Obstacles To Carbon-Free Electricity By 2035

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President Biden has set a goal to achieve carbon-free electricity by 2035 and pledged to establish an "Energy Efficiency and Clean Energy Standard" as a way to achieve this goal.[i] Without major technology breakthroughs, this goal would mean eliminating the production of electricity from coal and natural gas within the next 15 years, even though fossil fuels provide more than 60 percent of the nation's electricity, and some states rely on fossil fuels for more than 90 percent of their electricity.[ii] There are major obstacles to achieving carbon-free electricity, several of which are highlighted below.

Cost

Achieving President Biden's decarbonization goal would require an enormous investment. For example, the Electric Power Research Institute (EPRI) has modeled some of the impacts of achieving a carbon-free grid.[iii] These impacts include the following:

- The grid would need to add 900,000 megawatts (MW) of new wind and solar power, 80,000 MW of new nuclear capacity (almost doubling the size of the nation's existing nuclear fleet),[iv] and 200,000 MW of hydrogen-fueled turbines, all within 15 years.
- The cost for these additional electric generating resources is estimated to be $1.5 trillion plus $200 billion for transmission upgrades for a total of $1.7 trillion by 2035. This averages out to more than $100 billion per year.
- The average price of electricity would almost double by 2035 (increasing from $60/MWh to $110/MWh in 2035). Electricity prices would increase the most in the southern and eastern parts of the U.S.

Electric transmission

A multi-billion investment to add new electric transmission capacity will be required to deliver carbon-free electricity.[v] The MIT Energy Initiative found that transmission infrastructure would need to be nearly doubled in order to fully decarbonize the power sector in the most cost-effective manner,[vi] while the Brattle Group estimated additional transmission investment up to $25 billion per year would be needed for a grid that is just 75 percent renewables,[vii] more than doubling the power sector's $21.4 billion average annual transmission investment.[viii] The Brattle cost estimate of $25 billion per year would amount to $375 billion over a 15-year period.

In addition to the enormous cost, building out new transmission by 2035 will be virtually impossible because approving and building new transmission lines has become a time consuming and sometimes futile process. For example —

- The Transwest Express Transmission Line, a 700-mile 3,000-MW capacity line, is intended to deliver wind power from Wyoming to Nevada and California.

Development of the project began in earnest in 2005, but permits were not received until 2020, with construction finally scheduled to run from 2022 to 2024, almost 20 years after the project began.[ix]

- The Plains & Eastern Clean Line transmission project was a 700-mile $2.5-billion project begun in 2010 to bring wind power from Texas and Oklahoma to serve eastern power demand. Despite federal and state approvals and support from the Department of Energy, the project was essentially abandoned eight years later due to local opposition along the construction route.[x]
- The SunZia project — two high-voltage lines from New Mexico to Arizona — was initiated in 2008, but approvals have delayed construction until 2025. This means the project will have taken at least 17 years to complete.

In addition, new renewables and other electric generating resources must apply for connection to the transmission system via interconnection queues.[xi] However, the interconnection queue process has become time consuming. For that and other reasons, Lawrence Berkeley National Laboratory estimates that less than 20 percent of wind and solar projects that applied for interconnection ever reached commercial operation.[xii]

Reliability

Electricity output from wind and solar varies with weather conditions and, therefore, cannot be scheduled to coincide with electricity demand. This challenge will grow as more renewables come online. In ERCOT, the grid operator covering most of Texas, wind provided 20 percent of electricity in 2019 (up from 8 percent in 2010).[xiii] A sudden drop in wind production during a 2019 heat wave caused ERCOT to initiate emergency procedures in order to avoid blackouts.[xiv] MISO also was forced to initiate emergency procedures during the winter of 2019 when wind output dropped by two-thirds when it was needed most.[xv] California, where almost one-third of the generating capacity is renewable power,[xvi] was not as lucky last summer, when a drop in solar power contributed to rolling blackouts and other emergency measures that were necessary to avoid a collapse of the state's electricity grid.[xvii] Recently, the CEO of the North American Electric Reliability Corporation (NERC) emphasized his "increased concerns about the changes we're seeing on the grid and the potential consequences for reliability … In our hurry to develop a cleaner resource base, reliability and energy adequacy have to be taken into consideration."[xviii]

Technology innovation

At various times during the day, the gap between electricity demand and wind and solar output must be filled by other sources of electricity. Because carbon-emitting resources would not be available for gap filling if electricity is carbon free, energy storage technology would have to be deployed to store renewable power. The most commonly proposed energy storage systems are large-scale lithium-ion battery installations, though only 1,300 MW of battery capacity are currently installed on the grid.[xix] Battery cost and performance have been improving but remain high, with current cost estimates ranging from $132 to $245 per MWh of power provided to the grid.[xx] This makes battery storage cost prohibitive for widespread use in supporting wind and solar power.

Carbon capture, utilization, and storage (CCUS) technology could significantly reduce carbon emissions from fossil-fuel power plants, but the technology is not yet cost-effective for widespread use. Efforts to improve both CCUS and battery storage continue to show promise, but it is risky to assume they would be cost-effective enough to be widely deployed over the next 15 years.

Market design

As currently designed, the nation's wholesale power markets are not well-suited for high levels of renewable generation.[xxi] Prices in these markets are based on the cost of generating power when needed, but wind and solar power output are driven by weather, not price signals or power demand. By generating power whether needed or not, wind and solar tend to artificially depress market prices below a level that conventional power generators need to break even, even when conventional generators are necessary for grid reliability. New market structures and rules will be needed to ensure power generators are fairly compensated.[xxii] Past experience has shown that the process for developing and approving new market rules is very time consuming.

Stranded investments

More than 30 percent (334,000 MW) of the 1,107,000 MW of electric generating capacity in the U.S. is comprised of fossil-fuel generators less than 20 years old.[xxiii] Dealing with these stranded assets poses a significant challenge as power plant owners seek to be made whole for their undepreciated (stranded) investments, either through ratemaking proceedings or litigation.

Fuel security and fuel diversity

NERC has determined that fuel security — a power plant's immediate access to fuel when needed — is important enough to develop guidelines to help regional electricity planners assess their exposure to fuel risk (not having fuel when it's needed).[xxiv] Fuel diversity can reduce the cost of electricity by allowing system operators to rely on different power plants with different fuels as the relative costs of fuels change.[xxv] Both of these important attributes will decline as the grid transitions, but the impacts on reliability and electricity costs are not clear.

Jobs

Retooling the electricity grid will end the employment of many workers. A recent report by the Energy Futures Initiative found that more than 185,000 jobs are supported by coal-fired power generation.[xxvi] All would be at risk, as would some portion of the 686,000 jobs supported by the natural gas industry. Many of these jobs are in rural communities that would be disproportionately affected by job losses.

This paper is intended only to highlight a number of complicated obstacles to achieving carbon-free electricity. Overcoming any, much less all, of them will take considerable time.

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[i] While calling for carbon-free electricity, the Biden administration has not defined what the term means. Strictly speaking, even the use of coal or natural gas with CCUS would be prohibited because CCUS does not capture 100 percent of carbon emissions. On the other hand, the administration has implied that gas or coal with CCUS would qualify as carbon free.

[ii] EIA, "*Electric Power Monthly*," February 2020.

[iii] "*Powering Decarbonization Strategies for Net-Zero* CO_2 *Emissions,*" Electric Power Research Institute, February 2021.

[iv] Units 3 and 4 of Plant Vogtle in Georgia are estimated to cost $27 billion by the time the two 1,100-MW nuclear units begin commercial operation next year. This is double the original estimate of $14 billion, and it will have taken at least 16 years since Georgia Power Company sought approval from the Georgia Public Service Commission. Adding 80,000 MW of new nuclear capacity to decarbonize the grid would be roughly equivalent to building more than 70 new nuclear units the size of each of the Vogtle units.

[v] ScottMadden Management Consultants, "*Informing the Transmission Discussion: A Look at Renewables Integration and Resilience Issues for Power Transmission in Selected Regions of the United States*," study commissioned by WIRES, January 2020.

[vi] Brown, P.R., and A. Botterud, "*The Value of Inter-Regional Coordination and Transmission in Decarbonizing the US Electricity System,*" *Joule* 5:1-20, January 20, 2021. The report found that a 90 percent increase in transmission capacity would lower the cost of electricity on a carbon-free grid by 46 percent when compared to approaches that lack transmission expansion ($73/MWh vs. $135/MWh, on average). Note that $73/MWh is still roughly twice the cost of electric power today.

[vii] The Brattle Group, "*The Coming Electrification of the North American Economy Why We Need a Robust Transmission Grid*," study commissioned by WIRES, March 2019.

[viii] Edison Electric Institute, "*Historic and Projected Transmission Investment*," November 2020.

[ix] http://www.transwestexpress.net/about/timeline.shtml.

[x] ScottMadden Management Consultants, "*Informing the Transmission Discussion: A Look at Renewables Integration and Resilience Issues for Power Transmission in Selected Regions of the United States*," study commissioned by WIRES, January 2020.

[xi] Utilities and regional grid operators require projects seeking to connect to the grid to undergo a system impact study before they can be built. This process establishes what new transmission equipment or upgrades may be needed before a project can connect to the grid and assigns the costs of that equipment or upgrades. The lists of projects in this process are known as interconnection queues.

[xii] "*Queued Up: Characteristics of Power Plants Seeking Transmission Interconnection As of the End of 2020,*" Joseph Rand, Mark Bolinger, Ryan Wiser, Seongeun Jeong Lawrence Berkeley National Laboratory, May 2021. Only 19 percent of wind projects and 17 percent of solar projects in the queue ever reached commercial operation. https://emp.lbl.gov/publications/queued-characteristics-power-plants

[xiii] http://www.ercot.com/content/wcm/lists/181766/FuelMixReport_PreviousYears.zip.

[xiv] https://www.americaspower.org/coal-retirements-have-ercot-power-prices-soaring/.

[xv] *Energy Wire*, "*Turbine shutdowns in polar vortex stoke Midwest debate,*" Jeffrey Tomich, February 27, 2019.

[xvi] S&P Global Insight database, queried December 22, 2020.

[xvii] FERC, "*Preliminary Observations on the August 2020 California Heat Storm*," December 2020.

[xviii] *Utility Dive, "NERC sees potential summer energy shortfalls, says energy transition pace may threaten reliability,"* May 27, 2021. The article quotes NERC President and CEO Jim Robb in an interview with reporters.

[xix] EIA, "*Monthly Generator Inventory*," October 2020.

[xx] Lazard, "*Lazard's Levelized Cost of Storage Analysis Version 6.0*," October 2020.

[xxi] See, for example, "*Future Electricity Markets: Designing for Massive Amounts of Zero-Variable-Cost Renewable Resources,*" *IEEE Power and Energy Magazine*, Nov./Dec. 2019, and "*Preparing for Decarbonization: Reforming US Power Markets for the Energy Transition,*" Atlantic Council Global Energy Center, May 2021.

[xxii] Perchman, C., "*Whither the FERC? Overcoming the Existential Threat to its Magic Pricing Formula Through Prudent Regulation*," National Regulatory Research Institute, January 2021.

[xxiii] EIA, "*Monthly Generator Inventory*," October 2020.

[xxiv] NERC, "*Reliability Guideline: Fuel Assurance and Fuel-Related Reliability Risk Analysis for the Bulk Power System*," March 2020.

[xxv] "*Reliability, Resilience, and the Oncoming Wave of Retiring Baseload Units, Volume I: The Critical Role of Thermal Units During Extreme Weather Events*," National Energy Technology Laboratory, March 13, 2018.

[xxvi] Energy Futures Initiative, "*2020 U.S. Energy and Employment Report,*" https://www.usenergyjobs.org/.