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States of transmission: Moving towards large-scale wind power

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HIGHLIGHTS

- ► We present a comparative case study of state-level contexts linking wind and transmission.
- ► Barriers for wind transmission are identified based on stakeholder interview data.
- ► Framing of transmission issues was related to importer/exporter status.
- ► Local grid features and the role of wind in the power supply also proved important.

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ABSTRACT

Efforts to plan and site transmission for wind power cannot currently keep pace with wind power development. The very nature of wind power, whether distributed or intermittent, challenges traditional models of electricity grid development. Much of the decision authority for transmission is located at the state level, creating tensions between a system-wide need for transmission capacity and the local nature of planning and implementation. This study identifies and discusses barriers for wind power transmission and highlights the critical role of states and state policies in expanding and transforming the electricity grid to accommodate large scale wind power. Drawing on extensive interview data with energy stakeholders, we present a comparative case study of state-level contexts linking wind and transmission in Montana, Minnesota, and Texas. Stakeholders were found to portray transmission challenges and solutions for wind power based on the character of the local transmission grid, their status as power importer, exporter or self-sufficient state, and the role wind already plays in the power supply.

1. Introduction

> "*The list of top three [challenges] for wind industry I would say: transmission, transmission, and transmission.*" –*Texas Energy Stakeholder*

For the first time, transmission of renewable energy was the subject of a federal U.S. Senate hearing in 2010 (Wagman, 2010), demonstrating increasing attention to infrastructure development as a central step towards continued expansion of sustainable electricity resources. While state and regional efforts to plan and site wind power projects and associated transmission lines have been on-going for the past decade, the distributed nature of renewable power, comparatively small capacity of renewable energy facilities, and the complexity of integrating intermittent power sources into the grid challenge the current transmission infrastructure across the United States. Renewable energy, especially wind power, affects and alters transmission planning and operation. Conventionally, U.S. utilities built transmission lines to integrate large stationary power plants in response to projected electricity demand increases. For renewable energy, this process is largely reversed, as its development is less 'market pull', than 'regulatory push' emanating from state mandates for renewable energy that have created the need for new transmission lines (Brown and Rossi, 2010; Piszczalski, 2009).

Proposed solutions for renewable energy's transmission problems range from the local to the national and include building coast-to-coast "green super highways" (AWEA, 2009) that connect load centers with wind resources, or alternatively, integrating wind power into the grid in a more distributed manner (Rhoads-Weaver and Forsyth, 2006). No matter which solutions

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are chosen, more transmission capacity is needed. In addition to regional planning and coordination, this will involve the states, as the most important gatekeepers for interstate transmission are at the state-level (Oskvig, 2008). There is an inherent tension between a system-wide need for transmission capacity and the localized nature of planning and implementation (Brown and Rossi, 2010).

Transmission has been identified as a barrier to renewable energy development (Oskvig, 2008) and the underlying factors complicating transmission planning are well known (Bloom et al., 2010; Porter et al., 2009). In this discussion, the state level context for renewable energy transmission planning and implementation has received little attention although it is critical to renewable energy development. From state to state, factors facilitating or supporting transmission play out in very different ways. Therefore, this paper addresses the following questions: How is transmission for wind power perceived and addressed within a state context? Do stakeholders differ in their perceptions and proposed solutions for wind power transmission? This research explores how state-level energy policy stakeholders portray the challenges and opportunities of wind power and transmission. It provides insights into the state-level socio-political contexts for transmission development. Interviews of state-level energy policy stakeholders were conducted in three states with large wind resources, but varying levels of wind power and transmission build-out: Montana, Minnesota and Texas.[1] Content analysis of these interviews demonstrates that transmission is one of the most challenging and contentious aspects of wind power growth, and energy policy stakeholders across all three states recognize its critical importance. Transmission challenges, however, are envisioned and addressed differently across states.

2. The critical role of transmission in facilitating renewable power development

Renewable energy production continues to expand rapidly, helping to reduce pressing energy/environmental problems and to meet state-level commitments to generate electricity from renewable energy. For the first time, the Federal Energy Regulatory Commission (FERC), recognizing the need for coast to coast transmission for renewables, instigated a series of planning meetings in 2009 (Piszczalski, 2009). We focus this article on wind power. Wind has taken a central place in the discussion about renewable energy transmission, because 94% of non-hydro renewable development in the United States since 1998 has been from wind (Wiser et al., 2011) and wind became the fastest growing energy resource in the United Stated the late 2000s. Due to sheer size, transmission challenges are not as pronounced for other renewable resources (with the possible exception of large-scale solar power), although they may face other challenges. For instance, small scale solar power development requires solutions for net metering and distributed grids. A special challenge for wind power transmission is that the best wind resources are often far from population centers, meaning that exploiting them will not be possible without building more transmission. The unequal distribution of wind resources across the United States also raises questions related to state-to-state import and export of wind power.

The current infrastructure supporting wind power transmission has arisen out of a regionalized grid structure. Fig. 1 provides an overview of the distribution of wind power projects across the United States, and how they relate to existing and planned transmission lines and regional transmission organization areas. It highlights the challenges between wind and transmission in a graphical form, showing the distance between load and resource and depicting the regionalized nature of the US grid. Wind projects are very unevenly distributed across the United States and across regional transmission organizations, which operate local grids (Fig. 1a). It is also interesting to examine the relationship between wind projects and transmission lines. Current and planned wind projects are not necessarily located close to existing major transmission lines. Much of the planned transmission will connect the sites with the largest wind power concentration to major population and load centers. This demonstrates that local and regional planners have begun to address wind power transmission.

Even with these new state and regional planning efforts to link renewable energy to the grid, fundamental institutional challenges persist. The structure of the US energy supply system presents one such challenge. US regional electric grids can be described as "fractured along utility and regional lines, minimally interconnected, and mostly isolated from [their] larger neighbors, even when they are next door" (Maize, 2008). Historically, the U.S. electricity market has been dominated by vertically integrated utilities, which also operated control areas and maintained interconnections for reliability reasons only (Joskow, 2005). Transmission lines were generally built when a new, large stationary power plant justified their need. Renewable power facilities are much smaller than conventional power plants and often do not pass the threshold required to obtain a certificate of need for a new power line. For utilities or independent operators, building a new transmission line without power production already in place is risky (Talbot, 2009).

A less centralized grid structure could facilitate the interconnection of small renewable sources, while increased connectivity across regional grids could help balance the intermittency of wind power across sites by taking advantage of non-correlated wind resources (Archer and Jacobson, 2007; DeCarolis and Keith, 2006). The power production of non-correlated wind resources is independent of each other, generally due to spatial diversity, meaning that by integrating such resources into the grid, the problem of intermittency is addressed. Currently, decentralization, the lack of available interconnections, and insufficient transmission capacity all hinder wind power development. This is exacerbated by long-standing underinvestment in transmission capacity and ensuing grid congestion. The Energy Policy Act of 1992, and later state-level deregulation efforts, have allowed the entry of independent generators into the electricity market by giving them access to incumbent regulated utilities' transmission networks (Sharabaroff et al., 2009). Regulatory reform aimed at increasing competition in the electric utility sector had the unintended consequence of simultaneously discouraging transmission development. A system that deregulated generation, but not transmission and distribution, burdened incumbent firms with the stranded costs of infrastructure investment (Sharabaroff et al., 2009), and established a strong disincentive for investing in transmission lines. Deregulated energy markets also added to grid congestion, as power was now sold – and therefore transmitted – over longer distances (Talbot, 2009).

Given that the electric power grid is maladapted to accommodate more renewable power, with wind power already being curtailed – 7% in Texas to 2.2% in the Midwest (Ryan Wiser and

[1] The original study also included the state of Massachusetts. Given the contentious nature of wind power in this state, little new wind power has been built and transmission aspects found little mention in the interviews conducted. Consequently, this state was excluded in the present paper. Nevertheless, significant build-out of transmission capacity will be required in the North-Eastern United States to achieve higher penetration of wind power (Corbus et al., 2009).

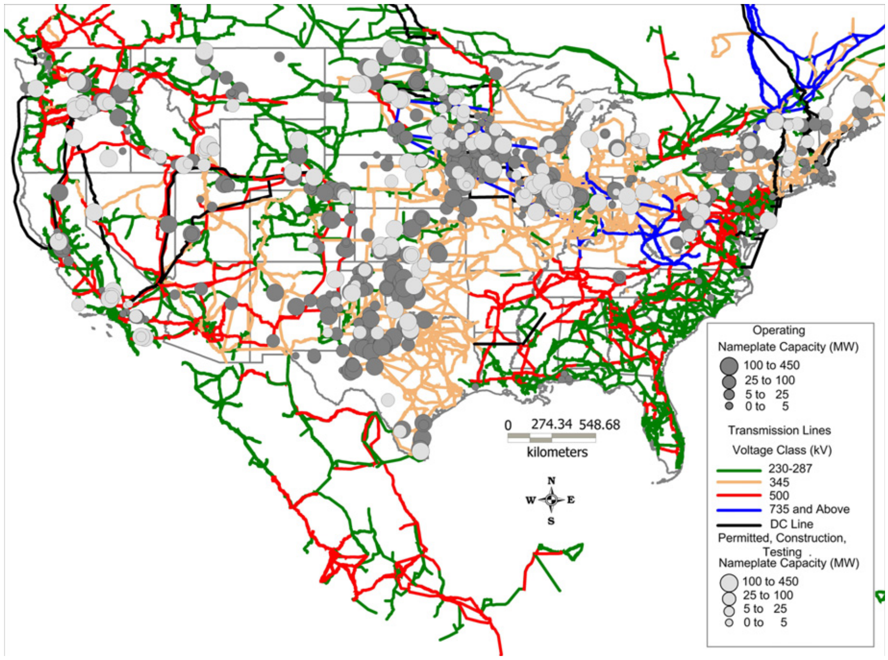

Fig. 1. Regional transmission organizations (RTO), planned and existing transmission lines, and planned and existing wind turbines in the United States. Wind power projects are concentrated within some RTO areas (Fig. 1a). Existing transmission lines offer insufficient grid connection for wind, but proposed transmission lines will link to some of the areas with the highest numbers of existing and proposed wind farms. *Source*: Ventyx Velocity Suite, 2011.

Bolinger, 2011) – transmission build-out is urgent. Transmitting wind from distant sites carries an energy penalty due to line losses directly related to distance, which is currently exacerbated by losses due to transmission constraints and congestion. From a cost perspective, it has often been cheaper to develop lower capacity-factor wind sites that are in close proximity to existing transmission infrastructure rather than developing high quality wind resources – and the associated new transmission – in distant locales (Hoppock and Patiño-Echeverri, 2010). At this point, wind projects have largely used up excess line capacity, so the challenge is not only about creating more transmission for renewable power, but also about how and where to expand transmission.

The construction of new transmission capacity for wind power is complicated by jurisdictional overlap between different entities, and the tension between national planning needs and primarily local siting and permitting authority. Electric power sector regulation predominantly takes place at the state level, with little authority at the federal level to adopt and implement a national transmission policy (Brown and Rossi, 2010; Joskow, 2005). Contrary to interstate highways, railways, or natural gas pipelines, states play a central role in siting, permitting, planning and constructing transmission lines (Best, 2010), complicating coordination in multi-state reliability organizations. The North American Electric Reliability Corporation (NERC) takes on a coordinating role between the eight regional reliability councils and their 22 sub-regions (plus Alaska and Hawaii). As a private organization NERC, like the reliability councils that compose it, does not have strong authority to plan and upgrade transmission or enforce reliability rules, with state regulators being the main authority to whom utilities report (Joskow, 2005). Even the federal regulator, FERC, which sets rates for transmission in the lower 48 states, does not have authority to overrule a state when it denies a permit for transmission line siting, according to a 2009 decision by the U.S. Court of Appeals for the Fourth Circuit (Dotson, 2010). All in all, there is no strong or coordinated central planning authority for transmission in the United States.

Given the veto power of states in cross-state transmission planning, disputes over cost allocation frequently erupt, creating hurdles for the creation of a coherent, functional and cost-effective transmission system. State regulators historically have taken into account only state-specific costs and benefits of transmission lines in their permitting procedures (AWEA, 2009), inhibiting planning for high-voltage interstate transmission lines, where benefits are not localized, but costs are. Cost allocation for new transmission lines can follow three models (Bloom et al., 2010): costs are born by consumers alone (allocation to load), by generators alone (allocation to supply), or are distributed across consumers, generators and transit areas. Additionally, the costs of a new transmission line must be allocated across projects over time; how costs are split between new projects, incumbent utilities and independent operators in expanding and maintaining transmission lines is often contentious.

With renewable energy, cost allocation is particularly challenging, because areas rich in wind resources are often far from load centers. Transit states where transmission infrastructure must pass may not be willing to share in the cost of transmission lines, as they may believe they reap neither the economic benefit, nor do they get the renewable power. To achieve integrated transmission planning for renewable power, regulatory methods must be reformed to allocate costs more fairly, make cost recovery more certain, and streamline siting and permitting across states (AWEA, 2009). Thus, expanding and improving transmission infrastructure involves integration of a multitude of existing state-level and regional political interests and concerns.

Finally, transmission for renewable power raises new political issues. Although environmental groups have been strongly supportive of renewable generation, they have been divided in their support of transmission lines. Transmission lines transporting power from remote locations rich in wind resources to load centers often traverse environmentally sensitive areas, creating a dilemma for environmental groups torn between supporting sustainable power sources and protecting the natural environment (Greenwald and Gray, 2008). This split often occurs even within a single organization, with national or regional offices often holding opposite positions from local chapters. Additionally, the construction of new transmission lines raises suspicions that these lines may someday be used for transporting 'dirty' electricity produced from coal (Best, 2010).

Faced with the multitude of challenges for wind power transmission outlined above, actors from industry (Utility Wind Integration Group, 2006), as well as from state, regional, and federal agencies (Corbus et al., 2009; Department of Energy, 2006; Porter et al., 2009) have started to study the integration of wind power into the existing grid and the need for new transmission. In terms of policy, there has been much innovation lately to address transmission challenges. At the state level, Texas identified five "Competitive Renewable Energy Zones" (CREZ) within the state to coordinate renewable energy and transmission planning, and California followed with a similar initiative (California Energy Commission, 2010; Public Utility Commission of Texas, 2010). The Midwest Independent System Operator (MISO) region (Upper Midwest) engaged in a 4-year study with the Midwest Governor's Association to integrate state-level renewable commitments, identify zones for renewable energy development, and define transmission needs across the region (MISO, 2011). A recent FERC ruling, Order No. 1000, reorganizes transmission planning and cost allocation, requiring transmission providers to participate in regional planning efforts and setting rules for regional cost allocation. It is likely to help share costs of multi-state projects by making it easier to plan regional transmission needs, build power lines across state lines and to accelerate the approval process for new transmission projects (FERC, 2011). These recent policy initiatives raise hopes that transmission build-out for renewable energy will increase in the near future. It is less clear how this will play out at the state level, a central arena for transmission planning.

3. Methods and case study selection

Transmission permitting and siting depends on a complex set of underlying factors, ranging from institutional and legal arrangements to economic conditions and public acceptance. Of these, the social science literature has addressed public acceptance in the most detail. Major infrastructure investments in the electric energy sector have stalled in the context of deregulation, explaining perhaps that little recent literature exists in this area. Furby et al. (1988) identify aesthetic reasons, land use and eminent domain issues, environmental and health risks, economic and cost sharing aspects, as well as concerns about noise levels as the most important factors in public opposition to transmission. Risks associated with transmission lines are studied less frequently than risk perceptions of other aspects of the electric power system, and where studied, transmission consistently scores low on perceived risk (Mullet et al., 1998). Health concerns due to exposure to electromagnetic fields were the main perceived health risk associated with transmission lines, although scientific studies have not supported this public concern (Genuis, 2008; Poortinga et al., 2008). A small number of studies mention concerns about risk to wildlife (Kitchings et al., 1974; Marshall and Baxter, 2002). Public acceptance issues related to the economic impacts of transmission lines have generally focused on property values (Delaney and Timmons, 1992), and land use and eminent domain (Parfomak, 2008; Vajjhala and Fischbeck, 2007). Judging by the number of studies on visual intrusion and the weight accorded to it, aesthetic concerns seem to be the most important contributors to public opposition to transmission lines.

While several other studies have examined public perception of wind (Devlin, 2005; Firestone and Kempton, 2007; Pasqualetti, 2000, 2001; Wolsink, 2007) and of transmission (Furby et al., 1988; Jay, 2004; Jay and Wood, 2002; Poortinga et al., 2008), the goal of this research is to understand perceptions of transmission systems as they affect wind technology development for stakeholders who actively participate in shaping the state-level policy and legislative processes. Analyzing the perceptions of stakeholders who are deeply involved in policy relevant to a technological system differs from assessing public acceptance, because stakeholder analysis focuses on institutional factors and stakeholders can be seen as representing the interests of their organizations (Agterbosch et al., 2007; Scharpf, 1997).

To better understand the diversity of state-level contexts within which transmission development is playing out, we present a comparative case study based on interviews conducted with state-level energy policy stakeholders in Minnesota, Montana, and Texas. In prior work (Fischlein et al., 2010), we have examined the political-institutional context affecting wind power deployment in these states. Table 1 provides an overview of variables that may influence transmission for wind power.

The interviews did not specifically prompt stakeholders to speak about transmission, but focused on challenges and barriers of wind power in general. Transmission aspects were the number one issues raised across these interviews, motivating the authors

Table 1
Indicators for energy system and policy context in Minnesota, Montana and Texas.

	MN	MT	TX
Population, 2010 (millions)[a]	5.3	0.99	25.1
Population growth, 2000–2008[a]	6.1%	7.2%	16.7%
Land area (sq. miles)[a]	79,600	144,600	261,800
Person per sq. mile, 2010[a]	66.6	6.8	96.3
Electricity consumption per capita (MW h), 2007[a,c]	13.1	14.1	16.1
Cost of electricity cent/kW h, 2007[c]	7.4	7.1	10.1
Import/export status	Importer	Exporter	Self-contained grid
Total electric power industry CO_2 emissions (million metric tons), 2007[c]	37,706	20,013	255,092
Carbon intensity of electricity (metric tons CO_2/MW h)[a,c]	0.88	0.91	0.73
Installed wind turbine capacity in MW (and ranking among US states), 2009[b]	1,805 (4th)	272 (21st)	8,361 (1st)
Renewable percent of fuel mix (excluding large hydro), capacity/generation 2007[d]	8.8%/4.8%	2.7%/1.7%	4.4%/2.2%
Wind energy price ($/MW h)[e]	30	29	27
Policies and bills affecting wind deployment 1995–2008, highlighting salience to state legislature, not effectiveness	50	6	14

[a] *Source*: U.S. Census Bureau (2012).
[b] *Source*: AWEA (2010).
[c] *Source*: EIA (2009a).
[d] *Source*: EIA (2009b).
[e] *Source*: Bohn and Lant (2009).

to explore this topic in more depth. Therefore, we focus on the role of the transmission system as a critically important barrier to wind power development. All three states have good wind resources, and Minnesota and Texas have experienced a rapid increase in wind power deployment over the past decade, with Montana just recently starting to develop their wind resource. Transmission bottlenecks, interconnection queues, and power line siting and permitting present significant obstacles in all states, but these obstacles manifest themselves in different ways.

Table 2
Distribution of interviews and word search counts across states.

	MN	MT	TX	Total
Stakeholder type				
Academic	**3**	**2**	**1**	**6**
Government	**3**	**7**	**9**	**19**
Industry	**10**	**6**	**6**	**22**
Environmental NGO	**7**	**5**	**6**	**18**
Total	**23**	**20**	**22**	**65**
Mentions of				
"Transmission"	**115**	**71**	**166**	**352**
"Power line"	**16**	**6**	**3**	**25**
"Interconnection"	**4**	**4**	**2**	**10**

The electricity landscape of each state, whether the state is a net electricity importer, exporter, or self-sufficient, influences how the transmission system development challenges are defined, presented, and resolved. Minnesota imports power, Montana is a major electricity exporter and Texas is relatively self-sufficient in electricity production, running its separate electric grid. These states also represent different models of regulation: Minnesota is a traditionally regulated state, Montana is semi-deregulated, and Texas restructured its electric industry in 2002.

We interviewed a diverse set of policy stakeholders that had taken part in state-level political activity related to energy policy. A roughly equal number of interviews in each state were conducted with stakeholders from industry, government, academia and environmental NGOs from 2007 to 2009 (Table 2). The policy

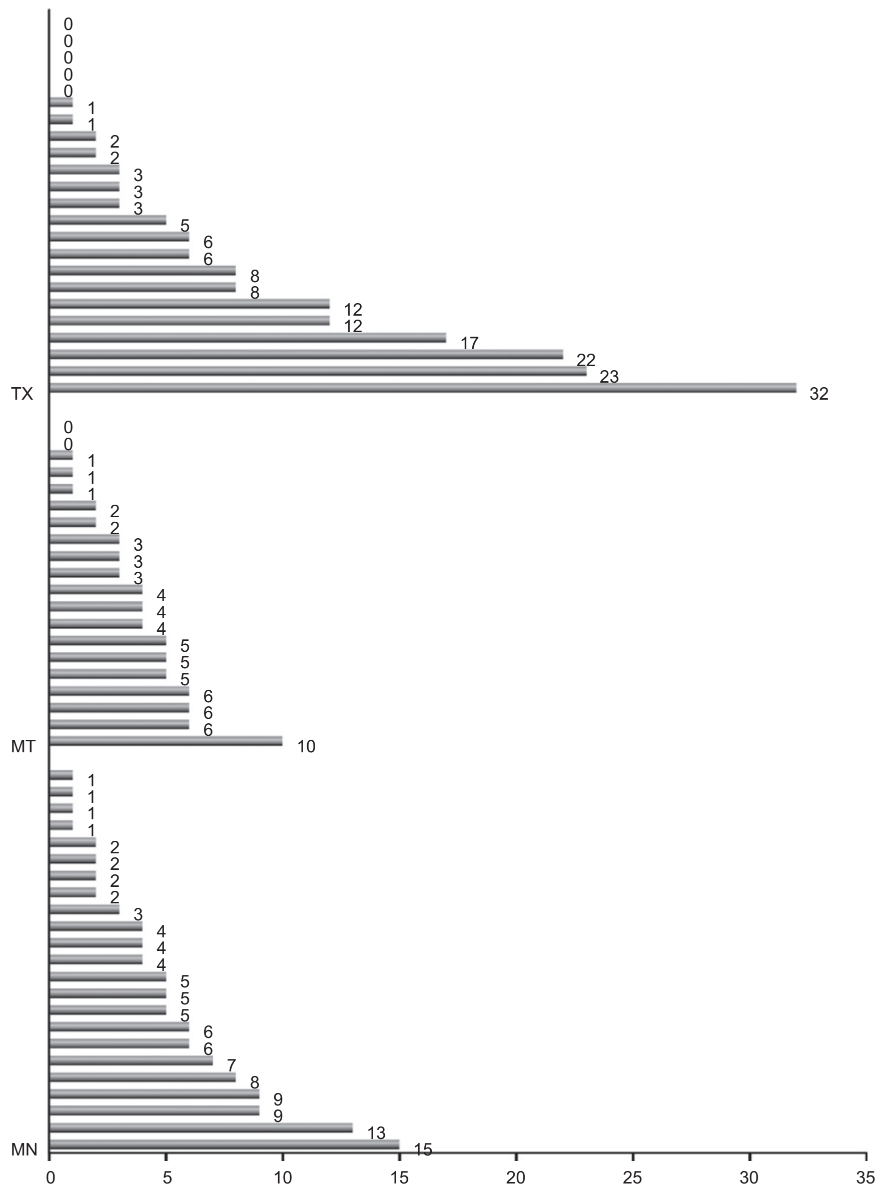

Fig. 2. Mention of the term "transmission" across interviews in MN, MT and TX. Each bar represents an individual interview.

stakeholders were initially selected through searching state legislative committee testimony on energy bills, and subsequently by snowball sampling. Content analysis of the interviews was used to provide comparative insights on stakeholder perceptions of transmission and wind power. As a method to identify patterns of meaning in qualitative data, content analysis is particularly appropriate for analyzing large quantities of material (Holsti, 1969; Krippendorf, 1980). For a more in depth description of methods and for the interview protocol, see Fischlein et al. (2010).

We analyzed the 65 stakeholder interviews for technical barriers and opportunities to wind deployment, with a focus on identifying aspects related to transmission, interconnection, and power line siting. To cross-check this analysis and capture discourse beyond what was captured using the barriers and opportunities framework developed previously, we also searched for the terms *interconnection*, *power line*, and *transmission*, because these keywords emerged as particularly salient.

The first two terms were rarely mentioned, while transmission was mentioned frequently across all states (see Table 2). It is important to note that interviewees were not specifically prompted to speak about transmission. The number of times transmission was mentioned in individual interviews varied (Fig. 2). Every interviewee in Minnesota used the term transmission at least once. In Texas, a handful of interviewees talked about transmission extensively, but other interviewees mentioned it only in passing or not at all. In Montana, transmission was mentioned fewer times on average, but featured in almost all interviews.

4. State by state analysis

In the following sections, we present our qualitative analysis of the stakeholder interviews from each state. Quotations from the interviews are identified by state and interview number, i.e., TX12 refers to the 12th interview from Texas.

4.1. Minnesota

Minnesota was one of the first states to experience substantial wind power development, driven by a 1994 agreement between the state and the largest local utility Xcel Energy, which required Xcel Energy to develop wind power in exchange for permission to store nuclear waste at one of its nuclear power stations. In 2007, Minnesota adopted one of the strongest renewable portfolio standards in the country, driving further wind development. Minnesota's largest investor-owned and cooperative utilities also operate in adjoining states, and Minnesota has historically imported some of its power from other states in the MISO control region. Minnesota's significant wind power development and increasing congestion has prompted far-reaching regional transmission proposals (Fig. 3), which are under development.

Within the Minnesota interviews, discussion about transmission was focused on the difficulties in permitting and building much needed new transmission infrastructure. As one stakeholder from an industry organization (MN06) put it, "a lot of the wind producers or people who want to be producing wind are very concerned they won't have enough transmission power." The existing transmission bottlenecks were also mentioned several times, in particular between the windy areas in the Southwest corner of the state and the load center in the Minneapolis/Saint Paul metropolitan area. Minnesota, as part of the MISO transmission area, has transmission line interconnections to other states. Wind developers have been able to circumvent the congestion problems in Minnesota by building up capacity in North Dakota, which has a very good wind resource, but minimal in-state demand for wind power and little public opposition to wind power. The need to circumvent transmission bottlenecks may explain why some states without strong renewable policies experience significant wind capacity development, as told by a utility manager:

> "We have been aggressively developing our wind resources and primarily in North Dakota, because a lot of the best areas in Minnesota have already been taken; … there's such congestion for transmission capacity down there, that you could go down there and build 50 MW of new wind next month and it might be 3 or 4 years before there is transmission capacity to get that power off the grid." (MN 13)

Minnesota stakeholders also pointed out that very few transmission lines had been built in the last 20 years, while utilities used up existing transmission reserves. Utilities had developed

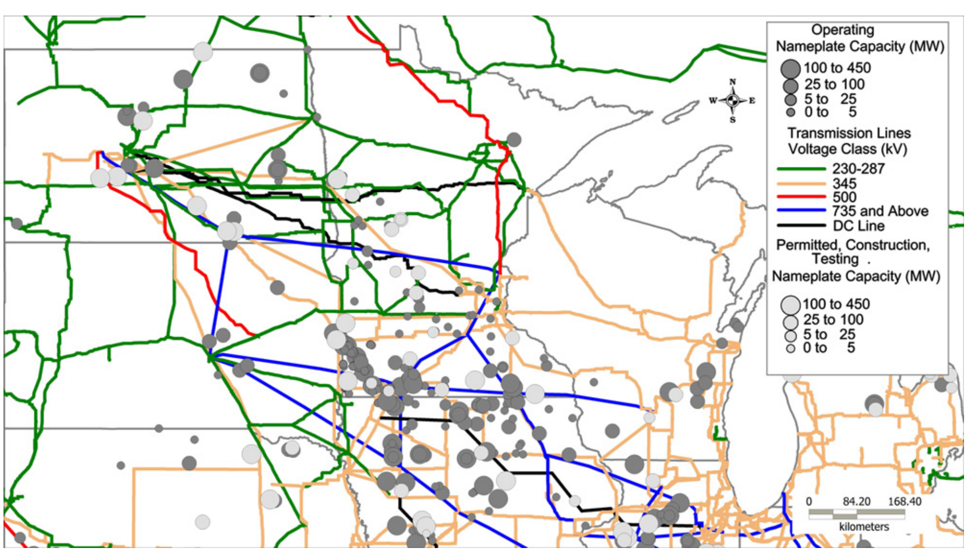

Fig. 3. Location of wind turbines and existing and planned power-lines in Minnesota. Minnesota is the fifth largest wind producer among US states, has the second highest penetration of wind power in its electric system. Much of the 2581 MW installed as of June 2011 (AWEA, 2011) are located in the Southwestern area of the state, along the Buffalo Ridge. The major power line projects in Minnesota seek to relieve the congestion along the Buffalo Ridge, as well as connect the state to additional resources in the Dakotas and Iowa, and to load centers to the East.

transmission lines in view of expected demand growth that did not materialize when the energy efficiency of industry and households improved subsequent to the 1970s' oil shocks. Then, in the 1990s, looming deregulation made utilities hesitant to invest in infrastructure, even in states like Minnesota that ultimately did not deregulate their electric industry. Due to these historic developments, the MISO transmission system is predicted to face transmission shortages in the near future, as pointed out by an interviewee from an environmental organization:

> "The transmission lines that had been serving the wind energy areas of the state are totally subscribed [...], and so that's why the controlling, the regulatory bodies are – between the public utility commission and the Midwest Independent System Operator – are saying we can't add more wind in that area unless we get more transmission." (MN05)

The boom in wind power has led to a congested permitting queue for new projects in the MISO system, partially due to phantom projects, which are strategically added to the queue, but never built. Until recently, projects were handled on a first-come, first-serve basis, an adequate method before renewable power, when the number of new proposed projects was low. Required deposits were nominal and projects could easily be suspended, without losing their position in the queue. In 2007, the MISO queue contained 60,000 MW in proposed projects and in 2008 alone, 151 of the 169 requests entering the queue were for wind projects, for a total of 24,000 MW in new requests (Porter et al., 2009). The surge in new requests stands in no relation to the permitting. In fact, less than 1% of new requests from 2005 to 2007 were in service in 2008 (Porter et al., 2009).

Traditionally, MISO has distributed interconnection costs exclusively to the additional project that triggered the need for a system upgrade. The position in the queue thus determined the price for interconnection, and developers took advantage of the low barrier to register a project, gaming the system by entering their project several times, looking for the best price and then withdrawing other entries. Once a project is withdrawn, prices are recalculated for the entire queue, creating a huge backlog. This gaming was described vividly be several stakeholders, including a utility representative:

> "Customers sign up in what's called the MISO queue and they don't have a PPA – a purchase power agreement – with anyone so they don't have any place to sell it; and this is thousands of MW long down this queue that's out there and no one knows how much of it is real and how much of it's not, because it's full of tire kickers." (MN13)

In light of this onerous system, FERC approved a reform of the MISO queue and under the new system, interconnection permitting moves to a milestone-based process, with fast-track procedures for projects not requiring transmission upgrades. Additionally, the deposit system was reformed to make withdrawal more costly. In 2009, FERC also approved a provisional cost allocation method for MISO, where 100% of costs are allocated to the interconnecting entity for facilities smaller than 345 kV; for larger facilities, no more than 10% of the costs are socialized to the MISO region (Puga and Lesser, 2009).

Minnesota stakeholders have also been involved in a regional transmission planning effort (MISO, 2011). What began as an in-state transmission planning effort termed CAPX2020 – both for wind energy and to relieve grid congestion – has become part of a larger intra-state planning effort through MISO and the Midwest Governors' Association, the Upper Midwest Transmission Development Initiative (MISO, 2011). This delicate political exercise, integrating state-level renewable energy standards into projections of transmission needs across the MISO region, has resulted in 17 proposed power lines (MISO, 2011). Current proposals have the entire 17 lines built as regionally beneficial projects, with all MISO member states sharing the cost. The first two are under construction (in Michigan and Minnesota), but it is uncertain if the ambitious regional plan will be fully built. Supporters cite lower electricity prices, and wind integration of non-correlated wind resources, with wind projects in Indiana and Illinois helping to balance wind intermittency in Iowa, North Dakota and Minnesota. Opponents worry about the cost of new infrastructure and the aesthetic and environmental impacts of the power lines.

Although cost is an issue, in Minnesota, the challenges associated with transmission are more frequently described in terms of the political and administrative process, such as transmission line siting and permitting, and interconnection approval. A general perception seemed to be that it would (MN 06, industry organization) "take political might" and that Minnesota (MN02, government official) "will need policy help" to get new transmission capacity built. In line with this, several stakeholders minimized cost aspects, noting that (MN06, industry organization) "the financial difficulties – financial costs of putting up the transmission lines – are not insurmountable." One representative of an environmental organization emphasized that transmission represented a small part of the cost of installing new wind power:

> "The cost of achieving 20 percent of our electricity from wind power would run about 750 million dollars, of which only about 70 [million dollars] would be for this transmission system. So, the transmission – in spite of the fact that it's massive – it really is dwarfed by the overall cost." MN05

People in the path of proposed power lines are opposed to them both for fear of having their property expropriated under eminent domain and on aesthetic grounds. An academic researcher described local populations as not wanting (MN12) "these big transmission lines running through our back yard." While people might regard wind turbines as beautiful, another interviewee from an environmental organization said that transmission lines were less likely to be viewed positively (MN05): "The only people I know who think transmission lines are beautiful are transmission engineers. Everybody else agrees they're kind of ugly."

Concerns were also raised by several stakeholders with regard to new transmission capacity opening the doors to increased coal generation. An academic involved in research on wind power acceptance pointed out that (MN12) "the wires can't tell the difference between a brown electron and a green electron." He added that there was fear that once new transmission capacity was in place, developers would use this as an argument for building new coal plants:

> "Transmission is directly related to which generation sources are economical [...] I think their strategy is that they will try and build as much transmission as possible and then they'll fight the generation case later." (MN12)

Consequently, environmental NGOs have fought hard to (MN20) "put conditions on those Certificates of Need to ensure that the new capacity gets used for renewable energy." On the other hand, surprising – and sometimes uneasy – new coalitions have formed, with some environmental groups actively supporting new transmission capacity, seeing it as a precondition to putting more renewable power on the grid:

> "For us as an environmental group now to be supporting new transmission investment, it's a surprise to some, but it's pretty

logical given where we want the wind energy industry to be able to go." (MN22)

Overall, energy policy stakeholders painted a picture of Minnesota as a state where realizing major infrastructure investment for wind power transmission will require political will and coordination, even if the economics seem favorable. They overwhelmingly agreed that transmission was the major obstacle to developing the existing wind resource in this state.

4.2. Montana

Montana currently has little wind development (Fig. 4), despite a vast and high quality wind resource. Wind power is seen as a valuable resource for export in this state, necessitating transmission build-out. Distributing the costs and benefits of this transmission fairly was a dominant theme in the Montana interviews.

In Montana, mentions of transmission in our interviews were generally associated with the state's role as a net electricity exporter. The small population of this large state is dispersed across a large area and growing slowly, meaning that energy demand growth is flat. As noted by a government official (MT08): "it's not as though there's a market here in Montana for almost any kind of generation." In contrast, other areas in the Western United States and Canada have an appetite for additional wind power and Montana could increase its already large exports to these areas, provided it develops (MT 05, government official) "the ability to move energy out." As in other states, the best wind resource is not located close to where demand for electricity exists (MT09, government official): "Montana is pretty remote from a lot of the load centers, transmission is an issue." Electricity generators in Montana already produce more energy than can be consumed in state, using Montana's large coal resources, but due to the congested transmission lines, they are not easily able to increase exports. One industry stakeholder voiced the opinion that (MT18) "Montana can have an enormous economic boom if we had transmission going out of the state. As it is right now Montana generates twice as much [electricity] as it uses. And all of the lines going out of the state are pretty full." In a similar vein, an academic researcher said (MT02), "The big problem is that Montana's got this tremendous resource for generating electricity using renewable sources, but the question is getting it out of the state."

Already, recent transmission line construction in Montana has included building lines for export both to Nevada (namely, Las Vegas) and to Alberta, Canada. Despite these projects, Montana was described by an academic researcher as (MT02) "maxed out as far as existing transmission," and more transmission lines are going to have to be built to take advantage of the state's wind resources for export. In Montana, building more transmission is seen as a necessary infrastructure investment to take advantage of a valuable (MT12) "export commodity," in the words of a representative of an environmental organization. The majority of stakeholders emphasized the economic opportunities associated with building more transmission and exporting wind power to markets in California, Nevada and Alberta, including this public official (MT10): "Montana could be a leader in energy development and supply a big portion of the country with our resources." Another researcher explained (MT15), "once we get that distribution conundrum solved, then we have vast areas, unpopulated areas, high wind, class seven or so, of electricity for the country." Overall, there was strong consensus across all stakeholder groups on the economic opportunities that wind power transmission could unlock for Montana.

At the same time, some stakeholders were wary of the cost distribution issues associated with building new power lines. A government official strongly cautioned against local customers having to pay the bill for new transmission without reaping the benefits:

> "there are enormous issues about who pays. … I really do need to know how it's gonna affect the […] vulnerable residential customer. […] There isn't any way for them to organize or do anything else. They're […] captive. They need electricity, and so how are they protected against having to pay for stuff that doesn't do them any good? The likelihood of […] any kind of new transmission being needed to serve customers in eastern Montana is pretty slight. And if it is, it's gonna be small – it might be a 69 kV line. Well, the cut-off point by which you start socializing the costs of these transmission lines is 345 kV." (MT08)

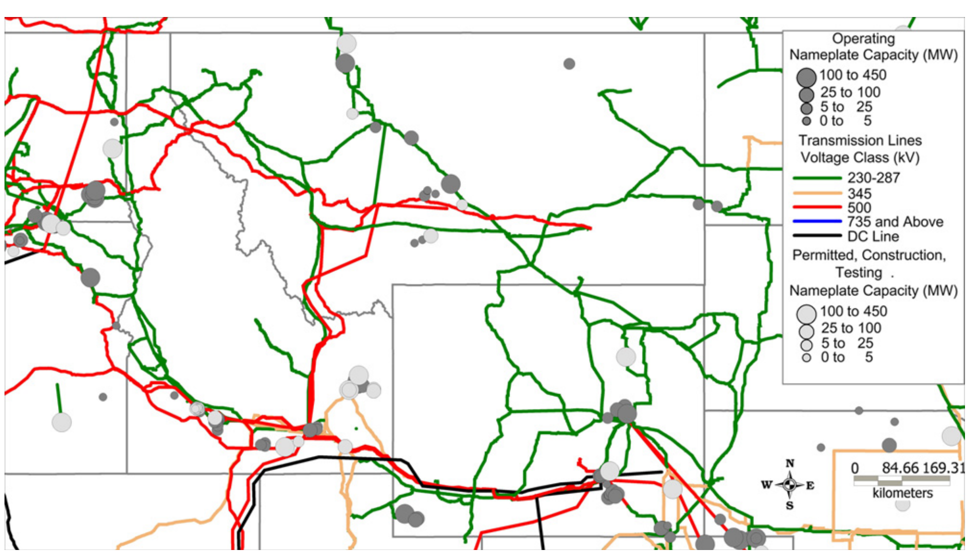

Fig. 4. Location of wind turbines and existing and planned power-lines in Montana. Montana is using only a small part of its vast available wind resource. Of the 386 MW installed by the end of June 2011, 135 MW are located at the Judith Gap project (AWEA, 2011). There is little need for additional transmission inside Montana; proposed transmission lines would strengthen its capacity for exporting wind and coal power to adjoining states and Canada.

As new transmission lines are proposed, the challenges of determining cost allocation (who pays for the investment) is likely to be exacerbated. Some stakeholders fear that industry players will try to have Montana's electricity consumers (households and businesses) foot the bill for new transmission lines to export wind power out of state under the guise of upgrading the in-state infrastructure. Another public official said:

> "From our perspective as a consumer advocate, the allocation of the cost related to transmission is going to be an issue [...] in the future. I've heard people talk about already justifying the construction of new transmission based on, 'Well, the existing system is pretty old, so it needs to be rebuilt to make it reliable anyway.' When I hear those comments, I hear the beginnings of the arguments to allocate those costs to the local utility customers rather than to the loads that might be using the power that is generated and exported out of the state. "(MT09)

In Montana, mention of opposition to transmission lines based on aesthetic grounds was minimal, although two stakeholders referenced concerns about preserving remoteness and untouched nature. Although Montana is home to heavy industry with severe environmental impacts, in particular mining, these activities are concentrated around Butte and Helena, in the Southwest quarter of the state. Montana's status as a wilderness state and the image of untouched nature remain important in the public imagination. Given the low population density, it is not clear how strong opposition on aesthetic grounds will become as more transmission projects are implemented.

Given the trade-off between facilitating more renewable energy and preserving the wilderness, the environmental community has taken different positions on transmission. An academic researcher (MT 02) described the situation as follows: "The environmental community in Montana is divided about wind. Most of the Montana environmental community supports it, but not 100%, and in California the Audubon Society, the Sierra Club fought wind." Another interviewee from an environmental NGO said that they were (MT07) "not fighting certain transmission that's clearly for wind development," suggesting that they would fight other transmission lines. The environmental community is also pushing for investment in distributed networks to solve the transmission bottleneck. Another NGO employee said (MT 03) "it would be a better use to invest in more of a localized distribution network, rather than creating these high-powered transmission grids [...] all over the western continent." At the same time, environmental NGOs are cognizant of the challenges of small wind projects, so they are prepared to support large scale wind:

> "we work in a world where utilities are the ones who give us our electricity, and moving away from that model is gonna be slow and painful .... We have a provision, a renewable energy standard for smaller scale wind or renewables, but that's gonna change this year, and we're gonna probably support that change and allow [...] investor owned utilities to expand the amount of energy they're getting from larger scale wind farms. Economies of scale matter." (MT07)

Of the three states in this study, Montana stakeholders were the most concerned with economic aspects of wind transmission, both with regard to the potential economic gains of exporting wind power and the potential cost allocation conflicts. One industry representative (MT06) adds that in addition to transmission, grid coordination and wind integration is also a bottleneck for wind development, "Until there's a grid operator that sort of takes over and creates a Grid West or an integrated western US grid operation, which was supposed to happen many times over the last several years and never has. And the grid operation in the Western US will never be coordinated. So it won't allow a lot of this energy development to happen in Montana." In both Texas (as part of ERCOT) and Minnesota (as part of MISO), RTOs are fulfilling this function.

4.3. Texas

Texas' best wind resource is located in the Panhandle area, and accordingly, wind turbines are concentrated in this area (Fig. 5). Load centers are however located in the Eastern part of the state, creating transmission challenges. Indeed, as in Minnesota, Texas is experiencing worsening transmission bottlenecks for wind power and in 2010, 7.7% of wind power was curtailed in the Electric Reliability Council of Texas (ERCOT) region (Ryan Wiser and Bolinger, 2011). Due to the rapid growth of wind power far from electricity load centers (the cities) and the unique

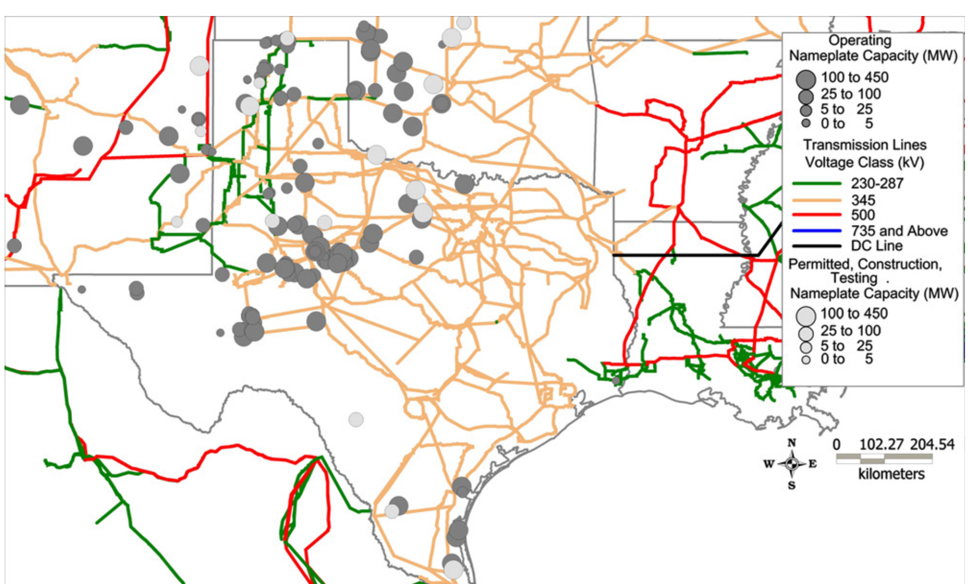

Fig. 5. Location of wind turbines and existing and planned power-lines in Texas. Today, Texas has the largest installed wind capacity (10,135 MW) and is the largest producer of wind power in the US, and the state with the fastest growth in wind power. In June 2011, installed wind capacity reached 10,135 MW.

confluence of the state borders with the regional transmission grid, these transmission issues are particularly severe.

ERCOT interconnection rules allow any new source of power generation access to the grid and the costs of infrastructure upgrades are allocated to loads or energy users and not electricity generators (Sioshansi and Hurlbut, 2010). Interestingly, this has created perverse incentives to overbuild wind power in Texas, even where transmission capacity is insufficient and wind resources are regularly curtailed. Accordingly, transmission was mentioned as an obstacle to future wind development in all but three stakeholder interviews in Texas, and it often topped the list of barriers. A representative of an environmental organization summed it up neatly (TX11): "The list of top three [challenges] for wind industry I would say [are] transmission, transmission and transmission." Several stakeholders explained that building a transmission line takes (TX12, industry organization) "on the order of five years" or longer, while developing a wind farm takes only about one year. The mismatch in development times meant that Texas (TX11, environmental organization) has "very quickly developed existing lines." In fact, it seems that initially developers may have pursued a 'if you build it, they will come' strategy, as described by a utility representative (TX14): "The developers all assumed, as it turned out, incorrectly assumed, that the transmission system would be beefed up to accept their wind energy when the wind farms were finished."

Contrary to Minnesota, where utilities and wind developers have been able to make use of inter-state transmission lines to develop wind energy in Iowa and North Dakota and circumvent transmission bottlenecks within the state, Texas has a self-contained grid. In addition, the best wind resources are located in the Panhandle region of Texas, whereas the load centers are located in the Eastern part of the state. Therefore, transmission bottlenecks quickly rose to the top of the agenda as wind power capacity grew rapidly throughout the past decade. Transmission development did not follow suit, in part because of the cost recovery structure for transmission under deregulation. In the words of a utility manager, "We allow private companies to build [power plants] anywhere, but it didn't deregulate transmission. Transmission builders would only build if they were assured by the regulators that they would recover their costs, and they were not assured of that, and therefore, they didn't build." (TX14)

Due to the unique geography and institutional structure of the Texan electric grid, these issues clearly had to be solved internally. The Texas Public Utility Commission (PUC) started a process to shore up the construction of transmission lines and plan an investment of US$ 5 to 6 billion. At the time the interviews were conducted, Texas had just announced the creation of Competitive Renewable Energy Zones (CREZ) which would target areas for renewable development and accompanying transmission lines, with upgrades scheduled to be completed by 2013. Beginning in 2005, the PUC had started to study the renewable resources in the state. According to one stakeholder from an environmental organization, the goal was to

> "determine what were the hot spots for wind and prioritize construction of transmission to those areas because the fear was that any ole' person could plop down farm and say, "Build an expensive transmission line to me," even though it didn't make sense. They determined what were the windiest parts of the state, and then [...] went through a variety of scenarios of how much transmission they were going to build." (TX10)

Stakeholders' descriptions of CREZ were generally positive, even hopeful. One stakeholder from an environmental organization expressed the opinion that (TX08) "to my mind transmission [...] is being dealt with well." In the words of another stakeholder (TX06, academic researcher), "we've made a commitment as a state to be able to improve the grid, to be able to get transmission from those areas that are at the edge of the Earth and edge of Texas." The creation of CREZ was also described as a "proactive transmission planning regime to support more renewable development in the future" by a member of an industry organization (TX12). This type of proactive planning allows for systematic development of wind power in the areas with the best resources. It also runs counter to established practices of transmission planning, where new generation generally predates the construction of new transmission. The process was described as follows by a representative of an environmental NGO:

> "Typically, in ERCOT, if you want to build transmission, you have to petition the PUC [Public Utility Commission] and say, "I have this power plant. Lines are already constrained, so I need transmission for that." The goal of the CREZ is to have the transmission built prior to a lot of the generation, to encourage people to build there." (TX08)

Regulators and the wind industry realized that this model did not work for decentralized development of renewable resources. Even large wind farms are generally sized on the order of 100 MW, and are not comparable to conventional coal or nuclear plants, with capacities up to an order of magnitude larger. Therefore, the CREZ planning process brought different stakeholders to the table to build power lines to where the best potential for wind power existed. A utility manager (TX14) chronicled the process as follows: "these zones effectively were created in a planning process between the wind developers and the utilities and the regulators, and within each zone, a decision would be made to build transmission proactively before it was needed because it takes more time to build transmission than it does to build wind farms." Overall, most stakeholders expressed the opinion that CREZ would provide a significant increase in transmission capacity and resolve the bottlenecks, including this government official (TX13) "Once that's built ... there will be significant transmission capacity to move wind to load."

A small number of stakeholders cautioned that even CREZ was not sufficient, given the pace of wind power development in Texas. For example, one environmental stakeholder pointed out that (TX11) "by the time that transmission system gets built, we will probably have built beyond its capacity. Because we can build it faster than [transmission]—and we have more capacity than we've planned in our transmission." Several stakeholders mentioned offshore wind as the next big step in wind power development. Its proximity to load centers made offshore wind attractive from a transmission perspective, as described by a researcher (TX06): "Most people would say that our lower gulf coast is one of the best places in the world for that shallow bottom prevailing winds; and, there again, we'll have to deal with transmission, but that can be done." Although the cost per mile is higher for off-shore transmission, the characteristics of off-shore wind should compensate for this. Studies have shown that the wind blows more consistently, and blows when load is high (as opposed to on-shore wind).

A few Texas stakeholders also mentioned the need to integrate solar power better with wind power in the build-up of the CREZ zones, because (TX19, government official) "if you can couple those two, you do get a much more efficient use of the transmission lines or constant use [...] of the transmission lines." As one stakeholder from an industry organization pointed out, the CREZ zones not only hold the best wind, but also the best solar resource in the state:

"we're building [...] thousands and thousands of megawatts of new transmission now toward where there's wind, but also [to] where there's the best sun in the state. And so, the conversation now is how do you drive utility scale solar development out there, so you really maximize the investment of the new transmission of a more balanced load coming during the day and at night." (TX09)

Texan stakeholders also addressed property rights and cost issues associated with transmission that remain to be resolved. Eminent domain is a lingering problem despite the CREZ process, so a public official emphasized that (TX19), "a number of the transmission service providers that were chosen in the CREZ process have committed to using existing rights of way where possible or where available." Again, the focus seems to be on developing as many transmission lines in as little time as possible, to avoid major siting disputes. Due to the self-contained ERCOT grid in Texas, siting of wind farms and transmission lines is somewhat less complicated than in other areas of the country (TX13, government official): "typically the wind farms have to go across state boundaries to get to significant load centers and so they have to deal with [...] multiple state agencies and have to deal with the Federal Energy Regulatory Commission, because you're dealing with interstate commerce." Cost sharing may still become a point of contention as more lines within CREZ areas are developed. This is due to the cost-sharing structure within ERCOT, described here by a representative of an environmental organization:

"we have historically [...] built transmission and improved our grid by having all our citizens within the grid share the cost. So that if you build a transmission line from a refinery or from a coal plant in east Texas down to a refinery on the Gulf Coast the guys in west Texas were paying for it just like the people in east Texas. And we've been able to spread the cost out of transmission historically." (TX11)

The practice of sharing transmission line costs across the grid is different from MISO, where historically, the marginal resource requiring additional transmission bears the cost. While the ERCOT system appears more equitable at first glance, it creates its own problems. Another environmental stakeholder described the CREZ process as (TX10) "a big fight, because a lot of the big industrial users didn't want to pay for transmission because that's shared across the system." One possibility discussed in Texas is to move towards a nodal electricity market, which includes the price of transmission in the price of power, with guaranteed access to transmission. The goal, according to an environmental representative is (TX08) "to better reflect the true cost of transmission and to some extent the cost of where your generation is located." Nodal markets provide efficiency, but can also present a temporary price risk, which consumers would need to hedge against (Bushnell and Stoft, 1996). Nodal markets incorporate congestion charges and line loss into pricing, which could create the incentive for investors to increase them to collect more money. Therefore, the institutional structure needs to be set up carefully to avoid perverse incentives (Bushnell and Stoft, 1996). Overall, Texas stakeholders were clearly supportive of wind transmission and cautiously optimistic about the prospects for its increased development.

5. Discussion and conclusions

In the U.S., the future of wind power is linked to transmission. While transmission needs for the first wind projects were relatively small and ad hoc development happened where excess transmission capacity was available, large-scale wind power requires increased coordination. Planning within and across states to transport wind to demand centers and balance the intermittency of the wind resource is necessary. Our interviews with stakeholders involved in making energy policy to support wind highlights the challenges associated with this transition from small to large wind and the importance of new transmission infrastructure. Our interviews also demonstrate that this transition is complicated and requires cooperation both within and across very different social and political environments. The coordination that is required also raises challenges of multi-level governance and federalism as transmission line planning, siting, and development intersect in many different state institutions. While this is also true with other critical infrastructures like natural gas or transportation, the balance of benefits and importance of state-level influence is unique in transmission planning.

For each state studied here, two crucial questions emerged: Who will pay for the transmission upgrades? And who will benefit from the wind resource? These questions are overlain on a potentially fractious matrix of political interests. Wind developers, electric power utilities, land-owners with turbines, land-owners with transmission towers, land-owners able to see wind turbines or transmission towers, environmental groups, Public Utility Commissions, State Energy Offices, Departments of Natural Resources all have different interests in developing wind resources and coalitions of political interests are evolving. How these interests – both existing and emerging – are shaping both transmission development and wind power development is rapidly changing, and is different in each state. For example, wind developers in Montana face strong opposition from established energy companies as well as local environmental groups concerned with protecting the landscape. These interests are mediated by established rules governing the interconnection of wind projects enforced by the different regional transmission organizations, and state-level electricity systems and institutions. States are engaging in different policy and planning approaches to overcome these challenges.

In Texas, a deregulated electricity industry and high electricity prices have led to a rapid build-up of wind resources and resulted in severe problems with grid congestion. ERCOT interconnection rules – where the cost of transmission infrastructure improvements are allocated to loads, and not generators – fueled the rapid expansion of wind energy and subsequent curtailment of wind power to manage the loads. Expanding the grid in Texas is, however, potentially *politically* simpler than in other regions of the country as ERCOT operates as a largely Texan island. Together, as a policy solution, state regulators and industry representatives created the CREZ, a coordinated plan to co-develop renewable energy zones and new transmission upgrades, allowing for a rapid build of new lines. This type of coordinated development has now been copied in other jurisdictions, e.g., the California Renewable Energy Transmission Initiative or the Upper Midwest Transmission Development Initiative.

For Minnesota, developing the future of transmission infrastructure will require regional coordination and this is a political as well as a technical effort. Energy stakeholders from Minnesota's non-profit and utility industries have been instrumental in supporting transmission planning across the region. Through the Midwest Governors Association and MISO regional renewable energy zone and transmission planning effort the region has proposed 17 "no regrets" transmission lines. While actually building the 17 proposed lines is an ongoing challenge, stakeholders realize that new transmission lines are crucial for the further development of wind power and the electric system.

For Montana, wind development is transmission development, but the policies necessary to support this are less clear. As an energy exporter, getting the electricity out of Montana and to electricity demand centers is hindering wind development. Who pays for wind transmission is crucial as the local benefits of wind development are often perceived as marginal. Additionally, siting transmission lines to transport energy out of state is proving to be a challenge. How transmission lines will be used (for wind or coal?) and will affect sensitive natural areas challenges some stakeholder ideas of Montana wilderness.

Across all three states, some common themes emerged among certain stakeholder groups. Industry stakeholders tended to emphasize the economic benefits of building transmission for wind power and the cost allocation of new transmission lines, while academics, government representatives, and environmental NGOs were far more likely to dwell on societal issues like cost allocation and environmental impact. Despite these broad similarities, the state context was far more dominant than stakeholder type in determining positions on transmission for wind power. For instance, all stakeholders in Texas strongly focused on the economic benefits, while Minnesota stakeholders almost uniformly addressed the need for policy as a driver for further transmission build-out.

The relationship between wind development transmission and policy is complex: all three states studied have strong wind resources, and all stakeholders identified transmission as important for future wind development. Transmission—and its associated challenges, however, is perceived and portrayed differently by energy policy actors in different states and is being shaped by the unique political and social context within each state. Stakeholder concerns that couple wind and transmission demonstrate the complexity involved in siting wind and other renewable energy sources. While aesthetic opposition to wind power has been influential in some projects, aesthetic opposition to transmission is simultaneously more and less severe. For example, opposition to the aesthetic degradation of a landscape is widespread, but energy transmission is also acceptable to many because alternatives to transmission are not obvious. Transmission infrastructure is a societal necessity, but the public recognizes that there are multiple ways to generate electricity—and long-distance transmission for wind may not be seen as a necessity. On the other hand, proposed new transmission infrastructure has been opposed by some environmentalists as unnecessary and perhaps facilitating more fossil-fuel based power and discouraging energy conservation, efficiency or other forms or electric load management.

Less and less, the policy questions facing wind are about building the actual wind power. Instead, how to resolve transmission and grid integration issues has become the lynchpin for further wind development. States would do well to learn from each other's experiences in solving these issues. Already, the special transmission development zones first conceived of in Texas have found imitators in other states. For instance, California has adopted a policy quite similar to CREZ: The Renewable Energy Transmission Initiative (RETI) will serve to identify preferred areas for transmission development. Nevertheless, replicating the success of CREZ is not self-evident. Texas benefited from having a self-contained grid and a system for cost allocation that did not lead to huge contention around the distribution of costs and benefits. Preferred transmission zones can help focus transmission planning efforts, but do not resolve the underlying issue of cost allocation and regional collaboration. Regional coordination efforts are also needed. The Western Governors' Association has started working on the Regional Transmission Expansion Project (RTEP) to ensure build out of transmission capacity for renewable power. Initiatives such as this will be essential to continue the ascent of wind power. In the Midwest, the coordinated modeling and planning efforts by the Midwest Governor's Association and MISO have prioritized new transmission lines, but building those lines is still dependent on state-specific approvals.

FERC Order 1000 has also gone a long way towards bringing consideration of renewable energy into transmission planning. Grid operators now have to take into account policies such as renewable portfolio standards for transmission planning. In addition, FERC order 1000 lays out cost allocation rules which emphasize regional benefits. This order has added momentum to overcome problems with long-standing transmission planning practices (Klass and Wilson, 2012).

If wind power is to grow sufficiently to meet a significant portion of North American electricity needs, solving the transmission dilemma is imperative. Any set of solutions must incorporate both technical feasibility and political interests. The future of large-scale wind development depends on overcoming the state-specific obstacles for power transmission, and requires a simultaneous integration of social and political needs pursued in tandem with wind technology development.

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