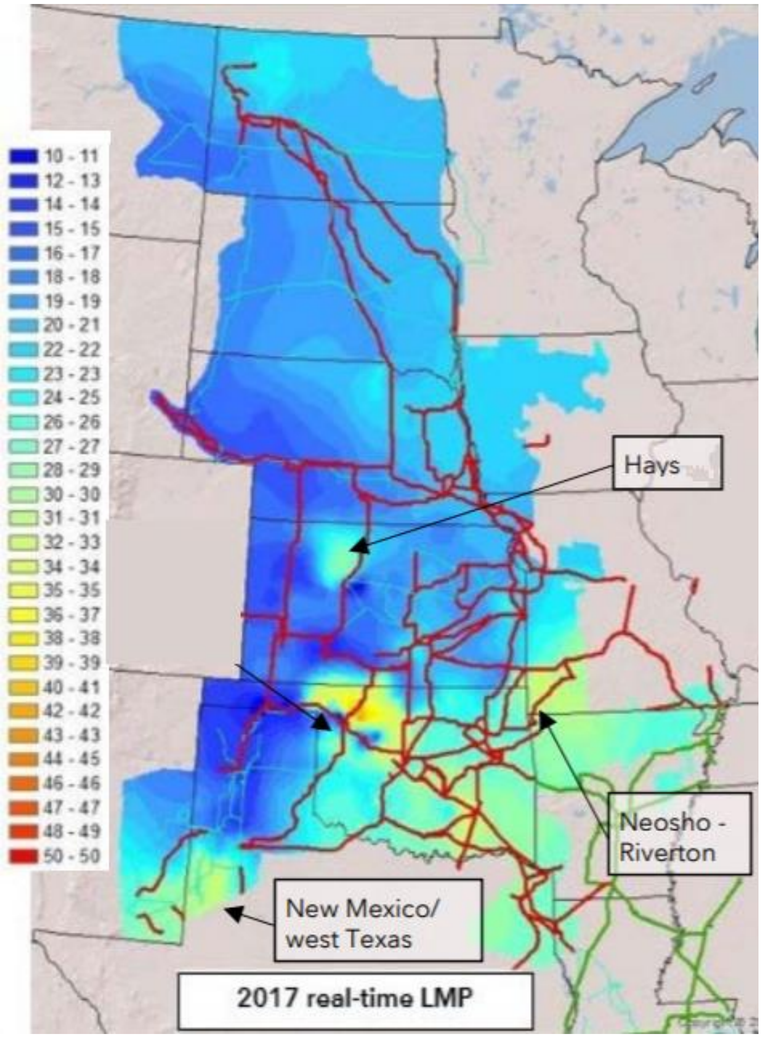

Figure 1: SPP Market Monitor map showing low prices in renewable-heavy western SPP

Transmission congestion reduces the value consumers receive from renewable generation. The following chart from a Department of Energy (DOE) and Lawrence Berkeley National Laboratory (LBNL) report shows the wholesale energy market value of wind generation in different regions in 2017.[17] The lower value in some regions illustrates the benefit of both intra-regional and inter-regional transmission for consumers and renewable generators. First, inter-regional transmission provides consumers in high-priced regions with access to low-cost electricity and abundant renewable resources in other regions. Second, intra-regional

[16] Available at https://www.spp.org/documents/57928/spp_mmu_asom_2017.pdf, page 134.
[17] Available at https://emp.lbl.gov/wind-technologies-market-report, page 62.

transmission helps alleviate the localized congestion that has reduced the value of wind generation in regions like ERCOT and SPP.

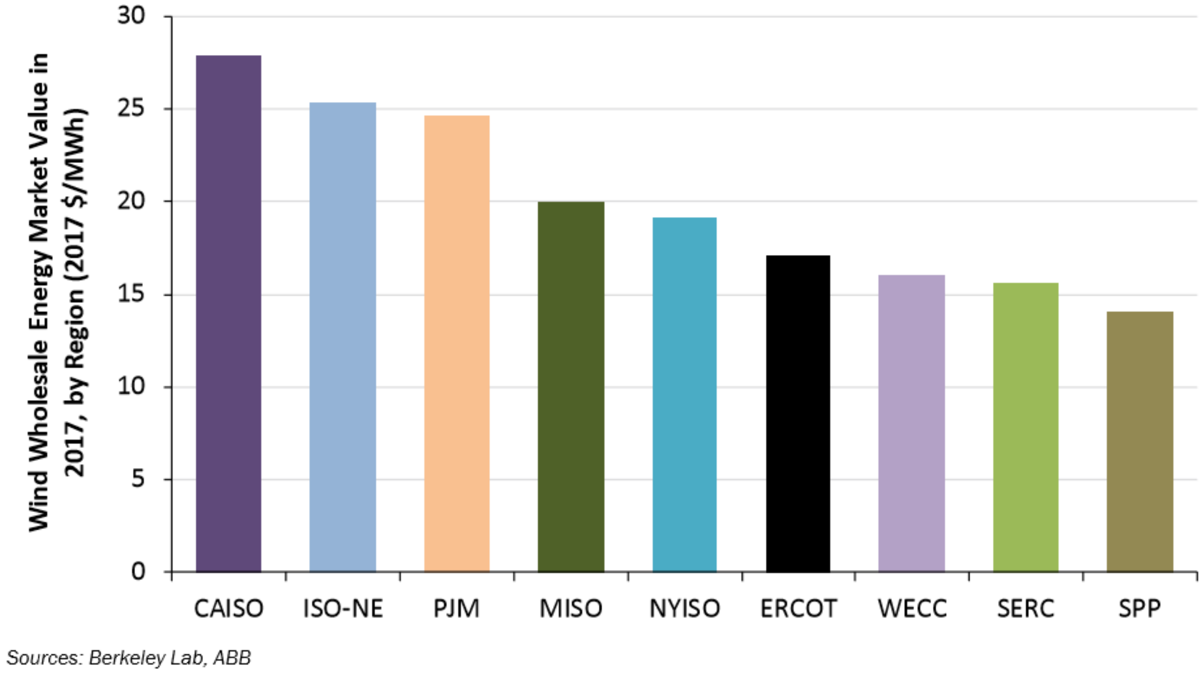

Figure 2: DOE-LBNL chart showing market value realized by wind by region in 2017

Transmission also benefits consumers by reducing the curtailment of renewable generation, providing them with greater access to low-cost wind and solar energy. As MISO and the Texas grid operator (ERCOT) have added transmission, they have seen a large decline in the curtailment of wind generation (blue bars) even though wind continues to be added (green dots), as shown in the following chart from the same report.[18]

[18] *Id.* at page 40

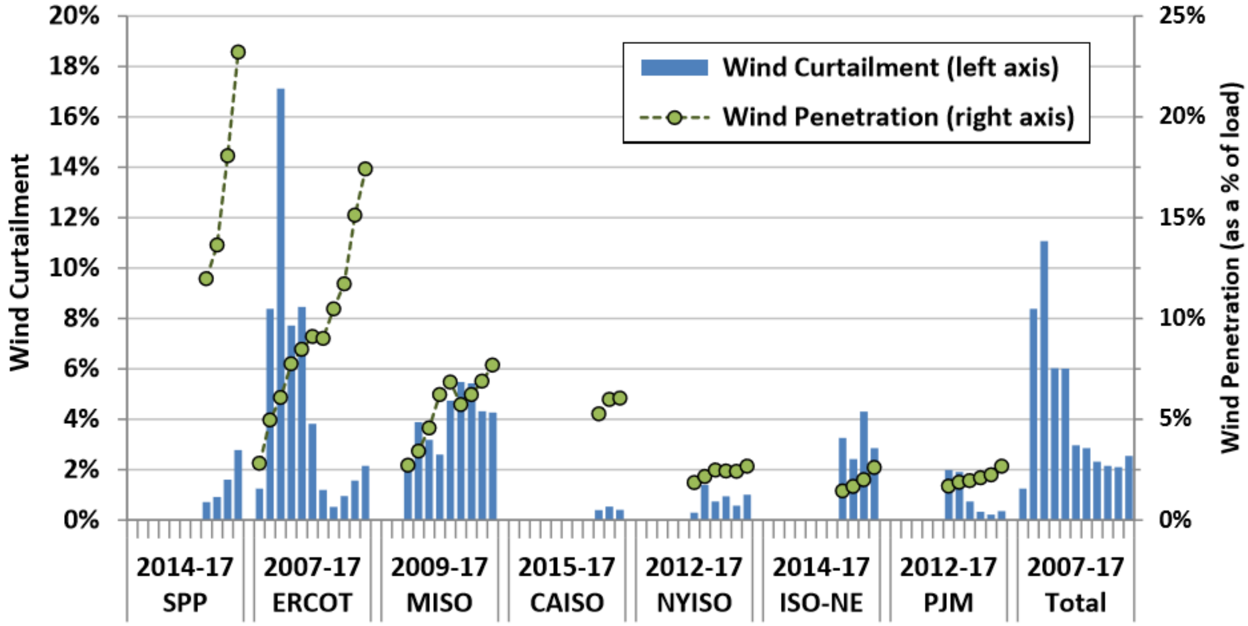

Figure 3: Wind curtailment by grid operator, from DOE-LBNL report

Curtailment data alone understates the impact of congestion on consumers. This is because in electricity markets, all resources and consumers participating in the market receive the market clearing price set by the marginal cost of producing electricity at the most expensive power plant that was needed to meet electricity demand. The cost of the generation lost to curtailment is typically only a fraction of the total cost of congestion because congestion affects the price of all electricity purchased and sold in the wholesale market, not just the generation that is curtailed.

II. The Congestion Study should also account for congestion related to new generation

As new generation additions outpace the addition of transmission capacity, transmission congestion will continue to increase. As a result, DOE's Congestion Study should incorporate data that indicate expected additions of generating capacity, particularly for location-dependent renewable generators.

As of the end of 2017, the DOE-LBNL report identified 180,170 MW of proposed wind capacity and 188,510 MW of proposed solar capacity in the transmission interconnection queues nationwide.[19] For comparison, the report identified 110,870 MW of gas generating capacity in the interconnection queue.

Not all proposed projects that enter the interconnection queue are ultimately built. In many cases, the queue study process finds that transmission congestion prevents the generating project from being connected to the grid. This typically results in large grid upgrade costs being assigned to the generating project, which often causes the project to drop out of the queue and not be built.

[19] *Id.*at page 9.

As a result, the quantity of projects in the interconnection queue is an indicator of the large amount of generation that could be built if transmission congestion were greatly reduced.

Other data sources provide insight into likely near-term generating capacity additions. As of the end of the second quarter of 2018, AWEA was aware of 37,794 MW of wind capacity that was under construction or in advanced development, with specific location information available for these projects.[20] AWEA defines a project as in advanced development if it has not yet started construction, but has either signed a Power Purchase Agreement (PPA), announced a firm turbine order, or been announced to proceed under utility ownership. SEIA projects that U.S. solar PV capacity will more than double over the next five years, from a total of 58,300 MW as of the end of the second quarter of 2018.[21]

AWEA also tracks the additional generating capacity that is needed to comply with state Renewable Portfolio Standards (RPSs). AWEA's latest report found 105 teraWatt-hours of unmet RPS demand through 2025, of which it expects 46.5 teraWatt-hours to be supplied by wind generation, which would require around 15,500 MW of wind capacity. Since that report was issued in September 2017, state RPS policies have been increased, most notably with the passage of SB 100 in California and the expansion of the New Jersey RPS earlier this year. It should also be noted that most renewable capacity being installed today is not being driven by state RPS policies, and the analysis only examines demand through 2025, so these figures do not account for all expected renewable demand.

AWEA's Integrated Resource Plan (IRP) database also tracks regulated utilities' expected renewable capacity additions from the plans submitted to state regulators. That database counts 23,364 MW of planned wind capacity and 35,383 MW of planned solar capacity for the 90 regulated utilities it tracks. Notably, demand from corporate and other non-utility purchasers of renewable energy would be additional to these figures, as would demand from utilities that are not required to submit IRPs. Since 2013, dozens of U.S. corporations have contracted 13.5 GW of wind and solar capacity, with strong growth expected to continue as the economics of renewable generation continue to improve.[22] PJM expects a significant amount of future generation choices to be driven by corporate procurements.[23]

III. <u>Benefits of transmission that should be included in DOE's Congestion Study</u>

Transmission provides many benefits that ultimately translate into economic savings for consumers from reducing congestion. For example, the Southwest Power Pool (SPP) recently evaluated the range of benefits provided by its recent transmission upgrades.[24] SPP found that the transmission upgrades it installed between 2012 and 2014 create nearly $12 billion in net present value benefits for consumers over the next 40 years, or around $800 for each person

[20] Available at https://www.awea.org/resources/publications-and-reports/market-reports/2018-u-s-wind-industry-market-reports/u-s-wind-industry-second-quarter-2018-market-report.
[21] Available at https://www.seia.org/us-solar-market-insight
[22] Available at http://businessrenewables.org/corporate-transactions/.
[23] Available at https://www.utilitydive.com/news/pjm-significant-chunk-of-renewables-to-come-from-corporate-procurement/533411/.
[24] Available at https://www.spp.org/documents/35297/the%20value%20of%20transmission%20report.pdf.

currently served by SPP, or $2,400 per each metered customer. The $16.6 billion in gross savings is higher than SPP's transmission planning models had initially estimated, and 3.5 times greater than the cost of the transmission upgrades.[25] As shown in the following chart from SPP's report, these upgrades are already more than paying for themselves, and the benefits only grow over time while the costs decline.

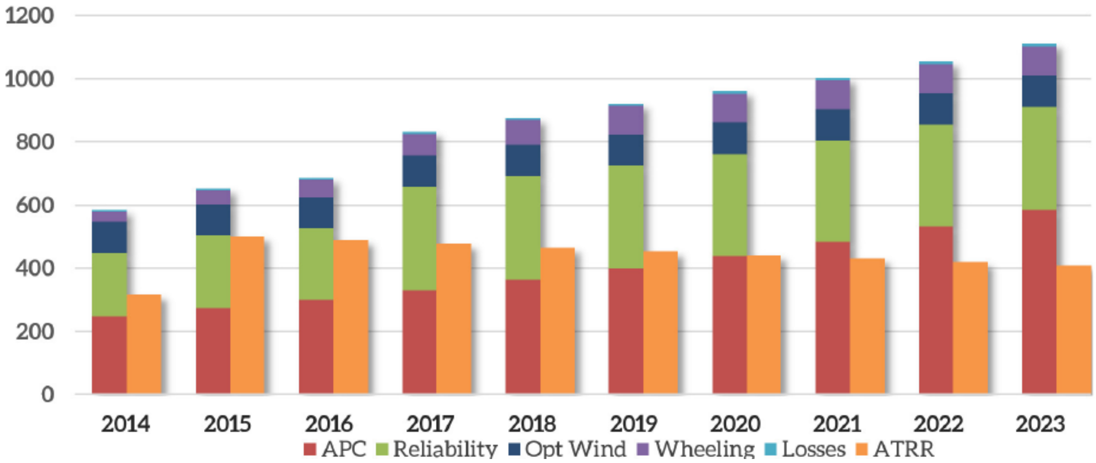

Figure 4: SPP found transmission benefits (left bar) exceed cost (orange bar)

The following table from SPP's report shows the wide range of benefits provided by transmission: transmission reduces the cost of producing electricity, reduces the need for power plants by improving power system efficiency, increases electricity market competition, improves electric reliability, makes the power system more resilient to unexpected events, reduces environmental impacts, and creates jobs and economic development.

Table 2: SPP calculation of benefits of transmission

[25] https://www.spp.org/documents/10047/benefits_of_robust_transmission_grid.pdf

BENEFIT CATEGORY	TRANSMISSION BENEFIT	NPV ($M)
Adjusted Production Cost Savings	Reduced production costs due to lower unit commitment, economic dispatch, and economically efficient transactions with neighboring systems	10,442*
1. Additional Production Cost Savings **	a. Impact of generation outages and A/S unit designations	INCLUDED
	b. Reduced transmission energy losses	INCLUDED
	c. Reduced congestion due to transmission outages	INCLUDED
	d. Mitigation of extreme events and system contingencies	PARTIAL
	e. Mitigation of weather and load uncertainty	PARTIAL
	f. Reduced cost due to imperfect foresight of real-time system conditions	INCLUDED
	g. Reduced cost of cycling power plants	PARTIAL
	h. Reduced amounts and costs of operating reserves and other ancillary services	PARTIAL
	i. Mitigation of reliability-must-run (RMR) conditions	N/Q
	j. More realistic "Day 1" market representation	N/Q
2. Reliability and Resource Adequacy Benefits	a. Avoided/deferred reliability projects	105
	b. Reduced loss of load probability or c. reduced planning reserve margin (2% assumed)	1,354
	d. Mandated reliability projects	2,166
3. Generation Capacity Cost Savings	a. Capacity cost benefits from reduced peak energy losses	171
	b. Deferred generation capacity investments	N/Q
	c. Access to lower-cost generation resources	PARTIAL
4. Market Benefits	a. increased competition	N/Q
	b. Increased market liquidity	N/Q
5. Other Benefits	a. storm hardening	N/Q
	b. fuel diversity	N/Q
	c. flexibility	N/Q
	d. reducing the costs of future transmission needs	N/Q
	e. wheeling revenues	1,133
	f. HVDC operational benefits	N/A
6. Environmental Benefits	a. Reduced emissions of air pollutants	N/Q
	b. Improved utilization of transmission corridors	N/Q
7. Public Policy Benefits	a. Optimal wind development	1,283
8. Employment and Economic Development Benefits	b. Other benefits of meeting public policy goals	N/Q
	Increased employment and economic activity; Increased tax revenues	N/Q
	TOTAL	**16,670 +**

Transmission not only benefits consumers by providing them with access to lower-cost energy, but it also saves them money by improving the efficiency of the power system. Most directly, higher-voltage, higher-capacity transmission lines greatly improve the efficiency with which power is transmitted by reducing losses relative to lower-voltage lines. In the studies discussed above, SPP calculated that its transmission upgrades are saving consumers around $100 million from reduced transmission losses, while MISO estimated line loss savings of $200 million to $1 billion dollars in net present value from its upgrades.

These efficiency savings are most pronounced when transmission lines are congested, which is when transmission is most valuable because power prices are high. This is because line losses significantly increase when power lines are being operated close to their maximum capacity and when lines are hot due to heavy use.

Transmission also keeps electricity prices low for consumers by facilitating competition in electricity markets, as congestion creates opportunities for the exertion of market power. Texas has some of the strongest pro-transmission policies in the country because its elected officials understand that a strong grid is essential to its free market for electricity. As a Board member for the Texas grid operator ERCOT 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."[26]

Like SPP, the Midwest grid operator has also conducted analysis of grid upgrades that are currently underway, and found $12 billion to $53 billion in net benefits over the next 20-40 years, across many different categories of benefits.[27] That translates into savings of between $250 and $1,000 for each person currently served by MISO. The benefits are 2.2 to 3.4 times greater than the cost of the transmission, an increase from the 1.8 to 3.0 benefit-to-cost ratio that was initially expected when the transmission was planned in 2011.[28]

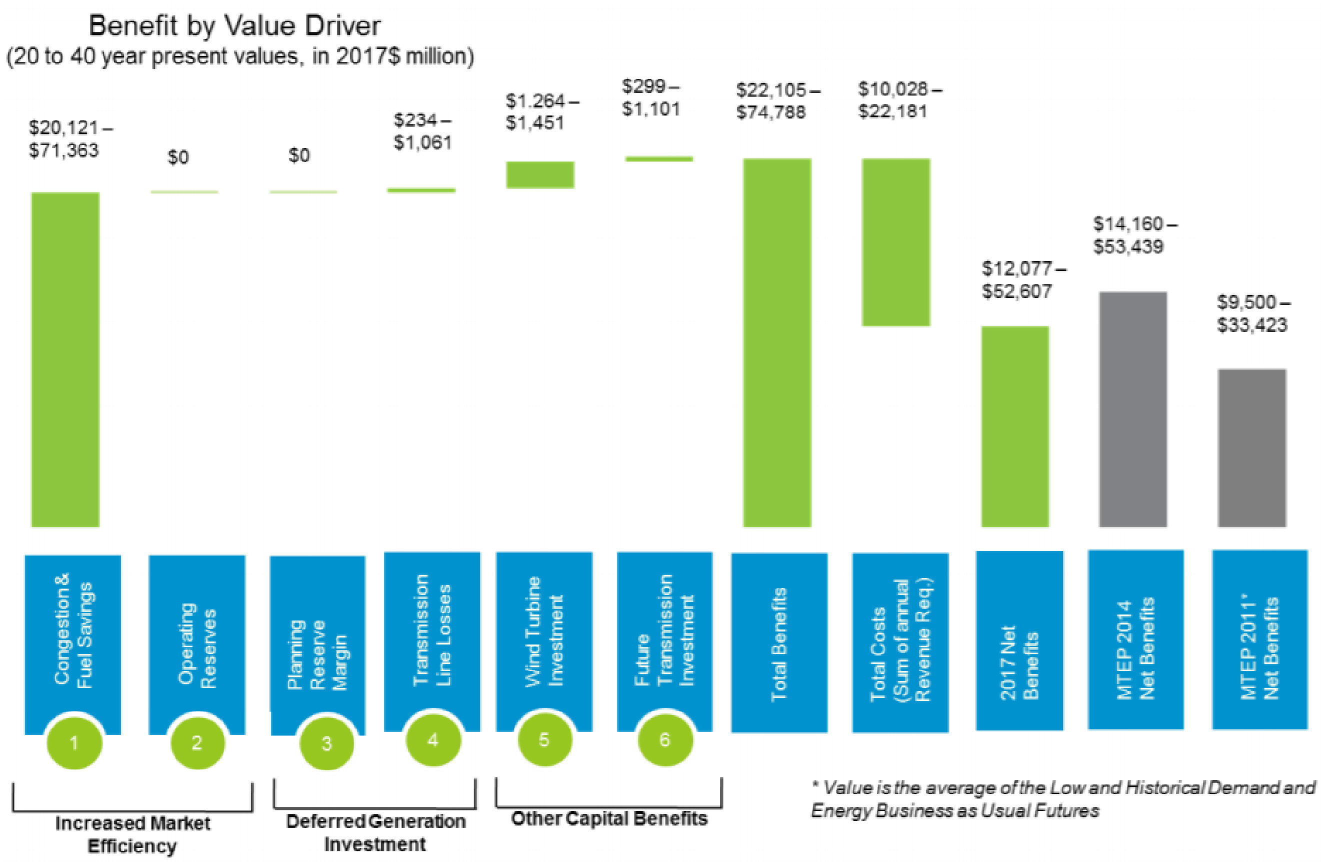

Figure 5: MISO net benefits of transmission, from Triennial MVP Review 2017

These analyses acknowledge that these are conservative estimates that do not include many transmission benefits that are difficult to quantify. SPP's analysis was reviewed by the Brattle

[26] Available at https://www.rtoinsider.com/ercot-board-rio-grande-valley-28040/.
[27] Available at https://cdn.misoenergy.org/MTEP17%20MVP%20Triennial%20Review%20Report117065.pdf.
[28] Available at https://cdn.misoenergy.org/MTEP17%20MVP%20Triennial%20Review%20Report117065.pdf.

Group, which found the analysis "path-breaking" and robust, but also noted the study is likely an understatement of transmission's benefits. SPP's Table 2 above lists many benefits that were not accounted for (N/Q = not quantified) or that could only be partially quantified. Importantly, many valuable benefits, such as greater market competition and liquidity, a more resilient power system, fuel diversity, and system flexibility were not quantified.

SPP found that $6.2 billion of the $16.6 billion in total gross savings came from benefits other than production cost savings, mostly reliability-related economic benefits. In several other studies, utility consultant the Brattle Group has found that transmission provides a similarly wide array of benefits.[29] The following sections highlight other benefits that transmission provides by reducing congestion, which should be accounted for in DOE's Congestion Study.

IV. <u>Reliability and resilience benefits</u>

A major benefit of a less congested grid is that transmission allows the grid to operate equally reliably with fewer power plants, by allowing the sharing of planning and operating reserves among neighboring power systems. Grid operators keep power plant capacity in reserve to ensure there is sufficient power supply to handle fluctuations in electricity supply and demand over the course of a day (operating reserves) and from year-to-year (planning reserves). Transmission enables fluctuations in supply and demand to cancel each other out over larger areas, allowing grid operators to keep a smaller share of plants in reserve. Transmission reduces the need for planning reserves, which saves consumers the cost of building extra power plants; and the need for operating reserves, which allows more efficient dispatch of generators. Transmission congestion prevents the realization of those benefits by limiting the inter-regional flow of power in real-time power system dispatch.

Reduced planning reserve needs are one of the largest benefits of reduced transmission congestion. With adequate transmission, grid operators can use imports and exports from neighboring power systems to help meet peak demand, saving billions in dollars per year by not having to build as many power plants for planning reserves.

SPP found $1.354 billion in net present value benefits, around 8 percent of the total benefits of its transmission upgrades, were due to transmission enabling a 2 percent reduction in the size of its generating fleet by reducing the need for planning reserves. A previous iteration of MISO's transmission upgrade analysis, conducted when load growth was expected to drive a need for new power plant capacity, found net present value savings of $1 billion to $5.1 billion from reduced planning reserve needs, and $33 million to $116 million from reduced operating reserve needs.[30] The aggregation of power plants into the large grid operating areas of MISO and PJM, enabled by existing transmission, respectively saves $2 billion to $2.5 billion and $1.1 billion to $1.4 billion annually on planning reserves, while operating reserve savings are around $100

[29]Available at https://cleanenergygrid.org/uploads/WIRES%20Brattle%20Rpt%20Benefits%20Transmission%20July%202013.pdf page v; http://files.brattle.com/files/6112_recommendations_for_enhancing_ercot%E2%80%99s_long-term_transmission_planning_process.pdf, Appendix B.

[30] Available at https://cdn.misoenergy.org/2011%20MVP%20Portfolio%20Analysis%20Full%20Report117059.pdf, page 57.

million annually.[31] An Xcel Colorado analysis found that 200 MW of transmission ties with neighboring Balancing Authorities enabled a reserve margin reduction from 19.2% to 16.3% while meeting the same reliability standard.[32]

The geographic diversity benefit is particularly large for inter-regional transmission, due to the diversity in weather and climate across large areas. Not all regions experience peak electricity demand at the same time, particularly with many northern regions experiencing peak demand in the winter and many southern regions peaking in the summer due to the use of electricity for heating and cooling. This geographic diversity benefit becomes even more pronounced as wind and solar make up a larger share of our electricity mix.

DOE data illustrate the value of transmission for reducing operating reserve needs.[33] The following map shows how at any point in time, some grid operators are experiencing more electricity demand than was forecast (indicated by darker shades of red), while others are experiencing less demand than expected (darker shades of blue). If sufficient transmission capacity is available, grid operators are able to exchange power with their neighbors to net out those deviations, reducing the need for one operator to ramp up its power plants while another ramps down its power plants. Due to this regional diversity, the total net deviation for the whole U.S. power system is typically about 1/5th as large as the sum of all individual grid operators' deviations from the day-ahead demand forecast. Transmission connections among regions reduce the amount of extra power plant capacity each grid operator must hold as operating reserves to accommodate those deviations.

[31] Available at https://www.misoenergy.org/about/miso-value-proposition/, http://www.pjm.com/about-pjm/value-proposition.aspx.
[32] Xcel (2011), p. 2-9.
[33] Available at https://www.eia.gov/realtime_grid/#/status.

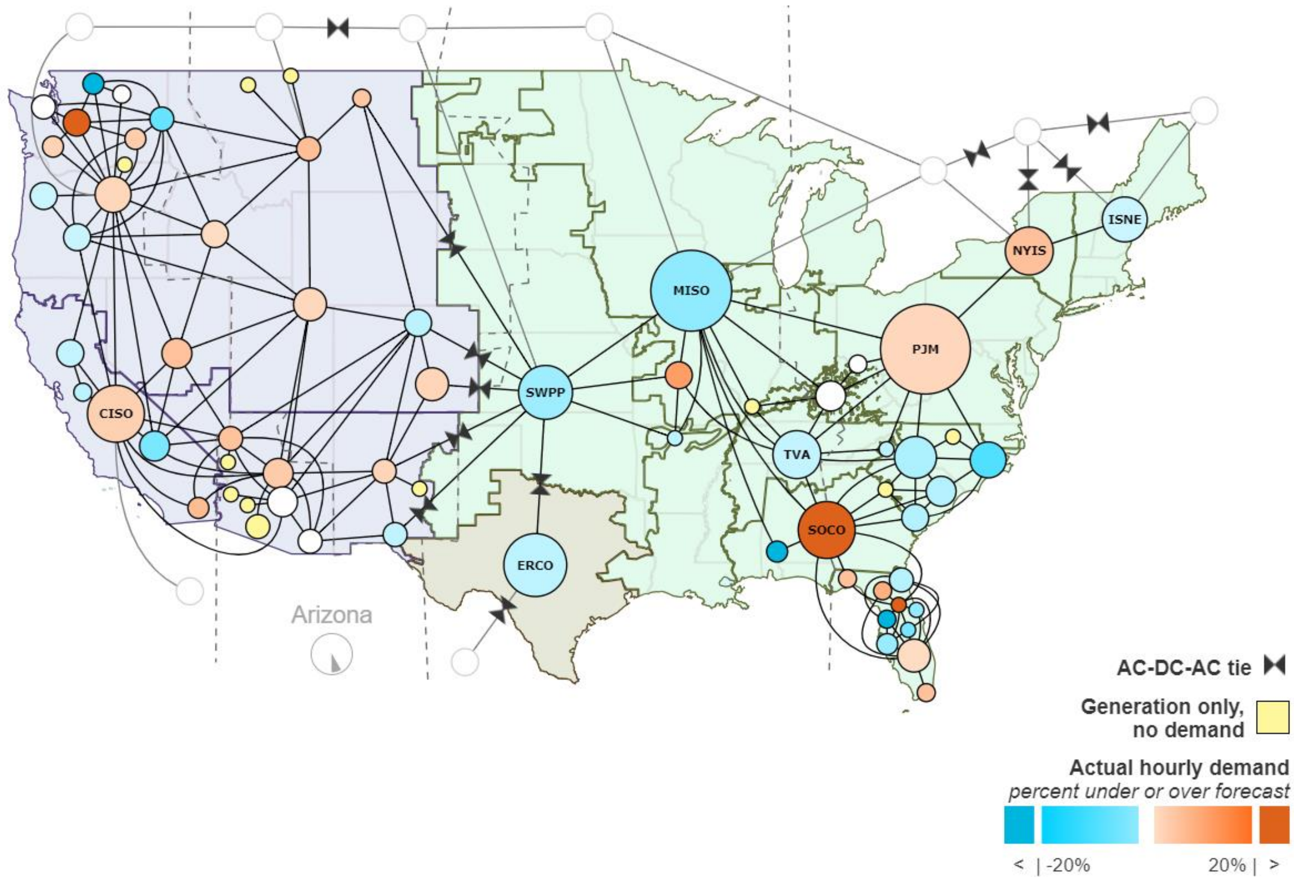

Figure 6: Transmission connections among U.S. grid operators help net out electricity fluctuations

Reducing transmission congestion also provides consumers with reliability and resilience benefits beyond reduced planning reserve and operating reserve needs. Kansas utility Westar has reported that transmission expansion has been associated with a 40% reduction in transmission-related customer outages.[34] Researchers have also modeled theoretical power systems and demonstrated that strengthening the grid by adding "backup" network paths significantly increases the system's resilience to damage and prevents power outages.[35] That study also found power flow control devices are highly effective at preventing outages.

Similar modeling of the U.K. power system has demonstrated that investing in stronger transmission infrastructure as well as additional backup paths for power significantly reduces the risk of a power outages due to windstorms.[36] If anything, that study likely understates the value of additional backup transmission paths because it only looks at wind storm events. With a wind storm there is a very high correlation between the failure of the first circuit and backup circuits because the storm affects a large area. With other events that account for most transmission line outages (equipment failure, human error, wildfire, lightning strike, tower collapse, tree contact,

[34] Available at https://www.spp.org/documents/35297/the%20value%20of%20transmission%20report.pdf, page 15.
[35] Available at http://public.lanl.gov/rbent/pscc_resilience.pdf.
[36] Available at https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7801854.

or tornado) there would be a much lower correlation for the loss of the two circuits, making additional backup paths much more valuable.

By enabling the delivery of electricity from other regions, transmission plays a particularly important role in keeping electricity reliable and affordable when unexpected events such as extreme weather affect part of the system. Because weather and other extreme events tend to be geographically limited in scope, one region is almost never experiencing its extreme supply shortfall at the same as all neighboring regions. As mentioned above, during the Bomb Cyclone event in early January 2018, the low temperature anomaly was far worse in eastern PJM than in western PJM, causing wholesale electricity prices in eastern PJM to be consistently hundreds of dollars per MWh higher than in western PJM. Greater west-to-east transmission capacity in PJM and an ability to import more power from MISO would have saved PJM consumers hundreds of millions of dollars during that event alone. The next extreme event might more strongly affect western PJM, causing greater demand and price spikes and generator unavailability there than in eastern PJM, so over time transmission expansion would tend to greatly benefit all in the footprint.

In a recent application to build a new transmission line in Minnesota, utilities Xcel and ITC explained that "the Project will improve the robustness of the regional backbone transmission system by improving the efficient delivery of energy and enabling the system to better withstand contingencies under multiple future scenarios. A robust transmission system is better positioned to deal with unplanned system outages."[37]

The reliability cost of inadequate transmission can be quite high. The 2003 blackout in the Northeast U.S. and Canada, which largely resulted from a congested transmission system and inadequate transmission maintenance, caused an estimated $7-10 billion in economic losses. A congested transmission system with poor coordination in transmission system planning and operations was also a contributing factor to the 2011 blackout that affected parts of Southern California and Arizona.[38] The costs to consumers and the economy from these transmission-related outages are a significant share of America's total annual spending on transmission, indicating that additional spending to increase transmission system resilience – in addition to transmission's other benefits – would be worthwhile.[39]

The official report to the President regarding the large-scale 1965 Northeast blackout concluded that "Isolated systems are not well adapted to modern needs either for purposes of economy or service" and recommended "… an acceleration of the present trend toward stronger transmission networks within each system and stronger interconnections between systems in order to achieve more reliable service at the lowest possible cost."[40]

[37] Northern States Power Company and ITC Midwest LLC, "APPLICATION TO THE MINNESOTA PUBLIC UTILITIES COMMISSION FOR A CERTIFICATE OF NEED FOR THE HUNTLEY-WILMARTH 345 KV TRANSMISSION LINE PROJECT," January 2018.
[38] Available at https://www.ferc.gov/legal/staff-reports/04-27-2012-ferc-nerc-report.pdf.
[39] Available at http://www.eei.org/issuesandpolicy/transmission/Documents/bar_Transmission_Investment.pdf.
[40] Available at http://www.wiresgroup.com/docs/reports/Transmission_Resilience_WIRES_FINAL_05092018.pdf p. 2.

Another reliability concern is that much of America's transmission infrastructure is now reaching the end of its useful life, including transmission lines, towers, transformers, and other substation equipment. Like most infrastructure, this equipment will likely see a higher failure rate as it nears the end of its life, putting reliability at risk. In part due to its obsolescence, the American Society of Civil Engineers recently gave America's power grid infrastructure a "D+."[41] Grid operators confirm that their transmission infrastructure is reaching the end of its life and must be replaced.[42] Nationally, most of our transmission infrastructure was built between 1960 and 1980; according to one estimate, just replacing that infrastructure alone will cost around $8-14 billion per year over the next 25 years.[43] A similar estimate is that the grid will need $57 billion over the next five years alone.[44]

A more robust grid helps protect against and recover from all types of unexpected events, including deliberate attacks on our infrastructure, while a weak and congested grid makes the system vulnerable to disruption.[45] Transmission expansion helps limit the potential impact of intentional attacks on the power system, whether caused by cyber-attacks, small-scale sabotage, or large-scale physical attacks. Power system cybersecurity experts have explained that infrastructure redundancy and regional diversity, both key benefits of transmission expansion, limit the threat posed by cyberattacks.[46] For any unexpected event that affects either generation or transmission infrastructure, a strong network of inter-regional transmission allows power to instantly be re-routed to the affected region.

Transmission also makes the power system more resilient to disruptions of the natural gas system. A recent analysis of the potential electric sector impact of gas supply disruptions in southern California and Arizona found that "The other sub-regions (PNW, Basin, and Northern California) are more resilient to major gas system disruptions, largely owing to the combination of market area gas storage, presence of alternative energy source (e.g. hydro), transmission connectivity which allows for more electric-side compensation, and convention of contracting for firm fuel supplies for capacity resources."[47]

In the recent grid resilience proceeding at FERC, the Regional Transmission Organizations unanimously and strongly agreed that transmission should be a primary focus of any efforts to increase resilience. In its March 9 comments to the Commission, MISO focused on "Transmission Planning" and "Inter-regional Operations" as two of the three areas the

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http://www.wiresgroup.com/docs/filings/WIRES%20Testimony%20ENR%20Senate%20Committee%20071218.pdf

[41] Available at http://www.infrastructurereportcard.org/cat-item/energy/.

[42] http://www.nyiso.com/public/webdocs/media_room/publications_presentations/Power_Trends/Power_Trends/2016-power-trends-FINAL-070516.pdf, page 2

[43] Available at http://files.brattle.com/system/publications/pdfs/000/005/190/original/investment_trends_and_fundamentals_in_us_transmission_and_electricity_infrastructure.pdf?1437147799, pages 6-7.

[44] Available at http://www.cg-la.com//documents/Maximizing-the-Job-Creation-Impact-of-%241-Trillion-in-Infrastructure-Investment.pdf.

[45] Available at http://thehill.com/opinion/energy-environment/365890-a-vulnerable-power-grid-lets-invest-in-critical-national.

[46] Available at https://fivethirtyeight.com/features/hacking-the-electric-grid-is-damned-hard/amp/.

[47] Available at https://www.wecc.biz/Administrative/WECC%20Gas-Electric%20Study%20Public%20Report.pdf.

Commission should focus for improving resilience (the other being "Information Technology Tools"). As MISO explained, "Continued industry dialogue on more effectively identifying, valuing, and incorporating resilience attributes in transmission planning processes will help the Commission identify further opportunities to support and advance grid resilience."[48]

Similarly, PJM argues that "resilience efforts will require changes to transmission and infrastructure planning," explaining that "the Commission could provide assistance to RTOs by requiring them to plan for and address resilience, and confirm that resilience is a component of regional transmission system planning" and that "Robust long-term planning, including developing and incorporating resilience criteria into the [Regional Transmission Expansion Plan], can also help to protect the transmission system from threats to resilience."[49]

In its comments, NYISO explained that the Commission "must also recognize the critical importance of maintaining and enhancing grid interconnections. 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."[50] It provided a detailed explanation of how "The resiliency value of an interconnected grid has been clearly demonstrated during recent periods of system stress," and explained that "Maintaining and protecting existing interconnections between neighboring regions and continually assessing opportunities to improve interregional transaction coordination can bolster the resiliency of the grid throughout an interconnected region. These interconnections foster the opportunity for the Northeast and Mid-Atlantic markets to rely on a broader, more diverse set of resources to meet the overall needs of the region."

ISO-NE discusses the consumer savings and resilience benefits of its recent transmission investments, noting that "As a result of these investments, the region has a robust transmission system that has the ability to operate reliably under myriad operating conditions."[51] SPP also notes how "This additional transmission has enabled resources of all fuel types to help meet customer demand during a range of potential threats to reliability and resilience," and that "The construction of new transmission facilities pursuant to modern design standards enhance the robustness of the system."[52] CAISO explains that a key function of its transmission planning process is "maintaining reliability through a resilient electric system."[53]

Finally, in their comments, ERCOT and the PUCT explain that "One of the most critical elements of system resilience is ensuring that the transmission system is planned in such a way as to ensure continued operations following an unexpected outage of one or more generators or transmission elements."[54]

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[48] Available at https://elibrary.ferc.gov/IDMWS/common/opennat.asp?fileID=14837872, page 2.
[49] Available at https://elibrary.ferc.gov/IDMWS/common/opennat.asp?fileID=14838232, pages 11, 69, 50.
[50] Available at https://elibrary.ferc.gov/IDMWS/common/opennat.asp?fileID=14838205, pages 10-12.
[51] Available at https://elibrary.ferc.gov/IDMWS/common/opennat.asp?fileID=14837909, page 15.
[52] Available at https://elibrary.ferc.gov/IDMWS/common/opennat.asp?fileID=14838087, pages 3, 5.
[53] Available at https://elibrary.ferc.gov/IDMWS/common/opennat.asp?fileID=14838234, page 148.
[54] Available at https://elibrary.ferc.gov/IDMWS/common/opennat.asp?fileID=14837920, page 7.

In its comments in an earlier resilience proceeding, NERC also explained the central role of transmission for reliability and resilience and the importance of improved transmission planning methods, noting repeatedly that "The right combination and amount of resources and transmission together maintain adequacy of the system."[55]

V. <u>DOE's Congestion Study should incorporate probabilistic methods, or at least account for the optionality/hedging benefits of transmission</u>

As utilities and state regulators confront growing uncertainty due to an increased reliance on volatilely-priced fuels, uncertain policy changes, rapid technology improvements, and large changes in the generation mix, transmission provides valuable flexibility to respond to unexpected changes. A robust network ensures customers can access low-cost power under a wide range of scenarios.

Every year, utilities invest tens of billions of dollars in power plants that will cost an additional tens of billions of dollars to operate over their multi-decade lifetimes. Those irreversible investments are made in face of massive uncertainty about future fuel prices, costs of other generating technologies, policies, electricity demand, and other factors. Transmission provides valuable optionality and hedging against those large sources of uncertainty, any of which can result in billions of additional dollars in annual operating costs if consumers do not have enough transmission to access a diverse portfolio of energy sources. As utilities Xcel and ITC noted in a recent application to build a transmission line in Minnesota, "A robust regional transmission system is also key to enabling access to a diverse mix of generation resources, which in turn allows customers to access the least expensive power available at any given time."[56]

Transmission is an important mechanism to protect consumers against the inherent but unpredictable volatility in the price of fuels used to produce electricity. Transmission can alleviate the negative impact of fuel price fluctuations on consumers by making it possible to buy power from other generators and regions and move it efficiently on the grid. This increased flexibility also helps to modulate swings in fuel price, as it makes demand for fuels more responsive to price as utilities can respond to price signals by decreasing use an expensive fuel and instead importing cheaper power produced from other sources.

Transmission also enables new power plants to be built to take advantage of unexpected shifts in the economics of different energy sources. Over the last decade, transmission has not only allowed customers to benefit from the large cost reductions for wind and solar generation, but also the increased availability of low-cost shale natural gas in many regions where gas resources were not previously available. Because it takes much longer to plan, permit, and build transmission than generation, it is often not possible to wait for economic and policy shifts to occur before investing in the transmission needed to optimally respond to them. The SPP and

[55] Available at https://www.nerc.com/FilingsOrders/us/NERC%20Filings%20to%20FERC%20DL/Comments%20of%20NERC%20re%20Proposed%20Grid%20Reliability%20and%20Resilience%20Pricing.pdf, page 2.

[56] Northern States Power Company and ITC Midwest LLC, "APPLICATION TO THE MINNESOTA PUBLIC UTILITIES COMMISSION FOR A CERTIFICATE OF NEED FOR THE HUNTLEY-WILMARTH 345 KV TRANSMISSION LINE PROJECT," January 2018.

Brattle studies mentioned earlier documented the value of transmission for providing optionality to hedge against uncertainty in future fuel prices, the generation mix, and other factors.[57] Additional analysis has shown the optionality value of transmission to be very large, and found that standard deterministic transmission planning greatly underestimates the value of transmission.

Specifically, DOE-funded analysis by Dr. Ben Hobbs at Johns Hopkins University and his graduate student Francisco Espinoza shows that current transmission planning methods, which at best use several deterministic scenarios to highlight ranges of future outcomes for the power system, are "a weak tool for decisions under uncertainty" and "don't account for flexibility."[58] Probabilistic methods that quantitatively account for uncertainty in the transmission planning process result in a larger and more optimal transmission build, saving consumers tens of billions of dollars relative to deterministic methods that fail to account for the value of transmission in providing flexibility. Moreover, the probabilistic method saved hundreds of billions of dollars relative to some deterministic planning methods that greatly underbuilt transmission.[59] Recent analysis found that the consumer savings from use of such probabilistic (stochastic) tools in the Western U.S. "can be as much as or even exceed the cost of the recommended transmission facilities themselves. Furthermore, we provide evidence that the transmission recommendations of stochastic programming models are more robust to scenarios that haven't been considered than recommendations by deterministic models. That is, stochastic plans appear to make the network more adaptable in the face of all uncertainties, not just those that were included as specific scenarios."[60]

Unfortunately, most grid planners do not currently account for this value of transmission, aside from limited analysis of a few potential scenarios. MISO does account for some uncertainty, noting that it "uses its value-based planning approach to proactively identify infrastructure that is valuable under a number of long-term future scenarios."[61]

Given that transmission infrastructure typically remains in service for 40 years or more, it is likely to provide many benefits that cannot be anticipated when it is built. Even though they were planned only 10 years ago, the Texas grid operator ERCOT has documented how the Competitive Renewable Energy Zone (CREZ) transmission upgrades have already had the unexpected benefit of addressing reliability concerns caused by the potential retirement of fossil generators.[62] Former Public Utilities Commission of Texas Chair Barry Smitherman has

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[57] Available at http://wiresgroup.com/docs/reports/WIRES%20Brattle%20Report_TransmissionPlanning_June2016.pdf.

[58] Available at https://www.sciencedirect.com/science/article/pii/S1040619015001025, http://energy.gov/sites/prod/files/2013/09/f2/1-2013RMReview-Hobbs.pdf.

[59] Available at http://hobbsgroup.johnshopkins.edu/docs/FD_Munoz_Dissertation.pdf, page 102.

[60] Available at https://www.wecc.biz/Reliability/Planning-for-Uncertainty-Final-Report.pdf

[61] Available at https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=14837832, pages 15-16.

[62] Available at http://www.ercot.com/content/news/presentations/2013/2012%20Long%20Term%20System%20Assessment.pdf, pages 33-35.

explained how those grid upgrades also addressed unexpected reliability concerns caused by a surge in electricity demand from oil and gas activities in West Texas.[63]

The economist Larry Summers has explained that, as a general matter, "improved infrastructure has benefits that go well beyond what is picked up in standard rate of return on investment calculations," including "spurring investment and promoting agglomeration by increasing the range over which the best companies can expand and compete." Networks like the power grid function in non-linear ways including economies of scale, with initial investments reducing the cost and increasing the benefits of subsequent investments, so investments yield positive externalities that are difficult to quantify.

To the extent possible, DOE should incorporate probabilistic methods into its Congestion Study, or at least report on the findings of DOE-funded and other analysis on the topic.

VI. Other analysis of reduced congestion from grid upgrades

Over the last decade, grid operators, DOE national laboratory experts, and other researchers have released dozens of conceptual transmission plans that provide large net benefits by reducing congestion. DOE should include these findings in the Congestion Study.

A large consortium of grid operators, DOE national laboratories, and other researchers are currently developing an optimized national transmission expansion through the ongoing Interconnection Seams Study.[64] The study examines a range of possible transmission upgrades:

-Modest grid upgrades and a slight increase in transfer capacity between the two primary power systems in the U.S., the Eastern and Western Interconnects (Scenario Design 2a)

-The addition of high-capacity DC lines and supporting AC infrastructure to more strongly connect the East and West (Scenario D2b)

-The addition of a nationwide high-voltage DC transmission network (Scenario D3)

As indicated in the following table from a presentation of the study's results, these transmission investments yield benefits that are many times larger than their cost. The blue cells show the cost of each transmission addition, while the orange cells tally the benefits of that transmission. The bottom yellow cell calculates the benefit-to-cost ratio for each design, which range from $2.50to $3.30 per $1 invested over a 15-year period, depending on the design.

In addition, the study found ongoing annual savings of $1.4 to $4.2 billion beyond that 15-year period; many transmission investments are expected to have a lifetime of 40 or more years. Even without accounting for the cost of carbon emissions, the transmission investments were found to have a positive benefit-to-cost ratio.

Table 3: Benefit-to-cost results of Interconnections Seam Study

[63] Texas Energy Report (subscription) article referenced here https://www.sierraclub.org/texas/blog/2014/10/comptroller-s-anti-renewables-report-gets-swift-rebuke.

[64] Available at https://www.nrel.gov/analysis/seams.html; results from "Interconnections Seam Study," presented at Iowa State Transgrid-X Symposium, July 2018, https://iastate.box.com/s/vfgn9nikl1rz7r8x0vaoauzpm2210t35.

ECONOMICS, NPV $B	Design 1	Design 2a	Delta	Design 2b	Delta	Design 3	Delta
Line Investment Cost	61.21	73.89	12.68	74.88	13.67	80.1	18.89
Generation Investment Cost	704.03	703.32	-0.71	696.99	-7.04	700.51	-3.52
Fuel Cost	753.8	738.98	-14.82	737.3	-16.5	736.12	-17.68
Fixed O&M Cost	455.6	450.2	-5.4	448.95	-6.65	450.23	-5.37
Variable O&M Cost	64.5	63.9	-0.6	64.27	-0.23	64.39	-0.11
Carbon Cost	171.1	164.2	-6.9	162.6	-8.5	162.5	-8.6
Regulation-Up Cost	33.29	31.63	-1.66	29.96	-3.33	26.63	-6.66
Regulation-Down Cost	4.76	4.52	-0.24	4.29	-0.47	3.81	-0.95
Contingency Cost	24.41	23.19	-1.22	21.97	-2.44	19.52	-4.89
Total Non-Xm Cost (Orange)	2,211.49	2,179.94	-31.55	2,166.33	-45.16	2,163.71	-47.78
15-yr B/C Ratio (Orange/Blue)	-	-	2.48	-	3.30	-	2.52

CAPACITY, GW	Design 1	Design 2a	Delta	Design 2b	Delta	Design 3	Delta
Total gen invested (W/S/G)	600 (386/177/37)	600 (392/172/36)	0 (-6/5/1)	600 (393/172/35)	0 (7/-5/-2)	600 (392/169/38)	0 (7/-6/1)
Total gen retired	240	285	45	287	47	294	54
Total 2024 creditable capacity	838.5	809.5	-29.0	792.0	-46.5	794.1	-44.4
Total AC Xm invested	228.9	251.3	22.4	234.8	-5.9	195.1	-33.8
Total DC Xm invested	0	25.6	25.6	35.9	35.9	125.8	125.8

Another study published in the journal *Nature Climate Change* examines the benefits of building an even larger nationwide transmission network that could save consumers as much as $47 billion annually, a roughly 10 percent reduction in electric bills.[65] As shown below, the network taps into the best renewable resources (green represents wind deployment, red shows solar deployment) to produce around 60 percent of America's electricity from renewable resources (the outer circle in the lower right shows generation by energy source, the inner circle shows power plant capacity by energy source). The network would cut carbon dioxide emissions by 80 percent while saving consumers money.

[65] Available at http://www.nature.com/nclimate/journal/vaop/ncurrent/full/nclimate2921.html; https://www.utilitydive.com/news/study-deep-decarbonization-of-us-grid-possible-without-energy-storage/412721/.

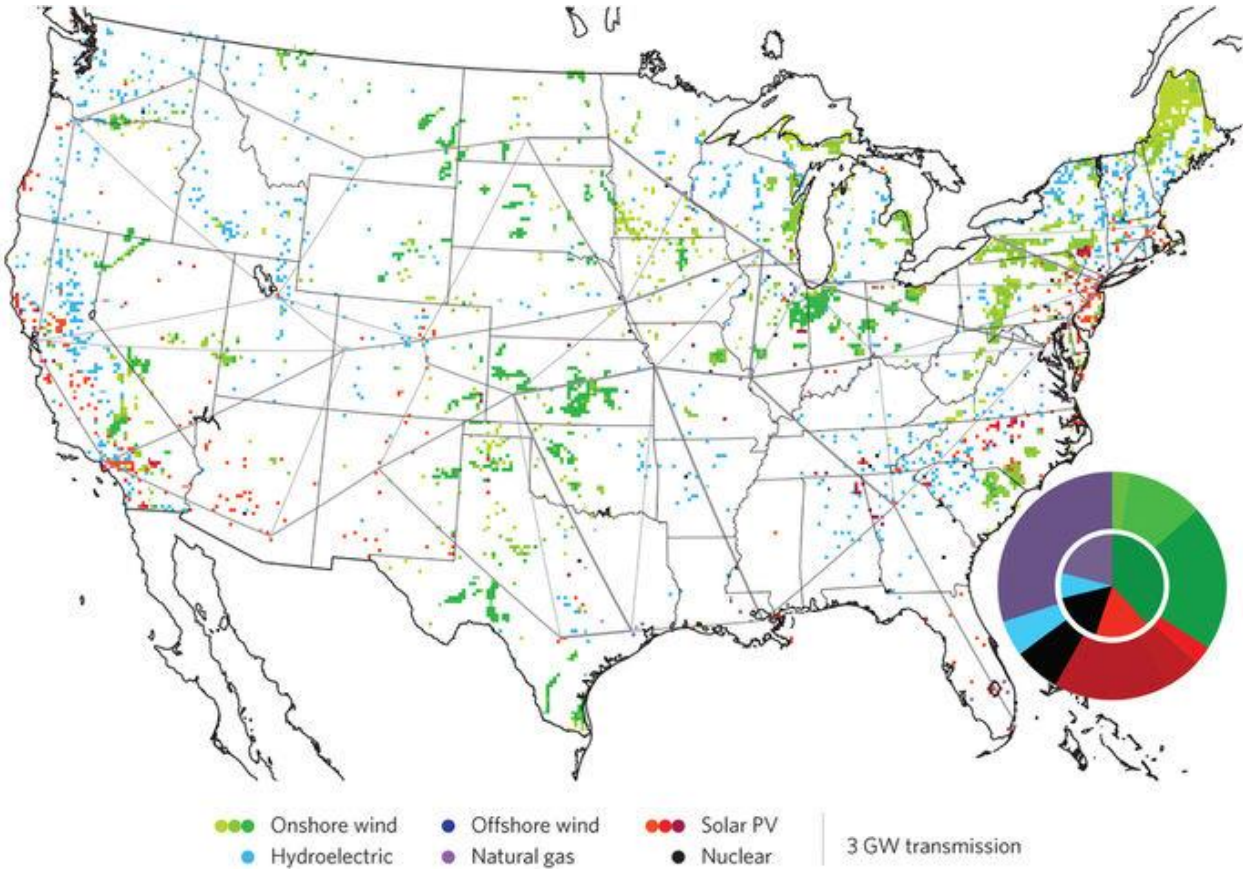

Figure 7: Transmission network and generating resource map, *Nature Climate Change* study

Earlier this decade, DOE also funded Interconnection-wide transmission planning in each of the three U.S. Interconnections. The Eastern Interconnection Planning Collaborative developed transmission plans for several scenarios, including a plan to utilize the best renewable resources in the Eastern U.S., as well as a smaller transmission investment to utilize more local renewable resources.[66]

EIPC found a large transmission investment to access the best renewable resources in the nation produced significant consumer savings relative to the smaller investment to utilize local resources. Specifically, a $206 billion larger upfront investment yielded additional savings of over $41 billion per year, indicating that the investment would pay for itself in 5 years.[67] The magnitude of these savings, tens of billions of dollars annually for the Eastern U.S. alone, confirms the critical importance of including large-scale transmission in our energy future.

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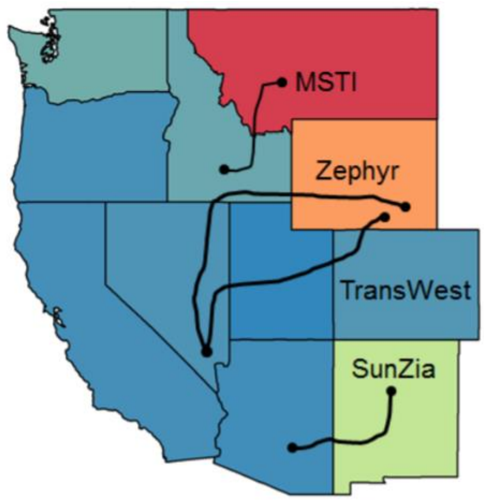
[66] Available at http://nebula.wsimg.com/c4e982819ff6b85ceffa0f6c124760f6?AccessKeyId=E28DFA42F06A3AC21303&disposition=0&alloworigin=1, page 10.

[67] Available at http://www.synapse-energy.com/sites/default/files/SynapseReport.2013-07.Sust-FERC.EIPC-Expanded-Analysis.13-047-Report.pdf, page 9.

Analysis DOE conducted several years ago of the Clean Power Plan also illustrates the value of transmission for enabling cost savings. The scenario with national trading enabled more efficient use of all energy sources, including both emitting and non-emitting resources, achieving $1-2/MWh lower electricity costs relative a scenario in which each state was forced to rely on its own resources.[68]

Other studies have looked at regional transmission investments. Last year, the National Renewable Energy Laboratory (NREL) released detailed analysis of several proposed transmission lines in the Western U.S., shown below. It found that these lines would cost $10 billion but save $2.3 billion per year,[69] which indicates the lines themselves would have a payback period of around 4 years.



Name	Rating (MW)	Dist (Mi)
MSTI	1500	460
Zephyr	3000	950
TransWest Express	3000	730
SunZia	3000	515

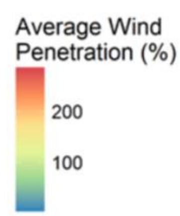


Figure 8: Proposed transmission additions in Western U.S. studied by NREL

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%.[70] 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."[71] 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.[72] The Great Plains

[68] Available at https://www.eia.gov/analysis/requests/powerplants/cleanplan/pdf/powerplant.pdf; for analysis of EIA's results, see page 10 at http://awea.files.cms-plus.com/AWEA%20report%20on%20EIA%20CPP%20analysis%20July%202015.pdf.
[69] Available at https://www.nrel.gov/docs/fy17osti/67240.pdf.
[70] Available at http://www.vibrantcleanenergy.com/wp-content/uploads/2016/05/VCE_MISO_Study_Report_04252016.pdf, page 23.
[71] Available at http://www.vibrantcleanenergy.com/wp-content/uploads/2018/07/MNSmarterGrid-VCE-FinalVersion-LR.pdf, page 4.
[72] *Id.* at 18.

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."[73]

In another regional study, Charles River Associates, International examined the potential for a high-voltage transmission overlay in SPP.[74] It concluded that the 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. Of these benefits, $900 million 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. The remainder would stem from reduced congestion on the grid allowing customers to obtain access to cheaper power.

Synapse Energy Economics also analyzed the net benefits of a large transmission upgrade in the MISO footprint. This analysis found significant net savings for consumers from this transmission expansion, between $3 billion and $9.4 billion in net savings per year, or $63-200 in annual benefits per household in the region.[75]

ERCOT, the Texas grid operator, has also evaluated the transmission expansions that would be needed under a range of future scenarios, including in a DOE-funded Interconnection-wide study.[76] Notably, it found that many transmission lines were needed across almost all scenarios, a finding confirmed by more recent ERCOT analysis.[77]

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[73] Available at http://roadmap.betterenergy.org/wp-content/uploads/2018/08/GPI_Roadmap_Web.pdf, page 28.
[74] CRA International, "First Two Loops of SPP EHV Overlay Transmission Expansion: Analysis of Benefits and Costs," available at http://www.spp.org/documents/8272/analysis_of_benefits_two_loop_sppfinal.pdf.
[75] Available at http://www.synapse-energy.com/sites/default/files/SynapseReport.2012-08.EFC_.MISO-T-and-Wind.11-086.pdf.
[76] Available at http://www.ercot.com/content/committees/other/lts/keydocs/2013/DOE_LONG_TERM_STUDY_-_Draft_V_1_0.pdf.
[77] Available at http://www.ercot.com/content/wcm/lists/89476/2016_Long_Term_System_Assessment_for_the_ERCOT_Region.pdf.