Local power: Understanding the adoption and design of county wind energy regulation

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Abstract

The majority of U.S. states have set targets for renewable energy, but the prospects for meeting most of these goals hinge on the willingness of local governments to allow large-scale renewable energy projects in their communities. In this paper, I investigate how exposure to lobbying by wind developers and the actions of neighboring jurisdictions inform the adoption and design of rules for siting commercial wind farms. Using data collected from 1603 counties in 23 states, I find local policymakers are more likely to enact wind ordinances when they have more time to interact with wind developers and when neighboring counties have adopted wind ordinances or approved the construction of wind farms. I also observe that counties tend to adopt more stringent rules when more wind farms have been built in neighboring counties. This evidence suggests that efforts to scale up renewable energy generation may encounter increasing resistance from local governments.

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Introduction

On September 10, 2018, the state of California enacted a legally binding renewable portfolio standard (RPS) policy, committing the state to the goal of generating 100 percent of its electricity from carbon-free sources by 2045. But just six months later, San Bernardino County became the eleventh county government in California to ban the construction of large-scale wind farms. The decision by San Bernardino County's Board of Supervisors prompted one trade group representative to wonder, "Where will California put the projects it will need to meet its clean energy goals if the counties keep saying no to solar and to wind?" (Roth, 2019).

Renewable energy generation is a key component of efforts to reduce the emission of greenhouse gases (Jacobson and Delucchi, 2011), and a wide array of state-level policymakers have adopted policies to promote the expansion of alternative energy, most prominently through RPS policies. As of 2020, 30 states have enacted legally binding targets and a further seven states have announced voluntary goals (Shields, 2021). RPS policies are often highly publicized and have attracted considerable attention from both the media (e.g., Mulkern, 2017; Domonoske, 2018) and scholars (e.g., Matisoff, 2008; Chandler, 2009; Nicholson-Crotty and Carley, 2016; Carley et al., 2017). However, most states delegate the authority to regulate and permit renewable energy projects to local governments. This group includes the majority of states with RPS policies and/or large renewable energy resource endowments. In these states, it is up to local governments, usually county zoning boards, to decide whether to regulate wind farms in their jurisdictions and, if so, what restrictions to place on their construction.

Existing explanations for the uneven deployment of renewable energy in the U.S. do not account for local renewable energy policy (e.g., Bohn and Lant, 2009; Schumacher and Yang, 2018; Carley et al., 2018). This is likely due in large part to the difficulty of obtaining data on local regulations in a systematic fashion. In this article, I help address this gap by collecting data on current wind energy ordinances in 1603 counties across all 23 U.S. states that delegate siting authority to county-level governments.

In my analysis, I consider two related questions. First, why do only approximately one-quarter of counties with authority over wind development choose to adopt defined standards governing the construction and operation of wind farms? Second, why do some counties enact more stringent development standards than others? Informed by open-ended interviews with county officials and wind farm developers, I argue that local policymakers adopt wind energy ordinances when they believe they are about to receive many proposals for wind development, and that policymakers select more stringent standards when the potential costs of wind development are highly salient.

Building on considerations of cost, access to information, and the dynamics of policy diffusion, I predict that policymakers should perceive wind development to be imminent and costly, and consequently adopt and design stringent wind ordinances, when 1) policymakers have had more time to interact with wind farm developers, 2) neighboring counties have adopted (stringent) wind ordinances, and 3) neighboring counties have experienced (intensive) wind farm construction. This account of developer pressure and experiences in neighboring jurisdictions offers parallels to other instances in which policymakers exercise discretion over whether and how to regulate emerging technologies, from new forms of media (Schejter and Han, 2011) to gene editing techniques (Sarewitz, 2015) to autonomous vehicles (Freemark et al., 2019).

To test these hypotheses, I develop an original cross-sectional dataset of current wind farm regulations in 1603 counties in 23 states. The outcome variable derived from these data is the minimum setback (distance from a wind turbine to the project boundary), which the developers I spoke with identified as typically being the most consequential component of wind ordinances for project viability.[1] I match these regulations to data on the construction of wind farms in neighboring counties and the number of years since wind development first became economically viable in each county. The latter measure represents a natural experiment, in which secular changes in wind turbine technology provide exogenous shocks in county policymakers' probability of having been approached by wind developers. I find support for all three hypotheses with regard to the adoption of wind energy ordinances, although only the construction of wind farms in neighboring counties is systematically related to the stringency of these standards.

Through this analysis, I provide a vivid illustration of the diversity of approaches to county wind farm regulation in the U.S. Exposure to wind developers, the policy choices of neighboring counties, and nearby wind farm construction motivate policymakers to use their limited time and money to develop wind energy ordinances. When development is intense in neighboring counties, policymakers tend to be more cautious and adopt more stringent development standards. In the conclusion, I discuss the implications of these findings for the future of local (and state) regulation of wind farm development, as well as other types of renewable energy, green infrastructure, and emerging technologies that pose economic and political trade-offs at the local level.

The local government gap in accounts of U.S. renewable energy politics

Conventional accounts of renewable energy development emphasize four types of factors: natural resource endowments (e.g., wind and solar resources), socioeconomic conditions (e.g., population growth and wealth production), market conditions (e.g., electricity prices and demand), and the political/policy context (e.g., politicians' pro-environment orientations, taxes, and subsidies) (Menz and Vachon, 2006; Carley, 2009). Political scientists have generally attempted to contribute to these accounts either by identifying the effect of public policy on renewable energy development (Bohn and Lant, 2009; Schumacher and Yang, 2018; Carley et al., 2018) or explaining the origins of these policies (Matisoff, 2008; Yi and Feiock, 2012; Carley and Miller, 2012; Matisoff and Edwards, 2014).

Although this literature has acknowledged the importance of siting and permitting procedures, in some cases incorporating state-level measures into their analyses (Bohn and Lant, 2009; Schumacher and Yang, 2018), no analysis has systematically considered the power that local governments exercise in the majority of U.S. states over renewable energy development. As a result, existing accounts overlook a potentially important part of the story of renewable energy development and the policies that support it. Some places may see less development than state-level analyses would predict due to local regulations that increase the time and financial cost of development, or even, as in San Bernardino, CA, ban utility-scale renewable energy projects in their entirety. Scholars of environmental politics have noted the relevance of local-level dynamics, but have largely focused on issues of public opinion, such as the perceived benefits and costs of wind development (Mulvaney et al., 2013; Walker et al., 2014) or beliefs about the fairness of local wind development planning processes (Baxter et al., 2013; Hall et al., 2013), rather than the substance of local policies themselves.

There are at least three possible explanations for the absence of local policies from existing accounts of the U.S. renewable energy policy landscape: visibility, preemption, and data accessibility. The first explanation foregrounds the relatively high visibility of federal and state initiatives to promote renewable energy development. Ambitious goals and large subsidies, often announced by prominent politicians at public events and circulated in news releases, easily attract the attention of both the media and scholars. In contrast, changes in county development standards may be reported in local newspapers, but their technical nature and the relatively low profile of county officials mean such events typically do not attract widespread attention and public engagement (Gormley Jr, 1986). Nevertheless, in light of the substantial authority local governments have over renewable energy development, examining the exercise of these regulatory powers is key to understanding renewable energy transitions in the United States.

The second explanation, preemption, suggests that local government regulation can be safely ignored because policymakers at higher levels of government preempt local policy decisions. However, exercising preemption over local wind development authority can be a costly and controversial decision for state lawmakers to take (Outka, 2015). As a result, while state preemption is a growing trend in wind regulation, it is not yet the norm (McElfish and Gersen, 2011). In a majority of states, local governments still have the final say over wind regulation policy.

The third explanation, data accessibility, refers to the practical challenge of acquiring data on local government policies. Existing databases of county codes and related policies (e.g., wind farm-specific ordinances) are not comprehensive. Additionally, there are no systematic records of policymaker interactions with representatives of private firms at the local level. As I describe in further detail below, an important contribution here is to collect data on the existence and design of county wind ordinances, as well as leveraging a natural experiment that exogenously assigned county policymakers different probabilities of being approached by wind developers.

County regulation of commercial wind farms

From the perspective of local governments, wind energy offers an intriguing combination of opportunities and challenges. The opportunity offered by wind development is largely fiscal. By installing valuable taxable assets, tax revenue from wind farms can provide a substantial boost to the local government's budget. For example, annual tax payments from wind farms in Franklin County, Iowa account for 14% of the county budget (Baer, 2017), while more than $26.1 million in tax revenues from wind farms in McLean County, Illinois have gone to local school districts since 2007 (Johnson, 2018).

But proposals to develop wind farms, like other forms of industrial land use (e.g., Bacow and Milkey, 1982; Cain and Nelson, 2013; Dokshin, 2016), can also provoke strong opposition (Pasqualetti, 2011). Utility-scale wind farms are highly visible installations, consisting of dozens or even hundreds of turbines spread over hundreds of acres of land, each typically standing over 400 feet tall (Zayas et al., 2015). Depending on where they are located, wind farms can pose negative health, visual, and environmental impacts in the immediate area during construction and operation (Rand and Hoen, 2017). While most analyses have not found wind turbines to lower average home values (e.g., Hoen et al., 2015), perceptions of decreased property values are common and may generate vocal opposition to proposed wind projects (Walker et al., 2014). Since local elections are often decided by small electorates, wind opponents are well-positioned to induce policymakers to address their concerns by credibly threatening to mobilize opposition in future elections.

These competing pressures have led to a patchwork of different approaches to regulating wind development, with the majority of states delegating the authority to permit and regulate commercial wind development to local governments. As shown in Figure 1, 22 states preempt local control entirely, place restrictions on local regulation, or reserve the right to overrule local siting decisions,[2] while the remaining 28 states give local governments the final say in regulating wind development. Using estimates derived from Zayas et al. (2015), these states currently account for 60% of the land area in the continental United States with sufficient exploitable wind resources for the development of utility-scale wind farms. Of the 28 states with local control, five states give municipal governments control over wind farm development.[3] The remaining 23 states, constituting 36% of land in the U.S. with commercially viable wind resources,[4] delegate regulatory power over commercial wind development to county governments, typically county zoning boards.

[Figure 1 about here]

County governments tend to be chronically underfunded and face severe human and financial resource constraints (Osborne and Hutchinson, 2006). Accordingly, counties typically wait to adopt wind farm regulations until they face a concrete possibility of wind farm development. Once a county decides to develop a wind energy ordinance, its policymakers must devote time and resources to do so, typically either by tasking the county government's own planners to write an ordinance or hiring private consultants, followed by a series of technical reviews and public hearings.[5]

Because counties tend not to regulate wind development until policymakers believe they need to do so, the regulation of wind farms may not be seen as a real possibility until policymakers meet interested wind farm developers. Decisions by neighboring counties to adopt wind energy ordinances or permit the construction of wind farms may also lead policymakers to believe they, too, may be presented with project proposals in the near future. The stringency of siting standards is likely to be a product of how policymakers balance potential benefits, which are primarily economic, and potential costs, including the risk of damage to other industries (e.g., tourism), visual and auditory aesthetics, and wildlife.

These are general statements, so I offer three important caveats. First, the financial, human, and informational resources at the disposal of policymakers, as well as their predisposition toward the regulation of economic development, are likely to play an important role in shaping their capacity and willingness to regulate wind development. Second, the perceived need to regulate depends on the potential economic, social, and environmental impacts of wind projects, which vary widely by location. The benefit of regulating wind development may be lower in more sparsely populated areas. Third, and most importantly, counties are not randomly approached by wind developers. I now develop this point further.

Technological development as an exogenous driver of interaction with wind farm developers

Before approaching policymakers with a proposal for a wind farm, developers weigh a variety of factors when considering whether to pursue a project in a particular location. These include access to high-voltage transmission, state and local incentives, local ordinances on wind development, and the receptivity of local residents to the prospect of wind development. However, a necessary condition for proposing any project is the presence of economically viable wind resources. While wind resources are a product of natural processes, an area's economic viability for wind development depends on the technology available for harvesting these resources (Zayas et al., 2015).

In the 1980s and up through the mid-2000s, most wind turbines built in the U.S. were considerably smaller than modern models (Kaldellis and Zafirakis, 2011). As a result of their limited size, these turbines were only capable of generating economically relevant quantities of electricity in locations with consistently high wind speeds. In the intervening years, wind turbine manufacturers have improved wind turbine technology, developing taller wind turbines with longer blades and more efficient engines capable of generating electricity even at relatively low wind speeds. Just over the past decade, improvements in wind turbine technology have approximately doubled the amount of land in the U.S. with economically viable wind resources, from 1,643,000 km^2 in 2008 to about 3,500,000 km^2 today (Zayas et al., 2015).

The gradual expansion of land with economically viable wind resources over time means that the probability that policymakers in a given county have interacted with wind farm developers is, in part, a function of secular improvements in wind turbine technology. This can be viewed as a natural experiment in which the probability of local policymakers receiving a treatment, interaction with wind farm developers, is assigned in part due to exogenous changes in technology, independent of the actions and attributes of both policymakers and wind developers. Due to changing wind turbine technology, policymakers in some counties have been potential targets for wind development for less time and, as a result, are correspondingly less likely to have interacted with wind farm developers. As I explain in the following section, I expect counties that have a higher likelihood of having interacted with wind developers to display systematic differences in their adoption and design of wind regulation.

To illustrate this idea, Figure 2 indicates for each county whether its wind resources would have been economically viable, if ever, for a typical utility-scale (100MW) wind farm using industry-standard technology in 2008, 2014, and the present. Of the 3108 counties in the continental U.S., 1139 (37%) have faced the possibility of being approached by interested wind developers for at least the past decade, while 884 (28%) have been potential targets for 6-10 years and it has only been possible to build commercial wind farms in 450 (14%) for 1-5 years. Modern wind turbine technology is still insufficient to make a commercial wind farm economically viable in 635 (20%) counties. A comparison of Figure 1 and Figure 2 suggests that counties that do not currently have economically viable wind resources rarely enact setback requirements on commercial wind farm development, as would be expected in light of the limited resources of county governments.[6]

[Figure 2 about here]

Determinants of local regulation of commercial wind farm siting

Local policymakers face two interrelated decisions in the context of regulating wind farm development (McElfish and Gersen, 2011). First, should they adopt formal standards for evaluating commercial wind projects? Second, if so, to what level of stringency should they set their development standards? I argue that policymakers decide to adopt wind energy ordinances if they believe that they will be presented with a large number of proposals for wind energy development and that these ordinances will be more stringent when the costs of wind development are highly salient. Based on open-ended interviews with wind developers and county officials,[7] I focus in the following sections on three potential drivers underlying both of these beliefs: the amount of time policymakers have had to interact with wind developers, policymaking in neighboring counties, and wind farm construction in neighboring counties.

Interactions with wind developers

When wind developers consider building a wind farm in an area, they often informally contact local policymakers to gain an understanding of local rules for siting wind farms and to build a rapport with their would-be regulators. In a later stage, developers submit their proposal to the county zoning board for approval. Through these interactions, policymakers may come to believe that is a real possibility in their jurisdiction. As these formal and informal interactions accumulate over time, two possible drivers of regulation come into play.

The first mechanism is the cost of evaluating wind proposals. In the absence of formalized standards for assessing wind projects, most (but not all) counties still require projects to receive approval through a conditional permitting process. These processes can consume considerable resources and time, leading to project development timelines that span four years or more (American Wind Energy Association, 2018, p.64). If officials believe they may need to consider conditional use permits for multiple proposals, they may choose to enact a wind energy ordinance to reduce costs. For example, after the government of Coconino County, AZ completed two complex permitting processes in short order, the county government decided to adopt specific regulations for wind farms to avoid the conditional permitting process.[8]

The second mechanism is the acquisition of more precise information about what the construction and operation of wind farms entail. As policymakers repeatedly consider wind farm proposals, they may seek to reduce the variability of permitting outcomes by moving away from the ad hoc standards used in conditional permitting processes and enact formal rules to codify their learning. These experiences may also increase the salience of wind regulation for the general public, mobilizing organized anti-wind groups and strengthening demand for policy change.

Both the cost and information mechanisms imply that policymakers should be more likely to enact wind energy ordinances if they have had more time to interact with wind developers. This leads me to pose the following hypothesis:

H1a: Counties should be more likely to have enacted a wind energy ordinance if they have had more time to interact with wind developers.

There are three reasons to expect counties with a longer exposure to wind developers to have less stringent regulation. First, counties that confronted the question of wind regulation earlier are likely to have standards designed for the smaller turbines of decades past. A 150-foot setback may have been appropriate for the 150-foot wind turbines of the 1990s, but is relatively lax for modern turbines with heights of 400 feet or more. While some standards may have been designed to scale with turbine height and others may have been revised over time,[9] it is nevertheless likely that a county that enacted its wind ordinance earlier will tend to be less stringent than counties that only recently considered wind regulation for the first time. Second, wind developers are incentivized to lobby policymakers for relatively less stringent standards to reduce the amount of land developers need to acquire to produce a given amount of electricity. The longer wind developers have engaged in lobbying the county government, the more likely their preferences are to be realized in policy. Finally, the ability of anti-wind citizen groups to mobilize support is likely to be strongest when the prospect of wind development is novel and weaken over time as residents become more familiar with wind turbines and better understand their impacts (Krohn and Damborg, 1999; Van der Horst, 2007). Moreover, wind development ordinances are technically complex, which may limit the ability of anti-wind citizen groups to impact the policymaking process (Gormley Jr, 1986). Accordingly, I expect counties with longer histories of interaction with wind developers to have relatively less stringent wind energy ordinances.[10] This hypothesis can be expressed as the following:

H1b: Counties should tend to enact a less stringent wind energy ordinance if they have had more time to interact with wind developers.

Policymaking in neighboring counties

Policymakers tend to view their counterparts in neighboring counties as peers in the context of wind regulation because wind resources (and other related factors, such as access to high-voltage transmission lines) tend to be spatially clustered (Nicholson-Crotty and Carley, 2016). As a result, policymakers may become to believe that wind development is likely to be a relevant issue for their jurisdiction, and that adopting a formal regulation is a good idea for handling such matters, when their neighbors decide to adopt a wind energy ordinance. This perception may be the result of a policy diffusion process driven by the mechanisms of socialization, learning, or competition (Graham et al., 2013).[11] In the case of diffusion driven by socialization, policymakers may interpret the decision by their neighbors to adopt a wind energy ordinance as a signal of the appropriateness of more formal approaches to wind energy regulation. If learning drives diffusion, then policymakers may be motivated to adopt ordinances due to reduced long-term processing costs and more consistent decisionmaking. And if competition drives the diffusion of wind energy ordinances, policymakers may feel the need to respond to attempts by their neighbors to reduce processing time for wind energy proposals.

Whatever the diffusion mechanism at play, interdependence in wind regulation across jurisdictions seems likely. Specifically, all three processes imply that the adoption of a wind energy ordinance in a jurisdiction should make the adoption of wind energy ordinances in neighboring jurisdictions more likely, generating geographically clustered patterns of wind energy ordinance adoption. This leads me to pose the following hypothesis:

> **H2a**: Counties should be more likely to enact a wind energy ordinance if a neighboring county has adopted a wind energy ordinance.

Although all three diffusion mechanisms should result in spatial clustering, they imply different consequences for the salience of wind development costs and, as a result, the stringency of the resulting ordinance. If policymakers are inspired to enact a wind energy ordinance due to socialization, they should base their perceptions of the costs of wind development off their neighbors. Faced with a technically demanding task like determining appropriate setbacks, noise restrictions, and height limits, policymakers motivated by a logic of appropriateness should be likely to use the typical stringency of their neighbors' policies (Watson et al., 2012). Therefore, stringent policies will tend to be spatially clustered when socialization is at play.

A second possibility is that policymakers design their wind ordinances via a learning process, interpreting the stringency of a neighbor's ordinance as a sign of the political importance of being responsive to concerns from wind development opponents. Although wind farms are generally well-received by local residents (Mulvaney et al., 2013; Carley et al., 2020), local elections with small numbers of registered voters and typically low voter knowledge may make local officials wary of the threats from economic actors and constituents who stand to lose from renewable energy development. Conversely, policymakers may learn that stringent wind policies are not necessary if their neighbors engage in wind development without stringent policies. Either way, a learning process should also generate spatial clustering in policy stringency.

Finally, if policymakers are instead motivated to regulate due to competition over wind farm development, they should tend to adopt less stringent ordinances when their neighbors. By allowing developers more flexibility in developing their projects in otherwise similar geographies, policymakers would attempt to attract wind developers who would otherwise work in their neighbors' jurisdictions. As a result, competition should result in spatial dispersion in policy stringency.

The socialization and learning mechanisms imply that policymakers should tend to adopt more stringent policies as the stringency of the neighbors' wind energy ordinances increases. However, this expectation is tempered by the possibility that economic competition could lead policymakers to instead enact less stringent wind energy ordinances than their neighbors to become relatively more attractive to wind developers. If none of these mechanisms dominate, it is possible that their effects on the spatial clustering may cancel out. Based on the impressions of the government officials and wind developers I spoke with, however, I expect socialization and learning to be more powerful than competition, producing spatial clustering in policy stringency:

> **H2b**: Counties should tend to enact a more stringent wind energy ordinance if their neighbors have more stringent wind energy ordinances.

It is important to note that, although **H2a** and **H2b** are motivated by the potential of policy diffusion, these hypotheses are formulated to test the determinants of *policy adoption*, an outcome, rather than *policy diffusion*, a specific process by which policies spread (Gilardi, 2016). Similarly, while spatial clustering in the current distribution of wind ordinance adoptions and stringencies is a common symptom of policy diffusion, it is not dispositive evidence of diffusion. Contiguity-based spatial correlations can be generated by other factors, such as access to transmission lines. Moreover, policy diffusion does not necessarily occur via contiguous jurisdictions (Matisoff and Edwards, 2014). However, evidence based on cross-sectional data on policy adoption in favor of **H2a** and **H2b** would provide motivation for future investigation into the effect of policy diffusion processes using a longitudinal data collection and research design.

Wind farm construction in neighboring counties

A third signal for policymakers of the potential for commercial wind development in their area is the construction of wind farms in neighboring counties. While policymakers may learn about their neighbors' policy in the local newspaper or by word of mouth, policymakers are likely to learn about the construction of nearby wind farms through personal experience in their day-to-day lives (e.g., driving by a wind farm). Even the construction of just one wind farm in the region could lead policymakers to believe they, too, may need to consider the question of wind development in the near future. This leads me to the following hypothesis:

> **H3a**: Counties should be more likely to enact a wind energy ordinance if a wind farm exists in a neighboring jurisdiction.

Intensive wind development in neighboring jurisdictions means higher densities of wind turbines and taller, more obtrusive turbines. The increased visibility of wind development may lead policymakers and their constituents to become more aware of the potential costs of commercial wind farm development, such as impacts on aesthetics, health, and rural lifestyles (Rand and Hoen, 2017; Walker et al., 2014). Larger projects in neighboring counties may also be more likely to attract the attention of external groups opposed to wind development (Hall et al., 2013). This would activate both concerns about the social desirability of wind development and the possibility of an electoral threat rooted in opposition to wind farm development. Accordingly, I pose the following hypothesis:

> **H3b**: Counties should tend to enact a more stringent wind energy ordinance if wind development in neighboring jurisdictions is more intense.

Data

County wind energy ordinances

Wind energy ordinances are a common, if not entirely standard, component of county zoning rules. These rules may take the form of standalone ordinances or be incorporated into land development codes and similar documents. I seek to explain why county governments decide to enact wind energy ordinances and adopt more or less stringent development standards.

To do so, I identify counties that currently have specific regulations on commercial wind farms. I consider only counties with final authority over the siting standards for wind development in states in the continental U.S. I focus in particular on the setback, or the minimum distance between a turbine and the project boundary. Larger setbacks are more stringent because they increase the minimum project area, making it more difficult (and costly) for developers to create parcels of sufficient size for a project to be economically viable. Wabash County, Indiana provides an example of a relatively stringent ordinance, requiring turbines to be at least twice the turbine height or 1000ft from the property line, whichever is greater. Conversely, communities that want to facilitate wind development can set smaller setbacks, making it easier to find a site for the project. An example of this is Dickinson County, Iowa, where wind turbines are only restricted from physically overhanging adjacent property lines. In most cases, counties with setbacks of one-quarter mile or more are functionally equivalent to a ban on commercial wind turbines (Kowalski, 2014), which can also be achieved by creating siting standards with low caps on turbine height and generating capacity. Other components of siting regulations include height, noise, and shadow restrictions, but these tend to be less commonly included in county regulations than setbacks, which are almost always specified if a county has a wind siting ordinance (346/393 counties, or 88%).

I collected data on local wind siting regulations from 1603 counties in 23 states with county-level control over wind power siting. To create a comparable measure of the stringency of a county's setback standard, I focused on the setback, the minimum distance from the turbine pole to the nearest nonparticipating property line. In a small number of instances, only the setback to the nearest inhabited dwelling is defined. In these cases, I assume the dwelling is located on the nearest nonparticipating property line. Since some counties define the minimum setback as a multiple of the turbine height, all setbacks were converted into feet using a hypothetical reference project of 50 2MW monopole commercial turbines of 400ft in total height (265-foot hub height and 135-foot rotor radius) with a footprint of 40 hectares. Data on county setbacks were collected directly from the most recent, internet-accessible version of county zoning codes, codes of ordinances, building codes, or standalone ordinances relating to commercial wind turbine siting.[12] To reflect both the non-linear relationship between setback distance and minimum project area (area $= \pi \times \text{setback}^2$) and to integrate counties that banned commercial wind turbines in a single measure, the county's siting stringency (stringency) is coded as a five-level ordinal variable with levels of none (no restrictions), low (1–399ft), medium (401–600ft), high (601–1319ft), and ban (more than 1319ft or ban). I determined these cutpoints through interviews with wind developers and county officials, as well as reports about wind ordinance design (e.g., McElfish and Gersen, 2011; Kowalski, 2014; Doerr, 2014).

Figure 1 shows that there is considerable spatial clustering in counties with more stringent setbacks, especially in the Midwest and along the Appalachian Mountains. There are also noticeable differences from state to state. No counties in Arkansas or Florida have defined setbacks for commercial wind development, while 55 counties in Iowa have done so. The states with the most stringent average setback are Hawaii, Illinois, Nevada, and Maryland, while the states with the least stringent average setbacks are Arkansas, Florida, Missouri, and Georgia.

I illustrate the distribution of commercial wind setbacks in Figure 3. Approximately 77% of counties in states with delegated wind siting authority have not defined setbacks for commercial wind development. In most cases, the absence of a specific wind energy ordinance means that any proposal for wind development would be evaluated in a conditional permitting process with ad-hoc development standards. Note that the desire to use ad-hoc standards in a conditional permitting process and the decision to require projects to not meet any setback requirement are observationally equivalent in most instances.

Among the remaining 23% of counties that have adopted formal siting standards for commercial wind development, approximately 60% of counties' commercial wind siting setbacks fall between 400ft and 600ft from the property line, or about 1-1.5 times the height of turbine from base to tip. Among counties with defined setbacks, the median setback is 440ft. However, about 17% of counties with wind ordinances have adopted setbacks less than 400ft and 22% of counties with wind ordinances impose setbacks of more than 600ft.

[Figure 3 about here]

Sample

I wish to examine the impact of policymaker exposure to wind developers, wind ordinances in neighboring jurisdictions, and wind farm construction in neighboring jurisdictions on the adoption and stringency of county commercial wind farm regulation, measured in terms of minimum setback standards. I was not able to collect data on changes over time in setback stringency because county websites do not typically publish superseded versions of their zoning ordinances online (data are, as far as possible, current as of July 1, 2020). Accordingly, I use the county i as the unit of analysis.

To determine the sample for this analysis, I begin with all counties in the U.S. I remove all counties in states that have preempted, placed limits, or reserve the right to overrule county siting decisions over utility-scale commercial wind farms. This leaves a total of 2031 counties. I then drop counties in states in which municipal governments are the primary authorities regulating wind development. This results in a sample of 1603 counties in 23 states: Alabama, Arizona, Arkansas, California, Florida, Georgia, Hawaii, Idaho, Illinois, Indiana, Iowa, Kansas, Louisiana, Maryland, Mississippi, Missouri, Montana, Nebraska, Nevada, North Carolina, Utah, Virginia, and Washington. This set contains all U.S. counties with final authority over commercial wind siting regulation. In the statistical analysis presented below, I make two further adjustments: 1) I drop counties in Hawaii due a lack of data over the viability of the state's commercial wind resources and 2) I use multiple imputation (described in further detail in the following section) to estimate the setbacks for the 89 counties that did not have county government websites as of July 1, 2020. To address the threat of potential bias introduced by these missing data, I conduct extreme bounds analyses that treat all counties in Hawaii as having either 0 years or >10 years of wind viability and all counties without websites as having either banned wind development or enacted no setbacks, as well as a related sensitivity test (see Appendix D).

Dependent and independent variables

The outcome variable is Stringency_i, an ordinal variable consisting of "None", "Low" (1–399ft), "Medium" (400–600ft), "High" (601–1319ft), and "Ban" (>1320ft or explicit ban). Recall that I use an ordinal measure of stringency to reflect the nonlinear relationship between feet of setback and functional stringency. Since I conceptualize wind farm regulation as the joint decision of whether to adopt a policy and how stringently to set standards in the policy, I use a zero-inflated ordered probit model. All models are calculated with robust standard errors and state fixed effects.

There are three main sets of explanatory variables. The first is Years viable_i, a four-level measure of number of years of county wind resource viability. As discussed above, Years viable_i captures variation in policymakers' experience with wind developers (**H1a** and **H1b**). A necessary (but not sufficient) condition for commercial wind development, the economic viability of wind energy production has expanded over time as improvements in wind turbine technology have enabled the construction of wind farms in locations with lower-quality wind resources. **H1a** and **H1b** are premised on the proposition that governments are more likely to have interacted with wind developers if their county has had viable wind resources for a longer period of time.

Following Zayas et al. (2015), I define a given area of land as "economically viable for wind development" at a given point in time if wind turbines of 80-meters in hub height equipped with industry-standard technology of the time could operate at a gross capacity factor of at least 30%. I define a county as "economically viable for wind development" at a given point in time if the county contains sufficient land that meets the above criterion to build a utility-scale wind farm (a hypothetical reference project of 50 turbines with a footprint of 40 hectares). I calculate the total number of hectares in a county with economic viability for projects using 80-meter hub height turbines equipped with industry-standard technology for the years 2008, 2014, and 2020 using estimates of land area with potential for wind development developed by the National Renewable Energy Laboratory.[13] I then make a binary determination of whether a county was viable for wind development in 2008, 2014, and 2020 by comparing the total number of hectares with economic viability to the footprint of the reference project multiplied by a landowner lease acceptance rate of 25%. Finally, I construct an ordinal measure of viability for each county according to the number of years since a wind farm first became feasible to construct in its jurisdiction. The years viable variable is coded as an ordinal variable with levels of 0 years of viability (not viable in 2020), 1–5 years of viability (viable in 2020, but not in 2014), 6-10 years of viability (viable in 2014, but not in 2008), and more than 10 years of viability (viable in 2008).

The second set of explanatory variables relate to the wind energy policies enacted in neighboring counties (**H2a** and **H2b**). Neighbor policy exists$_i$ is a binary variable set to one if any contiguous county has a wind ordinance and zero otherwise. Neighbor policy stringency$_i$ is an ordinal value set to the median stringency of all contiguous counties, rounded to the nearest level.

The third set of explanatory variables represent the intensity of wind farm development in neighboring counties (**H3a** and **H3b**). Neighbor wind farm exists$_i$ is a binary variable set to one if a wind farm has been built in any contiguous county and zero otherwise. Neighbor wind farm count$_i$ is the inverse-sine transformed count of discrete commercial wind farms built in all contiguous counties. I use the U.S. Wind Turbine Database (Hoen et al., 2018) to calculate this variable.

I also consider several county-level covariates. County GDP$_i$, calculated as 2019 log total gross county product per capita in 2012 U.S. Dollars (U.S. Bureau of Economic Analysis, 2020a), accounts for both existing economic productivity and the capacity of citizens to express their preferences to local officials. Local government jobs$_i$, calculated as the 2019 log total jobs in local (county and municipal) government (U.S. Bureau of Economic Analysis, 2020b), measures government capacity. County GDP from extraction$_i$, measured as the 2019 log gross domestic product per capita in 2012 U.S. dollars from the mining, quarrying, and oil and gas extraction sectors (U.S. Bureau of Economic Analysis, 2020a), represents the strength of incumbent fossil fuel energy interests. Population density$_i$, calculated as the 2019 log total population per square kilometer (U.S. Census Bureau, 2019), measures a county's rural character. Transmission distance$_i$, measured as the straight-line distance in log meters from the county centroid to the nearest electric power transmission line above 220 kilovolts (Oak Ridge National Laboratory, 2019), represents the cost of bringing a county's wind resources to market. Republican vote$_i$, the average percent of all votes cast for the Republican presidential candidate in elections from 2000 to 2016, is a proxy for the regulatory attitudes of county commissioners and zoning board members (MIT Election Data and Science Lab, 2018), as well as support for government regulation of private property. Descriptive statistics are provided in Appendix B.

Empirical strategy

I represent the two-part process of deciding to create a wind siting ordinance and, conditional on creating a wind siting ordinance, setting the ordinance's stringency using the following zero-inflated ordered probit model:

$$\Pr(Stringency_i) = \begin{cases} \Pr(Policy_i = 0|\boldsymbol{z}_i) + \Big(\Pr(Policy_i = 1|\boldsymbol{z}_i) \times \Pr(\widetilde{Stringency}_i = 0|\boldsymbol{x}_i, Policy_i = 1)\Big), & \text{if } h_i = 0 \\ \Pr(Policy_i = 1|\boldsymbol{z}_i) \times \Pr(\widetilde{Stringency}_i = h|\boldsymbol{x}_i, Policy_i = 1), & \text{if } h_i \in 1, 2, \ldots, H \end{cases}$$

for $i = 1, 2, \ldots, N$ counties. $Policy$ is the probability of deciding to enact a siting policy and $\widetilde{Stringency}$ is the probability of selecting a level of policy stringency $h \in 1, 2, \ldots, H$. $\boldsymbol{z}$ is the vector of covariates in the inflation (binomial) portion of the model, which are:

$$\begin{aligned} \boldsymbol{z} = {} & \text{Years viable} + \text{Neighbor setback exists} + \text{Neighbor wind farm exists} \\ & + \text{County GDP} + \text{Local government jobs} + \text{County GDP from extraction} + \text{Population density} + \text{Transmission} \end{aligned}$$

$\boldsymbol{x}$ is the vector of covariates in the ordered probit portion of the model, which are:

$$\begin{aligned} \boldsymbol{x} = {} & \text{Years viable} + \text{Neighbor setback stringency} + \text{Neighbor wind farm count} \\ & + \text{County GDP} + \text{Local government jobs} + \text{County GDP from extraction} + \text{Population density} + \text{Transmission} \end{aligned}$$

where State$_i$ refers to state fixed effects. To account for the lack of variation in the dependent variable in southeastern states, I combine the state fixed effect indicators for Alabama, Arkansas, Florida, Georgia, Louisiana, and Mississippi. Three variables were missing data: county setbacks (5.5% missing, due to county governments lacking websites), Local government jobs$_i$ (12.3% missing, suppressed to protect confidentiality), and County GDP from extraction$_i$ (2.0% missing, suppressed to protect confidentiality). Since the missing-at-random (MAR) assumption is plausible, I estimated the missing data in Stata 16 via multivariate imputation using chained equations with 50 iterations, an ordered logistic distribution for county setbacks, and predictive mean matching for Local government jobs$_i$ and County GDP from extraction$_i$.

To assess the robustness of the results, I ran several alternative specifications. These consisted of 1) a version of Stringency$_i$ in log feet (with bans as 5280ft, or one mile), 2) a binary version of the Years viable$_i$ variable (0-10 years vs. >10 years), 3) two alternative lease acceptance rates (12.5% and 40%), which affected the minimum amount of land in a county with economically viable wind resources, 4) a version of the Neighbor setback exists$_i$ using the percentage of neighbors with setbacks, rather than a binary measure, 5) a version of the Neighbor setback stringency$_i$ variable using the maximum, rather than median, stringency of neighboring counties, and 6) a version of the Neighbor wind farms$_i$ variable using total installed generating capacity (log megawatts) instead of total number of wind farms. I also conducted two extreme bounds tests for counties with missing data, one specifically for counties in Hawaii and the other for all counties without websites. In the former, I treated all counties in Hawaii as having 0 years of wind viability and then as having >10 years of wind viability. In the latter, I treated all counties without websites as having no defined setback and then as having banned commercial wind development.

Results

The results of the main analysis are presented in **Table 1**. The model is a zero-inflated ordered probit with robust standard errors in which the dependent variable is the stringency of a county's setback. The left column shows the coefficients for the inflation (binomial) portion of the model, while the right column shows the coefficients for the ordered probit portion of the model conditioned on the county deciding to adopt a wind ordinance.

Since the coefficients of zero-inflated ordered probit models are not directly interpretable, I also present the results for the primary covariates of interest in terms of average marginal effects in **Figure 4**. The inflation (binomial) portion of the model is shown in the left facet as the percent change in a county's probability of enacting a commercial wind siting ordinance as a function of a marginal increase of each covariate. The ordered probit portion of the model is shown in the right facet as the percent change in a county's probability of enacting a commercial wind siting ordinance of a particular level of stringency, conditional on the government's decision to enact a wind siting ordinance. Note that the calculation of standard errors for the marginal effects varies slightly from that of the regression coefficients, producing small changes in statistical significance.

[Table 1 about here]

[Figure 4 about here]

Starting with the inflation (binomial) portion of the model, as per **H1a**, policymakers whose counties have been viable targets for wind energy development for a decade or more are more likely to enact a wind siting ordinance ($\beta = 1.296$, SE = 0.306, $p < 0.001$), with a 2% higher probability of doing so than policymakers in counties that have never been commercially viable for wind energy ordinance. This is also true, although to a lesser extent, for counties with 6–10 years of commercial viability ($\beta = 0.457$, SE = 0.207, p = 0.028), with an 8% higher probability of enacting a wind energy ordinance relative to counties that have never been viable for wind development. In line with **H2a**, the adoption of a wind ordinance is positively associated with the adoption of such an ordinance in a neighboring jurisdiction ($\beta = 0.279$, SE = 0.139, p = 0.048), yielding a marginal increase of 5% in the probability of adoption. As expected in **H3a**, counties are also more likely to adopt a wind ordinance when a neighboring county has approved a wind farm ($\beta = 0.484$, SE = 0.160, p = 0.002), translating to a marginal increase of 9% in the probability of adopting a wind ordinance.

In terms of policy stringency, the relationship between a county's experience with wind developers and policy stringency is not statistically significant, contrary to **H1b**. Similarly, the relationship between the median setback stringency of neighboring counties and policy stringency does not reach conventional levels of statistical significance, with the sole exception of a 19% lower probability of banning wind development when the neighboring counties' policy stringency is a ban. This result is counter to the expectations put forward in **H2b**. However, as per **H3b**, counties tend to have more stringent policies as the number of wind farms in neighboring counties increases ($\beta = 0.152$, SE = 0.079, p = 0.054). A marginal increase in the scaled and logged count of wind farms in neighboring counties is associated with a 4% increase in the probability of banning wind development.

The results for **H1a** (Years viable$_i$) and **H3a** (Neighbor wind farm exists$_i$) retain their sign and significance across all alternative model specifications presented in Appendix C, as do the results for **H2a** (Neighbor setback exists$_i$). The sign for **H3b** (Neighbor wind farm count$_i$) is consistent across these alternative specifications, although the relationship does not always attain conventional levels of statistical significance. For the extreme bounds analysis presented in Appendix D, all results are consistent for the Hawaiian counties, while **H3b** (Neighbor wind farm count$_i$) is not supported when all counties are treated as having enacted bans. To explore this result further, I conducted a sensitivity analysis (also reported in Appendix D) and found that Neighbor wind farm count$_i$ maintains its sign and statistical significance until 20% percent of counties with missing setback data are treated as having banned on wind development. This seems an unlikely scenario, as only 3.2% of counties with websites have enacted wind development bans.

Conclusion

Scholars have long known that sub-national governments in the United States play an active role in promoting and regulating the development of renewable energy. However, previous work has almost entirely focused on state governments, with little consideration of local governments' power to determine rules directly affecting the construction of renewable energy projects. I present evidence that county governments are actively regulating commercial wind development, and that there are systematic factors associated with county policymakers' decisions to enact and design wind ordinances.

When county governments have had more time to interact with wind developers, they are more likely to take action to formalize their regulation of commercial wind projects, but these regulations are no more or less stringent than other counties. This finding indicates that, as policymakers gain experience working with wind developers, they will be more likely to adopt wind ordinances, but that the stringency of these ordinances is not systematically related to policymakers' exposure to the lobbying influence or the concerns such interactions can engender.

Policymakers also appear to be spurred to act when they see wind farms go up next door. As nearby wind farm development becomes more intense, county officials tend to opt for more stringent standards. This suggests that policymakers tend to be more motivated to address concerns about the growing potential of obtrusive wind turbines than cultivating the potential economic benefits promised by larger wind farms.

Surprisingly, while the decision by neighboring counties to enact wind ordinances seems to spread across jurisdictions, the stringency of these ordinances does not. One possible explanation for this discrepancy is that a policy's underlying idea may diffuse more easily than its specific settings. Alternatively, the apparent null effect could be due to the effects of socialization and learning cancelling out with those of competition, as these mechanisms have conflicting implications.

My findings highlight the importance of taking a wider view of the regulatory context for emerging technologies like wind energy. As in other areas, the deployment of wind energy is often viewed through the prism of federal and state policies. My research challenges this approach, showing that, not only do local governments have the final say over wind development in the majority of U.S. states, they systematically vary in their exercise of that authority. The uneven development of wind generation could be attributable to, in part, the local regulatory terrain in which the companies constructing wind farms operate. Accounting for local regulation may also be extended to other regulatory areas that initially appear to be driven solely by policies at higher levels of government.

In addition to laying the foundation for future analyses of renewable energy development that better account for the local regulatory context, this analysis points to three additional paths for future research. First, the lack of widely available time-series data on county ordinances suggests that an effort to compile longitudinal data on county wind regulation would be extremely valuable, as direct observation of policy change over time is needed to understand, among other considerations, the specific mechanisms that may drive an underlying policy diffusion process. Similarly, the absence of systematic data on corporate lobbying practices at the local level points to an opportunity to generate insights into the role of policy advocacy in local governance.

Second, in light of how challenging it would be to compile longitudinal policy adoption data for a large number of counties, there is a good opportunity for developing case studies that process trace the effect of developer-county government interactions, neighbors' policy actions, and, critically, the role of individual opposition to wind development in shaping the stringency of county wind ordinances. The importance of connecting the known drivers of individual opposition to actual policy outcomes will only become more pressing as wind developers continue to expand into new areas.

Finally, there is considerable room for studies on when states decide to preempt local government authority. The incentive to centralize control over wind development siting would seem particularly strong when a state has adopted a high-profile, legally binding target like an RPS goal and county governments enact stringent regulation. But the incentive to preempt local control could be equally strong when counties enthusiastically promote renewable energy development, especially given the threat renewable energy poses to incumbent fossil fuel-based energy companies. Combining state and local energy politics in a polycentric framework could be highly informative for identifying vertical diffusion mechanisms that complement the horizontal processes identified in this analysis.

Looking forward, my analysis suggests that as developers propose larger projects, they are increasingly likely to be greeted with skepticism and caution from local policymakers. This could potentially lead to lobbying by developers to support state preemption of local wind siting authority or to increase the use of community benefit agreements that create a broader set of financial transfers than tax payments alone (e.g., direct payments to community members beyond the existing set of lessors). In the meantime, developers may instead opt to expand their focus to new counties that lack formalized standards for commercial wind farms.

These decisions, both by wind developers and county governments, not only affect the future prosperity and health of local residents, but also the ability of cities and states to transition their energy grids to renewable energy sources. If the key to addressing environmental problems is to "think global and act local," then the decisions made by county planners and zoning commissions may well reveal the political dynamics at the heart of the United States' transition to a low-carbon future.

Notes

[1] Setbacks are most frequently defined with reference to the project boundary, but setbacks can also be defined with reference to the nearest residential structure. While residential setbacks can be important in densely populated areas, I focus only on project boundary setbacks in this analysis.

[2] For a hypothetical reference project of 100 megawatts (MW), states preempting local wind siting are Alaska, Connecticut, Massachusetts, New Hampshire, New Mexico, New York, Oregon, Rhode Island, South Carolina, South Dakota, Vermont, West Virginia, Wisconsin, Wyoming. States with minimum or maximum restrictions on local wind siting are Delaware, Minnesota, North Dakota, Ohio, and Tennessee. Kentucky has enacted a default wind siting restriction from which local governments may, but have not, deviate. Maine has enacted wind siting regulations for unincorporated areas, Colorado reserves the right to overturn local siting decisions.

[3] Municipal governments are the primary siting authorities in Michigan, New Jersey, Pennsylvania, Oklahoma, and Texas.

[4] This figure excludes Hawaii, for which Zayas et al. (2015) does not provide wind resource estimates.

[5] All observations about actions and procedures undertaken by county governments and wind developers are drawn from open-ended interviews with county government officials and wind developers. In June 2020, I conducted open-ended interviews by telephone or email with officials in the planning offices of seven county governments, namely: Coconino County (AZ), Maricopa County (AZ), Amador County (CA), Calaveras County (CA), DuPage County (IL), Sampson County (NC), and Wilson County (NC). I also conducted two open-ended interviews with five employees of a commercial wind energy company working in the Midwest and Northeast. The first interview was with a lawyer who works with project developers on environmental regulations and permitting (February 27, 2019). The second interview was with four project developers responsible for collecting leases and working with state and local government officials to comply with development standards (April 9, 2019). Their names and affiliations have been withheld at their request.

[6] In Appendix A, I show that counties with more years of wind viability tend to have a longer history and higher average number of commercial wind farm projects per county per year. Since the construction of wind farms implies communication with local officials, this supplementary analysis provides additional assurance that a county's years of wind viability tracks with its policymakers' probability of interacting with wind developers.

[7] See footnote 5.

[8] Personal communication with officials in the Coconino County (AZ) Community Development department

on June 23, 2020.

[9] See Winikoff (2021) on the revision of local wind farm ordinances.

[10] Although it is beyond the scope of this study, future research should examine the interesting and related question of the specific attitudes of local policymakers toward wind regulation, including the conditions under which Not-In-My-Backyard sentiments prevail.

[11] Counties are not typically in a position to coerce each other to make policy decisions. (Simmons et al., 2006, , p. 787) provide the following definition of policy diffusion: "[P]olicy diffusion occurs when government policy decisions in a given [jurisdiction] are systematically conditions by prior policy choices made in other jurisdictions."

[12] Counties are coded as having no setback if no wind ordinance is present, if commercial turbines are mentioned as a conditional use without specific setback requirements, and if standards are listed only for non-commercial wind turbines. If a county did not have a website, it was coded as missing and excluded from the analysis. I investigate the robustness of the results to these coding decisions in Appendices C and D.

[13] Defined as land with a gross capacity factor of 30% and greater, excluding areas unlikely to be developed such as wilderness areas, parks, urban areas, and water features. These data can be downloaded from windNavigator® (http://navigator.awstruewind.com/) at a spatial resolution of 200m for the contiguous U.S. Present-day (2020) viability is approximated using the "near future" estimates, which were intended to represent technology available five years from 2014. See Zayas et al. (2015) for more on the methodology for estimating wind potential.

Data Availability Statement

The data that support the findings of this study are openly available at Harvard Dataverse at https://doi.org/10.7910/DVN/ZXHGVG.

Conflict of Interest

The author declares no conflicts of interest caused by financial support or relationships.

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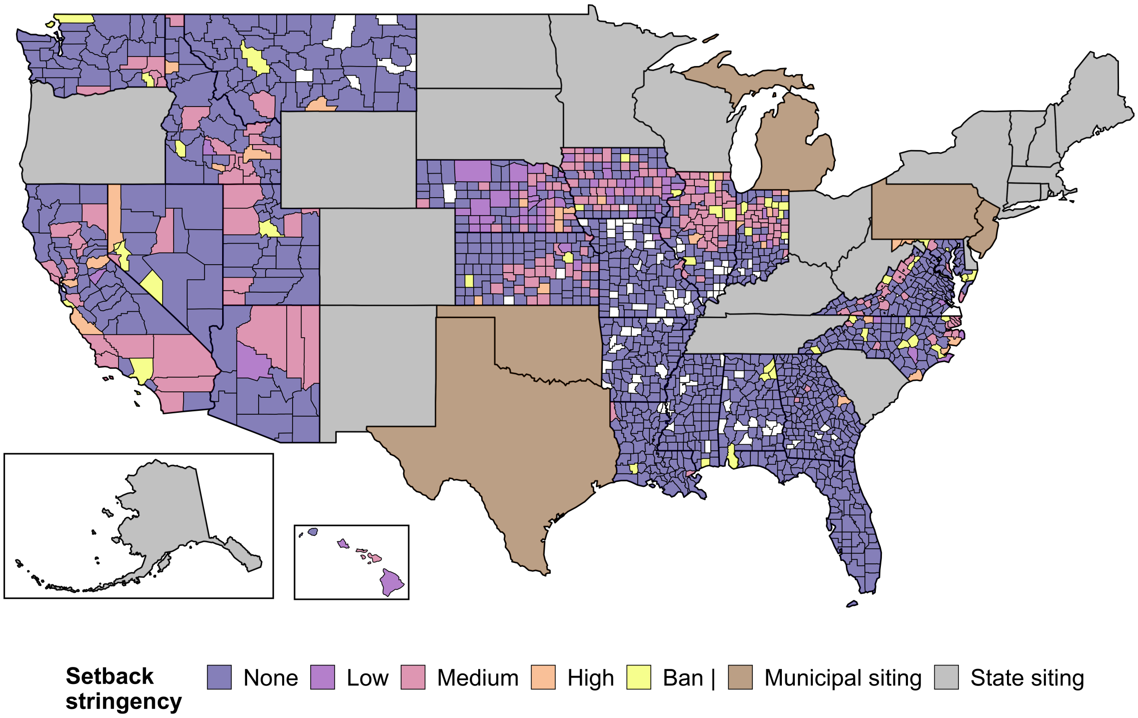
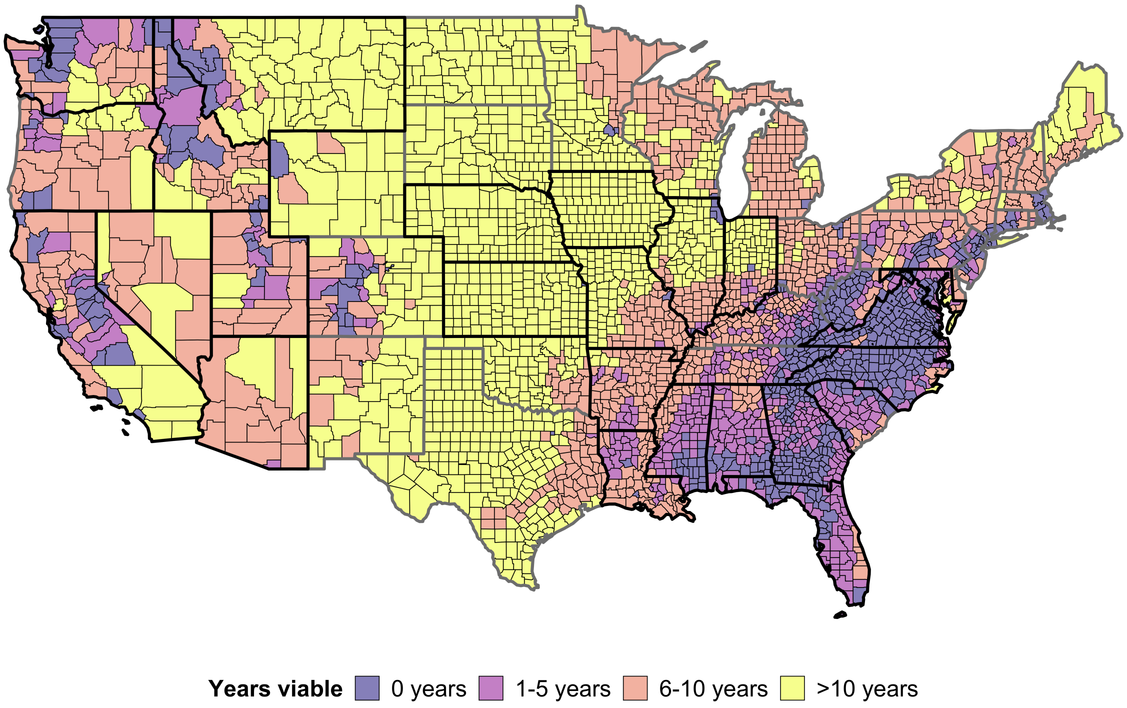
Figures and tables

Figure 1: County commercial wind siting ordinance stringency in the continental U.S.



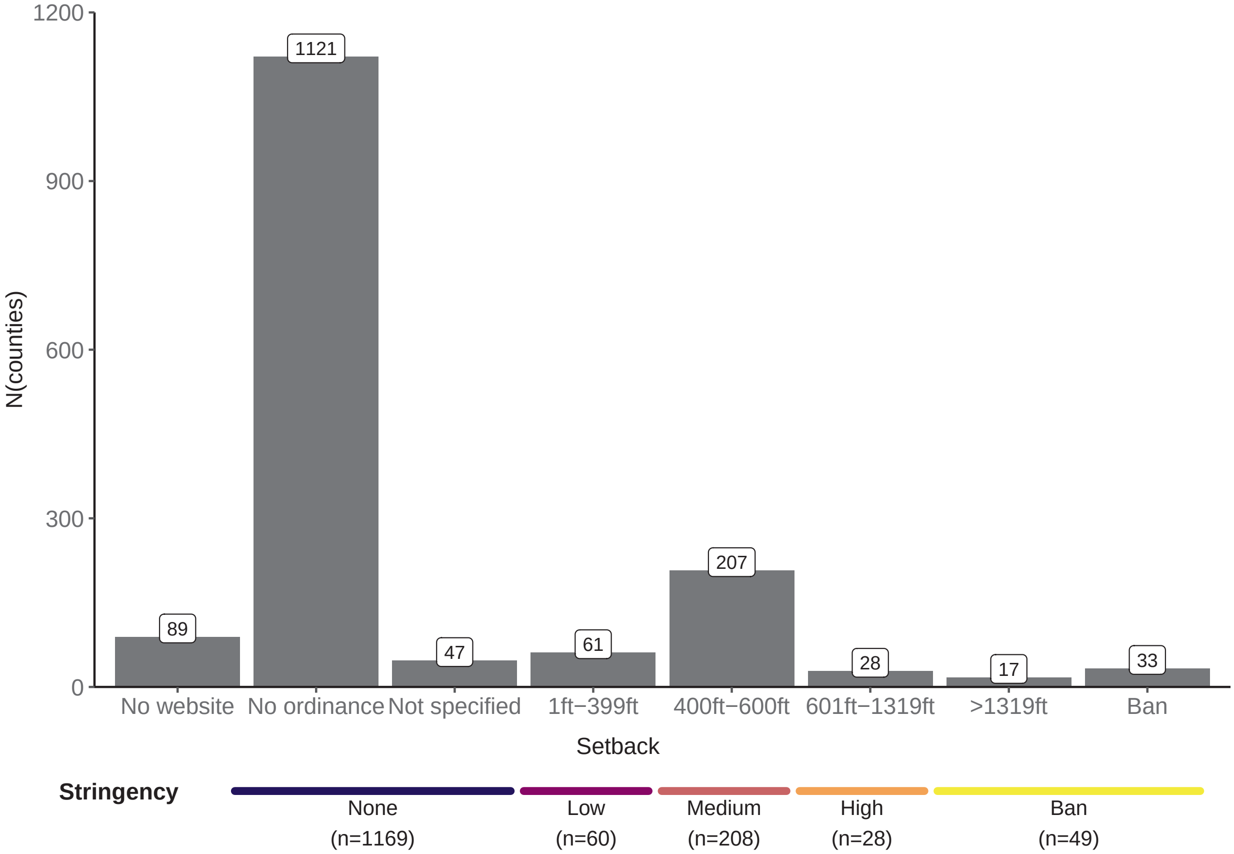
Notes: Setback stringency reflects setback distance to nonparticipating property line: None (0ft), Low (1–399ft), Medium (400–600ft), High (601–1319ft), Ban (>1319ft). N(counties) = 1514.

Figure 2: Years of viability for commercial wind farm development



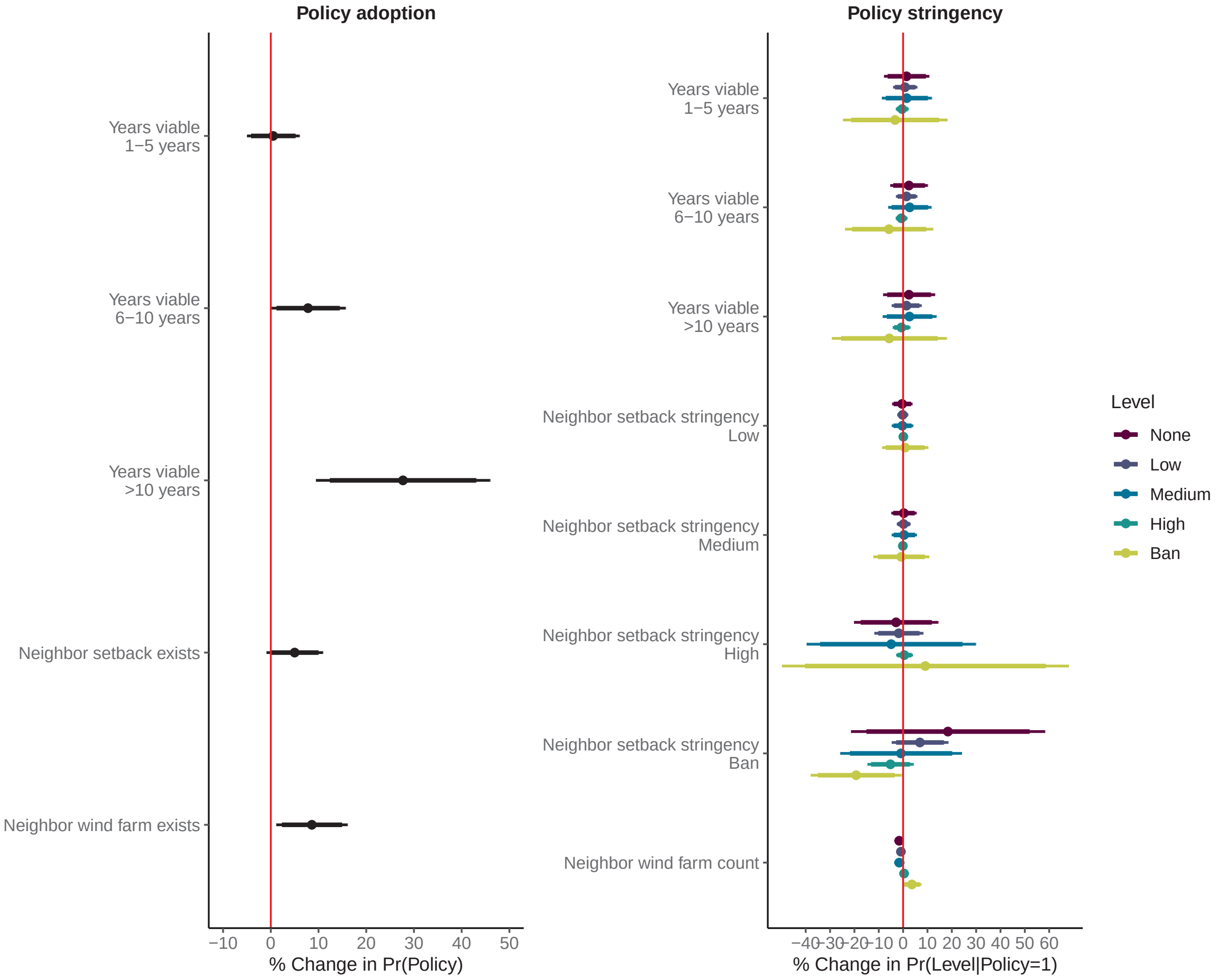
Notes: Derived from estimates of commercial wind viability by Zayas et al. (2015) for 80-m turbines equipped with 2008, 2014, and current industry-standard technology, summed at the county level. Counties are deemed viable for commercial wind farm development at each time point if county contains at least 160km^2 of land with wind resources of at least 30% gross capacity factor. States with siting authority at the local (county or municipal) level are outlined in black.

Figure 3: Distribution of county setbacks for commercial wind turbines.



Notes: N(counties): 1603. 89 counties are missing because they lack county government websites.

Figure 4: Existence and stringency of county wind ordinances, average marginal effects.



Notes: Zero-inflated ordered probit with robust standard errors, 90% and 95% confidence intervals. Missing data estimated using 50 imputations.

Table 1: Main model (zero-inflated ordered probit with robust standard errors)

	Binomial	Ordered probit
Years viable (base = 0)		
1-5 years	0.031	-0.134
	(0.190)	(0.447)
6-10 years	0.457**	-0.238
	(0.207)	(0.377)
>10 years	1.296***	-0.230
	(0.306)	(0.493)
Neighbor setback exists	0.279**	
	(0.139)	
Neighbor setback stringency (base = None)		
Low		0.034
		(0.199)
Medium		-0.034
		(0.247)
High		0.360
		(1.139)
Ban		-1.170
		(0.954)
Neighbor wind farm exists	0.484***	
	(0.160)	
Neighbor wind farm count		0.152*
		(0.079)
County GDP	-0.035	0.146
	(0.234)	(0.295)
Local government jobs	0.212	-0.146
	(0.212)	(0.295)
County GDP from extraction	-0.146*	0.206**
	(0.077)	(0.090)
Population density	0.065	0.331
	(0.161)	(0.219)
Republican vote	0.056	0.002
	(0.073)	(0.111)
Transmission distance	0.003	-0.056
	(0.065)	(0.091)
State fixed effects	✓	✓
Constant		-1.718***
		(0.474)
None → Low		-1.315
		(0.827)
Low → Middle		-0.706
		(0.812)
Middle → High		1.121
		(0.817)
High → Ban		1.495*
		(0.821)
N(counties)		1598

Notes: * $p < .10$, ** $p < .05$, *** $p < .01$ (two-sided). Dependent variable (setback stringency) is measured as an ordinal variable from None (0ft) to Low (1–399ft) to Medium (400–600ft) to High (601–1319ft) to Ban (more than 1319ft). Missing data estimated using 50 imputations.

SUPPORTING INFORMATION

The following additional materials are available in the online appendices:

Appendix A: Average commercial wind farms per county per year, by years of wind viability

Appendix B: Descriptive statistics

Appendix C: Additional models

Appendix D: Extreme bounds and sensitivity analyses