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Policy stakeholders and deployment of wind power in the sub-national context: A comparison of four U.S. states

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ABSTRACT

As climate change mitigation gains attention in the United States, low-carbon energy technologies such as wind power encounter both opportunities and barriers en route to deployment. This paper provides a state-level context for examining wind power deployment and presents research on how policy stakeholders perceive wind energy in four states: Massachusetts, Minnesota, Montana, and Texas. Through semi-structured interviews, state-level energy policy stakeholders were asked to explain their perceptions of wind energy technology within their state. Interview texts were coded to assess how various drivers promote or hinder the deployment of wind power in sub-national contexts. Responses were dominated by technical, political, and economic frames in all four states, but were often driven by a very different rationale. Environmental, aesthetic, and health/safety frames appeared less often in the discourse. This analysis demonstrates that each state arrived at its current level of deployment via very different political, economic, and technical paths. In addition to helping explain why and how wind technology was – or was not – deployed in each of these states, these findings provide insight into the diversity of sub-national dialogues on deployment of low-carbon energy technologies.

1. Introduction

Climate change mitigation in the United States requires fundamental changes in the way electricity is produced and consumed. In this context, renewable energy has emerged as an important component of a less carbon-intensive electricity generation system. Wind power is the fastest growing energy resource in the United States, at 42 percent of all capacity additions in 2008 (Wiser and Bolinger, 2009), but significant geographic variability persists in its deployment. The distribution of the wind resource is one factor influencing these disparities, but cannot fully explain the geographic differences (Toke et al., 2008). The complexity of wind deployment patterns becomes apparent when mapping the best wind resources over actual deployment. Six states (Texas, California, Iowa, Minnesota, Washington, and Oregon) accounted for 65 percent of nationwide new turbine installation in 2008 (AWEA, 2009). In contrast, the Great Plains states of Nebraska, South and North Dakota have some of the nation's best wind resources, but they make up only 4 percent of the total national installed wind capacity (AWEA, 2009).

State-level energy policy such as renewable portfolio standards, siting policies, and mandatory green power programs have been shown to be correlated with wind deployment (Bohn and Lant, 2009; Menz and Vachon, 2006), although some states have seen little new deployment despite seemingly supportive policies (e.g., Massachusetts) and vice versa (e.g., Texas, Iowa). Neither energy policy nor the distribution of the wind resource fully explains state-variation in patterns of deployment. A highly complex socio-political context surrounds state-level decisions, policy, and discourse around energy technology development; understanding this context is critical to comprehending deployment of wind power as well as deployment of other emerging energy technologies.

State level processes, institutions, and organizations are important forces influencing electricity generation and consumption across the United States (Rabe, 2004). Although federal energy policies outline broad directions for the U.S. energy system, states have historically been the main locus of influence on the electricity system. State legislatures have authority to pass

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statutes that shape the electric power industry, impact the relative use of different energy sources, target local economic development, and set environmental goals. Some state legislatures have paved the way for restructuring the electric industry (Mattoon, 2002). Public utility commissions permit the construction and expansion of power plants and transmissions lines, and – together with other agencies – monitor compliance with environmental regulations (Sautter and Twaite, 2009). In traditionally regulated states, commissions also set electric power rates. Various stakeholders at the sub-national level also have an informal influence on state policy adoption (Berry and Berry, 2007; Gray, 1973). The diffusion of energy technical innovations is also influenced by stakeholders (Bird et al., 2005; Breukers and Wolsink, 2007; Jacobsson and Johnson, 2000; Rao and Kishore, 2010).

Energy technology development is embedded within various energy system institutions at the state level. Stephens et al. (2008) have proposed an integrated research framework, the socio-political evaluation of energy deployment (SPEED) framework, to facilitate a more nuanced understanding of the interconnected complexities of energy technology deployment. The SPEED framework provides a structure to explore interactions among socio-political factors influencing deployment, including regulatory, legal, political, economic, and social factors. The framework encourages multiple approaches to exploring these socio-political factors including policy review (Wilson and Stephens, 2009), media analysis (Stephens et al., 2009), and stakeholder interviews.

Building on this structure, this paper uses the results of semi-structured interviews with policy stakeholders to provide a comparative assessment of wind deployment in four states: Massachusetts, Minnesota, Montana, and Texas. It examines the state-level interactions among economic, political, technical, cultural-aesthetic, and environmental factors that have facilitated deployment of wind power in Minnesota and Texas, and hindered deployment in Montana and Massachusetts.

2. Case study selection and context

This research applies a comparative case study approach, which can be a powerful tool to study uncommon or multifaceted phenomena (Ragin and Becker, 1992; Siggelkow, 2007). Small-n qualitative studies are widely used in policy studies (Bennett and Elman, 2006; Mahoney, 2007). Cases that are negative for the outcome of interest are often included to assess whether "disconfirming observations" (Mahoney and Goertz, 2004: 656) exist that contradict hypothesized relationships. Here, we use a diverse case selection method to conduct a cross-case analysis of negative and positive outcomes of interest, since "encompassing a full range of variation is likely to enhance the representativeness of the sample of cases" (Seawright and Gerring, 2008: 301).

Massachusetts, Minnesota, Montana, and Texas were selected because their contexts for wind deployment are very different and they exhibit variation in two important dimensions: (1) wind deployment and (2) policy status relevant to wind technology deployment. This variation enables a comparative assessment of the context in states where policy has been more or less effective and in states where other socio-political factors are important. Texas, Montana, and Minnesota each have a large on-shore wind resource potential while Massachusetts has a smaller, but still sizeable resource. Texas and Massachusetts also have an off-shore resource. An important number of policies relevant to wind technology deployment are in place in both Massachusetts and Minnesota, whereas Texas and Montana have fewer such policies. Montana and Massachusetts have relatively little installed wind power, but the wind energy sector is large and growing in Minnesota and Texas.

Texas has a significant wind resource, particularly in the Panhandle area, and wind capacity is growing faster than in any other U.S. state (Wiser and Bolinger, 2008). At 9410 megawatts installed wind capacity in December 2009, it is the largest producer of wind energy in the United States (AWEA, 2009). Electricity prices are fairly high compared to other U.S. states and have helped wind power's competitiveness with other power sources. Minnesota also has a strong wind resource, in particular in the Southwestern part of the state, along the Buffalo Ridge. With an installed capacity of 1809 MW as of December 2009, Minnesota is the fifth largest wind power producer in the nation (AWEA, 2009). Of all U.S. states, Minnesota has the second highest penetration of wind power in the electric system, with wind generation providing 4.8 percent of all electric power in 2007, more than twice as much as in Texas (EIA, 2009c). Recent increases in wind capacity have been driven mainly by an agreement between the state and Xcel Energy (the power company that supplies 50 percent of Minnesota's electricity) over the storage of nuclear waste that involved a commitment to wind production. Wind deployment in Minnesota has also been supported by a commitment to community-based wind projects. In contrast, wind resources in Massachusetts and Montana have not been extensively developed. Of the four states, Massachusetts has the least installed wind power, currently only 15 MW (AWEA, 2009). The majority of the wind resource is located off-shore.[1] The Cape Wind Project, which was to become the nation's first off-shore wind farm, has "faced tremendous political, social, and legal challenges" (Phadke, 2010: 1) and is lodged in a lengthy permitting process as local residents have opposed the project on aesthetic, environmental, and economic grounds (Kempton et al., 2005). Likewise, Montana, a state with high wind power potential, has just begun to utilize its large resource, with only 375 MW capacity developed in December 2009 (AWEA, 2009). Much discussion of wind power development in Montana has focused on transmission, because as an electricity exporter Montana could potentially satisfy demand in nearby states that are ramping up their renewable goals.

3. Methodology

To evaluate socio-political differences and their impact on wind deployment, interviews were conducted with influential actors from each of the case-study states. While several other studies have examined public perception of wind power (Devlin, 2005; Firestone and Kempton, 2007; Wolsink, 2007), the goal of this research is to understand the perceptions of stakeholders who actively participate in shaping the policy and legislative processes that influence energy technology deployment at the state level. Analyzing the perceptions of experts who are deeply involved in policy and markets relevant to a technology differs from assessing public acceptance in its focus on institutional factors (Agterbosch et al., 2007). A diverse set of policy stakeholders that had taken part in state-level political activity related to energy technology policy were identified and solicited for interviews. The policy stakeholders were initially selected through searching state legislative committee testimony where energy bills were presented and discussed. Additional stakeholders were identified via snowball sampling[2] during the first round of interviews. A total of eighty-four stakeholders from all

[1] Off-shore wind power is generally estimated to be 2–3 times more costly to develop than on-shore resources (Blum, 2009; National Academies of Science, 2009).

[2] Snowball sampling consisted in asking interviewees for suggestions of additional policy stakeholders to interview.

Table 1
Distribution of interviews across states and policy stakeholders.

	MA	MN	MT	TX	TOTAL
Academic	1	3	2	1	7
Government	6	3	7	9	25
Industry, industry NGO	5	10	6	6	27
Environmental NGO	7	7	5	6	25
Total	19	23	20	22	84

four states in various positions within the policy process were interviewed (see Table 1). The interview protocol can be found in the supplementary online material.

Content analysis of the interviews was used to provide comparative insights on stakeholder perceptions of wind deployment. Content analysis helps identify patterns of meaning in qualitative data, especially when analyzing large amounts of text (Holsti, 1969; Krippendorf, 1980). We employed *a priori* coding (Creswell, 1998), meaning that our coding categories were developed from a theoretical foundation as opposed to emerging from the material (Stemler, 2001). In this approach, codes are prestructured from theory and refined during coding to ensure a high degree of exhaustiveness and mutually exclusive coding categories (Weber, 1990). Interviewees were prompted to speak broadly to challenges and opportunities of wind power, and responses were coded into theoretically predefined categories. Building on previous analysis (Stephens et al., 2009), we developed explicit guidelines for analyzing and assigning interview content to socio-political context and risk/benefit frames.

Stephens et al. (2009) proposed adapting Luhmann's (1989) social function systems theory for analysis of the socio-political context of state-level energy deployment. In applying social function systems theory to ecological communication, Luhmann (1989) proposes that society's responses to environmental perturbations are structured by functional subsystems, with economy, law, science, politics, religion, and education playing key roles. Responses to system-wide issues such as environmental pollution can only be achieved through communication across multiple subsystems. Since each subsystem possesses its individual code (e.g., money in the economic system), and messages have to be translated across subsystems, responses to system-wide issues are encumbered and slowed down. A full assessment of any system-wide issue therefore requires systematic examination of the codes used to communicate its perception across all relevant subsystems (Peterson and Peterson, 2004). This analysis used social function systems theory to provide the systematic framework for analyzing stakeholder perceptions associated with wind technology. The codebook was developed based on six social function frames: aesthetic and cultural, economic, environmental, health and safety, political, and technical (see Table 2). Additionally, to differentiate patterns of negative and positive evaluations, risk perception served as a frame for evaluating and incorporating discourse on wind technology.

The transcribed text of each interview was coded using QSR International's NVivo^{TM} 8 qualitative analysis software, a text-analysis program that facilitates coding and quantitatively assessing large amounts of text. The unit of analysis was an "utterance" – a complete unit of spoken language – into which interviews were segmented as proposed by Hruschka et al. (2004). Because utterances do not have an equivalent in written language (Kurasaki, 2000), we used sentences as the proxy unit of analysis. Due to the complexity of both the codebook and the analyzed material, each interview was coded by two coders, who then compared their work to reconcile the interview into a single set of codes (refer to supplementary online material for a more detailed description of this method). The results were analyzed quantitatively by comparing the number of sentences coded in each frame and qualitatively by reviewing the content of the coded text.

Table 2
Signaling words and themes used to code interview content into socio-political context and risk perception frames, based on Luhmann's (1989) social function systems theory and reproduced from Stephens et al. (2009).

Frames	Positive (facilitator)	Negative (barrier)
Aesthetic	Positive visual impacts.	Negative visual impacts or other nuisance (e.g., noise).
Economic	Market is available for technology. Financial incentives make technology feasible. Low cost. Creates jobs.	Technology is expensive. Technology is not developed to commercial scale.
Environmental	Technology will reduce GHGs or carbon emission, mitigate climate change, reduce other air pollution.	Negative environmental consequences (e.g. bird kills, habitat loss, groundwater contamination).
Health and safety	Technology may improve human health and safety (i.e. reduce respiratory problems, asthma, etc.).	Technology may pose health risks for workers, public.
Political	Legislation is present or being considered that would help or facilitate the technology. Technology is easy to sell to public, socially acceptable, popular among the public or the community. Technology helps reputation of the state, or some other political entity.	Technology is politically sensitive or controversial. Technology deployment may be difficult due to permitting or siting process. Technology deployment is difficult because of the absence of a legal framework or regulatory uncertainty.
Technical	Technology has been proven reliable in other uses. Takes advantage of existing natural resource. Technology is feasible, doable, promising and/or has potential.	Technology may not work, is unproven, or uncertain. Infrastructure does not yet exist to support technology. Technology is limited in its technical capacity.

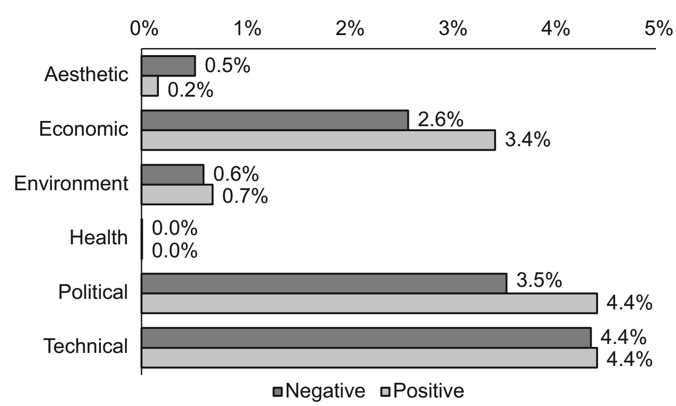

Fig. 1. Proportion of sentences coded in social function frames, shown as a percentage of all sentences in the interviews.

4. Coding results

One out of four sentences was coded as relevant to one of the six frames, for a total of 4198 coded sentences. An overview of all coding frames, broken down by negative and positive coded sentences as a percentage of the entire interview material, is provided in Fig. 1.

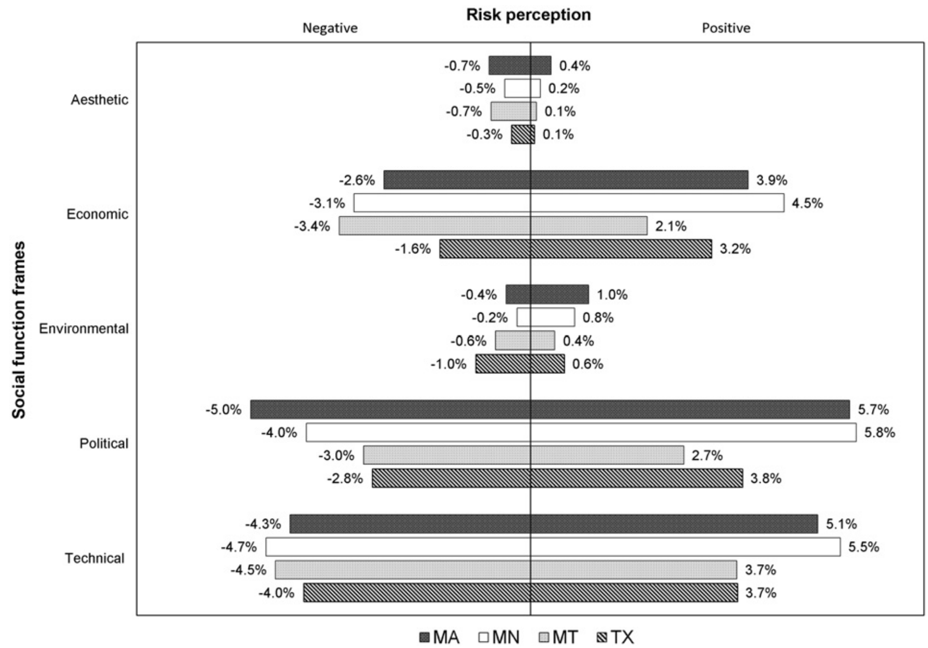

Fig. 2. Positive and negative coding in risk/benefit frames for each state, shown as a percentage of all sentences in the interviews. Negative percentages represent the proportion of negative sentences in the interviews; positive percentages represent the proportion of sentences that were positive.

Overall, the technical aspect of wind technology was mentioned in almost 9 percent of sentences, making it the most frequently discussed frame. Responses were almost evenly balanced between positive and negative categories. This indicates that technical challenges and opportunities take a prominent position in the framing of wind technology. The political frame was the second most commonly referenced frame, closely followed by the economic frame. In both of these categories, the interview texts included more positive than negative comments. The environment and aesthetic frames were discussed much less frequently. The former was roughly balanced between positive and negative responses, while the latter was more negative than positive. The health frame was only mentioned twice, indicating that potential health benefits or risks from wind power do not emerge as salient issues in any of these states.

When broken down by state, substantial differences in stakeholder perceptions of wind power emerge from each frame (Fig. 2). The technical frame captures aspects of the technology related to a state's resource base, electricity infrastructure, and research potential. Within the technical frame, on the positive side, wind energy was seen as having substantial "resource" and "promise." On the negative side, problems with transmission capability and intermittency were mentioned most often. Based on the aggregate numbers, policy stakeholders' discussions appeared relatively balanced between positive and negative aspects of technology. On average, positive comments outweighed negative comments in Massachusetts and Minnesota, while stakeholders in Montana and Texas had more negative comments.

This simple comparison of the number of comments does not reveal the very different state contexts which become apparent when assessing the substance of the interview texts. While Massachusetts stakeholders attach positive aspects to wind technology in principle, the Minnesota stakeholders spoke often from personal experience. Similarly, in Texas, the slightly more negative discourse seems related to system saturation and integration issues experienced with large-scale wind power deployment. Further, stakeholders in Montana, a state with relatively low wind deployment, appear to attach more importance to technical barriers than in Massachusetts, where public acceptance issues are more salient.

The political frame of wind deployment was the second most commonly mentioned risk/benefit frame. Its frequency indicates the relevance of political processes in wind deployment, confirming findings by Menz and Vachon (2006) and Bohn and Lant (2009) on the importance of policy for the deployment of renewable technologies. In particular, Minnesota and Texas stakeholders spoke more of both the positive and negative aspects of the political frame than those in the other two states. In Montana, negative comments prevailed, while Massachusetts stakeholders had only slightly more positive than negative comments, reflecting the contentiousness of wind energy in this state.

References to the economics of wind energy were also common. Across all four states, the economic frame incorporates the financial aspects of wind development, including its costs relative to other energy sources, potential for revenue-generation and job creation, and ownership patterns within each state. Texas had twice as many positive as negative economic references, the largest difference of any state (Fig. 2), and a sign of the economic success of wind power in this state. In Massachusetts and Minnesota, positive economic references also outweighed negative ones. Montana was the only state where negative economic comments predominated.

With regard to the environmental frame, stakeholders' attention to risks and benefits in this category varied considerably, and showed the greatest disparity across states of all categories. In Minnesota, positive comments outweighed negative ones more than 3:1, while Massachusetts had two positive comments for every negative reference to the environment. In contrast, both Montana and Texas had 30 percent more negative than positive references to the environment. More frequent mention of the environmental frame by stakeholders in Massachusetts and Minnesota corresponds to the stronger policy status in those

Table 3
Indicators for energy system and policy context in Massachusetts, Minnesota, Montana, and Texas.

Indicator	MA	MN	MT	TX
Population, 2008 (millions)[a]	6.5	5.2	1.0	23.3
Population growth, 2000–2008[a]	2.3%	6.1%	7.2%	16.7%
Land area (sq. miles)[a]	7800	79,600	144,600	261,800
Person per sq. mile, 2000[a]	810	62	6.2	80
Electricity consumption per capita (MWh), 2007[a, c]	8.8	13.1	14.1	16.1
Cost of electricity cent/kWh, 2007[c]	15.2	7.4	7.1	10.1
HHH-Index of industry concentration (> 1000 = high)[c]	1984	2747	3879	775
Electric industry CO_2 emissions (million metric tons), 2007[c]	25,539	37,706	20,013	255,092
Carbon intensity of electricity (metric tons CO_2/MWh)[a, c]	0.47	0.88	0.91	0.73
Installed wind turbine capacity in MW (and ranking among U.S. states), 2009[b]	5 (33rd)	1805 (4th)	272 (21st)	8361 (1st)
Renewable percent of fuel mix (excluding hydro), capacity/generation 2007[d]	< 0.05%/0%	8.8%/4.8%	2.7%/1.7%	4.4%/2.2%
Wind energy price ($/MWh)[e]	48	30	29	27
Policies and bills affecting wind deployment 1995–2008	14	50	6	14
Renewable portfolio standard[f]	22% of retail sales by 2020	15% of retail sales by 2015	25% of retail sales by 2025 (Xcel Energy: 30% by 2020)	5880 MW capacity by 2015
Public benefits fund[f]	$25 million per year	$19.5 million per year	$9 million per year	–
Community wind allotment[f]	–	Community-based energy development tariff	–	–
Greenhouse gas reduction goal[g]	80% below 1990 levels by 2050	80% below 2007 levels by 2050	–	–
Regional greenhouse gas initiative[g]	Regional GHG Initiative active in 2009	Midwest GHG Reduction accord in negotiations	Western climate initiative	–
Green pricing[f]	–	Voluntary program by Xcel Energy	Mandatory utility green power option	–

Sources:

[a] U.S. Census Bureau (2008).
[b] AWEA (2009).
[c] EIA (2009a).
[d] EIA (2009b).
[e] Bohn and Lant (2009).
[f] DSIRE (2009).
[g] Pew Climate Center (2009).

states, and could indicate that the connection between environmental issues and wind energy is more salient. In Montana and Texas, wind deployment is not strongly associated with climate change mitigation, although environmental concerns such as habitat loss and bird and bat kills did feature prominently within the discourse of some stakeholders.[3]

In every state, aesthetic comments were more negative than positive. This result is consistent with a previous comparative study on media framing of wind deployment in the same states (Stephens et al., 2009). In contrast to the media analysis results, stakeholders mentioned the aesthetic category significantly less often than other frames, indicating that aesthetic concerns are present in every state, but appear to be less influential or pertinent than other categories for implementers and others deeply involved in wind energy policy. They are not as prevalent in these stakeholders' perceptions as in the media.

There is minimal mention of the health and safety frame (one mention each in Minnesota and Texas), indicating that they are not perceived as playing a major role in wind deployment. Although the possibility of decreased air pollution was brought up by a handful of respondents, associated health benefits were not mentioned explicitly in any of the interviews.

5. Comparative state context discussion

This section details the interview analysis results within each state context by exploring stakeholder quotes within the discourse patterns emerging from the frame analysis, and discussing them in relation to the differing energy and regulatory systems (see Table 3 for an overview of the energy and policy context in each state). Quotations from the interviews are identified by state and interview number, i.e. MA11 refers to the 11th interview from Massachusetts. To allow for the assessment of themes within a state, Fig. 3 depicts the distribution of coded sentences by frame for each state, with percentages based on only the coded material.

5.1. Massachusetts

A typical New England state, Massachusetts is densely populated and relatively affluent. This urbanized state uses less energy than the other states in the study.[4] The population of 6.5 million has grown little in the past decade (U.S. Census Bureau, 2008), and energy demand increases have likewise been slow. Despite deregulation, its electricity system is characterized by high rates and a highly concentrated industry structure.

[3] Note that the environmental category overall was quite small in all states, and counts were driven by a small number of stakeholders, mostly from environmental NGOs. Many stakeholders did not mention environmental impacts or benefits at all.

[4] It should be noted that while Massachusetts is more energy efficient than other U.S. states, per capita electricity use and carbon emissions are higher than in industrialized European countries.

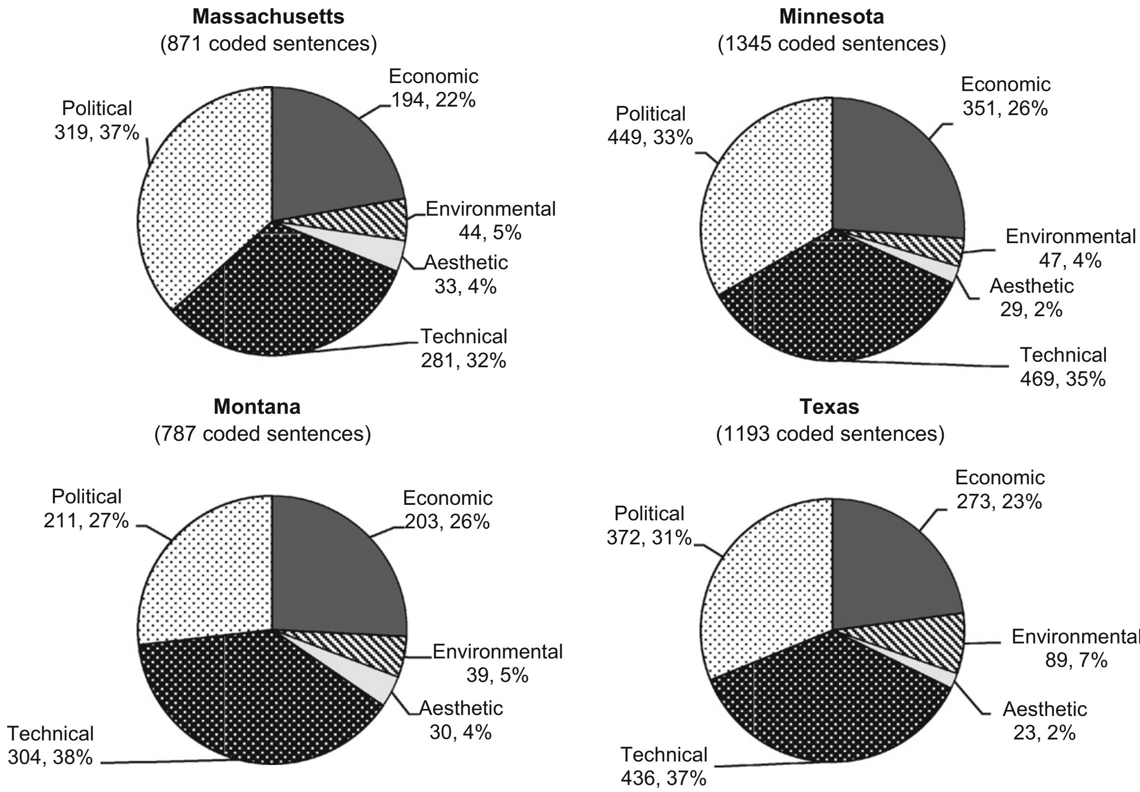

Fig. 3. Coded sentences in each frame for Massachusetts, Minnesota, Montana, and Texas. Absolute numbers represent the total number of sentences coded in a frame; percentages represent the proportion of all coded sentences in the state for each frame.

Massachusetts has no notable fossil fuel reserves. It relies heavily on imported natural gas (50 percent of resource mix) to satisfy electricity demand, and at a quarter of all generation, coal is used significantly less than in the average U.S. state (EIA, 2007). As a result, both absolute carbon emissions and carbon intensity are not as high as in the other states in this study (EIA, 2009b).

Massachusetts has taken several different approaches to reduce greenhouse gas emissions, including emissions targets, climate action plans, and regional greenhouse gas reduction initiatives. Massachusetts also has adopted legislation aimed at renewable energy deployment, including interconnection standards, a renewable portfolio standard, and net metering. The RPS requires renewables to make up 22 percent of sales in 2022, and an additional 1 percent every consecutive year, with no expiration date set at this point. In addition, Massachusetts' public benefits fund spends $25 million annually on renewable energy.

Policies encouraging renewable energy development, however, provide no guarantee that wind power technology will be deployed in the state. Although they have increased the amount of renewable energy *sold* in this state, it is generated elsewhere: "historically, Massachusetts has never been able to produce enough renewables to meet its standards (MA1)." 2007 was the first year no alternative compliance payments were used to meet the renewable portfolio standard; at the same time, only 12 percent of the energy used to satisfy the renewable goal was generated in-state (Massachusetts Department of Energy Resources, 2008). As part of the ISO-NE (Independent System Operator New England) interconnection system, Massachusetts faces congested transmission infrastructure while also struggling with severe siting difficulties (Vajjhala and Fischbeck, 2007). So while "there are actually a lot of market signals that have happened in the state through legislation over the last couple of months (MA11)," "the real challenge is to site the major wind facilities (MA10)." In fact, 17 of the 18 stakeholders interviewed in Massachusetts mentioned siting, permitting or 'not-in-my-back-yard' issues as important obstacles to wind development. Many stakeholders cited a combination of local resistance and burdensome siting and permitting rules as the main factor in delaying wind deployment: "there are multiple projects that have been in the planning and permitting stages for many, many years that have been appealed, that have bumped into local opposition, etc., and that has been probably the greatest thing that has slowed down wind development in the state (MA4)."

Technical difficulties also hinder rapid expansion of wind energy in the state. Specifically, transmission is lacking between areas with good wind resources and the population centers that require additional electricity. In the words of one environmental non-profit manager, "there's no transmission lines in the places where they want to build wind. They tend to be in the very remote areas (MA01)." At the same time, "It's a huge resource and we should find a way to use, to get more of it out there (MA10)."

In economic terms, stakeholders in Massachusetts had more positive references than negative, reflecting the perceived economic benefits of the technology. Wind is competitive with conventional generation in the state, but only through aid from policies subsidizing its installation and operation. According to an employee at a regional environmental non-profit, "The Global Warming Solutions Act […] will incorporate the cost of carbon into the marketplace and I think will put wind energy and other renewables on a more even keel or even footing with traditional fossil fuel generation (MA17)." Many of these policies encouraging wind development make a direct connection between the technology and its ability to mitigate climate change: "Wind has this sort of large scale industrial capability that is very promising from a climate change perspective to deliver bulk alternative energy from burning carbon, [...] from burning coal and oil (MA08)."

These environmental benefits, however, are countered by the potential for negative consequences. For example, one staffer at a prominent environmental non-profit said, "We went to a series of hearings for the Cape Wind project, for instance, and a lot of the community feedback was, it's ugly, it hurts wildlife (MA05)." Despite this perception by members of the public, many of the stakeholders did not view those concerns as a substantial barrier to the technology's deployment. "Actually the data with the new wind turbines and wind blades, it's actually very nominal [...]. You have more birds flying into buildings than you have getting affected by the turbine technology (MA05)." Likewise, while interviewees acknowledged that there was substantial opposition to wind development based on aesthetic concerns, they considered it a minor setback to the large-scale deployment of the technology:

> I strongly believe that once you start getting turbines up, it will ease some of the arguments on aesthetics, and getting turbines up will [...] educate people about how wind works. [...] They don't quite understand how it works and what the noise level is or what it looks like, etc. (MA11).

5.2. Minnesota

Like Massachusetts, Minnesota, with a population of 5.2 million (U.S. Census Bureau, 2008), has strong policy relevant to wind technology, but it has been much more successful in deploying wind technology. Minnesota is significantly less urbanized than Massachusetts, and faces quite different challenges in its energy system, having to continuously balance between the Minneapolis-Saint Paul metropolitan area and the rest of the state. While the urbanized Minneapolis-Saint Paul area is prosperous, fast growing and densely populated, much of the remainder of the state is less affluent, with many areas sparsely inhabited and experiencing population decline. A small number of investor-owned utilities serve the interstate corridors connecting the major population centers, resulting in a highly concentrated electricity industry. In contrast, rural areas are generally supplied by small municipal and cooperative utilities, which account for about a third of the electricity sold in the state (EIA, 2007). High voltage transmission line siting has historically been a contentious issue in Minnesota, not so much because of proximity to populated areas, but in part because of perceptions of unfair distribution of benefits and costs to urban versus rural populations. Minnesota's electricity generation is dominated by coal (61 percent). Although nuclear power supplies another 25 percent of the state's electricity (EIA, 2007), the large amount of coal results in a carbon-intensive fuel mix and significant absolute greenhouse gas emissions. Despite the importance of the electric sector in greenhouse gas emissions, neither environmental nor health concerns were mentioned prominently in the Minnesota interviews, suggesting that these concerns are not perceived as influential in wind deployment. Stakeholders in Minnesota talked about some opposition to wind based on environmental concerns, but its importance was downplayed in several interviews.

In contrast, technical aspects play a significant role in the Minnesota context. Reliability and storage were frequently cited as important technical issues to address. Similar to Texas the wind resource is large, but the power lines used to transmit that resource to the load centers are used to capacity. "We have tremendous wind potential here, [but] some of the big obstacles that we have are [...] the transmission capacity to deliver that wind, so there's a lot of things that have to happen, in a lot of areas where we'll need policy help to move us in that direction (MN02)." Transmission aspects were mentioned by all but five interviewees in Minnesota.

Minnesota has policies in place to encourage wind development, including a staggered renewable portfolio standard, culminating in 25 percent renewable sales by 2025 for all utilities but Xcel Energy, which has to achieve 30 percent renewable sales in 2020. In addition, Minnesota's public benefits fund spends $19.5 million annually on renewable energy programs. Similar to Massachusetts, there are several pieces of legislation that focus on greenhouse gas reduction. In Minnesota, "Climate change has really driven the market for wind power, the environmental benefits; and it has served to catalyze the governors in their region, through the Midwest Governor's Association, through their climate change goals (MN20)."

Almost all stakeholders portrayed these renewable energy and climate change policies as very successful in encouraging wind deployment, and most saw additional policy as a major factor for the continuing growth of wind power. "I think that in Minnesota we've done the right thing by working on the policies necessary to promote wind actually in all forms for development in the state (MN15)." Actors in the state have even gone as far as saying that Minnesota is a leader in developing wind through policy action:

> Minnesota's already taken a fairly aggressive stance on wind power and it's one of the leading states right now in saying what proportion of power has to come from renewable resources, which most likely means wind. So I think that in the last legislative session, Minnesota sort of went toward the head of the pack in the nation as far as states on the wind power issue (MN19).

These policies have also been successful at making wind economically competitive with conventional generation. "Many of those [renewable energy] standards are met through wind power because it's right now so economical compared to a lot of the other renewable technologies (MN08)." Partly, that is due to the fact that "carbon emissions have to be considered in the decision process of selecting new generating sources (MN5)," by attaching a price to carbon in the integrated resource planning process. An additional economic factor in Minnesota is the incorporation into the renewable portfolio standard of community-based energy development (C-BED), including a special tariff, micro-loan programs, and tax exemptions.[5] This type of legislation supporting community wind aims to establish local ownership that directly benefits rural communities and is not seen in the other states studied. As a result of the C-BED regulations, local communities have "see[n] a benefit in wind (MN21)." Overall, the economic benefits of wind power have reduced local opposition to the technology's development:

> The fact that we live in an area where we have a very sparse population sort of automatically facilitates the development of wind farming in this area. And it works; it's a synergistic opportunity with agriculture. [...] I've encountered very little resistance in the general population to doing more (MN15).

While there was some discussion of aesthetic-based opposition to wind power in Minnesota, public acceptance issues were not prominent. Most of the pushback has been associated with

[5] In 2005, the state legislature passed regulations and incentives to encourage the local development of energy resources throughout the state. The legislation accomplished this goal through two major avenues. First, it required that C-BED projects incorporate local ownership. In addition, no single owner was allowed more than a 15 percent stake in an energy project and each project required a statement of support from the local government. The second piece of the legislation encouraged utility providers to purchase energy from C-BED projects. It mandated power purchase agreements with levelized cash flows and provided incentives for utilities to connect with and purchase power from these projects.

concern about transmission lines, rather than wind turbine siting or permitting. According to one environmental advocate,

> I just extol them with how beautiful wind turbines are, [...], but [there is] nobody, nobody that's come up to me and says, 'I really love the sight of the transmission line' (MN05).

Opposition to transmission lines dates back to the controversy between utilities and farmers in the late 1970s, when two electric cooperatives attempted to site a line from North Dakota to the Minneapolis area.

5.3. Montana

Montana is a Rocky Mountain state with a population of less than 1 million people (U.S. Census Bureau, 2008) spread out over a very large land area, without any major metropolitan areas. Per capita income is low; energy consumption is moderately high and growing slowly. Montana is a major exporter of electricity, selling 45 percent of total generation in 1999 to other states (Jiusto, 2006). Montana holds more than a quarter of the nation's estimated recoverable coal reserves, and close to two thirds of its electricity is produced from coal (EIA, 2009b). Consequently, the state has the highest carbon intensity of all states in this study, at 0.9 metric tons per MWh. However, it is also one of the top producers of hydroelectric power in the U.S. and combined, coal and hydro generation provide 97 percent of Montana's energy needs (EIA, 2007). The electric industry is highly concentrated and retail sales are dominated by investor-owned utilities, with about a third of load served by rural electric cooperatives (EIA, 2009b).

Montana's status as an electricity exporter was frequently cited by the stakeholders interviewed in the state. Technical and economic concerns were often placed in the context that any electricity generated by wind would be exported. "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 (MT02)." From another respondent's perspective, "We've got good potential for wind development but we don't have the resources to firm that wind power up. We can't have the ups and downs on the power or on the electrical grid (MT10)." In addition, Montana stakeholders were more likely to question general feasibility of wind projects, reflecting the fact that there is currently less experience with wind power in Montana than in Texas or Minnesota.

This perspective is also reflected in Montana's policies and legislation. The state created a renewable portfolio standard in 1999, but "there have been some attacks on renewable energy standards, pieces of legislation that would undermine it, that would reduce its impact, its ability to spur growth of new wind development in the state (MT17)." Despite having both a mandatory green power option and a public benefits funds, few wind projects have been fully developed, and while the American Wind Energy Association ranks Montana as fifth in the nation for potential capacity, it is 21st in total generation (AWEA, 2009).

Montana was the only state in our study where negative economic references outweighed positive ones. In this largely rural state, stakeholders were concerned about the costs of wind power's intermittency and the difficulty that small generators face when entering the electricity market. In the words of one respondent, "We don't have an economic system that creates a situation where small players can get involved in a distributive power system. We have huge forces, huge companies coming in and charging us rent basically to use our resources (MT16)." As more wind power is developed, channeling at least some of the economic benefits to local residents may prove important in maintaining public acceptance for wind power. The example of Minnesota shows that community-based development can be instrumental in creating broader support for the wind industry.

Unlike in Massachusetts and Minnesota, no connection was made between climate change and the adoption of wind energy in Montana. Rather, proponents of the technology felt they had to distance themselves from environmental concerns while advocating for its deployment. In the words of one energy developer: "They don't talk about climate change much, because it's easier to talk about saving money with wind power (MT04)." Stakeholders in Montana also raised some substantial concerns about the technology's environmental impact on wildlife, including bird and bat kills and impacts of transmission lines on prairie species.

5.4. Texas

Texas, the largest state by landmass among the lower 48, has a population of over 23 million (U.S. Census Bureau, 2008), distributed among a number of urban centers (Houston, Dallas, Austin and San Antonio) amid large rural areas. Per capita income is moderately high, but unequally distributed between rural and urban areas. The state has experienced rapid population growth over the past decade. Electric consumption is the highest of all states in this study, at roughly 16 MWh per capita. Texas is one of the few states to have successfully deregulated its electric energy sector and created a highly competitive industry with a large number of power marketers balancing traditional utilities. Natural gas makes up 50 percent of the electricity supply, but despite the higher cost of this resource, electric rates hover around the national average (EIA, 2009a). Another 37 percent of electric energy is produced from coal, and as a consequence, the carbon intensity falls in the mid-range. The majority of lower 48 natural gas and petroleum reserves are in Texas; the state supplied 25 percent of all natural gas and 21 percent of all oil produced in the U.S. in 2005 (EIA, 2008).

While all four of the states talked about technical problems and benefits, stakeholders in Texas discussed the technology from the perspective of already having an abundance of wind deployed and experiencing both system integration issues and transmission bottlenecks. In Massachusetts and Montana, the technical issues were represented as problems faced at the beginning of deployment. In Minnesota, transmission and saturation issues were surfacing, but were not as prevalent as in Texas. One reason why the Texas case is unique is that the state encompasses its own transmission reliability structure – Electricity Reliability Council of Texas (ERCOT) – that is separate from other regional grids. Therefore, almost all wind deployed to comply with the Texas RPS is installed within the state boundaries. In the words of one state government official,

> We now have so much wind on the grid that Texas being an electrical island, having ERCOT, Electricity Reliability of Council, contained within the state boundaries, it means that if you rely heavily on wind generation and the wind generation does not occur because a front blows through or low pressure system dips and suddenly there's no wind, then you have to be ready to back it up with other generators that have to be dispatchable within ten minutes. And ERCOT is really just learning how to operate a grid with this much wind energy on it. No other grid anywhere in the United States has had to do this yet (TX07).

An additional difference within the technical discussion in Texas was its focus on concrete steps to ensure the future development of wind energy in a state that has already seen much capacity installed. Both Texas and Montana voiced more negative than positive assessments of technological issues, but in Texas, problems were associated with the development and system integration of even more wind, in a context where wind is already an important part of the resource mix.

Legislation relevant to wind-power deployment first came about in the late 1990s, when the inclusion of specific quantities of renewable power was made a condition of restructuring. Unlike the other three case study states with their generation goals, Texas sets a capacity goal. The most recent goal mandates 5880 MW of renewable generation capacity by 2015, with at least 500 MW from non-wind sources. As of 2009, that goal has already been surpassed. It amounts to about 5.5 percent of current nameplate capacity, a far less ambitious goal than in the other states, and it will be interesting to see if the legislature adopts higher targets in line with actual deployment. In absolute terms, a lot of new capacity has been added, although proportionally, Texas actually generates less wind power than states like Minnesota or Iowa.

More recent state energy bills in Texas frequently deal with transmission, property rights clarification and the costs of wind development, reflecting the issues experienced by a large and rapidly growing wind industry. To address intermittency and transmission problems, the state authorized the development of additional power lines intended explicitly for wind energy. As part of its Competitive Renewable Energy Zones (CREZ) initiative, the state government has determined the areas within the state with the best wind potential, and is building transmission lines in those areas as an incentive for developers to begin wind farm construction. While transmission limitations have been identified as problems in other states, Texas is actively taking steps to improve their electricity infrastructure and ensure that there will be market access for wind generated in West Texas and the Panhandle area:

> once we had the trade success in terms of wind generation in Texas, it became obvious that there were major transmission constraints, and the PUC […] had a couple of big announcements on [the CREZ process] recently to put between $5 billion and $6 billion worth of transmission lines in place to bring wind energy from the Panhandle and West Texas to the urban areas of the state (TX 19).

Even though Texas was one of the first states in the country to establish a renewable portfolio standard, it was not framed within the context of climate change mitigation. Instead, it was viewed as an economic development opportunity, with supporters interested in ensuring that urban air pollution does not increase with a deregulated energy market. Texas also did not pass any additional green laws to support the renewable mandate, unlike Minnesota and Massachusetts. It does however have simplified siting rules. The Texas legislature implemented the minimum policy possible, and then stepped back. In the words of one Texas energy industry consultant,

> In Texas, we have sort of a lighter touch on the rules. We have this RPS. We have a few other things that say, 'This is what we want you to do. We're trying to level the playing field. We're gonna give you some incentives. But then it's up to you guys to decide what you want to do beyond that.' Well, those rules have served as enough of a catalyst to get the wind market going. […] And if you can compare to 2007 as a year […] Texas installed 25 times more wind than California, even though their laws require more than our laws. But [it is] just sort of the voluntary, letting the market work [mentality]. Because even though they've got all these laws, they kill it, they strangle it with all these regulations. And it just, it doesn't go forward (TX12).

Economic factors offer a partial explanation for why wind has expanded so quickly in Texas. First, Texas has a restructured electricity market and the energy market and infrastructure is a profit driven system where anyone expecting a favorable return on investment will propose and build generation facilities. The second economic factor that has driven the development of wind energy in Texas has been competition with natural gas and its relative price of installation. Much of the generation within the ERCOT grid comes from natural gas. As a result,

> Wind typically displaces natural gas generation. As natural gas prices have gone up and stayed high, the cost of generating electricity with natural gas is basically what wind is competing with. So it competes very favorably. If wind had to compete with coal or nuclear, it wouldn't, but it doesn't (TX07).

Because wind energy was competing with natural gas instead of cheaper sources such as coal, the Texas renewable energy credits and federal production tax credit helped ensure the technology's economic feasibility. It remains to be seen how recent decreases in natural gas prices will affect this.

Like Montana, there has been minimal association between wind deployment and climate change mitigation.

> It's […] politically difficult for a legislator to […] stand arm in arm with the environmental community, regardless of how good the idea is. And […] that's a problem perception. Alternative energy, renewable energy, wind energy, solar power, have the perception of being things advocated by tree huggers, with beads, you know, wacko, liberal type folks. And so, there's […] just the knee jerk perception among some legislators that anything that some of those folks may have to say is just rejectable out of hand (TX03).

To get around this barrier, stakeholders "don't talk about climate change when [they] go over to the capitol; [they] talk about economic development (TX09)." Although climate change was not mentioned specifically to encourage wind development, some environmental concerns have arisen as the technology has been adopted. Most of the negative environmental references in Texas concerned a pending lawsuit with high media attention. The suit focuses on the siting of turbines along the Texas coast and associated concerns about high numbers of projected migratory bird kills. "They have a whole legal challenge, and they've been joined by some small, local environmental groups like the Corpus Christi Audubon Society and others that are uncertain about the impacts to birds and the wetlands (TX10)." These specific issues are compounded by the concern that "the rush […] [to] go forward with all wind power may actually set the whole movement back, if you put it in the wrong place and you start having […] big impacts on bats or migratory birds and raptors (TX09)."

6. Discussion and conclusions

Our results highlight the different issues and pathways that have led each state to its current wind power situation. In Montana, stakeholders seem to struggle most with uncertainty related to costs and technical feasibility in a newly established sector, and they question the role of large companies outside of the state exploiting the wind resource for their own gain. In Texas, with a large amount of wind already deployed in the state's electricity generation system, technical issues also are a major concern, but in the context of system integration and transmission bottlenecks. Economics also appear to be a major driver in Texas; economies of scale combined with the relatively high price of electricity, a competitive market and the relatively low price of wind make wind power a financially viable resource. In contrast, the case of Massachusetts shows that where costs of wind are high and societal perceptions of a technology are negative, the desired deployment outcomes can be difficult to achieve even in a high-price energy system with supportive policies. Finally, wind in Minnesota benefits both from a supportive policy environment and positive public opinion. Although the proportion of wind within the system is much higher in Minnesota than in Texas and transmission is an issue, within Minnesota transmission is not yet perceived as highly limiting as it is in Texas, with its unique alignment of overlapping state borders and transmission reliability system boundaries.

Examining the state context for wind technology deployment reveals many different discourses surrounding wind energy in the four study states. Technical, political, and economic aspects of wind power were most frequently mentioned by interviewees. In all of the states, policy stakeholders suggest that these aspects of the socio-political system play a much larger role in the development of wind technology than environmental, aesthetic, and health/safety risks or benefits. Another common thread across all states was the issue of transmission, which currently seems to be perceived as the most important challenge for further increases in wind power.

Despite these similarities, each of these states is at a very different stage of wind deployment and the discourse within the states reflects these differences. The cost competitiveness and market access for wind is emphasized in both of the high deployment states. In Minnesota, it was traced back to the policy regime and subsidy structure, while in Texas, it was associated with the characteristics of the existing energy system. In contrast, costs were described as a major barrier towards diffusion in both low deployment states. Responses also varied with policy status. Minnesota and Massachusetts have several policies that explicitly call for reductions in greenhouse gas emissions and stakeholders more often linked wind deployment directly to climate change mitigation, but only Minnesota has managed to deploy wind energy to meet climate-related goals. Montana and Texas, on the other hand, do not have policies focused on greenhouse gas emission reductions, but Texas has become the leader in wind deployment across the country. This set of observations suggests that climate policy and energy technology deployment are decoupled in some contexts. The weakness of environmental motivations merits further analysis, since it remains unclear whether environmental benefits are perceived as unimportant, or, on the contrary, are so well-established that they merit no further discussion.

Overall, the results of this study demonstrate why current deployment patterns cannot be explained simply by either resource capacity or enabling policy. The success of wind development depends on the state-level socio-political context and each state has a unique combination of factors contributing to this context. Policy, although successfully driving wind power in some places, is not sufficient, nor is it necessarily the dominant factor in determining deployment patterns. As wind and other renewable resources continue to be developed, it is important to recognize the influence of other socio-political and economic factors. The relative importance of these interconnected factors will evolve with the maturation of the technology and the industry, as well as growing public awareness about climate change and energy issues and evolving climate and energy policy.

These results, while based on the specifics of four states, have relevance to deployment in other states and contexts. Proponents of wind technology in a state just beginning deployment can learn from successful framing strategies in areas with a more mature industry. Proponents of wind technology in a state with significant deployment have a host of different issues to address. State-specific barriers are also important to consider, including the political risk of linking wind energy to climate change, transmission constraints, economic development, and distributional conflicts between urban and rural populations. As wind turbines become more common, transmission and system integration constraints, as well as resistance against visual impacts could slow deployment in some areas. In a similar vein, the secondary nature of environmental and health aspects associated with wind power implies that stressing these aspects may in fact be, if not detrimental, at least unhelpful for proponents of wind power.

Unlike other studies focused on general public opinions of different energy technologies, this study presents how policy stakeholders think about wind power deployment within their particular state contexts. It offers insights into the discourse of actors who are both deeply involved in the deployment of wind power and participate actively in the policy process. Social acceptance of renewable technology has institutional market and political dimensions (Wüstenhagen et al., 2007). Interviews with influential experts can surface these complex issues directly, rather than accessing them indirectly through social acceptance indicated by public opinion and media discourse. In particular, political and technical deployment aspects emerge as more salient than in work on public perception or media portrayal of wind. Along with other expert stakeholder studies (Hansson and Bryngelsson, 2009; Varho and Tapio, 2005), our approach therefore provides a complimentary view to studies on media and public perception of new energy technologies.

Each of these on-going state-level debates informs the creation of a federal climate and renewable technology policy. As the U.S. begins to design policies to reduce greenhouse gas emissions and deploy low-carbon technology, policy makers and energy planners would be wise to recognize the influence of state-level socio-political factors in shaping the context of low-carbon technology deployment. Acknowledging and understanding these state-level socio-political factors can help bridge the gap between designing low-carbon energy policy and deploying energy technologies for climate change mitigation.

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Appendix A. Supplementary material

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