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CAPACITY FOR CHANGE: THE ROLE OF TRANSMISSION INFRASTRUCTURE IN ENERGY TRANSITION

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I. INTRODUCTION

The nature of electricity in the U.S. has undergone significant change. A growing renewable energy industry has created competition for traditional fossil fuel generating resources in the marketplace. American consumers—both residential and commercial—have also voiced demand for cleaner electricity, leading utilities to pursue greater investment in renewables. Meanwhile, considerations for the retirement or conversion of aging generation with significant carbon emissions has grown, in particular coal-fired power plants.

One key factor in the prosperity of renewables has been improved access to electricity produced by these systems. For more than a decade, regional transmission planners have labored to address shortfalls in the electric transmission system, and to create a network that can connect additional generation to the grid. These efforts have provided several other benefits as well, including improving reliability across the transmission network and reducing potential bottlenecks on the system.

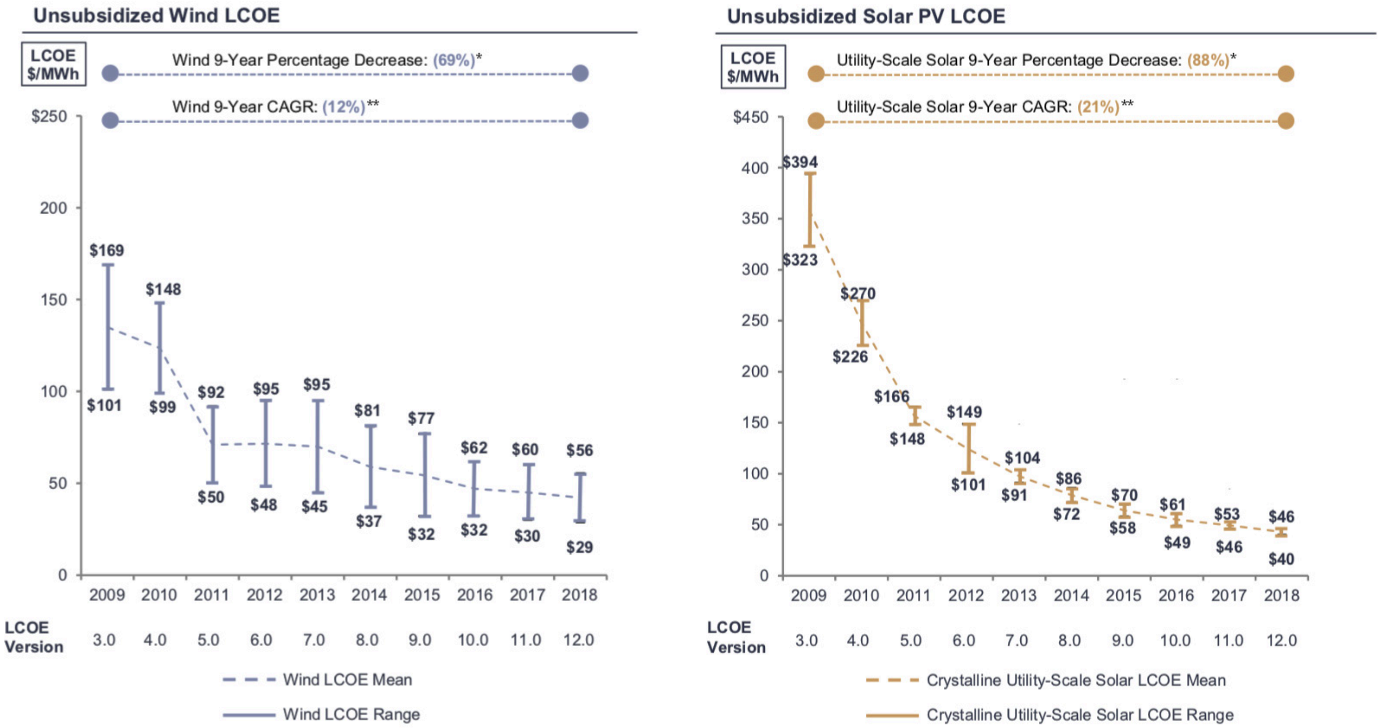
While transmission improvements have allowed for additional development of renewable energy resources, much of the new grid capacity has already been occupied. Given the accelerating demand for clean energy and the shrinking capacity from traditional fossil fuel resources like coal, subsequent upgrades are likely necessary for the electric grid to adapt to the changing landscape.

II. SHIFT IN GENERATION

The electric transmission system was not built to take advantage of wind and solar energy resources. This is especially true in the Midwest and Great Plains—regions with significant wind and solar energy potential but with few and fairly dispersed population centers. Instead, the system was built to link individual generating units—historically coal-fired power plants—to distant cities and the highest demand for electricity. However, these generators are no longer the only competitor in the market, and the diversification of electric generation has prompted planners to take action to transform the grid.

A decline of coal-fired generation signaled the need to revamp regional electric grids to keep pace with the changing electric industry. Coal capacity peaked in the U.S. in 2011, and has since seen significant decline through retirements or reduced capacity factors. Between 2011 and 2018, 23.5 percent of capacity has been retired across the country, taking a total of 75 gigawatts (GW) of coal generation offline. Capacity factors have also fallen, with the average dropping below 70 percent in 2009 and finally stabilizing around 54 percent. Both of these

FIGURE 1: LEVELIZED COST OF ENERGY COMPARISON (LCOE)—HISTORICAL ALTERNATIVE ENERGY LCOE DECLINES



* Represents the average percentage decrease of the high end and low end of the LCOE range.
** Represents the average compounded annual rate of decline of the high end and low end of the LCOE range.

trends signal a larger transformation in the electric power sector.[1]

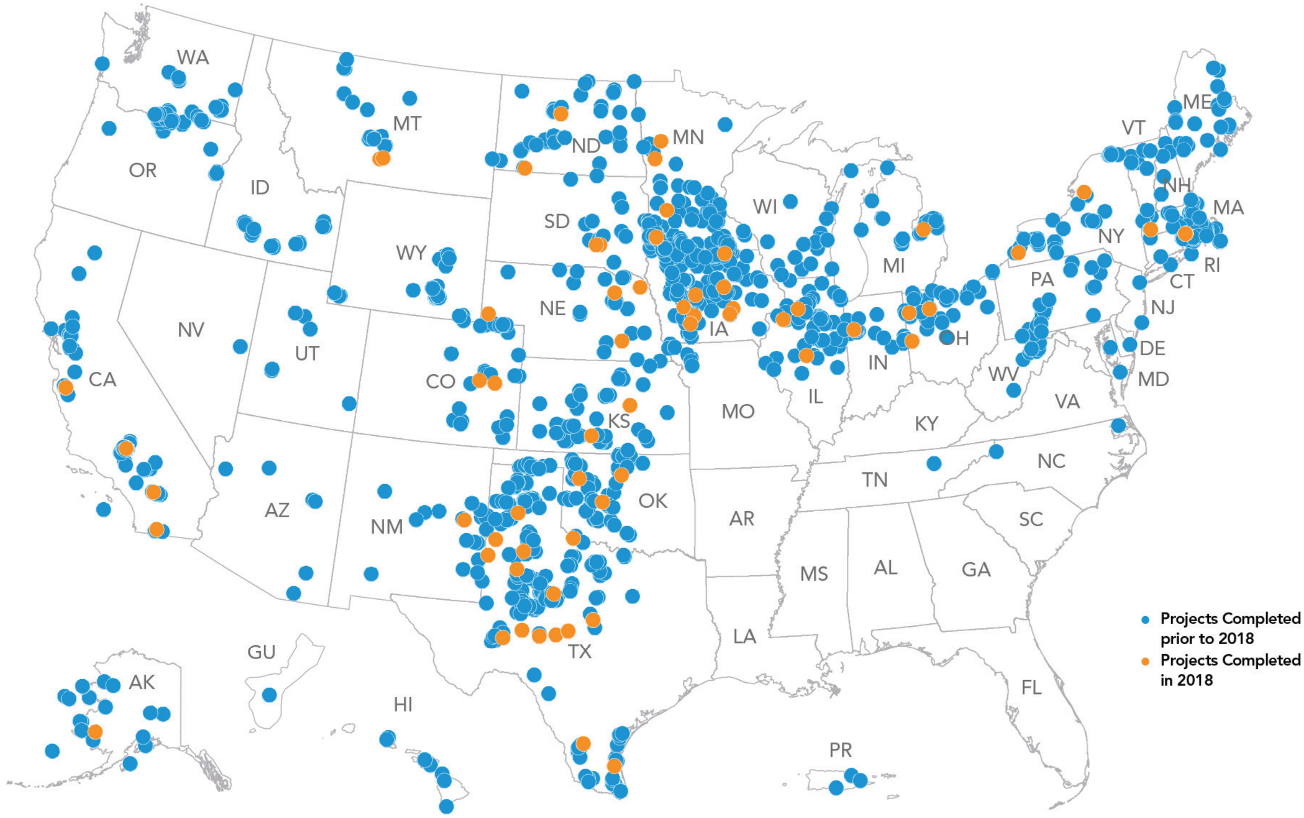
Several factors contributed to the increase in coal plant retirements and reduced capacity factors. For instance, much of the coal fleet in the U.S. is fairly old, and many coal plant retirements likely made financial sense given the operational lifespan of facilities. Compounding this economic issue are requirements to upgrade these plants to comply with emissions standards while cheaper forms of electricity become available, posing a difficult choice for utilities to either make investments to upgrade facilities or retire plants that have become uneconomical. This problem is not isolated to a select few facilities. In 2018, nearby wind and solar were cheaper generating resources when compared to 211 GW of existing coal-fired capacity, or about 74 percent of the entire coal fleet in the U.S. Wind and solar were also projected to put 94 GW of that total in substantial risk by providing energy for prices at least 25 percent lower than competing coal-fired generation.[2]

Advances in technology have assisted in bringing cheaper electric generating sources into the market, creating real competition for traditional coal-fired facilities. One example is the use of hydraulic fracturing, or fracking, which increased access to natural gas and allowed for the influx of cheap gas into electricity markets. The availability of low-cost natural gas made it viable to replace coal as the primary dispatchable generation for utilities, and provided an oppor-

1 Wamsted, Dennis, et al. "Coal Outlook 2019: Domestic Market Decline Continues." Institute for Energy Economics and Financial Analysis, March 2019, ieefa.org/wp-content/uploads/2019/03/Coal-Outlook-2019_March-2019.pdf. Accessed June 2019.

2 Gimon, Eric, et al. "The Coal Cost Crossover: Economic Viability of Existing Coal Compared to New Local Wind and Solar Resources." Vibrant Clean Energy, Energy Innovation Policy & Technology LLC, March 2019, energyinnovation.org/wp-content/uploads/2019/04/Coal-Cost-Crossover_Energy-Innovation_VCE_FINAL2.pdf. Accessed June 2019.

FIGURE 2: MAP OF U.S. WIND POWER PROJECTS



tunity to convert existing plants to natural gas. Forecasting from the U.S. Department of Energy's Energy Information Administration projects most electric generation retirements will occur by 2025, due to the relatively low prices of natural gas and additional capacity from inexpensive renewable resources.[3]

While greater access to natural gas has made it a lower-cost fuel option when compared to coal, renewables have already outpaced gas in terms of pricing. The levelized cost of energy of wind and solar dropped 69 percent and 88 percent respectively from 2009 to 2018, due in large part to improved efficiency and declining costs of technology. See Figure 1 on page 2. These declining costs have given rise to a greater abundance of renewables, as new capacity is developed across the country, particularly in rural areas.[4]

III. RENEWABLES EXPANDING MARKET SHARE

Leading the way in the expansion of renewables, wind energy has seen continued growth in capacity across the nation, with significant development in the Midwest and Great Plains. See Figure 2. According to the American Wind Energy Association's Annual Market Report for 2018, there were a total of 35,135 megawatts (MW) of wind capacity in development in 31 states at the end of the year, or an expected 36 percent increase in capacity from the 96,433 MW already in operation.

3 "Annual Energy Outlook 2019 with projects to 2050." U.S. Energy Information Administration, U.S. Department of Energy, Jan. 24, 2019, eia.gov/outlooks/aeo/pdf/aeo2019.pdf. Accessed June 2019.

4 "Lazard's Levelized Cost of Energy Analysis—Version 12.0." Lazard, November 2018. lazard.com/media/450784/lazards-levelized-cost-of-energy-version-120-vfinal.pdf. Accessed June 2019.

FIGURE 3: CITIES WITH 100 PERCENT CLEAN ELECTRICITY COMMITMENTS

Powered by 100 percent renewable energy. These communities have currently achieved their 100 percent clean, renewable electricity targets.

Committed to 100 percent renewable energy. These communities have made community-wide commitments to transition to 100 percent clean, renewable electricity by no later than 2050.

In addition to the low-cost electricity provided by this development, increased wind capacity has brought other benefits to the U.S., particularly for the rural communities that frequently host projects.[5]

In 2018, the wind industry paid $289 million in land lease payments, generating supplementary income for landowners across the nation. State and local governments have found new revenue streams in the form of tax payments from projects each year, totaling $761 million in 2018. Wind energy also provided employment opportunities in the U.S., with the industry supporting 114,000 jobs across a variety of fields including project operation, planning, manufacturing, construction, and others.[6]

Market trends have shown that solar is well-positioned for a surge in development at the small- and utility-scale. Residential photovoltaic (PV) solar installations were up 7 percent from 2017 to 2018 with a total 2.4 GW capacity installed. In contrast, utility-scale capacity experienced a slight drop of 3 percent in 2018 with 6.2 GW installed over the year. Although development was down from the previous year, utility PV hit 25.3 GW for contracted projects, an all-time record in the U.S.[7] See Figure 3.

Alongside technological improvements and cost declines, a major driver of renewable growth in the U.S. has come at the demand of customers and policymakers. Clean power commitments have increased at the county and city level, with a total of 11 counties and 104 cities pledging to 100 percent clean energy goals at the end of 2018. Approximately 50 million people live in places with these goals, making up about 15

5 "U.S. Wind Industry Annual Market Report." American Wind Energy Association, 2019.

6 Ibid.

7 Perea, Austin, et al. "U.S. Solar Market Insight." Solar Energy Industries Association and Wood Mackenzie Power & Renewables, 2019, woodmac.com/research/products/power-and-renewables/us-solar-market-insight/. Accessed June 2019.

percent of the nation's population.[8] Legislation in support of clean energy goals has also been proposed in several states, in the form of 100 percent carbon-free or renewable standards—currently, 29 states and the District of Columbia have renewable portfolio standards and eight states have renewable portfolio goals.[9]

As more renewable energy is developed across the country, regulators and policymakers must prepare for the changing electric power landscape. Because many of these projects are located in rural areas with historically low demand, one particular challenge to the continued deployment of renewable generation is access to reliable transmission infrastructure. Confronting this challenge will require significant investments to update and expand the existing electric transmission network.

IV. TRANSMISSION'S ROLE IN THE ENERGY TRANSITION

Meeting the public policy goals set by policymakers and meeting the demands of consumers will require ready access to geographically-dispersed renewable generation. New and upgraded transmission will create avenues for a greater diversity of resources, allowing for the transportation of electricity from wind and solar dispersed across a broad geographic region.

Increased capacity would allow for state and local governments to make use of existing electric power markets to achieve clean energy standards—taking advantage of the efficiency that markets provide in terms of reliability and competitive pricing. While localities may wish to achieve clean energy goals through the use of nearby renewable resources, there are few cases in which relying solely on local distributed generation would allow for expedient attainment of clean energy goals. Instead, a combination of local distributed generation and dependable access to market resources affords utilities and policymakers greater latitude in achieving policy goals.

Additional transmission capacity can also stand in for storage, limiting curtailment of renewable resources by allowing for the offtake of surplus renewable energy and access to low-cost electricity for consumers. Curtailment is the reduction in generation output, which often affects renewable energy due to the variability of these resources across a region and constraints such as limited transmission capacity. Decreasing curtailment would infuse the grid and electric markets with more low-cost renewable energy while improving revenue for generators—a key concern in the initial planning of projects.[10]

New transmission investments could take a variety of forms to achieve these ends, with several potential methods available to connect renewable capacity while also improving the efficiency and resiliency of the electric grid. One method would be the deployment of high-voltage direct current transmission that would directly link large population centers to locations with high renewable capacity. Several examples of proposed high-voltage direct current lines in the U.S. are intended to carry wind power from the Midwest and Plains—regions with capacity factors that range from 40 to 50 percent—to eastern power markets. One drawback is there are rarely ties to transmission networks that run parallel to these lines, meaning any offtake from these lines typically occurs at the end point.[11]

Another model would be incremental improvements to regional electric transmission systems, investments that would be made by re-

8 Feldman, David, et al. "Q3/Q4 2018 Solar Industry Update." National Renewable Energy Laboratory, U.S. Department of Energy, January 2019, nrel.gov/docs/fy19osti/73234.pdf. Accessed June 2019.

9 "Renewable Portfolio Standard Policies." DSIRE, NC Clean Energy Technology Center, U.S. Department of Energy, Energy Efficiency & Renewable Energy, October 2018, ncsolarcen-prod.s3.amazonaws.com/wp-content/uploads/2018/10/Renewable-Portfolio-Standards-2018.pdf. Accessed June 2019.

10 Denholm, Paul, et al. "On the Path to SunShot: Emerging Issues and Challenges in Integrating High Levels of Solar into the Electrical Generation and Transmission System." National Renewable Energy Laboratory, U.S. Department of Energy, May 2016, nrel.gov/docs/fy16osti/65800.pdf. Accessed June 2019.

11 Hurlbut, David, et al. "Transmission Challenges and Best Practices for Cost-Effective Renewable Energy Delivery across State and Provincial Boundaries." National Renewable Energy Laboratory, U.S. Department of Energy, March 2017, nrel.gov/docs/fy17osti/67462.pdf. Accessed June 2019.

gional transmission organizations. The Federal Energy Regulatory Commission encouraged the formation of these organizations to manage regional transmission grids, ensuring reliability and economic efficiency through regional electric markets. These organizations have also been tasked with planning for the future needs of the transmission network, determining the best investment to achieve the goals set by Federal Energy Regulatory Commission—including meeting the public policy goals of states within the region.[12]

An additional consideration is bridging the gap between the different electric grids in the U.S., such as the Eastern Interconnection, Western Interconnection, and the Electric Reliability Council of Texas. Bolstering the connections between these grids, commonly referred to as "seams," would increase generating resource diversity across multiple regions—both in type of generation and geographic location. Seams improvements could include a combination of high-voltage direct current transmission and alternating current projects, and further study is likely necessary to determine the ideal configuration to maximize benefits for consumers and utilities. The National Renewable Energy Lab is currently reviewing models for strengthening seams, reviewing existing resources and the potential to maximize the use of resources through different system models.[13]

Case of the Midcontinent Independent System Operator and the Multi-Value Projects

An example of improvements made by regional transmission organizations are the Midcontinent Independent System Operator's Multi-Value Project portfolio which was approved in 2011. See Figure 4 on page 7. Projects in the portfolio aim to meet several criteria: improve reliability, reduce congestion on the system, and allow states to meet public policy goals such as Renewable Portfolio Standards.

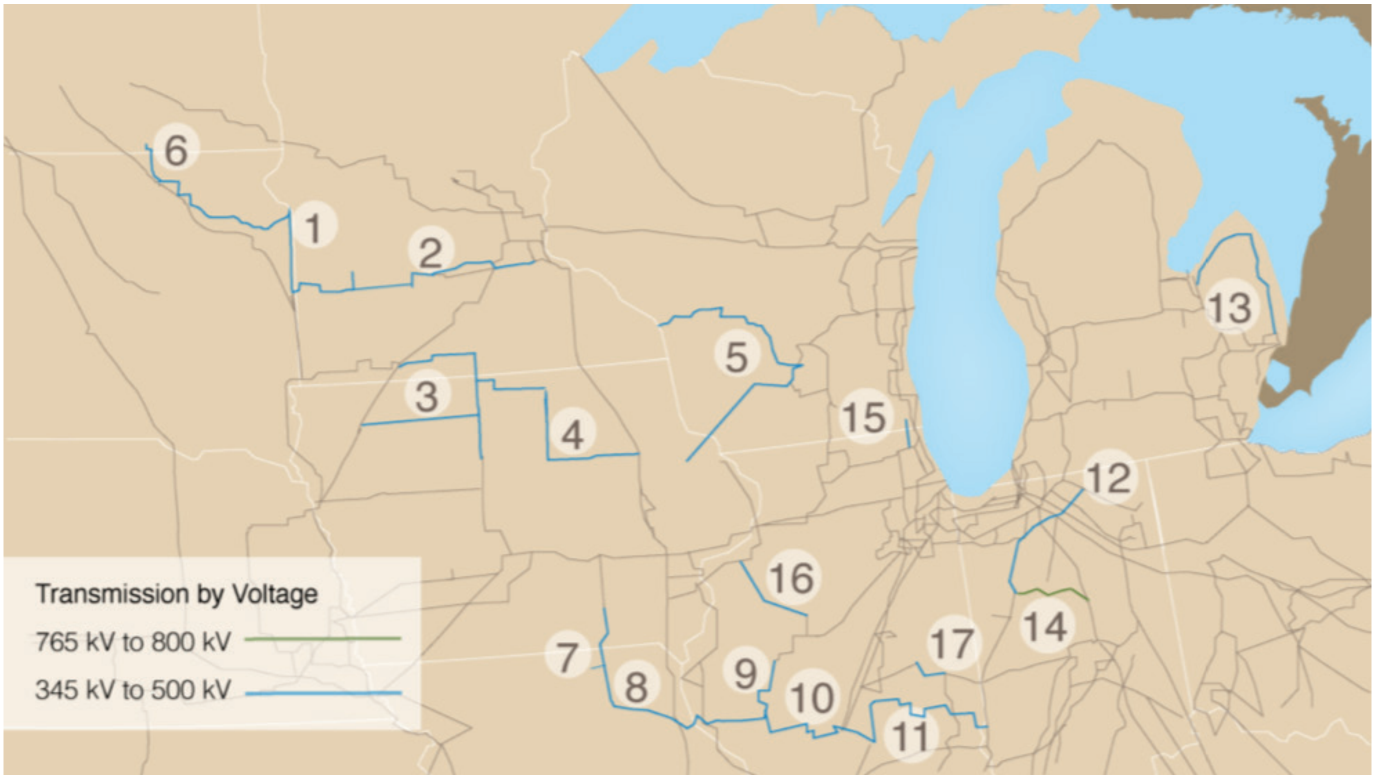
These projects provide additional transmission capacity in the region and contribute to the reduction of curtailed wind resources while allowing for the deployment of new wind generation in the Midcontinent Independent System Operator footprint. According to Midcontinent Independent System Operator's analysis, when complete, the Multi-Value Projects will enable 52.8 million megawatt hours of wind energy through 2031. In providing access to low-cost renewables, the Multi-Value Projects have also assisted in lowering fuel costs and congestion on the system, generating up to $71 billion in production cost benefits.[14]

12 "Transmission Planning and Cost Allocation by Transmission Owning and Operating Public Utilities." U.S. Federal Energy Regulatory Commission, July 21, 2011, ferc.gov/whats-new/comm-meet/2011/072111/E-6.pdf. Accessed June 2019.

13 "Interconnections Seam Study." National Renewable Energy Laboratory, U.S. Department of Energy, nrel.gov/analysis/seams.html. Accessed June 2019.

14 "MTEP17 MVP Triennial Review." Midcontinent Independent System Operator, September 2017, cdn.misoenergy.org/MTEP17%20MVP%20Triennial%20Review%20Report117065.pdf. Accessed June 2019.

FIGURE 4: MIDCONTINENT INDEPENDENT SYSTEM OPERATOR'S MULTI-VALUE PROJECTS PORTFOLIO



V. KEEPING PACE WITH RENEWABLE BUILD OUT

Although the Multi-Value Projects offer a useful glimpse into the potential benefits of expanded transmission, the portfolio is likely not enough to meet the demand for interconnection from the growing number of renewable energy projects in the Midcontinent Independent System Operator footprint. Currently, there are 483 projects in the Midcontinent Independent System Operator generator interconnection queue, totaling 81.5 GW of capacity. Notably, 36.7 GW and 35.2 GW of that capacity is made up of wind and solar projects, respectively. In an effort to meet this challenge, Midcontinent Independent System Operator has already proposed 442 new transmission projects that would amount to a $3.3 billion investment into the grid.[15]

This increase in renewables is not unique to Midcontinent Independent System Operator, and a comparison with the neighboring Southwest Power Pool's generator interconnection queue—totaling 81.3 GW—can offer some context. Southwest Power Pool currently has 21.5 GW of installed wind energy, with 50.4 GW of wind under study in its generation interconnection queue. At only 215 MW of in-service capacity, solar still makes up a small portion of generation for Southwest Power Pool, although there is 25.9 GW of solar in the generation interconnection queue.[16]

Policymakers and regulators must plan for this continued rise in renewables, and invest in the necessary infrastructure to provide interconnection of resources as well as the efficient delivery of clean energy to consumers. This investment will likely have to be considerable, especially

15 "MTEP18 Transmission Enhancement Plan." Midcontinent Independent System Operator, 2018, cdn.misoenergy.org/MTEP18%20Full%20Report264900.pdf. Accessed June 2019.

16 "SPP 101: An Introduction to Southwest Power Pool." Southwest Power Pool, May 2019, spp.org/documents/31587/intro%20to%20spp.pdf. Accessed June 2019.

given historical context and the likelihood of continued electrification of different sectors of the economy. There were 93 GW of wind and solar put into service in the U.S. from 2007 to 2016, followed by $120 billion worth of investment in transmission. Given the capacity developed over nearly a decade and historic investment, an estimated kilowatt (kW) of renewable capacity would require $300 to $700 of accompanying transmission investment.[17]

While additional transmission capacity may become available due to the retirement of fossil fuel generation, new renewable energy will require an infrastructure buildout that is at least in line with the historic trend. Although Midcontinent Independent System Operator has already identified more than $3 billion in grid investments, this falls short of the share that would be required to connect current renewable generation and maintain grid reliability. Considering past investment, the 71.9 GW currently in the Midcontinent Independent System Operator queue would necessitate $21.57 billion to $50.33 billion worth of new transmission for the region. Similarly, Southwest Power Pool would likely require significant investment for the 76.3 GW of renewables currently in the region's queue, totaling $22.89 billion to $53.41 billion.

Notably, some of the projects currently entered into these regional interconnection queues may never be put into service, electric demand is likely to grow as electrification increases for transportation and other sectors—an increase that may range from 5 percent to 15 percent by 2030. Estimates point to 70 GW to 220 GW of new electric generation required as early as 2030 to meet growing demand. This will require an annual buildout of $3 billion to $7 billion of transmission infrastructure to service this new electric generation, on top of investments that are necessary to merely maintain the electric grid.[18]

17 Weiss, Jurgen, et al. "The Coming Electrification of the North American Economy: Why We Need a Robust Transmission Grid." WIRES, The Brattle Group, March 2019, wiresgroup.com/new/wp-content/uploads/2019/03/Electrification_Brattle Report_WIRES_FINAL_03062019.pdf. Accessed June 2019.

18 Ibid.

VI. CHALLENGES AND OPPORTUNITIES

The buildout of new transmission has not been without its pitfalls. Projects commonly require approval from state and federal regulators, a process that includes engaging local stakeholders across multiple phases. Due to long distances covered by transmission lines and projects often crossing state boundaries, the entirety of this engagement and regulatory process may extend the development timeline for transmission. However, involving local communities in the development process is key to better transmission projects, taking advantage of unique insight to form routes that are less intrusive and have limited environmental impact. Stakeholder engagement and regulatory approval have proven to be a challenge for developers in recent years, especially as coordinated opposition has arisen in response to large transmission projects.

Many of these challenges will require developers to rethink traditional approaches to projects, whether that be the design phase of a project, conducting community outreach, or the actual construction of a line. But, implementing changes in the development process presents opportunities for transmission lines to be routed and built in ways that better consider the needs and desires of local stakeholders.

Significant early engagement of stakeholders will likely assist developers in determining efficient routing options that avoid impacts to properties and residents. Building relationships at this early stage is essential to addressing the questions or concerns of community members and landowners, and it is a prime opportunity to ensure that those who will be affected by a transmission line have a voice in the project.

Opportunities for innovation also lie in the development process. Adopting new techniques can mitigate potential impacts from transmission projects while achieving additional benefits for the local area. An example is integrated vegetation management, a process of managing trees and other high-growing plants under a transmission line without simply removing all vegetation through the use of mowing or spraying.

This alternative uses low-growing plant species—often native plant species—in conjunction with targeted removal to eliminate vegetation that could interfere with a transmission line. Additional benefits of integrated vegetation management are the reduction of invasive species and the possibility of creating new pollinator or wildlife habitat, offering a considerable amount of acres in the form of right-of-way corridors in new habitat across the U.S. These corridors can also serve an important role in providing transition landscape for several species, promoting biological diversity while reducing habitat fragmentation.[19]

Developers may also wish to explore opportunities to increase the economic benefits from the expansion of transmission capacity. Compared to renewable energy generation, in particular wind, transmission often falls short in offering tangible economic development opportunities for communities. For example, while landowners who host wind turbines receive annual land lease payments, payments for a transmission line are regularly one-time sums that are much smaller in comparison. There is an opening for utilities and developers to form new models that create greater or additional benefits to communities near transmission projects, bringing these projects on par with other forms of energy development.

Identifying opportunities to broaden the benefits of transmission expansion and upgrades along with greater stakeholder involvement are essential as new projects are planned and developed. As rural citizens benefit from renewable generation, efforts must be made to ensure they gain from accompanying infrastructure buildout to service those resources.

19 “Benefits of Integrated Vegetation Management (IVM) on Rights-of-Way.” U.S. Environmental Protection Agency, Pesticide Environmental Stewardship Program, Nov. 4, 2016. epa.gov/pesp/benefits-integrated-vegetation-management-ivm-rights-way. Accessed June 2019.

VII. CONCLUSION

The U.S. has already experienced a shift in the way electricity is generated, and this shift will likely continue. As more renewable generation comes online across the nation, more communities will have access to the benefits of development—including low electricity prices. This low-cost renewable energy will also be key to aggressive goals being set by policymakers across the country to acquire electricity from carbon-free resources.

A robust transmission system will be essential to reap the benefits of renewable energy resources. Planners should aim not just for the immediate needs of the transmission grid, but take a long-term view of the changing electric power sector. Transmission developers must work to change the process for designing and constructing projects, employing approaches and techniques that will lead to increased satisfaction for stakeholders and improved impact mitigation outcomes.

To address the challenges of a changing electric power sector, regulators and policymakers must plan for an improved electric transmission network that will ensure renewable generation can continue to provide benefits to rural communities while offering opportunities to reduce carbon emissions and meet demands for clean energy.

ABOUT THE CENTER FOR RURAL AFFAIRS

Established in 1973, the Center for Rural Affairs is a private, nonprofit organization with a mission to establish strong rural communities, social and economic justice, environmental stewardship, and genuine opportunity for all while engaging people in decisions that affect the quality of their lives and the future of their communities.