Please cite this article in press as: Joskow, Transmission Capacity Expansion Is Needed to Decarbonize the Electricity Sector Efficiently, Joule (2019), https://doi.org/10.1016/j.joule.2019.10.011

Joule

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COMMENTARY

Transmission Capacity Expansion Is Needed to Decarbonize the Electricity Sector Efficiently

Paul L. Joskow[1,*]

Paul Joskow is the Elizabeth and James Killian Professor of Economics, Emeritus, at the Massachusetts Institute of Technology (MIT) where he joined the faculty in 1972. He has served as the Chairman of the Department of Economics and as the Director of the Center for Energy and Environmental Policy Research. From 2008 to 2017, he was the President of the Alfred P. Sloan Foundation. He is a Fellow of the American Academy of Arts and Sciences and the Econometric Society, and a Distinguished Fellow of the American Economic Association and of the Industrial Organization Society. He has published widely on topics in industrial organization, energy economics, electricity markets, and government regulation.

Policies to facilitate deep decarbonization of electricity sectors play a key role in strategies to reduce total greenhouse gas emissions dramatically to meet climate stabilization goals. A common strategy is to fully or close to fully decarbonize electricity generation and use carbon-free electricity to help decarbonize the transportation, building, and industrial sectors. In most developed countries, deep decarbonization of electricity generation requires a substantial increase in electricity generation from wind and solar generators to replace CO_2-emitting fossil fuel–powered electricity-generating plants (coal, gas, oil) and to replace the anticipated retirements of a large fraction of the world's 450 operating nuclear plants by 2050. Substantial investment in new transmission capacity will be needed to allow wind and solar generators to develop projects where the most attractive natural wind and solar resources are located. Barriers to expanding the needed inter-regional and inter-network transmission capacity are being addressed either too slowly or not at all.

Carbon-free electricity generation options other than wind and solar are likely to be limited in most countries. Only about 50 nuclear plants are now under construction globally, of which only 5 are in the US and Europe, reflecting the high cost of building new nuclear plants and public concerns about safety and waste disposal. Opportunities to expand hydroelectric generation are limited by resource, environmental, and public acceptance constraints in most countries. Thus, the decarbonization of the electricity sector over the next 30 years requires major expansion of wind and solar generation. An important goal is to accomplish this electricity generation transformation as economically as possible, while maintaining the reliability of the electric power system.

A great deal of attention is being paid to mechanisms to stimulate investments in the wind- and solar-generating plants needed to meet deep decarbonization goals. There has also been considerable interest in wholesale market design reforms to respond to the intermittency and zero marginal-operating-cost attributes associated with wind and solar generation.[1] However, much more attention needs to be paid to the expansion of *transmission* networks to support the economic deployment and use of wind and solar resources. An efficient transmission network infrastructure transition requires reforms to current transmission planning, permitting, and financial arrangements that overcome traditional boundaries between transmission networks. Transmission investment has focused historically on reliability and economic needs *within* transmission system operating regions rather than *between* the transmission operating regions. The transmission operating and planning regions may be defined by the geographic boundaries of legacy vertically integrated utilities, multi-utility power pools, independent transmission system operators, states, provinces, or countries.

In most regions, the least-cost location of grid-based wind- and solar-generating facilities is very different from the location of the legacy fossil, hydroelectric, and nuclear plants. The most attractive locations for wind- and solar-generating facilities reflect primarily natural wind and solar irradiation patterns. On the other hand, the locations of the legacy fleet of fossil and nuclear plants largely reflect fuel, cooling water, safety, and land availability requirements, as well as the geographic distribution of demand and historical boundaries between transmission networks. Most of the considerations that have guided the location of conventional generating plants are relatively unimportant for locating wind and solar facilities to take advantage of the best natural wind and solar resources.

For example, in the US, wind patterns vary widely across the country, with many of the best wind resources located in the Midwest along a relatively narrow corridor that stretches from Canada to North Western Texas, as well as offshore, with the East coast and portions of the Gulf coast offering a favorable combination of high relatively stable wind speeds and relatively

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shallow waters. Solar irradiation is much higher across the South and especially the Southwest than it is in the rest of the US. These areas tend to be lightly populated and far from demand centers. Similarly, in Europe, the best wind resources are in the North, especially offshore, while solar resources are much more attractive in Southern Europe (and North Africa).

Substantial investment in new transmission facilities will be required to support the least-cost location of a rapidly growing fleet of wind- and solar-generating facilities that take advantage of the best natural wind and solar resources. In particular, transmission capacity *between* existing transmission networks—often referred to by incumbent transmission system operators and regulators as interconnectors—must be expanded. In order to do so, the barriers to expanding transmission capacity between legacy transmission networks need to be broken down so that inter-system and inter-regional transmission facilities can be planned, financed, built, and operated efficiently. The primary barrier to achieving this goal is that for historical, economic, regulatory and political reasons, existing transmission organizations focus on planning transmission investments to meet reliability criteria and economic needs *within* their traditional boundaries. Regulatory and financing arrangements have evolved to be compatible with these boundaries. As a result, interconnections between incumbent transmission networks are typically very weak today. More importantly, existing organizational, financing, and regulatory arrangements are not well adapted to the development of inter-system transmission capacity, and vested interests are a barrier to the needed changes in these arrangements.

What needs to be done to reduce the barriers to efficient transmission investment? First, the problem needs to be recognized and the barriers identified. Second, either the boundaries that presently define transmission network planning and operations need to be expanded to cover much larger geographic areas and/or inter-system, including transmission systems in multiple countries, or new cooperative inter-transmission system planning and development mechanisms, must be created. Third, it is important to resolve issues associated with both controlling and recovering the costs of building these facilities—how can costs be contained, how are developers compensated, and who pays these costs?

These challenges have been recognized in both the US and Europe.[2,3] In the US, the Federal Energy Regulatory Commission (FERC) began to address many of these issues seriously in its Order 1000, issued in 2011 with compliance filings completed in 2016.[4] It defined relatively large transmission planning regions, including the networks governed by independent system operators (ISO), required each transmission region to create an open transmission planning process, ended preferences for incumbent transmission owners to build new transmission facilities, required each region to develop inter-regional transmission planning processes, defined principles for cost allocation both within and between transmission planning regions, required consideration of transmission facilities to support public policies such as wind and solar procurement mandates, and authorized the utilization of competitive procurement to choose transmission facility developers. On paper, Order 1000 reflects admiral goals and places obligations on transmission planning regions to identify and develop inter-regional transmission facilities needed to support efficient deployment of wind and solar capacity.

Unfortunately, while there has been some progress on inter-regional transmission planning and investment in the US, progress has been very slow.[5] The development of transmission facilities for offshore wind, apparently not anticipated by Order 1000, has also been delayed in the absence of a comprehensive framework for aggregating offshore wind development projects in order to facilitate more efficient development of transmission facilities to connect to and reinforce on-shore networks.[6] The utilization of competitive procurement mechanisms to identify innovative transmission solutions and to control costs has also been quite limited.[7] One bright spot has been the Competitive Renewable Energy Zones (CREZ) competitive procurement used in Texas (ERCOT) that has led to the development of 3,500 miles of new transmission lines specifically planned to bring electricity from an area of enormous wind-generating capacity in Northwestern Texas to load centers hundreds of miles to the South.[8] However, CREZ involved expanding transmission capacity between regions within a single large state with a single transmission system and wholesale market operator (ERCOT), a single state regulatory authority, and no overlapping FERC regulation. Thus, the institutional barriers to CREZ were relatively low. Developing projects crossing multiple states, multiple system operators, multiple incumbent transmission owners, and multiple state regulators has been much more challenging.

Some progress has been made in Europe as well. The expansion of interconnections and the associated geographic expansion of wholesale power markets have attracted a lot of talk in the European Union (EU) in the last several years. The Revised Electricity Regulation issued in 2019 targets, among many other EU-wide wholesale and retail market reforms, expanding cross-border transmission capacity and electricity trade stimulated by the need to support a large expansion of wind and solar,[9] though in practice,

the goals for expanding interconnectors and expanding cross-border trade have been modest. The UK is a bright spot. Office of Gas and Electricity Markets (OFGEM), the regulator in the UK, has developed and utilized a good competitive procurement mechanism to develop transmission facilities for offshore wind parks.[10] However, overall, progress has been too slow in Europe as well as in the US.[11,12]

Expanding inter-regional transmission capacity and inter-regional power trading raises challenging intra- and inter-country political, economic, and public acceptance issues. However, the failure to address these transmission issues more quickly and effectively also undermines the complementary goal of wholesale market integration to support achieving electricity sector decarbonization goals with wind and solar. In the absence of more and faster progress, either decarbonization goals will not be met, or they will be unnecessarily expensive, or both. Thus, expanding transmission capacity linking incumbent transmission networks requires priority attention by policymakers focused on decarbonizing the electricity sector efficiently.

DECLARATION OF INTERESTS

The author is a Director of Exelon Corporation, a public utility holding company, and owns common stock in the company. He also owns common stock in National Grid PLC and TransCanada Corporation, on whose boards he served in the past.

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[1]Department of Economics, Massachusetts Institute of Technology, Cambridge, MA 02139, USA

*Correspondence: pjoskow@mit.edu

https://doi.org/10.1016/j.joule.2019.10.011