A Comparative Analysis of RTOs' Integration of Wind Energy + Transmission: ERCOT and MISO

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List of Acronyms

CCN Certificate of Convenience and Necessity

CREZ Competitive Renewable Energy Zones

DOE U.S. Department of Energy

EPACT The Energy Policy Act of 1992

ERCOT Electric Reliability Council of Texas

FERC Federal Energy Regulatory Commission

FPA The Federal Power Act of 1935

GHG Greenhouse Gas

GW Gigawatt

IOU Investor-Owned Utility

IPP Independent Power Producer

ISO Independent System Operator

MISO Midwest Independent System Operator

MVP Multi-Value Projects

MW Megawatt

MWh Megawatt-hour

NIMBY Not-In-My-Backyard

PUC Public Utility Commission

PUCT Public Utility Commission of Texas

PUHCA The Public Utility Holding Company Act

PURPA The Public Utility Regulatory Policy Act of 1978

RE Renewable Energy

RPS Renewable Portfolio Standard

RTO Regional Transmission Organization

SP Stranded Power

VIU Vertically Integrated Utility

VRE Variable Renewable Energy

Table of Contents

Abstract

Wind energy generation has grown considerably in the United States over the past few decades but has faced several challenges integrating into the electricity grid. While a number of states have implemented renewable portfolio standards (RPS) and other policies as a means to reduce greenhouse gas emissions (GHG), the need for transmission infrastructure to accommodate new generation has not received adequate policy and market incentives. Transmission is critical for deep penetration of renewable energy and bringing zero-carbon electricity to customers for use. This paper focuses on the role regional transmission organizations (RTO), specifically the Midwest Independent System Operator (MISO) and the Electric Reliability Council of Texas (ERCOT), play in providing support schemes to connect wind energy to the electricity grid. Building on existing literature, I employ a qualitative analysis to uncover what political, social, and financial conditions in the RTO framework are most conducive to promoting wind energy with transmission. My results indicate that, in a wholesale electricity market encompassing multiple states, like in MISO, institutional constraints hinder a rapid buildout of transmission infrastructure. On the other hand, Texas, with its relatively insulated social, political, and financial contexts, was able to promote an earlier, more efficient buildout of its transmission infrastructure to accommodate wind generation. Unified control over transmission planning seems to be the most effective way to encourage renewable energy expansion.

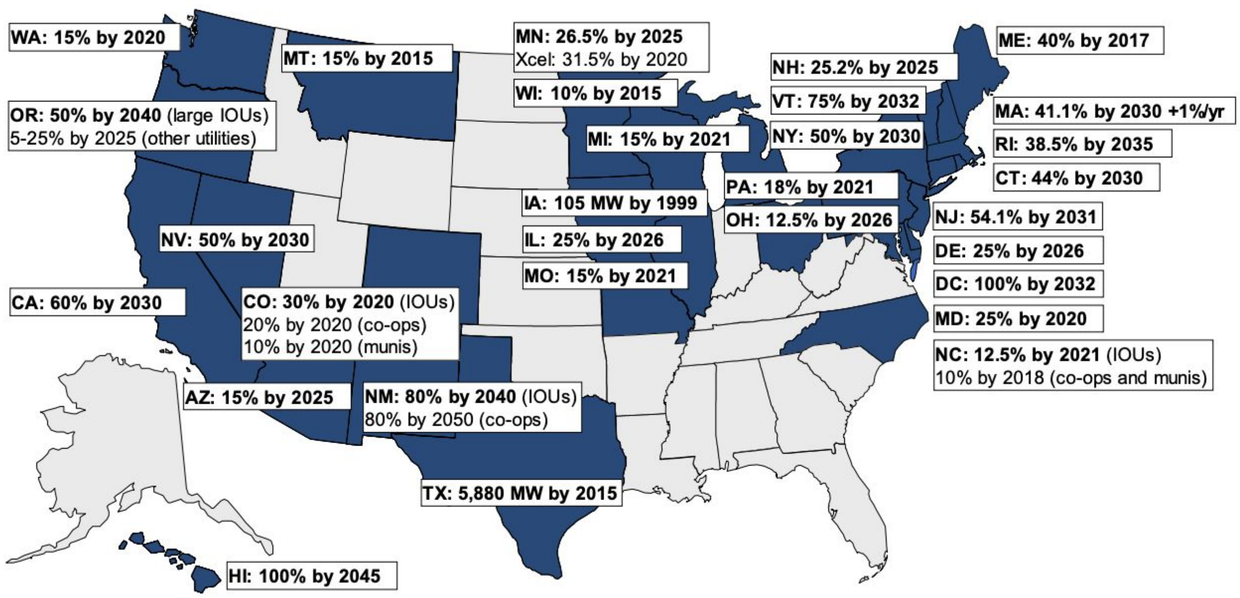
Introduction

The development of large-scale renewable energy (RE) generation plants has long been sought as a means to combat climate change. Since the dawn of the Industrial Revolution in the 18th-century, fossil fuels—oil, coal, and natural gas—have been used to power our electricity, transportation, and industry sectors. In addition to agriculture and land-use changes, non-renewable energy sources are the main contributor to GHG emissions and our current global climate crisis. RE, which sources energy from natural and replenishable processes like wind, solar, and hydro, has the potential to replace traditional fossil fuels if given adequate regulatory and market incentives. In the United States, efforts to deploy RE to battle climate change have been historically fragmented and unsuccessful. As of 2020, there remains no comprehensive national plan to reduce GHG emissions, but rather piecemeal policies, like the since-overturned Obama-era Clean Power Plan, and federal subsidies, which lack longevity. The federal production tax credit (PTC) and investment tax credit (ITC), which provide subsidies for renewables on a $/MWh basis, have been the most influential federal financial support mechanisms for RE, but are set to expire in the coming years.

In response to the lack of meaningful progress on the federal level, individual states have implemented their own policies and incentives. These include but are not limited to renewable portfolio standards, rebates, subsidies, standalone legislation, executive orders, carbon taxes, and cap-and-trade programs. RPS, which require that a specified percentage of the electricity that utilities sell comes from renewable sources, are by far the most popular, with 29 states and the District of Columbia having such standards in place as of 2020 (see Figure 1). Particularly following the United States' withdrawal from the 2016 Paris Accord, an non-binding international commitment aiming to keep global temperature increases below 2°C, state policies like RPS have proliferated in the 21st-century. RPS have been critical to reducing the carbon footprint of the United States. The electricity sector, which encompasses the energy used by commercial and residential buildings, is the most carbon-intensive sector of our economy and contributes 40 percent of the United States' GHG emissions. Comparatively, the transportation and industrial sectors each contribute 30 percent of the nation's GHG emissions. Not only will decarbonizing the electricity sector have the most significant effects, but once technology advances to electrify our transportation and industrial sectors, virtually all of our nation's economic sectors can become carbon-free.

Wind, solar, and hydropower are among the fastest-growing renewable energy sources in America. In 2018, wind constituted 21 percent—7,588 MW—of all new capacity additions. Solar and natural gas were the only other sources to achieve similar rates of growth (Wiser and Bolinger 2019). In the interior region spanning from North Dakota to Texas, wind energy's incredible potential has been recognized. As indicated in Figure 7, the majority of new renewable capacity in this area comprises wind energy. Despite its impressive growth, which has been primarily driven by state policies, wind energy continues to face challenges, particularly with transmission. While the aforementioned state policies target growth in wind generation, transmission upgrades—wires that carry electricity from generating source to substations for distribution to end-use customers—have not received adequate attention. While RPS and wind mandates have incentivized investments in new farms, in many areas, these projects have been canceled due to lack of sufficient transmission. Gardner and Lehr (2013) identify the lack of cost-effective transmission as "the single greatest impediment to the rapid development of utility-scale renewable energy in the United States" (p.248).

Figure 1. State Renewable Portfolio Standards



Source: "2018 Wind Technologies Market Report"

Much of the United States transmission system falls under the jurisdiction of regional transmission organizations (RTO) and independent system operators (ISO). These non-profit entities coordinate, control, and monitor two-thirds of the nation's electric grid. In the Midwest, the two main transmission organizations include the Midwest Independent System Operator (MISO) and the Electric Reliability Council of Texas (ERCOT). Given the interior region's wind potential, MISO and ERCOT have done much to integrate wind with transmission upgrades. ERCOT has been much more successful on this front, experiencing an earlier, more rapid development of wind energy with transmission. Given both ERCOT and MISO's comparable potential, their discrepancies in integrating wind with transmission require a comparative analysis to uncover the most productive ways to promote renewable energy. In the remainder of this paper, I analyze how ERCOT and MISO have differed in their political and financial frameworks to integrate wind energy and transmission. First, I provide a background on the energy industry to outline how RTOs came about and their responsibilities for managing the grid. Next, I contextualize the region's transmission system, highlighting the benefits of and the barriers to achieving an adequate electricity grid. Following this, I conduct a quantitative comparative analysis of the different methods ERCOT and MISO have used to ramp up VE generation with transmission. I conclude with a discussion and suggestions for the future of America's electricity industry.

Evolution of the Electricity Industry

The traditional structure of the nation's electricity system consisted of investor-owned, vertically integrated utilities. These entities owned and controlled the entirety of the electricity process: generation, transmission, and distribution. Investor-owned utilities (IOU) served customers exclusively within their state and were regulated by the state's public utility commission (PUC) (Tuttle et al. 2016). By the early 1900s, IOUs were granted monopoly status with the concession that they provide reliable and cheap electricity, as well as nondiscriminatory access to customers within a determined geographical area. Power prices were regulated by a state's PUC and generally considered to be low cost (Blumsack 2006). As electric power companies grew and crossed state lines, the industry recognized the need for federal regulation. The 1927 *Public Utility Commission of Rhode Island v Attleboro Steam & Electric Company* Supreme Court decision determined that electricity was an interstate commodity and should be subject to both state and federal regulations (Gardner and Lehr 2013). After years of increasing consolidation in the energy industry, growing sentiments against the anti-competitive nature of the industry and rising energy prices in America motivated regulatory changes. Subsequently, several landmark federal legislation targeted the prevailing monopoly structure and encouraged energy sovereignty. I briefly outline these mandates in the remainder of this section.

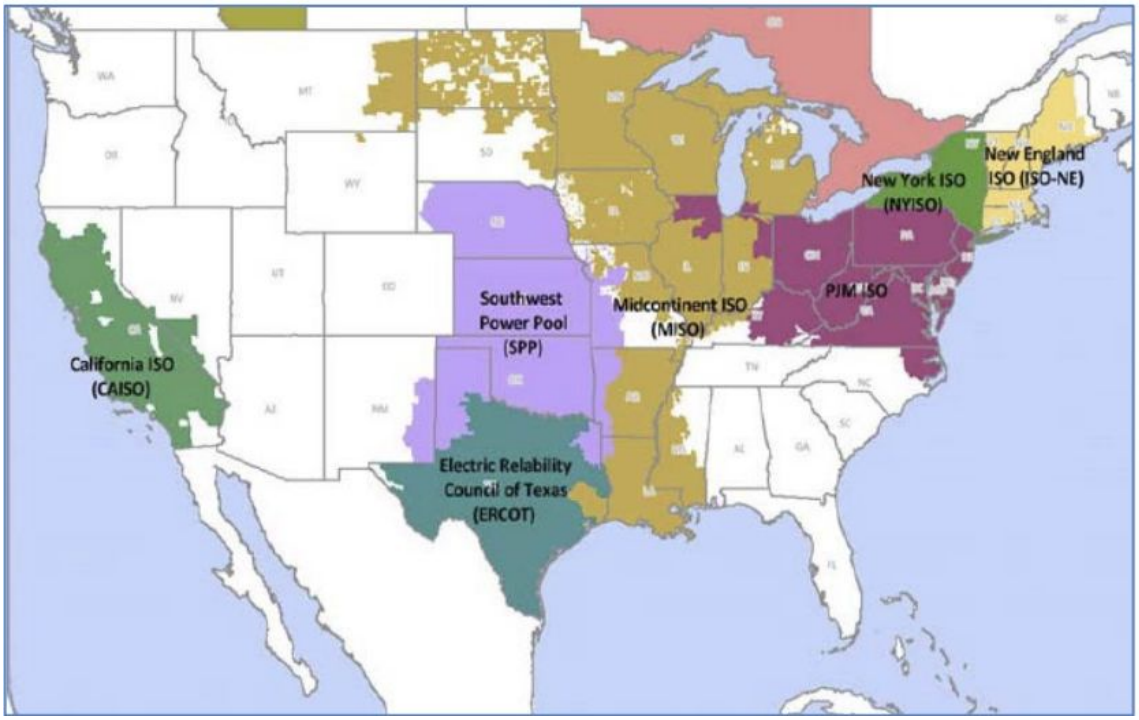
The Public Utility Holding Company Act (PUHCA) and the Federal Power Act of 1935 limited the scope of state utility companies and gave the Federal Energy Regulatory Commission (FERC) jurisdiction over wholesale pricing and transmissions, respectively (Gardner and Lehr 2013). Following the 1973 Arab Oil Embargo crisis, several policies emerged aiming to achieve American energy independence and lower energy prices through increased market competition in the energy sector (Tuttle et al. 2016). The Public Utility Regulatory Policy Act (PURPA) of 1978 required monopoly utilities to buy power from independent generators. The Energy Policy Act (EPACT) of 1992 strengthened PURPA by mandating that utilities open their transmission cables to these independent generators. Several FERC orders implement the provisions outlined in EPACT. In 1996, FERC Orders 888 and 889 required existing transmission systems to guarantee "open access" to third party power producers. In addition to allowing independent power producers (IPP) access to the grid, Order 888 promoted the concept of independent system operators (ISO), which would come to independently operate the transmission grid and foster competition among wholesale market participants (Gardner and Lehr 2013). Following FERC Order 888, Order 2000 established regional transmission operators (RTO). Similarly to ISOs, RTOs would come to maintain functional control rather than ownership of transmissions systems, ensuring electricity reliability and equity. These non-profit entities invited existing utilities to join their organizations, creating wholesale energy markets in which buyers and sellers could bid for or offer generation (FERC Office of Enforcement 2015). In addition to promoting American energy independence, these orders remedied “undue discrimination in access to the monopoly owned transmission wires that control whether and to whom electricity can be transported in interstate commerce” (FERC Order No. 888 1996). In 2007, due to concerns that the transmission planning process was unfair and discriminatory to customers, FERC Order 890 amended the flaws of Order 888. Order 890 mandated that RTOs include in their open access transmission tariff an appendage outlining how the organization fulfilled nine obligatory principles: “(1) coordination; (2) openness; (3) transparency; (4) information exchange; (5) comparability; (6) dispute resolution; (7) regional participation; (8) economic planning studies; and (9) cost allocation for new projects” (Clark 2013, p.11).

Through decades of restructuring policies, vertically integrated utilities were divided between generation and “wires”—transmission and distribution—companies, a process Sugimoto (2019) refers to as “unbundling.” What were once fully-integrated utilities with aligned interests down the supply chain—from generation to distribution—now consisted of separate companies responsible for different segments of the electricity market. 20th-century restructuring policies were a blow to the existing utility monopoly structure and fostered a competitive market in which energy prices matched buyers’ and sellers’ preferences. Historically, vertically integrated utilities (VIU) had little incentive to incorporate renewable generation technology because such sources competed with their incumbent generation assets (Sugimoto 2019). Following restructuring, and as renewable energy technologies developed, smaller independent renewable generators could compete and offer generation in the wholesale electricity market.

While federal policies encouraged electricity industry restructuring, changes took place on a state-by-state basis. Many states chose not to change their structures or enter regional transmission organizations. Thus, large swaths of the country, particularly in the Southeast and Northwest, remain under the traditional, state-regulated VIU structure. Electricity in these states and regions is generated by integrated investor-owned utilities, federal power producers, and municipally or cooperatively owned utilities and sold directly to retail consumers. However, the majority of electricity capacity—two-thirds of the nation’s load—resides in RTO/ISO-served regions in which the traditional structure has been broken up (FERC Office of Enforcement 2015). Despite this, several utilities in states encompassed by RTOs or ISOs still operate under the vertically-integrated utility model, such as the majority of the Midwest Independent System Operator (Tierney et al. 2015). These utilities remain under FERC jurisdiction and are required to abide by the mandates and orders outlined in this section, like to provide open access on their transmission networks. Currently, RTOs and ISOs are located in California, Texas (The Electric Reliability Council of Texas), New York (NYISO), the Midwest (MISO), New England (ISO New

England), the Southeast (PJM Interconnection and Southwest Power Pool). Figure 2 depicts the geographic boundaries of these organizations. In the remainder of this piece, I use the term RTO to refer to RTOs and ISOs interchangeably.

Fig. 2: Regional Transmission Organizations



Source: "2018 Wind Technologies Market Report 2018"

The Transmission Landscape

Overview

The transmission system is a vast network of infrastructure that transmits electricity from generators to substations for distribution to end-use consumers. In this paper, I use the terms 'transmission system', 'power grid', and 'the grid' interchangeably to refer to the infrastructure and policies used to transmit electricity from generating farms to substations. Transmission infrastructure refers to the various elements—power lines, transformers, circuit breakers—that the transmission system incorporates (Eto et al. 2018). Today, the United States transmission system consists of 150,000 miles of high-voltage lines. The grid is organized into three sections—the Western, Eastern, and Texas Interconnections—that operate independently and are weakly connected by a few direct current conversion links. Within the interconnections lie those aforementioned RTOs (Hoffman et al. 2015). In the remainder of this section, I provide context on the transmission system and its implications for renewable energy integration.

Benefits of Improved Transmission

Adequate transmission upgrades would provide our electricity system with several benefits. Aside from easing the integration of variable renewable energy sources (VRE), transmission upgrades improve the reliability of the entire electric power system by sourcing power from other generating sources when peak loads exceed supply, reducing congestion, giving low-cost power plants access to high-cost power markets, enabling competition among power plants, improving the efficiency of electricity as it flows through transmission infrastructure, and giving electricity customers flexibility to diversify the sources that produce their energy. Several occasions of breakdowns and blackouts—the August 2003 Northeast and Midwest and the September 2011 Pacific Southwest outages—highlight general system weaknesses, independent of the challenges associated with incorporating renewable energy (Gardner and Lehr 2013).

When it comes to VRE, transmission plays a central role in providing customers with low-carbon fuel sources to customers. Previous literature has long recognized the necessity for large-scale transmission buildout to accommodate the influx of renewable technologies mandated by state policies. Insofar as state and federal policymaking are concerned, while the urgency for new utility-scale renewable generating sources has been recognized in many parts of the country, a corresponding imperative for new transmission infrastructure has not received adequate attention. Improved transmission access improves the feasibility and reduces the costs of state policy objectives, like RPS. Even when renewable generation sources exist, the lack of adequate transmission cables leads to congestion, which occurs when insufficient transmission capacity exists to move electricity from source to customer. While wind and solar farms may be in place to effectively capture energy, energy users cannot utilize renewably generated electricity in a congested grid. In many circumstances, congestion leads to curtailment—a reduction in the output of the energy generator. Thus, the zero-carbon energy capacity constructed to combat climate change essentially becomes unused and wasted (Pfeifenberger 2016). Numerous instances over the past two decades in which plans to develop wind farms were canceled due to lack of transmission infrastructure highlight the inadequacy of incumbent transmission infrastructure. If America were to address these weaknesses by investing more in its transmission system, states could more easily implement and achieve their RPS goals and expand renewable energy.

<u>Barriers to Developing an Adequate, Cost-Effective Transmission System for Wind Energy</u>

The geographic regions that encompass the majority of America's wind potential are typically incompatible with existing transmission infrastructure. Located in more remote areas of the country, wind energy resources lack easy access to the electricity grid, which was constructed by and for VIU generators. Unlike conventional fossil fuel plants, the fuel for which is provided on-spot and transformed into energy in propinquity to existing transmission loads, wind and solar generation require high-cost transmission infrastructure to bring energy from high potential regions to load centers (Gardner and Lehr 2013).

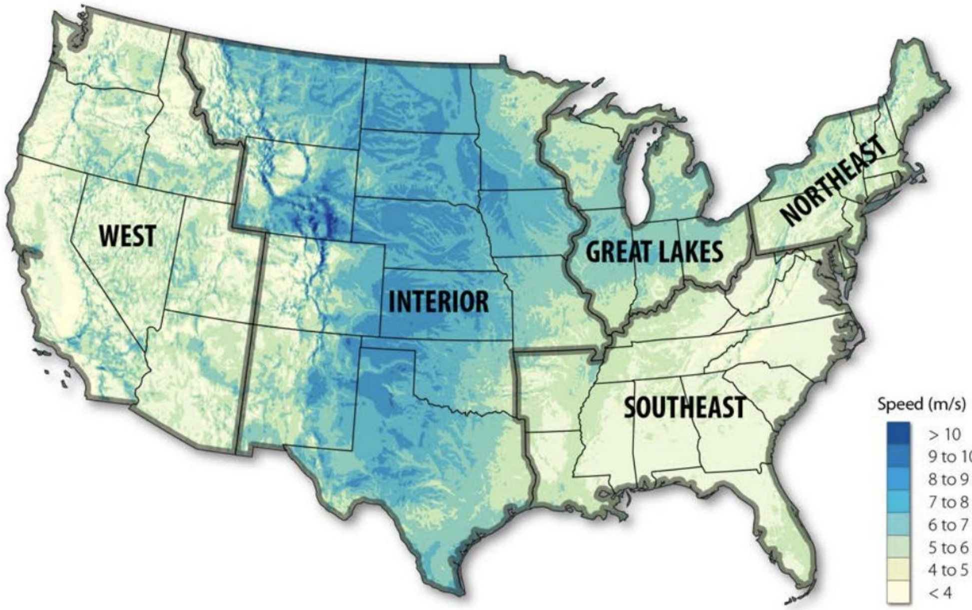
Adding electric transmission capacity is extremely costly, especially when taking into account the location constraints of wind energy potential. The common conundrum of VRE development re transmission is often referred to as the 'chicken and egg' problem. While wind farms can be developed relatively quickly, transmission lines take longer periods of time to surpass land acquisition, permitting, and construction impediments. Oftentimes, the number of federal, state, and local authorities in charge of approving the various elements of transmission planning, construction, operation, and finance work to slow the development of transmission upgrades. Furthermore, while the benefits of transmission projects are often regional, the states and localities through which transmission traverses often incur significant costs. As a result, developers and financiers of wind farms are unwilling to build new generation projects unless they are certain that adequate transmission infrastructure will accommodate them. Additionally, even when sufficient funding is available to develop the infrastructure, the inefficient and complicated nature transmission project approval at the various local, county, state, and federal levels serves to hinder their development (Grace et al. 2018).

Another barrier to upgrading the transmission system to accommodate wind energy includes the inherent variability of VRE generation. As the availability of wind power depends on weather conditions, electric system operators face complexity and uncertainty in balancing generation and demand. For example, when winds are not blowing, system operators must quickly adapt to draw generation from other generation sources, which typically comprises high-carbon fossil fuels. On the other extreme, when winds are constantly blowing, operators must deal with curtailing these generating sources. If system operators cannot accommodate these changes, power outages can occur. Ultimately, the variability associated with VRE increases the demands and costs placed on system operators. To the extent that operators can control and manage such fluctuations, variability remains a barrier for transmission systems in incorporating wind energy (Gardner and Lehr 2013). One way states have dealt with variability is through expanding battery storage capacity. While batteries can alleviate the variability issue, existing technology is expensive and cannot store energy for longer than a few hours at a time. More investment in battery research and development is needed to advance these technologies to sufficiently benefit renewable energy usage.

Role of RTOs

The geographical extent of America's regional transmission organizations highlights their profound role in and influence over the future of America's transmission infrastructure upgrades, as well as our overall renewable energy transition. In addition to their designated responsibilities of operating the grid to ensure reliability and balance supply and demand, RTOs plan transmission expansion, conduct interconnection feasibility studies, and issue interconnection agreements for renewables projects (FERC Office of Enforcement 2015; Sugimoto 2019). According to Kirby and Mulligan (2008), compared to non-restructured, non-RTO electricity markets in the Northwest and Southeast, RTOs' inherently foster an ideal environment for wind energy. Several structural factors, like their temporally narrow balancing market, broad geographic control, and flexible generation sources provide RTOs with the agency to incorporate wind energy into the grid. Sugimoto (2019) provides tangible evidence for this supposition: following 1996 restructuring measures, as of 2016, un-bundled states have seen greater wind energy penetration than non-unbundled states. Aside from the structural factors that promote VRE integration in RTOs, the meteorological conditions in these regions are the main driver behind wind energy. Particularly in the Midwest region—spanning from North Dakota to Texas—wind-rich areas have provided an ideal location for the development of many utility-scale farms (Figure 3). In fact, the top seven states with the most wind generation are in RTO markets (Pfeifenberger 2016). Given their copious wind resources, as well as influence over transmission, regional transmission organizations have the power to dictate the future upgrades of America's wind resources and accommodating transmission infrastructure.

Fig. 3: Wind Potential in the United States



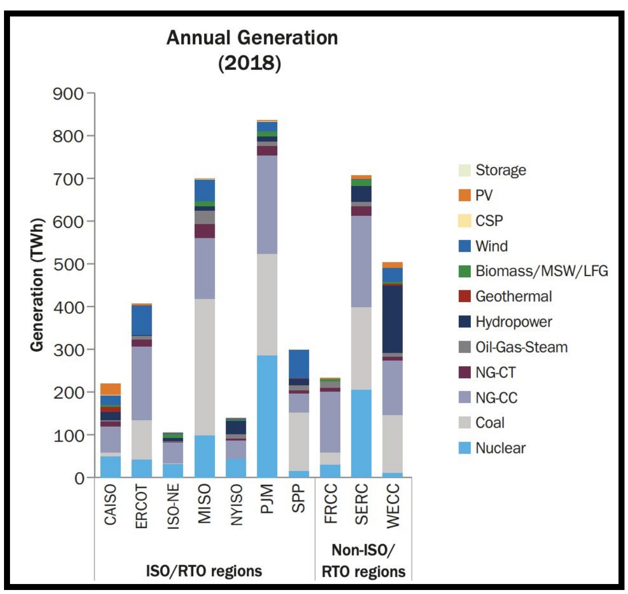
Source: "2018 Wind Technologies Market Report

MISO and ERCOT

Overview

ERCOT is contained entirely within Texas and represents nearly 90 percent of the state's load (Bade 2019). MISO manages the electric grid in all or most of Arkansas, Illinois, Indiana, Iowa, Kentucky, Louisiana, Michigan, Minnesota, Mississippi, Missouri, Montana, North Dakota, Ohio, South Dakota, Wisconsin, and Manitoba, Canada (American Public Power Association 2017). The geographic extent of MISO coverage makes the organization the largest grid operator in the U.S. and the second-largest RTO in the U.S. in terms of electrical load (Tierney et al. 2015). As discussed in the previous section, the interior region of the United States presents massive wind potential. Despite this, the region largely relies on traditional fossil fuels for energy generation. Figure 4 below highlights the makeup of the energy portfolio in different RTOs. While wind has grown considerably in ERCOT and MISO, it remains only a small contributor to electricity generation. In the following subsections, I highlight how these RTOs have dealt with the aforementioned challenges associated with wind and transmission, including pricing, cost allocation, location, governance structure, and variability. The different responses by ERCOT and MISO highlight their relative strengths and weaknesses. Following this section, I present the outcomes of these different responses, which indicate that Texas has been more successful than MISO in promoting wind energy with transmission.

Fig 4. Annual Generation Sources in RTOs



Source: Sun et al. 2018

Pricing

The pricing system for electricity in RTOs is relatively complex and varies by organization. RTOs, responsible for keeping the power grid balanced between generation and load, forecast and schedule generation to ensure sufficient power is supplied and distributed. In carrying out this task, RTOs administer auctions for the sale and purchase of electricity in different time frames, including electric energy (near-term—both in day-ahead and real-time purchases), electric power capacity market (long-term—within a frame of several years), and ancillary services (balancing system as electricity moves from generation to retail customers). Prices are set every five minutes and are based on the bids that sellers submit to the RTO, which the organization accepts in ascending order until the last bid needed to supply power in that interval. The price that sellers receive from each bidder is based on the marginal unit, also known as the clearing price.

ERCOT is the sole grid operator to not fall under FERC jurisdiction. Since FERC regulates transmission and wholesale transactions of electricity in interstate commerce, the intrastate nature of ERCOT's market removes it from FERC regulation, as outlined in the Federal Power Act. Thus, unlike other RTOs in which a capacity market operates to plan for peak-demand years in advance, ERCOT's energy-only market allows utilities to pay generators only when they provide power day-to-day (Bade 2019). MISO, however, falls under FERC jurisdiction and operates a capacity market. To ensure sufficient generation, MISO locks in prices for electricity one year before it is needed (Hoffman 2015). Industry experts and economists debate the long-term feasibility of each market structure, as well as which system can best handle the energy transition. As wind and other renewable sources have grown, so has the debate over these markets.

Unlike fossil fuel plants, which require high input costs, renewable sources have zero marginal operational costs. While this sounds appealing at first, its questionable long-term implications for the energy industry paint a different picture and highlight the weaknesses of existing market structures. In the future, as states expand renewable sources to fulfill their RPS targets, wind and other VRE sources will set the market price for electricity at zero for many parts of the year. Moreover, due to federal subsidies like the PTC and state renewable energy credits (REC), renewable sources can even achieve negative prices. Near-zero and negative electricity prices ultimately amount to the same thing, however, and have negative implications for fossil fuel generators which cannot earn resource rents when prices are set to zero. If a fossil fuel plant cannot acquire revenue higher than its long-run average costs, the plant was a bad investment and will eventually shut down. The capacity versus energy-only market debate is centered around the pricing issue and its implications for inducing investments in future capacity.

In ERCOT's energy-only market, there is no upper cap on how high electricity prices can go. For example, if wind comprises the majority of capacity, setting prices at zero for most of the year, a fossil fuel plant may only run for 5 percent of the year and cost $4,000/MWh. Since there is no price cap, a fossil fuel plant can earn resource rents and cover its capital and input costs in a short period of time, remaining economically viable. In MISO's capacity market, however, there is an upper cap on how high prices can go. If fossil fuel plants are called on for only a small fraction of the year, prices may not rise high enough to recover their capital and input costs. This is known as the "missing money problem"—for markets that cap electricity prices, plants cannot earn sufficient resource rents. This problem is exacerbated in the long-run. Capacity markets, aiming to ensure reliability, provide generators with an additional revenue stream to generate electricity during periods of peak demand a year in advance, regardless of whether they are ultimately called upon to generate (DOE 2018). This may signal to developers that new plants are an attractive investment, leading to overdevelopment. This inefficiency of the capacity market has been observed in MISO and PJM, which have experienced an overdevelopment of natural gas plants in recent years. Proponents of Texas' model point to these flaws in the capacity market and argue that energy-only markets encourage just the right amount of new power plant development.

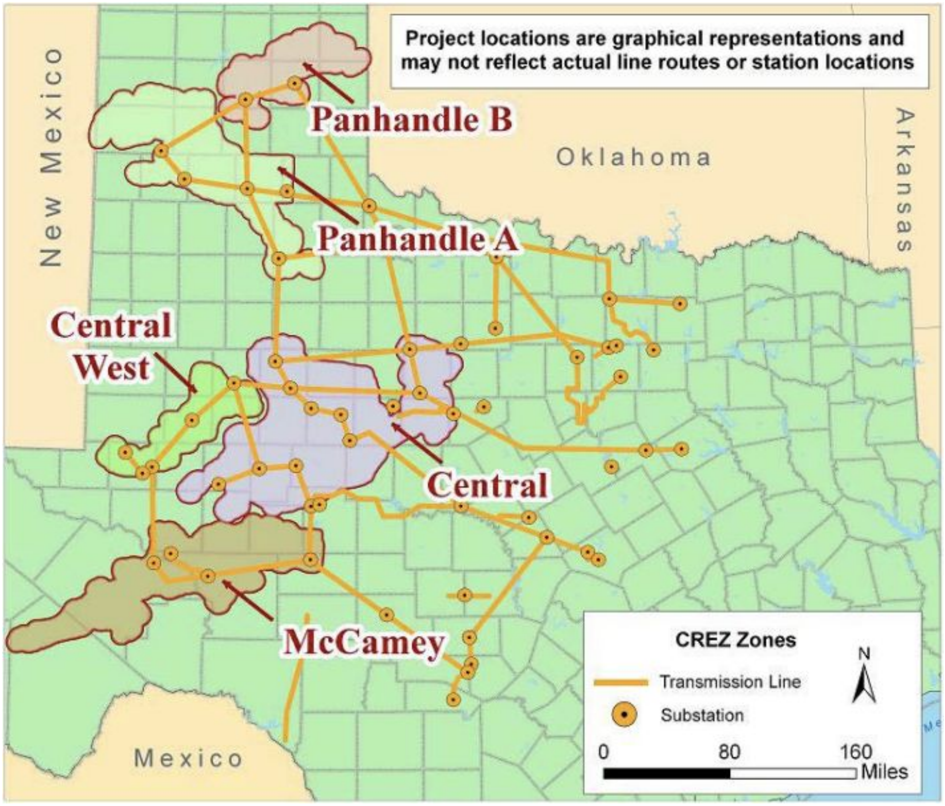
On the other hand, proponents of MISO's system argue that the guaranteed revenue for plant developers in a capacity market is attractive for plant developers, encouraging investments in plants, while the lack of guaranteed revenue from the energy-only model discourages future investments (Fremeth and Marcus 2016). These proponents ignore the inefficiency problems that result from the capacity market, as well as the "missing money problem." In the short-term, concerns over potential capacity problems in Texas' energy-only market have been pacified, as the ERCOT grid has sustained record-breaking levels of demand while keeping reserve margins low. In August 2018, a period of hot weather, high electricity demand, and low wind generation drove the Texas grid to its limits. While some anticipated this period would bring the entire grid down, demand response kicked in, fossil fuel plants were turned on to meet demand, and prices exceeded $9,000/MWh (FERC Office of Energy Policy and Innovation 2020). Without over-developing fossil fuel plants, Texas was able to provide sufficient generation with accommodating transmission infrastructure in a time of record-breaking demand. The absence of a price cap has also allowed fossil fuel plants to recover their costs and earn sufficient rents to remain economically viable. All the while, ERCOT has maintained among the lowest reserve margins in the country, meaning that it has very little unused electric generating capacity during times of peak demand (EIA 2019). Compared to MISO and PJM with reserve margins around 20 percent, ERCOT's 2019 reserve margin was 8.5 percent (FERC Office of Energy Policy and Innovation 2020). This is not to say that the Texas grid will never fail. In the short-term, reserve margins have remained low while ensuring sufficient capacity.

Ultimately, industry experts and economists remain concerned about the future of both systems as states implement their RPS goals and renewables approach high saturation levels throughout the country. In the next few decades, if states are successful in achieving their energy goals, renewables could generate over 70 percent of electricity. This would mean that, for over 70 percent of the year, renewables set the marginal price for electricity at zero. The reality is that while both systems may be sustainable in the short-term, the auction mechanism for providing electricity may not be feasible in the long-term. For now, the energy-only model may be more efficient and sufficient to meet demand. In the future, a new system for pricing electricity may be required to benefit all generators. Potential alternatives like a subscription-based system have been floated by some economists and industry experts, but are not realistic in the near-term.

Cost Allocation Methods for New Transmission

Texas began planning for VRE integration and its accommodating transmission infrastructure relatively early compared to the rest of the country. One way Texas sought to promote transmission upgrades to accommodate wind energy was through the 2005 Senate Bill 20, which created Competitive Renewable Energy Zones (CREZ). CREZs were designed to address the existing problem of too many wind farms without sufficient transmission infrastructure to deliver their energy. The bill gave the Public Utilities Commission of Texas (PUCT) oversight of Competitive Renewable Energy Zones; the Commission designates CREZs, selects its transmission providers, and reports back to the legislature (Diffen and Smith 202). At the same time, ERCOT began to engage with wind mapping company AWS True Wind to perform an analysis of wind resources throughout the state. AWS presented 25 regions, all located in the Panhandle and West Texas, that were most suitable for CREZ wind developments. ERCOT soon realized that these areas would require transmission upgrades and subsequently developed preliminary plans to provide the PUCT with a number of cost and location options to accommodate these zones (Diffen and Smith 2010). In 2007, a PUCT Interim Order designated five Competitive Renewable Energy Zones in the state. The Interim Order also outlined a second study for ERCOT to identify and optimize transmission plans for nearly double the MW output compared to the initial study (Diffen and Smith 204). ERCOT actively worked with various stakeholders to identify the level, type, and cost of transmission upgrades necessary to maintain grid reliability and wind integration. The result of this second study was the identification of nearly 3,600-miles of new transmission capacity, worth nearly $6.5 billion, with 19,000 MW of capacity to transmit abundant wind resources (Tsai and Gürcan 2017). The costs of these new transmission lines would be paid for evenly by all ratepayers. Figure 5 outlines the location of the planned transmission projects under CREZ.

Fig. 5: CREZ Transmission Plan Projects

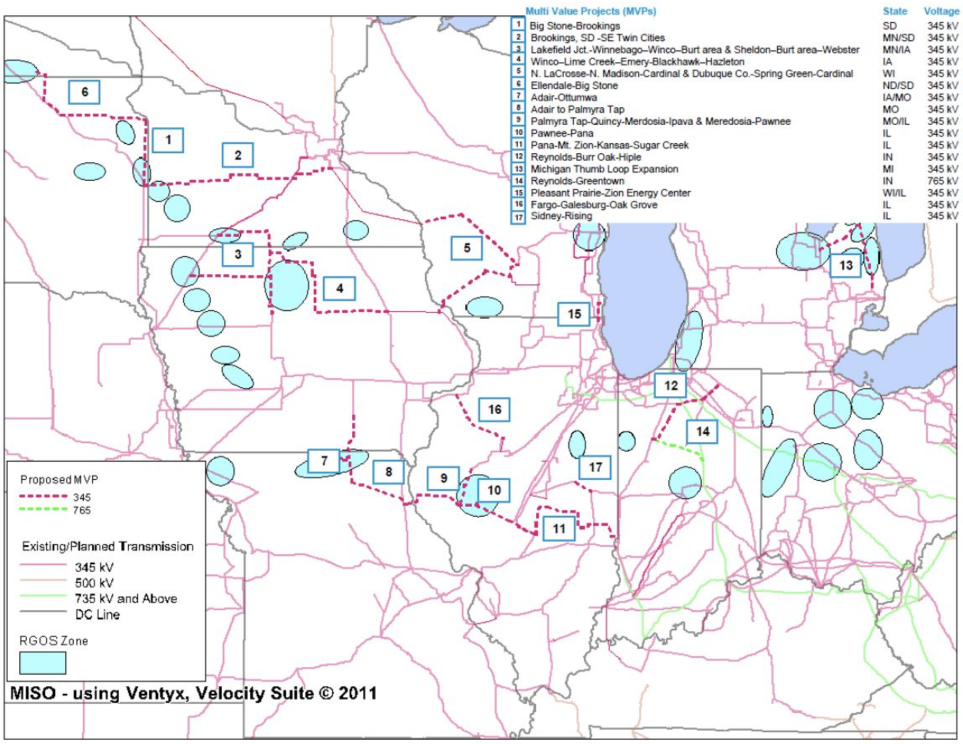


Source: Fink et al. 2018

In compliance with FERC Order 890, MISO developed a transmission plan to abide by the principles for a regional process that is "open, transparent, coordinated, and equitable" (Clark 2013, p.15). Accordingly, to accommodate a number of MISO states with RPS, MISO developed a cost allocation method for regional transmission projects called "multi-value projects" (MVP). This approach identified transmission projects that "support reliability, economic efficiency and policy goals of the states and which provide broad benefits to the region" (Tierney et al. 2015, p.38). MISO began to implement multi-value projects in 2011—several years later than CREZ in ERCOT. Following the 2010 FERC approval of MISO's MVP plan, the organization released its MISO Transmission Expansion Plan (MTEP). The 2011 MTEP, which is released annually and "identifies solutions to meet transmission needs and create value opportunities over the next decade and beyond," proposed a suite of 11 MVP projects totaling $5.6 billion until 2021, the locations of which are outlined in Figure 6 ("MISO

Transmission Expansion Plan 2011”). If a project qualifies as an MVP, costs are allocated to transmission customers within the MISO region based on a per-MWh electricity usage charge. This “beneficiary pays” method, referred to as “postage-to-stamp load,” implies project costs will be spread among MISO customers based on their amount of electricity used (Clark 2013).

Figure 6: Proposed MVP Portfolio



Source: “MISO Transmission Expansion Plan 2011”

As outlined above, both MISO and ERCOT have developed cost allocation methods to facilitate the development of new transmission facilities. While the Competitive Renewable Energy Zone and Multi-Value Project programs spread costs to ratepayers in their respective regions, the MVP program distributes costs based on energy use while the CREZ program distributes costs evenly. The MVP program was designed to follow FERC Order 1000’s mandate that public utility transmission companies develop a cost allocation method in which “costs are roughly commensurate with benefits” (Clark 2013, p.12). Since ERCOT does not fall under FERC jurisdiction, the state was not required to follow this mandate and chose to distribute costs equally (i.e., socialize) among the organization’s ratepayers. Texas’ earlier adoption of a comprehensive transmission planning program, as well as its decision to socialize costs under CREZ, highlights the state’s preferential attitude toward wind energy. Implicit to the socialized cost structure in the CREZ program is the notion that "the value of new transmission is inherently shared by everyone in a region, as it is the network itself that provides reliable service to all, and that the environmental benefits of adding clean new supplies are enjoyed widely in the region" (Fox-Penner et al. 2014, p. 85-86). The decision to socialize costs in Texas was thus grounded in an understanding that the benefits of wind energy extend to all customers on the grid, as well as the acknowledgment that the investment required to experience those benefits need not be made by any one individual or entity more than another. While effective in Texas, the socialization of costs would likely not be supported in a multi-state wholesale electricity market like in MISO. Utilities and state regulators in these regional markets would likely oppose the imposition of costs that do not have benefits within a state, according to Clark (2013). Even with MISO's multi-value project program, there is an ongoing debate as to whether it complies with FERC Order 1000. While costs are passed onto ratepayers based on electricity usage, FERC has recognized that the benefits from regional projects often cannot be calculated and allocated "to the last penny, or for that matter to the last million or hundred million dollars" (Anderson et al. 2011, p.1). Ultimately, the longevity of the MVP program may be threatened if those paying more for electricity can effectively argue that costs are not commensurate with benefits.

While the "beneficiary pays" method in MISO and the socialization of costs in ERCOT may simply reflect the former's subjection to FERC regulation, ERCOT could have likewise pursued a "beneficiary pays" cost allocation method. In fact, it seems contradictory to the Texan "Lone Star," anti-big government ideology to implement a program with socialized costs. One potential explanation for this is grounded in Texas' relatively insulated political context. I explore this idea in greater depth in the following subsection.

Governance Structure

When 20th-century restructuring reforms were enacted, ERCOT and MISO responded quite differently. Texas embraced restructuring policies, as indicated by the PUCT introducing reforms that allowed for retail competition, independent power production, and advanced wind power. Fremeth and Marcus (2016) highlight that Texas strove to maintain existing power dynamics, electric utilities continued to exert power over the electricity supply chain, and reinforced interests in supplying wind power, which provided economic and environmental benefits to the public. MISO, due to its interstate structure, had to consider the fragmented interests of its many actors. One MISO state, Minnesota, struggled to respond to these drastic structural changes. Despite its significant wind resources, Minnesota failed to coordinate the litany of stakeholders and actors, and no one organization emerged to authoritatively push wind energy policy forward (Fremeth and Marcus 2016).

ERCOT's intrastate nature also empowers elites in the state to wield power and political support for wind energy. The Texas energy arena comprises a relatively close-knit circle of technical staff, elected officials, firm executives, and engineering consultants who dictate and implement generation and transmission outcomes. Unlike MISO, which plans generation and transmission projects regionally and thus must consult a broader array of stakeholders, ERCOT has lowered the risk for wind developers and encouraged higher rates of investment (Fremeth and Marcus 2016). Because Texas owns its own electric grid, it does not require approval from multiple states or the federal government (Galbraith and Price 2013). With its more narrow focus on swaying industry stakeholders and localities in one state, Texas has been able to incorporate wind energy with transmission more efficiently. The implications of Texas' insulated governance structure reflect Mancur Olson's theory on collective action: in large groups, actors' interests are less likely to coincide, making collective action more difficult. Individual actors are likely to sit on the sidelines when organizing collectivity is costly. Olson asserts that the most effective collective action occurs in smaller groups with homogeneous interests (Shughart 2004). Uniform political and economic interests, as well as insulation from external pressure, have been favorable to VRE and transmission expansion in Texas. MISO's lack of social, political, and economic homogeneity, as well as its requirement to abide by federal regulations, serve to obstruct the rapid development of VRE and transmission (Fremeth and Marcus 2016).

Despite renewable energy facing pushback from the contemporary conservative movement, Texas, a largely conservative state, has been able to achieve incredible progress in developing wind energy with transmission. Thus, renewable expansion in the state does not reflect a 'liberal' political ideology on low carbon generating sources. In fact, Texas falls behind in other areas of environmental policy compared to those in MISO. Its weak RPS expired in 2015, and the state has not pursued a price on carbon. The success of wind generation in Texas rather reflects a push from policymakers to allow Texans to enjoy its economic benefits. The socialization of costs under the CREZ program also reflects this attitude that everyone shares the costs and benefits of wind energy. In fact, a 2010 study found that, while only 33.8 percent of Texans believe the use of fossil fuels to generate electricity is detrimental to the environment, 59.6 percent indicated a positive attitude toward wind energy. Most respondents indicated support for the expansion of renewable energy (84.2 percent) and wind energy (70.2 percent) to fulfill energy demands (Swofford and Slattery 2010). These attitudes could explain why ratepayers accepted the socialization of costs promulgated by the policymakers of the CREZ program, as well as more generally why wind has prospered in Texas.

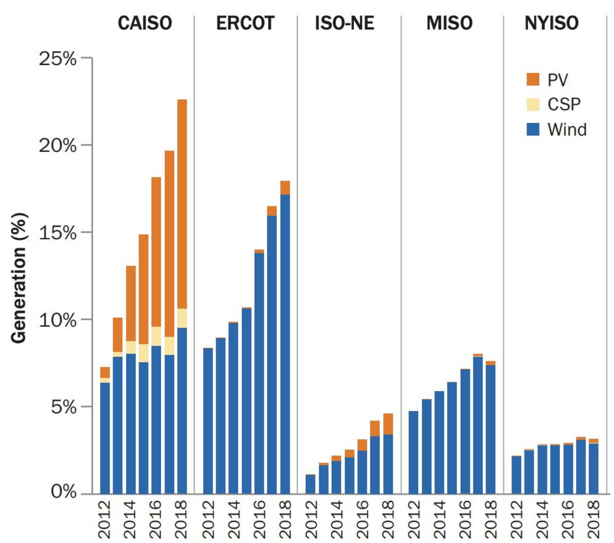
Structural differences in the RTOs governing institutions also contributed to divergent conflict management responses. While MISO's intergovernmental framework promotes engagement among different consumer groups, environmentalists, and independent energy developers, it provides little authority to manage conflict among these groups. Renewable developers, eager to obtain interconnection to the grid, were at odds with incumbent transmission owners reluctant to grant them access. Furthermore, FERC's lack of adequate rules for managing conflict and accountability, as well as federal delays in approving projects, hindered interstate RTOs' ability to deploy wind energy. In contrast, the governance structure in Texas allowed the PUCT to assert its central authority to resolve conflicts. ERCOT also took a hands-off approach to the permitting requirements of renewable developers, allowing local interests to dictate the locations of wind farms (Fremeth and Marcus 2016). Additionally, the state's 2005 RPS mandates gave the PUCT significant authority to ensure timely grid expansion. Developers were granted financial freedom from being charged to use transmission facilities. As one renewable developer argued, "the relative ease with which wind energy companies can compete within ERCOT was one of the driving forces behind the development of wind energy in Texas" (Fremeth and Marcus 2016, p.353). These efforts indicate Texas' more hospitable regulatory environment for wind energy. The state's unique rules for allocating costs and benefits among various actors were favorable to a more rapid buildout of VRE and transmission developments.

Outcomes

Wind Power Installment

As of 2018, Texas is the leading U.S. state in wind developments with 24.8 GW of installed capacity. This is nearly three times as much as the next-highest state—Iowa, with 8.42 GW. Compared to MISO, which achieved 24.2 GW at the end of 2018, the two RTOs have achieved roughly equal integration of wind energy in terms of installed capacity (Sun et al. 2018). However, when accounting for the differences in population—ERCOT with 42 million people and ERCOT with 26 million—as well as wind's percentage of total capacity—18.6 percent in ERCOT and 7.3 percent in MISO—Texas is the clear winner in installed capacity (Sun et al. 2018; "2018 Wind Technologies Market Report"). As depicted in Figure 7, when comparing wind's fraction of annual generation, ERCOT outpaces most other RTOs.

Fig. 6 Fraction of Annual Generation from Solar and Wind

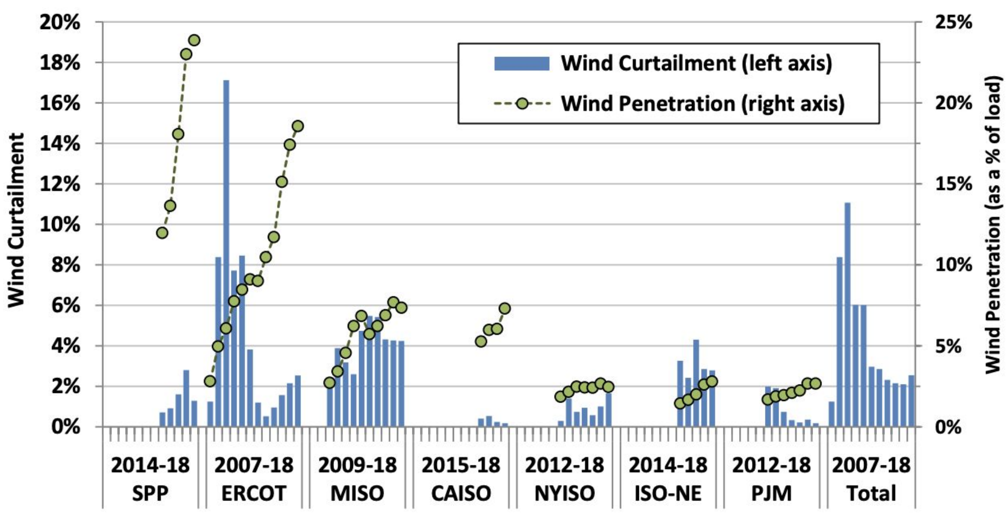


Source: Sun et al. 2018

Curtailment

As previously stated, curtailment, which results from transmission inadequacy, is the act of reducing energy delivery from a generator to the grid. When wind generation is high, but transmission capacity is insufficient to move excess generation to load centers, overgeneration can push wholesale power prices below zero, forcing an RTO to curtail renewable generation for economic reasons. As mentioned in my subsection "Pricing," some industry experts expressed concerns about the long-term implications for ERCOT's energy-only market structure given the potential for extended periods during which zero marginal cost renewables are the marginal generation resource. These concerns should be assuaged, given that ERCOT has lower curtailment rates of wind compared to many of its RTO peers. As indicated in Figure 8, while curtailment rates in Texas were high before 2013, they fell subsequently and sit at 2.5 percent as of 2018. In MISO, curtailment rates were nearly double—4.2 percent in 2018. The 2013-2014 decline in ERCOT curtailment rates corresponds with the significant buildout of new transmission serving West Texas following the completion of many CREZ projects in 2013 ("2018 Wind Energy Market Report"). Competitive Renewable Energy Zones have thus served to mitigate curtailment and increase the market value of wind, which has created incentives for investments in remote areas in Texas (Du and Rubin 2018). While curtailment rates have slowly increased in ERCOT following the completion of several CREZs in 2013, one should note the ratio of wind penetration to curtailment rates—nearly 10:1 in ERCOT versus 7:5 in MISO. These low rates of curtailment relative to wind penetration highlights the success of transmission buildout in Texas relative to MISO.

Fig. 7: Wind curtailment and penetration rates by ISO



Source: "2018 Wind Energy Market Report"

Another factor that contributes to lower curtailment rates in ERCOT is the growth of battery storage capacity. In Chien et al.'s (2016) paper on stranded power (SP)—the collective term for curtailment and negative or zero pricing—the authors identify battery storage as one avenue to alleviate the negative implications of SP. During times of surplus wind generation or negative pricing, which both encourage curtailment, battery storage can help save the generated energy so it is not wasted. To the extent that battery storage reduces curtailment rates, it would make sense that ERCOT's curtailment rates are lower than MISO's given Texas' growth in battery capacity. Between 2016 and 2018, battery capacity grew 58 MW in ERCOT compared to 3 MW in MISO (Sun et al. 2018, p. 29).

<u>Planned Transmission Projects</u>

In accordance with CREZ and MVP, ERCOT and MISO have planned many transmission projects to fulfill their VRE generation needs. In August of 2019, two wind farm developers NextEra Energy Inc. and Southern Power Co. in MISO states Minnesota and North Dakota, respectively, withdrew requests to tie into the Midwest power grid. These two companies are part of a much larger group of developers who are pulling out of requests to connect to the MISO grid due to congestion concerns. According to a major Midwest-based renewable energy advocacy group Clean Grid Alliance, of the 5,000 MW of wind and solar projects planned in MISO's western region, projects totaling 95 percent of this potential installation have been withdrawn due to congestion concerns. As of December 1st, only 250 MW of those projects remain in the planning stages. Southern Power's 200-MW Ruso wind farm in North Dakota was among the withdrawn projects. After noting that transmission upgrades would cost $500 million in addition to the $250 million wind farm, Southern Power dropped construction plans. The remaining 250 MW will likely not go through either, as transmission upgrades would require $100 million of capital (Tomich 2019).

In addition to congestion concerns, cultural and political circumstances in MISO have also served to halt transmission projects. Clean Line Energy Partners, a firm that develops new transmission projects in North America, has been blocked by state Supreme Courts over local opposition. The $2 billion Rock Island project, which was designed to bring 3.5GW of wind power from northwest Iowa to Illinois, was blocked by the Illinois Supreme Court due to opposition from landowners and lawmakers. Another Clean Line project, the $2.3 billion Grain Belt Express Clean Line, which is planned to deliver 4GW of wind power from western Kansas to Missouri, Illinois, Indiana, is delayed by a Missouri court ruling, which demands the approval of each individual county along its path." (Du and Rubin 2018). Transmission projects have not faced such intense backlash in Texas, where rules have apparently served to minimize "local opposition and prevented not-in-my-backyard (NIMBY) siting concerns" (Fremeth and Marcus 2016, p.345). In Texas, transmission projects constructed under the Competitive Renewable Energy Zone framework required a Certificate of Convenience and Necessity (CCN) by the PUCT to the utility constructing the line. These CCNs were granted quickly, as indicated by the completion of a number of CREZ in 2013. Given the geographical and financial insulation of Texas' new transmission projects, there have been fewer challenges in court to proposed developments compared to MISO.

Discussion

The above analysis has laid the groundwork for a discussion on the relative strengths and weaknesses of the Midwest Independent System Operator and the Electric Reliability Council of Texas. Over the past decade, Texas has experienced a rapid and relatively smooth buildout of its transmission grid to accommodate wind energy developments. MISO, in contrast, has lagged. So far, I have discussed several social, economic, and political issues that account for ERCOT's success. This section is devoted to connecting these various factors to provide an encompassing view of ERCOT and MISO's differential success.

Among the most notable factors that contributed to Texas' success is their governance framework. In the face of sweeping 20th-century electricity market restructuring, Texas embraced such changes with ease. The state maintained existing power dynamics, electric utilities continued to exert power over the electricity supply chain, and reinforced public interest in supplying wind power. When Texas decided to establish a regional transmission organization that did not cross its state borders, ERCOT was able to circumvent FERC mandates relating to electricity pricing and transmission cost allocation methods. The Midwest, on the other hand, established a regional transmission organization that encompassed several states. The implications of this are wide-ranging: political and social circumstances are heterogeneous, and projects require approval from multiple states, counties, and the federal government. Interstate projects tend to be dramatically slowed down by the patchwork of often conflicting state and federal regulations (Malewitz 2013). The insulated political and social context of Texas allowed ERCOT to ramp up transmission much earlier and with greater ease compared to MISO. To this day, projects in MISO have yet to overcome significant hurdles, like siting battles in state courts. This has led to a number of wind projects being canceled due to congestion concerns.

The cost allocation methods for new transmission projects in ERCOT and MISO are similar in that they spread the financial burden among ratepayers. Due to FERC Order 1000, MISO was required to develop a program in which the allocation of costs was roughly commensurate with benefits. Despite MISO implementing a program that charged ratepayers for wind and transmission developments based on their electricity usage, the notion that wind development transmission upgrades benefit everyone could pose a significant roadblock for the long-term feasibility of the Multi-Value Project program. Even in the short-term, MVPs have yet come to fruition. In contrast, the CREZ program in ERCOT led to the rapid completion of a number of transmission upgrades by 2013. Following their construction, wind curtailment rates are lower than in MISO—meaning that more generated wind power enters the grid and serves customers—and grid congestion has decreased. According to Du and Rubin (2018), this has incentivized more investments for plants in remote areas of Texas.

The implications of Texas' energy-only electricity market structure has prompted concerns among industry experts about ERCOT's long-term feasibility. Without the guaranteed revenue of a capacity market, which pays generators years in advance, some experts worry that depressed energy prices in ERCOT will discourage future investments in new wind farms, although this point is hotly contested. Texas has addressed these concerns to some extent by building out its transmission system early and rapidly. The addition of new transmission cables has reduced congestion on the grid, reduced curtailment, increased the market value of wind in the state, and encouraged investments in new wind farms. Even during a time of record-breaking demand in August 2019, Texas provided sufficient capacity to keep the grid running. MISO's capacity market, on the other hand, has resulted in an inefficient overdevelopment of natural gas plants, which may not be able to cover their costs in years to come. The sunset of federal tax incentives, like the ITC and PTC, which serve to lower electricity prices for renewable energy artificially, should mitigate concerns about the implications of low electricity prices in MISO and ERCOT in the years to come. That being said, zero marginal cost renewables setting the price margin for extended periods of time remains an ongoing concern across the entire country.

Conclusion

The unified control over transmission planning in ERCOT has fostered a hospitable environment for wind energy development. Due to MISO's interstate nature, when proposed transmission projects cross multiple state and county lines, such proposals are likely to be met with opposition. When a transmission project is regionally beneficial, individuals on the local level who have to bear the burden of siting concerns and rights-of-way are likely to find ways to halt such projects, as indicated by the number of cases pending in MISO state supreme courts. Although MISO states have more ambitious RPS than Texas, the lack of a cohesive consensus among policymakers, utilities, industry stakeholders, and customers on how wind development should be carried out in MISO has disadvantaged the region. Additionally, FERC's lack of protocol and inability to manage such conflicts further slows down new wind and transmission developments.

When comparing the two RTOs, ERCOT appears to have better facilitated wind generation with transmission. This is not to say that Texas has done everything perfectly, however. The nature of U.S. electricity deregulation resulted in state-level control over energy policy and a patchwork of regions managing our transmission grid. Ultimately, across the country and even in Texas, this framework has been insufficient in motivating our energy transition in a timely manner. However, the relative success of Texas compared to the rest of the country should inform future changes to energy market structures and delegation of control over transmission planning. In Europe, nations have been prosperous in running an energy-only market and implementing transmission plans at the federal level; they have done what the state of Texas has done but on the national level. These countries have likewise experienced a more efficient buildout of renewables to power their electricity sectors. If the United States wishes to become a world leader in achieving renewable energy and climate goals, the federal government should take a more active role in transmission planning. In the absence of this, the ERCOT framework of unitary control should serve as a guide for states to follow.

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