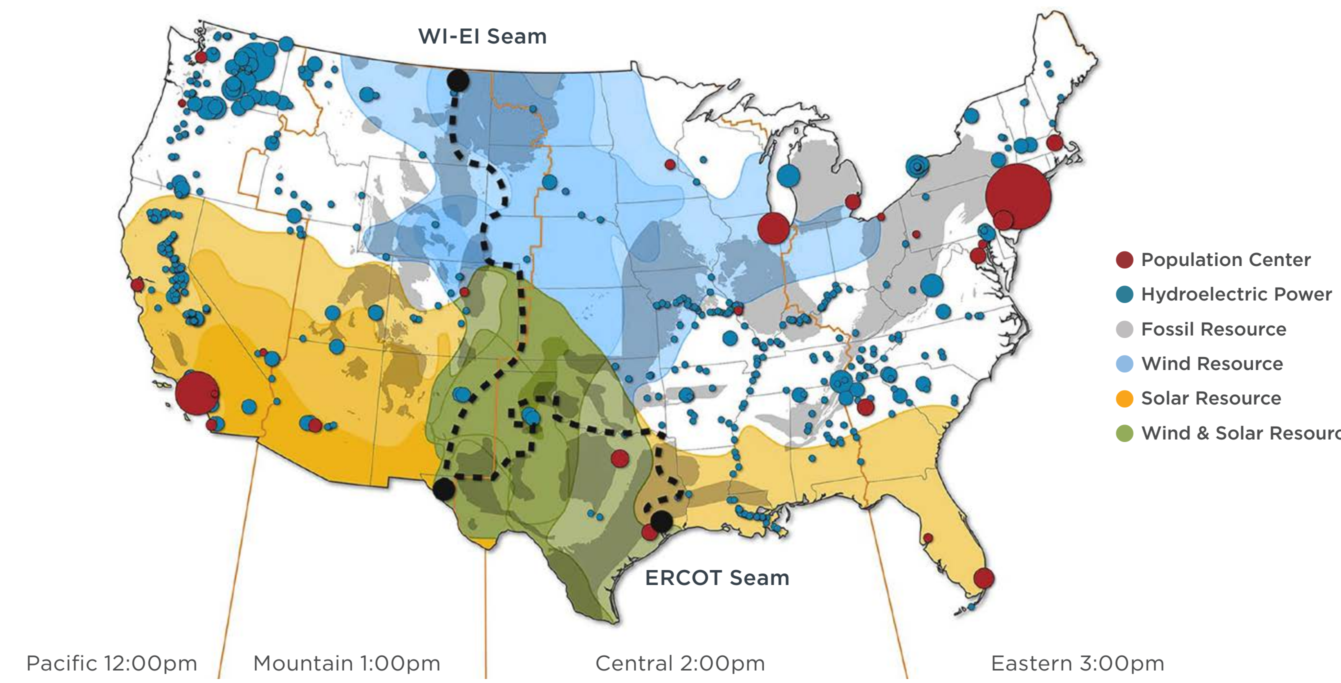
Decarbonizing the U.S. Economy with a National Grid

Steve Cicala, *Assistant Professor of Economics, Tufts University; Non-Resident Scholar, EPIC*

A seamlessly integrated market and abundant, diverse resources are foundational strengths of the U.S. economy. Together, they allow local areas to specialize in what they do best—whether it's growing oranges or building cars. The United States would certainly be a much poorer country if every state required all of its goods to be made locally. Yet that is essentially how the power sector operates. A century of state-led regulation has delivered a balkanized grid that is incapable of moving electricity from coast to coast. This means that production from renewable sources is limited to how much power is required to meet demand locally, at the moment the wind is blowing or sun is shining.

FIGURE 1 - CHAPTER IN A CHART

Renewable Resources and Load Centers



Source: NREL Interconnections Seam Study.

Significantly expanding renewables generation is going to require moving power—to *when* it is needed with storage, and to *where* it is needed with transmission. While storage is an area of active research, a national grid that can transmit power from the Sun Belt and wind corridor to major cities is possible with existing technology. To decarbonize the economy, the regulatory and institutional dysfunction that have so far made the construction of such a grid impossible need urgent attention.

Heart of the Problem

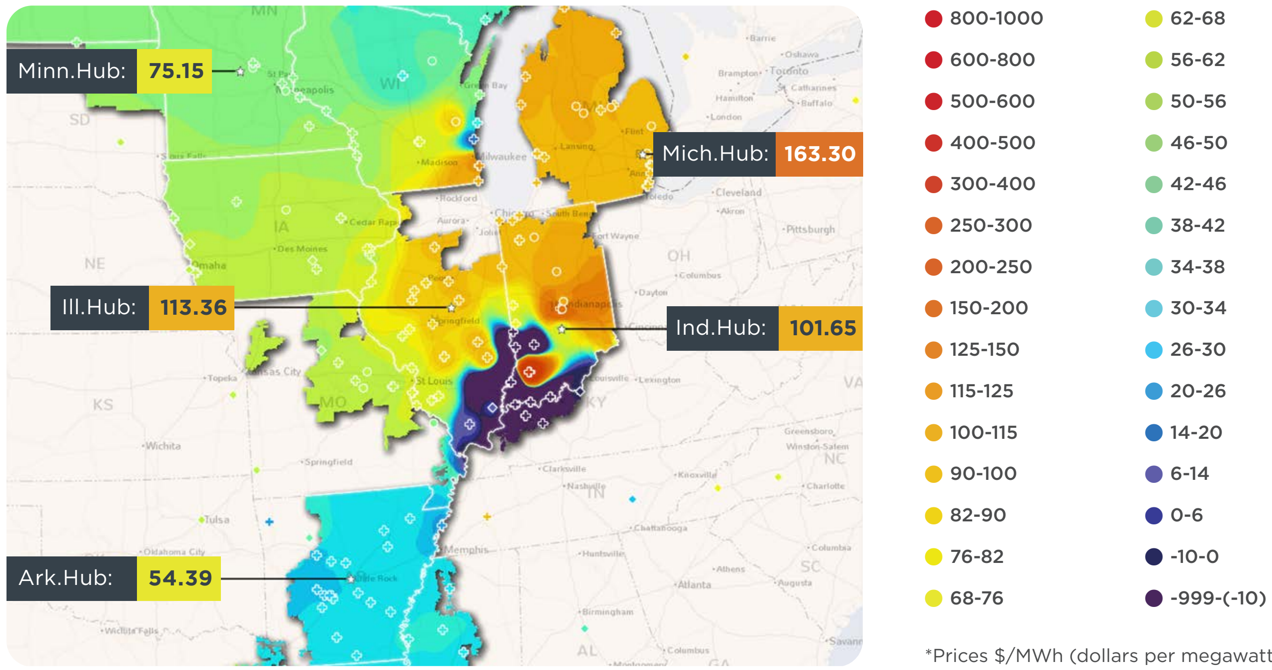
The United States is endowed with vast energy resources of virtually all kinds. The challenge is that those resources are located far from where people live. The country's existing energy transportation infrastructure is geared toward moving power as fuel and converting it to electricity near its location of final use. Over one third of the coal used for power generation, for example, comes from a single Wyoming county.[1] It is extracted from surface mines and carried by rail cars to power plants across the country at great expense. Oil and gas make their way from underground and offshore deposits to refiners and consumers around the country in pipelines. The system transports the power as fuel, and local generators deliver it to consumers as electricity. This means that even though fuel resources are highly concentrated in specific locations, virtually every part of the country has sufficient electricity generation resources to meet its peak demand. As long as it is possible to move the fuel, this system keeps the lights on.

Just as some parts of the country have more fossil fuel deposits than others, renewable sources of energy are also unevenly distributed throughout the country. The key difference is that the wind and sun cannot be put on a rail car or in a pipeline to travel to consumers' locations as fuel for local generators. It must be converted to electricity the moment it is harvested and transported over a transmission line. However, the transmission grid was not built to move a substantial fraction of the nation's power from one remote county to the rest of the country, as the rail system can. And, until recently, there was little incentive for change.

1 According to the 2018 Annual Coal report from the Energy Information Administration, Campbell County, WY produced over 300 million of the nation's 750 million tons of coal.

FIGURE 2

Insufficient Grid Capacity Causes Prices to Diverge



*Prices $/MWh (dollars per megawatt-hour)

Source: MISO Energy, Real-Time Displays.

Ten years ago, the principal challenge for reducing emissions from the power sector was technological: wind and solar technologies were not cost competitive with conventional fossil-based sources. The metric used for such comparisons is the levelized cost of energy (LCOE), which adds up all of the lifetime expenses of a plant, and divides by its output. In 2010, the unsubsidized LCOEs of conventional wind and solar generation were about $125 and $250 per megawatt-hour, respectively.[2] Compared with $82 for combined-cycle gas generation, it was clear that renewables required substantial improvements before they might be competitive resources without significant subsidies. The technological progress over the last decade has been extraordinary. Renewables today are highly attractive investments, with LCOEs of $40 per megawatt-hour, well below the $56 now required for combined-cycle gas.[3]

With economical renewable generation technologies proliferating, the next challenge in decarbonizing the economy is to deliver power to where people are, when they need it.

The current approach is equivalent to using coal resources only to power the communities near the mines. “Coal country” has existed as an economic force because railroads deliver its energy to the rest of the country. “Wind country” is being hamstrung not because wind power is expensive, but because it lacks what the railroads have historically provided for coal—a route to consumers.

Figure 2 is a snapshot from one of the major wholesale electricity markets in the United States.[4] These markets are run as auctions and the heat map corresponds to the prices that distribution utilities are paying, and generators are being paid. The variation of prices across space shows telltale signs of the inadequacies of U.S. transmission infrastructure. Just as oil prices are essentially uniform around the world (adjusted for quality) because oil is sold in a global market, the price of electricity would be uniform across the map if it could flow without restraint. During hours when power flows without congestion, prices from Canada to the Gulf of Mexico are typically within a few cents of one another, reflecting the fact that it is cheap to send power long distances over the bulk transmission system.

2 Lazard, “Levelized Cost of Energy Analysis.”

3 Id.

4 MISO Energy, Real-Time Displays.

Prices begin to diverge across places when the system lacks transmission capacity. In the figure, there are generators willing to sell power for $54 per megawatt-hour in Arkansas, but the consumers in Michigan are unable to buy it at that price because there is not enough transmission capacity to deliver it. As a result, a more expensive generator in Michigan is fired up to serve local demand, costing consumers $163 per megawatt-hour. The difference in prices reflects a lost opportunity for low-cost generators to expand their output, and the inability of consumers to get the best possible price. This kind of problem occurs every day throughout the country because of the difficulties of moving electricity to where it is needed.

The day-to-day operations of the grid are in fact even more perverse. Prices typically determine the revenue that generators earn for their valuable output. But when generators are producing more power than the system can use, prices actually turn negative in order to discourage generators from producing more. A negative price means that consumers are being paid to use electricity, and generators are being fined for production. Everything is upside-down from how a market for a valuable commodity should work.

Nonetheless, generators do actually pay money to produce power (rather than getting paid for it) in these circumstances. Production subsidies for renewables provide revenues to wind and solar generators that are larger than the fines from the market, ensuring that those facilities continue producing even when there is no place for the power to go. This is not uncommon: in 2017, California’s wholesale market experienced negative prices 10 percent of the time.[5] However, as in the figure above, prices were not negative everywhere; it was a local phenomenon. At the same time that some generators were being fined for producing, other generators were earning substantial revenues to serve local demand. The inability to connect renewable generators with population centers means that consumers in cities are paying higher prices while renewables generators are paying to produce power. This is not a problem that additional subsidies to renewable generators can fix.

In the absence of a national system that produces renewable energy where it is abundant and ships it to where it is needed, state governments have relied on local tools to produce renewable energy within their jurisdictions, largely in the form of renewable portfolio standards (RPS). Recent research has found that this approach indeed increases the share of electricity from renewables, but at great expense.[6] As an example, Massachusetts has one of the highest rooftop solar penetration rates in the country, with nearly 8 percent of its electricity coming from solar after years of aggressive state-level policy.[7] Massachusetts, however, is not terribly sunny. According to the National Renewable Energy Laboratory, the solar panels installed in Massachusetts would have produced over 50 percent more power if they had been installed in the sunnier Southwest. Local governments encouraging the construction of windmills where the wind does not regularly blow, and solar panels where it is cloudy is not a cost-effective way of decarbonizing the grid.

The electrical grid is of central importance in decarbonizing the economy. Though electricity generation is responsible for 30 percent of total U.S. carbon emissions, the primary means of decarbonizing the transportation system (which accounts for 30 percent of emissions), industrial processes (20 percent), and residential use (10 percent) is through electrification.[8] Successfully decarbonizing these other emissions sources through electrification depends on two key factors: emissions from the grid, and the price of electricity.

First, electrification only reduces emissions if the grid is green. The environmental benefits of replacing the entire petroleum-based transportation sector with electric vehicles would be substantially undermined if the United States continued to rely on coal and natural gas for large shares of overall power generation. In 2012, reliance on coal for electricity generation meant that environmental damages from charging electric cars were significantly larger than damages from internal combustion engines for all but a handful of congested urban areas.[9] The shift away from coal in subsequent years was sufficiently large

5 California ISO, “Q2 2018 Report on Market Issues and Performance.”

6 Greenstone and Nath, “Do Renewable Portfolio Standards Deliver?,” 2019.

7 EIA, “Electric Power Monthly.”

8 EPA, “Sources of Greenhouse Gas Emissions.”

9 Holland, Mansur, Muller, and Yates, “Are There Environmental Benefits from Driving Electric Vehicles?,” 3700-3729.

that by 2017 electric vehicles were cleaner than internal combustion engines for much of the country.[10] Continued progress on this front requires not only more power from renewable sources, but also the capacity to deliver that power to consumers.

Second, even if the grid becomes completely green, the cost at which this is accomplished will be pivotal for decarbonizing the wider economy. Ultimately the decision to electrify cars, trucks, industrial processes and residential heating is made by households and firms. It is an easier switch to make when it saves consumers money. The cheaper green electricity is relative to the price of gasoline and natural gas, the more electrified other sectors will become. Sourcing renewable power from the places where it is most abundant will allow for lower electricity prices in population centers, and a more deeply decarbonized economy.

How We Got Here

In the early days of electrification, it was important to co-locate generation and users because power diminished quickly with distance when transmitted at the low voltages that were common at the turn of the 20th century. The interface between the industry and government was at the local level: many competing companies with their own wires created a tangled mess of public thoroughfares.

State and municipal governments took on the primary role of regulators when centralized power stations and alternating current became the dominant mode of production and delivery in the decades that followed. The Public Utility Holding Company Act of 1935 solidified this regulatory model, with local, vertically integrated utilities receiving a monopoly franchise to generate and deliver power in exchange for oversight from a public utilities board, which would determine prices based on the costs of producing and distributing power. The dominant form of energy transportation between states was in the form of fuel carried on rail cars and in pipelines. The cost of transporting the fuel meant that it was more expensive to generate power in places far from fuel deposits, but the regulated utility model protected local utilities from being undercut by competing generators that might have generated closer to the energy source, and transmitted the power by wire.

If utilities had no problem buying fuel from out of state, an astute observer might ask why they didn't buy power from out of state if it was cheaper. An important part of the answer lies in the formula that determines how utilities make money. When a regulated utility buys power, or fuel, or labor for that matter, rates are set to simply reimburse it for its expenses. Utilities do not mark up these costs to earn profits. By law, any liabilities they incur from suppliers are paid back at cost by ratepayers. The only thing they can do is break even.

Capital projects are a different story. Public utilities commissions set the price of electricity so that investor-owned utilities cover their costs, and earn what they determine to be a fair return for their investors. For private investors to be willing to invest in building a power plant, for example, they require an interest rate that is competitive with the other potential investment opportunities. This means that when the state regulator approves a $100 million capital project for the utility, it sets the price of electricity so that the utility will earn a competitive return—say, 10 percent, or $10 million per year—to compensate the utility's shareholders for financing the project. If the regulator approves a $1 billion capital project, a 10 percent rate of return earns shareholders $100 million per year in additional revenue from ratepayers. The incentive for shareholders is clear: the larger the capital project, the more profit they are able to reap. The end result is that utilities have strong incentives to generate power themselves with their own capital rather than buy it from someone else.

Early attempts by the federal government to introduce competition in electricity generation in the 1970s fell flat because the local utility was the only real potential customer, and they were not eager to encourage new entrants. The Public Utility Regulatory Policies Act of 1978 mandated that non-utility generators be paid at "avoided cost," (i.e. paid at the rate it would cost them to generate it themselves) but selling power remained a contentious bilateral process between a new producer and a seasoned incumbent that preferred to produce power from its own plants.

10 Holland, Mansur, Muller and Yates, "Policy Consequences of Decline in Air Pollution from Electricity Generation," 244-74.

Siting new transmission lines in existing infrastructure corridors should ease the permitting process.

In the mid 1990s there was a renewed push to restructure the electricity sector. State legislatures around the country considered ways of injecting competition into the sector. Three main types of reforms came from this period: the introduction of retail competition so consumers could choose their provider,[11] the divestiture of power plants to unregulated entities, and the introduction of wholesale electricity markets.

Selling off the power plants helps mute the incentives to build capital projects as described above—utilities become buyers' agents and are no longer actually producing the power sold to consumers.[12] However, this reform was unevenly implemented. California, Illinois, Ohio, Texas, and several northeastern states passed restructuring legislation, but the California electricity crisis of 2000-2001 put an abrupt halt to further initiatives.[13] Vertically integrated, investor-owned utilities remain dominant forces in much of the country.

One reform that did continue in spite of the California crisis was the expansion of wholesale electricity markets, in large part due to leadership from the Federal Energy Regulatory Commission (FERC). With wholesale markets, power plants' operations are determined by competitive bidding in auctions. Local utilities can no longer deny access to the transmission system, or treat their own generation assets preferentially because access to the transmission system is open and run by an independent system operator (ISO). Local utilities are also unable to impede the transmission of power across their service territory, which helps connect low-cost producers and population centers to the extent possible on today's grid. Two-thirds of U.S. generation is now determined by these competitive auction mechanisms. Recent work has found these market-based rules for determining which power plants operate has reduced generation costs by $3-5 billion per year.[14]

Reforming incentives in the U.S. electricity sector has therefore been incomplete, both geographically and along the supply chain. The southeast and much of the west of the country operate in the same manner as they have for about eighty years. Where markets exist in the country's interior, most local utilities continue to own generation based on rate of return regulation. And while wholesale markets have reformed how the transmission system is operated, it has not systematically introduced market incentives to the construction of the transmission system itself.

While the process for securing access to the grid and selling power competitively has become somewhat easier, the incentives that guide the development of the transmission system itself are still a vestige of the old days of locally regulated utilities. Even in areas with wholesale electricity markets, the market stakeholders who help set priorities for capital projects, including new transmission lines, are incumbent

11 Retail choice largely provides consumers with alternative billing structures, or secures renewable energy credits to cover consumption. These are financial arrangements outside of the day-to-day operations of the grid.

12 Cicala, "When Does Regulation Distort Costs?"

13 Wolak, "Diagnosing the California Electricity Crisis."

14 Cicala, "Imperfect Markets vs Imperfect Regulation in U.S. Electricity Generation."

generators and utilities. New entrants hoping to link generation and demand centers with transmission find themselves literally and figuratively in someone else's backyard, and playing by their rules. It's as though regulators opened up the back roads on the grid while simultaneously ensuring that a highway was never built. The Midcontinent ISO, which covers the nation's interior and 16 percent of generation capacity, estimates that congestion on its grid cost it $1.5 billion per year from 2016-18.[15] Because increased generation from renewables is like putting more cars on the road, these costs will rise substantially as demand for transmission grows.

The current process for building transmission lines is rife with opportunities for parochial interests and anti-competitive forces to block construction. The decade-long debacle to connect wind generators in Oklahoma and Kansas to population centers in the East is a cautionary tale.[16] Although this is an inter-state project, the leading role state regulators have historically played in the electricity sector means that any individual state can effectively veto the project. Each state has a century of regulatory procedure on the books that defends its local utilities from outside competition. Arkansas law, for example, requires the owner of the proposed project to be a utility, explicitly preventing non-utility entrants from gaining permits. Years of rejections and appeals over similar issues in Missouri have finally been settled, only to begin anew in Illinois. These hurdles ensure that prices remain high for consumers and keep prospective investors from delivering cheaper power.

Policy Recommendations

Even without jurisdictional fights, transmission line construction and the use of eminent domain in particular is a topic that often inspires fierce opposition from local landowners, businesses, and residents alike. A prospectively fruitful approach for the Biden administration would be to pursue two complementary approaches in tandem: one is a hammer, the other is a feather. The hammer is to assert FERC's primary role in transmission permitting to ease obstacles at the state level. The feather is to encourage the upgrading and re-use of existing rights of way to develop a nationwide high voltage direct current grid. Reserving the right to use the hammer is likely to make prospective opponents more amenable to the lighter touch.

THE HAMMER

Make FERC the primary venue for transmission project permitting, as it already is for oil and gas pipelines.

The federal government has been the primary permitting venue for interstate oil and gas pipelines since the Natural Gas Act of 1938. The process relies heavily on contracts between proposed buyers and sellers to demonstrate the need for new capacity—essentially a market test for economic viability to determine whether the project is in the public interest. This market test, combined with an environmental impact review and siting work, addresses all of the major roadblocks for potential projects in a single forum at the federal level. This streamlined process has enabled private investments to expand the U.S. network with about one thousand miles of new pipeline per year over the last two decades, and an additional one thousand miles per year of pipeline upgrades and conversions.[17]

The regulatory structure for oil and gas pipelines provides a template that could be adopted for electricity transmission—it is only by historical accident that they are treated differently. The current process for transmission permitting gives state (and even county) authorities veto power over electricity transmission projects. Legislation that consolidates FERC's permitting authority for energy transportation across modes of transit would remove this problem. This approach is a hammer because legislation is difficult to pass and it requires the assertion of the federal government's primacy over a question that has historically been handled by states.

Empowering FERC is not conditional upon new legislation, however. The Biden administration could instead use authority created under the Energy Policy Act of 2005 to designate National Interest Electric Transmission Corridors (NIETC). Under this Act, the Department of Energy (DOE) conducts transmission congestion studies every three years. The DOE is authorized to designate areas as NIETC based on the results of these studies, which enhances the federal government's role in the permitting process.

Once the DOE designates a new transmission corridor between wind and solar resources and population centers, states would have one year to consider permit requests at the state level before FERC would be empowered to take over permitting. This is a potentially weaker route than new legislation because a 2009 decision determined that the language of Section 216 of the Federal Power Act does not allow FERC to overrule a state permitting rejection—it only applies when states fail to act on a permitting request.[18] There is nonetheless room for FERC to assert its authority, even though it has been largely reluctant to take the lead to date.

THE FEATHER

Encourage the use of existing rights of way for new high-voltage transmission lines.

Even a streamlined permitting process runs into the unavoidable fact that virtually no one wants a transmission line in their backyard. Instead of fighting to use eminent domain to secure easements from unwilling property owners, the federal government may also use the Federal-Aid Highway Program to encourage creative use of existing rights of way such as waterways, railroads, and highways. Examples of this approach include the Cross Sound Cable, which connects Long Island, New York and New England with a high-voltage, direct current submarine cable, and the Neptune Cable, which similarly connects Long Island and New Jersey. Following in this approach is the Champlain Hudson Power Express, which if built, would connect hydropower from Quebec to New York City with a high-voltage direct current line that would run down the bed of Lake Champlain, along railroad tracks, and then down the bed of the Hudson River. In other words, by using land that has already been designated for public infrastructure use, the amount of new land required to build this line is minimized. Construction is set to begin in 2021.

The United States has nearly endless existing rights of way that could be utilized in a similar fashion. The Eastern

15 Potomac Economics, "2018 State of the Market report," Figure A83.

16 This story is detailed in Gold, *Superpower.*

17 EIA, "U.S. Natural Gas Pipeline Projects".

18 Piedmont Environmental Council v. FERC. 558 F.3d 304 (4th Cir. 2009).

FURTHER READING

National Electric Grid

Imperfect Markets versus Imperfect Regulation in U.S. Electricity Generation

American Economic Review (Conditionally accepted)

Natural experiment using the U.S. electricity system shows regions using a market approach save about $3 billion a year.

When Does Regulation Distort Costs? Lessons from Fuel Procurement in U.S. Electricity Generation

American Economic Review

When do competitive markets drive costs down? Study uses electricity market deregulation to find out.

seaboard could be connected via undersea cables that provide grid access to wind turbines sufficiently offshore as to be beyond the horizon from the shoreline. These paths are both out of sight, and under federal jurisdiction. In addition to rivers, there are highways, railroad beds, and pipelines already running from east to west. While these existing rights of way are generally not under federal jurisdiction, the Federal-Aid Highway Program provides the lion's share of funding for the maintenance of the nation's surface transportation network. Expanding the permitted usage of these existing rights of way to include transmission lines would greatly simplify the siting process. The federal government can encourage this process by either supplementing existing funding, or making some funding conditional upon expedited permitting in these corridors.

Upgrading existing transmission lines is another potentially low-resistance means of expanding renewable generation's access to markets. This would appear to be a no-brainer, so it is unclear why it has not already happened. FERC and the Federal Trade Commission should conduct a close examination of the incentives facing existing transmission line owners and ISOs to determine whether market power concerns, perverse regulatory designs and/or across-state issues are impeding transmission upgrades and, if so, to recommend or implement policy changes.

FERC rulemaking has played a central role in the creation of wholesale electricity markets, and continues to guide their refinement. In recent years, this has focused on the design of capacity markets, which are payments to generation owners to cover the fixed costs of keeping power plants open and ensure sufficient capacity to meet peak demand. What is missing is a longer-term view toward what the grid itself should look like. Guidance from FERC can ensure that wholesale markets establish market-based practices that are transparent and promote competition in the expansion of the nation's electrical grid.

Closing Argument

Every economist knows that demand curves slope downwards: if a good is more expensive, people will buy less of it. It is expensive to generate solar power in cloudy places. Doing so means less renewable energy, no matter how noble the intentions behind such initiatives. More expensive power means less electrification of transportation. And the more expensive it is to reduce greenhouse gas emissions, the more Americans will continue to pollute. Costs matter.

One of the cheapest things the government can do to encourage the growth of renewables generation is remove the regulatory obstacles that prevent generators from delivering power to consumers. Decarbonizing the grid will be hard enough. The least the Biden administration can do is not make it harder.

REFERENCES

California ISO, Department of Market Monitoring. "Q2 2018 Report on Market Issues and Performance." (August 20, 2018). http://www.caiso.com/Documents/2018SecondQuarterReportonMarketIssuesandPerformance.pdf

Cicala, Steve. "Imperfect Markets versus Imperfect Regulation in U.S. Electricity Generation." National Bureau of Economic Research Working Paper No. 23053 (January 2017).

Cicala, Steve. "When Does Regulation Distort Costs? Lessons from Fuel Procurement in US Electricity Generation." *American Economic Review*, 105, No. 1 (2015): 411-44.

Gold, Russell. *Superpower*. New York: Simon & Schuster, 2019.

Greenstone, Michael, and Ishan Nath. "Do Renewable Portfolio Standards Deliver Cost-Effective Carbon Abatement?" University of Chicago, Becker-Friedman Institute for Economics Working Paper No. 2019-62 (Last revised: November 2019).

Holland, Stephen P., Erin T. Mansur, Nicholas Z. Muller, Andrew J. Yates. "Are There Environmental Benefits from Driving Electric Vehicles? The Importance of Local Factors." *American Economic Review*. 106(12) (December 2016): 3700-3729.

Holland, Stephen P., Mansur, Erin T., Muller, Nicholas Z., Yates, Andrew J. "Decompositions and Policy Consequences of an Extraordinary Decline in Air Pollution from Electricity Generation." *American Economic Journal*: Economic Policy. 12(4) (November 2020): 244-74.

MISO Energy. "Real-Time Displays: LCA Contour Map." Last updated November 25, 2020. https://www.misoenergy.org/markets-and-operations/real-time--market-data/real-time-displays/

Piedmont Environmental Council v. FERC. 558 F.3d 304 (4th Cir. 2009).

Potomac Economics. "2018 State of the Market report for the MISO Electricity Market, Analytic Appendix." (July 2019): Figure A83. https://www.potomaceconomics.com/wp-content/uploads/2019/08/2018-SOM-Appendix_Final.pdf

"Lazard's Levelized Cost of Energy Analysis—Version 13.0." Lazard: New York, NY, (November 2019): 20. https://www.lazard.com/media/451086/lazards-levelized-cost-of-energy-version-130-vf.pdf

U.S. Energy Information Administration. Electric Power Monthly (September 2020) Table 1.17.B. https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_1_17_b

———. "U.S. Natural Gas Pipeline Projects." Released November 16, 2020. https://www.eia.gov/naturalgas/pipelines/EIA-NaturalGasPipelineProjects.xlsx

U.S. Environmental Protection Agency. Greenhouse Gas Emissions: Sources of Greenhouse Gas Emissions (2018). https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

Wolak, Frank. "Diagnosing the California Electricity Crisis." *The Electricity Journal* 16, No. 7: 11-37.