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Original research article

Farmers vs. lakers: Agriculture, amenity, and community in predicting opposition to United States wind energy development

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ABSTRACT

Utility-scale wind energy is now the largest source of renewable electricity in the US. Wind energy's continued growth remains contingent upon finding adequate resource potential and transmission capacity, along with communities willing to host turbines. While previous research on the social acceptance of wind has relied predominantly on case studies, resident surveys, and reviews of development practices and strategies, here we use a new method. We use a wind contention survey of energy professionals (n = 46) to assess the contention associated with 69 existing wind farms in four US Midwest states and identify underlying characteristics, i.e., agricultural, land-use, and demographic characteristics, that may have predisposed communities to either support or oppose wind farm development. We then use publicly available data to parameterize and model those characteristics using wind farm contention as our dependent variable. Our analysis shows that a greater proportion of production-oriented farming and fewer natural amenities in a community are associated with reduced opposition to wind farm development. Additionally, and perhaps counterintuitively, communities with a greater percentage of residents that voted Republican in the 2016 Presidential election demonstrate less opposition. Rather than negating the need for employing best practices in community engagement, stakeholder development, and participatory decision-making processes, this study can help prepare developers for the type of reception that might await them in potential host communities.

1. Introduction

There is widespread agreement that rapidly decarbonizing the US electric power sector is critical to slowing global temperature increases and minimizing the impacts of climate change [1,2]. While scholars debate how exactly to do so and to what extent the US should rely on renewables [3–6], utility-scale wind power remains a significant and growing contributor of (near)zero-carbon power in the US [7]. In 2019, wind power accounted for 9.1 GW (GW) of capacity additions and 105 GW of installed capacity, equating to approximately 7% of US electricity demand and surpassing hydroelectric power as the largest source of renewable power in the US [8]. Despite expiring federal production tax credits, the declining costs of both turbines and installed wind projects have made wind power the most cost-effective choice for new power plant construction in many states [9]. Continued growth of wind power in the US is contingent however upon development in areas with resource potential, transmission capacity, and—the focus of this study—communities willing to host turbines [10].

The need to identify such communities is not unique to the US (see [11] in Switzerland; [12] in the UK, [13] in Canada, and [14] in Ethiopia); however, developers in the US often encounter local governments with far more control over land use than do their non-US counterparts. This is consistent with an American tradition of conferring much more local control over land use decisions than is common in other countries [15–17]. While some U.S. states have retained full- or partial- control of siting utility-scale wind projects (there are wide differences in what MW threshold is applied), siting decisions rest exclusively with local governments in more than half of U.S. states [18]. Even within the US Midwest this control can differ considerably; for example, permits in Ohio are reviewed at the state level by the Ohio Power Siting Board, while permits in Michigan can be reviewed at the county or even sub-county (township) level.

Apart from jurisdictional control, a considerable body of research examines factors affecting the social acceptance of wind projects in the US [19]. Much of this work focuses on i) case studies of a single wind farm or a small number of wind farms [e.g., 20,21, ii) surveys or

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interviews examining the role of individual characteristics—e.g., a person's sensitivity to sound [22], their values, preferences, or distance from turbines—in determining attitudes or support for wind energy [e.g., 23,24; or iii) reviews of development practices, highlighting the importance of fairness and trust during the planning stage [25], compensation made to communities and individuals, or turbine placement decisions specifically regarding density or proximity. Case studies [26] and qualitative empirical research in particular [27] can be limited in generalizability and may overweight contentious cases. Surveys often show associations between certain characteristics and positive attitudes toward wind power, but these associations sometimes weaken at the local or project level [28]. Reviews of developer practices suggest that fairness and trust are consistently associated with support or opposition; however, conflicting evidence exists regarding whether process measures are conflated with residents' preexisting attitudes [29] and how distance to the nearest turbine and turbine density impact perceptions of process or outcome fairness and favorability [30,31].

To the extent that projects are often met with contention before their specific details are known to a majority of community members, or that the same developer using similar practices often receives different reactions, there is more to the social acceptance of wind energy than just developer practices [32]. In the US Midwest, accounts of communities welcoming wind projects abound, with citizens lauding the economic benefits wind power provides to both landowners who host turbines on their property [33,34] and local governments in the form of property tax revenues [35]. At the same time, a growing body of literature and accounts in the popular press describe wind farm proposals meeting significant community opposition [36,37], with citizens voicing concerns over potential changes to the landscape [38], impacts to human health [39], quality of life and property values [40], as well as a perceived lack of fairness in zoning and decision-making processes [25]. High levels of community opposition can delay or even terminate wind projects via moratoriums [41], referendums [42], and restrictive zoning ordinances, while vocal support of projects, increasingly by landowner groups, can enable more rapid development [43]. Regardless of whether wind projects are ultimately rejected or completed, contentious processes can have lingering effects on community cohesion [44].

In this study, we examine whether community characteristics assessed using publicly available data can assist in distinguishing communities that are more likely to support or oppose utility scale wind development in four US Midwest states. As such, our focus in this study is to examine the precursors to opposition, not how opposition develops over the course of a project. To do so, we combine a survey of energy professionals familiar with wind development in these states with public datasets to characterize communities along a select group of parameters.[1] These three parameters include agricultural characteristics, land use characteristics, and demographics; each of which has been examined to differing degrees and resulted in inconsistent conclusions across the scholarly literature. We briefly review these characteristics below before turning to our research design and findings.

1.1. Farm characteristics

Wind turbines are predominantly sited on farmland in the US Midwest. In Midwestern communities, farming is both a common profession and a significant source of income and tax revenue, as well as a contributor to both individual and community identity. Farmers often view wind energy development favorably as wind-turbine leases can be used to diversify farmers' portfolios, provide flood and drought-proof income, and improve the chances of succession [45]. Farmers have also been shown to view wind farm development as an economic development opportunity for the greater community [46].

Both the number and the size of agricultural farms in a community may affect levels of support or opposition demonstrated toward wind farm development. For instance, larger farms are often able to accommodate a greater number of turbines *per farm*, as well as allow for increased setback distances in township or county zoning ordinances. Setback distances tend to be the greatest concern of community members, particularly those opposed to development, and the developers themselves [47]. More and larger farms also mean fewer residents, and thus fewer residents to be potentially concerned about wind development. Smaller farms, on the other hand, are more often owned by "hobby farmers" in the US, or farmers who manage land as a lifestyle choice, for amenity purposes, or as a recreational activity [48,49]. Relative to production farmers, hobby farmers are more often ex-urban, wealthy middle-class individuals purposely seeking idyllic locations and resisting production-oriented agriculture [50]. These particular farmers are likely to be more sensitive to the aesthetic disamenities associated with wind energy.

Not all farmland is owned by either owner-operators or hobby farmers. In many communities, farmland is owned by one party and leased out to an off-site farm operator, often a neighbor with larger agricultural landholdings of their own. Thus, high instances of off-farm operators may not be an indication of a community with little agricultural activity, but instead another indicator of a community with more production-oriented farm operations where opposition to wind development may be reduced. We can also assume that landowners that are positively inclined toward wind would sign a lease, regardless of a principal operator's opposition [51].

1.2. Land-use characteristics

There is general agreement amongst scholars that opposition to wind farm development is less about "not in my backyard" or NIMBY concerns, and more about distributed and procedural justice concerns [24,25,52] and perceptions of landscape fit, place-based values and place attachment [24,53,54]. In particular, communities that have a stronger place attachment are less likely to support drastic land-use alterations [53], or in the case of Midwest farming communities suburban sprawl or widespread industrial development [55]. This may be especially so in areas of high amenity value, or landscapes defined by topographic change, e.g., rolling hills and valleys, and their proximity to water. These areas often attract seasonal residents and transplants, and research finds that such individuals often favor stronger land use controls than longer-term landowners, often to protect those amenities [56,57].

There may also exist distinct land-use cultures with regard to wind development in and across Midwestern states [58]. In a series of workshops, Phadke [58] found that Minnesota residents were often concerned with the tradeoffs of not choosing wind energy while Michigan residents preferred smaller scale wind projects, the latter often referencing the state's tourist economy and the "pristine" and "peaceful" elements of what Michiganders refer to as "up North." To illustrate, since 2006 Michigan has invested tens of millions of dollars annually in its "Pure Michigan" advertising campaign to attract tourists. While certainly each community is different, Midwestern states likely have unique land-use cultures that may result in different levels of support for wind energy development.

1.3. Demographic characteristics

In addition to farm and land use characteristics, community demographics certainly play a role in wind farm acceptance, though how

[1] It is important to note that the terms support and acceptance are not interchangeable—neither in the literature nor in reality, and an accepting population is not necessarily pro-wind. Likewise, opposition and contention are not always synonymous; however, based on a focus group of renewable energy experts who also participated in the survey reported on here, the terms opposition and contention were considered synonymous and are thus reported on as such in this study.

they do specifically is not yet clear. Wind development in the US most often occurs in politically-conservative rural districts [59], and conservative lawmakers have increasingly taken up the cause of renewable energy development [60]. While a widening partisan divide has been documented regarding liberals and conservatives' views on climate change [61], environmental concerns [62], and a national clean energy standard [63], less partisan polarization has been observed with respect to support for renewables [64], and wind energy specifically [65]. Mills' et al [65] national survey showed that 79% of US Republicans supported increasing the use of wind energy compared to 89% of Democrats. Despite positive attitudes and general support for wind energy across parties in surveys, recent evidence suggests that conservatives might be more supportive of local wind development because of its economic benefits, also because of their desire to protect personal property rights [66].

However, as Sovacool [67] points out, newcomers to rural communities can severely impact development processes, and compared to the long-term residents of a community, newcomers entering from an urban or suburban setting are less likely to be conservative. These individuals, similar to hobby farmers, may not only be wealthier, but perhaps also more likely to work from home than long-term residents and commuters and thus more likely to experience the disamenities associated with a local wind project. Newcomers, in particular those that are retired or semi-retired, may also have more time to attend public meetings and the resources necessary to participate in online opposition efforts. Additionally, newcomers to a community are more likely to either have moved as a lifestyle choice (e.g., to return home) or to enjoy a community's rural or recreational amenities [e.g., 68. Recent accounts in the popular press support these propositions, with residents arguing they would not have purchased or moved to a location had they known a wind farm was to be developed [36].

While newcomers may be more educated than long-term residents, education levels have to this point done little to explain local support for or opposition to wind energy [19]. Positive associations between education and support for renewable energy and renewable energy policies have been demonstrated [69]; however, Bidwell [70] found that education levels in Michigan were positively associated with wind caution. Girodono et al [26] showed that high education levels in the western US were positively associated with opposition, but only in the presence of negative wildlife, economic and aesthetic framing and negative experiences with previous wind projects. Those authors add that education may simply represent strong community resources to mobilize in the presence of opposition (or support), but not necessarily serve as an antecedent. Education may also be complicated by its interaction with politics; environmental concern has been shown to increase with education in liberals and moderates, but decrease in conservatives [71]; similar trends were shown regarding individuals' priorities for renewable energy [64]. These trends may be a result of more highly educated individuals being better at seeking out information that reinforces identity-appropriate positions [72].

1.4. Measuring contention and predicting opposition

Relationships between the above characteristics and communities' support or opposition to wind development have been hypothesized and tested. Yet despite a host of studies examining US residents' perceptions, attitudes and support (or opposition) for wind farm development, there are few large datasets aggregating individual perceptions at the community level or tying them to specific wind farms or wind developers. This gap in community-level response is particularly troubling as, in most of the US, power is vested in the communities to set the land use regulations that would allow or disallow projects to feasibly be built.

Giordono et al. [26] do provide insights on this gap for wind projects in the Western US, but in this study we look at wind projects in the US Midwest, in considerably different landscapes in which wind is sited, and employ a different method to measure community-level opposition to a proposed wind development. While Giordono et al. [26] employed content analysis of newspaper article coverage of projects, we survey energy professionals knowledgeable about wind farm development processes, and ask them to provide a contention rating for all of the projects they were either associated with or had knowledge regarding. This survey not only identifies but provides further justification for the above characteristics' importance in generating opposition or support for wind energy. The survey also provides our dependent variable, i.e., the wind farm contention rating.

Finally, in order to inform actual wind development processes, i.e., empower the community members, wind energy developers, and government regulators so often mired in contentious processes, we limit the scope of our work with respect to community characteristics to data that can be easily retrieved without cost from publicly available datasets. This ensures that all interested parties could replicate our methods, use regional and recent data, and approach—or forego [73]—the development process on a level playing field. In doing so we hope to contribute to what Batel [74] has identified as critical research on the acceptance of wind energy, rather than working to reduce public opposition overall or provide developers improved understanding of or strategies for overcoming oppositional communities.

The remainder of this paper is structured accordingly. In the next section, we describe the energy professional survey, the measures used to represent our community characteristics, and introduce our hypotheses. In Section 3, we present the results of our model. And finally, in Section 4 we discuss the implications of our work and how this approach can be used not only to identify those communities that are most likely to desire wind farm development, but also discourage development in communities likely to oppose it.

2. Methods

2.1. Study context

This research examines the extent to which the contention associated with wind farm development in four US Midwest states can be predicted using six underlying community characteristics. Sixty-nine wind farms were examined: 7 in Indiana, 13 in Illinois, 20 in Michigan, and 29 in Minnesota—these four states are commonly grouped together for the purpose of energy and agriculture analysis; see Fig. 1. Contention was measured using a 2018 survey of 46 professionals knowledgeable about wind farms developed in their state. Via that professional survey and the literature review described above, six community characteristics were identified and their data gathered from publicly available datasets. Wind farms and community characteristics were then associated using an American Wind Energy Association (AWEA) geodatabase of wind turbine locations and ArcGIS. The University of Michigan Internal Review Board approved this study (IRB # HUM00140680).

2.2. Dependent Variable: Measuring opposition

Eighty-two wind farms, developed between 1998 and 2017, were initially identified via AWEA's WindIQ database (https://windiq.awea.org/). Based on their involvement in state-level renewable energy siting discussions, 111 professionals were then identified and emailed a short online wind farm contention survey for any of the four states in which they were active (i.e., some professionals received only 1 survey; some received as many as 3 separate surveys). Surveys were distributed to 27 individuals in Michigan, 29 in Illinois, 29 in Minnesota, and 26 in Indiana in April 2018. Individuals who did not respond within a week were sent a follow-up email, and a final notice was emailed two weeks later. Responses were received from a total of 46 individuals with an overall response rate of 41% (IL: 28%, IN: 58%, MI: 47%, MN: 36%). Respondents included staff from 14 environmental NGOs, 4 university researchers, and 26 individuals from energy development companies or consultancies.

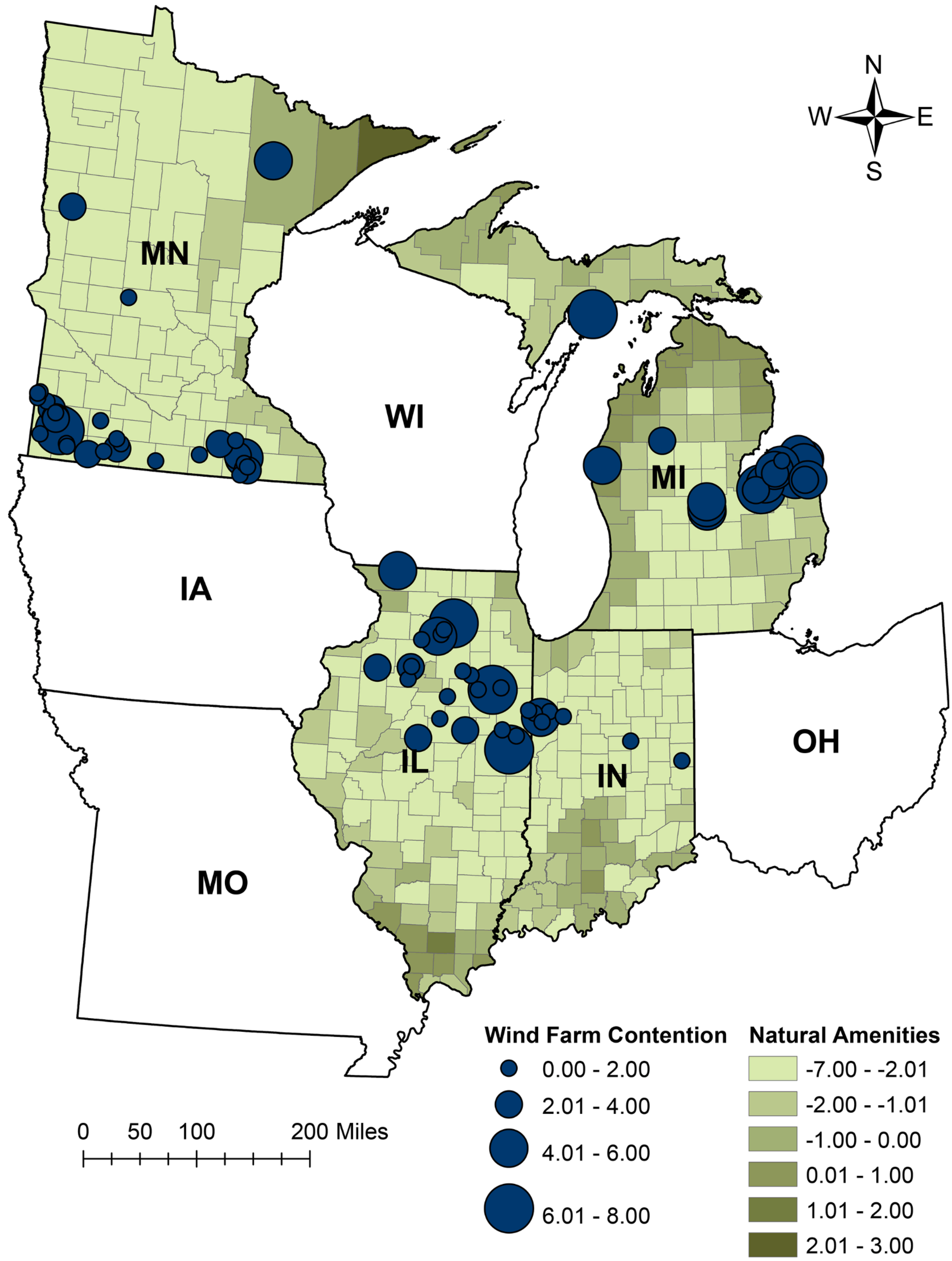

Fig. 1. Wind farm contention and natural amenity index scores. Larger circles denote more contentious projects; darker shading denotes greater natural amenities.

The survey asked participants to rate the level of contention associated with each wind farm in their state using a 11-point Likert scale with 0 representing no contention and 10 representing the highest level of contention. As this study focuses on community characteristics already present in an area rather than wind developer practices and interactions with the community, respondents were asked to rate the level of contention of each project *prior to its construction*. Additionally, wind developers that may have worked on one or more of the projects listed in the survey were explicitly encouraged to *avoid making projects appear less contentious as this study was not intended to reflect developer practices*. Finally, respondents were given the option to skip the question or select "I don't know" if they were unfamiliar with a project. Projects that were given two ratings or less (n = 13) were excluded from this analysis. Of the remaining projects (n = 69), the number of rating-responses ranged from 3 to 9, with each wind farm receiving 5 ratings on average. Table 1 lists the projects, project developers, information about the projects' size and number of turbines, and the mean contention and standard deviation associated with each project.

The wind farm contention survey also included an open-ended question: "Based on your experience, which factors predispose a community to support or oppose wind development?" Participants' responses were manually coded and ultimately separated into three groups: i) community-level factors (underlying), ii) community level factors that arise during or mid-development, and iii) developer

Table 1
Wind Farm Contention Survey Ratings.

	Wind Farm Information (Source WindIQ, EIA)							Contention (0:None to 10: High)		
No.	Master Project	MW	Year Online	State	Project Developer	Turb. Count	Turb. Capacity (MW)	# of Ratings	Mean	St Dev
1	Lee/Dekalb Wind	218	2009	IL	NextEra Energy Resources	145	1.5	3	7.67	2.52
2	Bent Tree	201	2011	MN	Alliant Energy, Wind Capital Group	122	1.65	8	7.00	1.85
3	Lake Winds	101	2012	MI	Consumers Energy Co.	56	2	5	7.00	2.35
4	Michigan Wind 2	90	2011	MI	Exelon Wind	50	1.5	7	6.29	3.04
5	Brookfield Wind Park	75	2014	MI	NextEra Energy Resources	44	2, 2.1	6	6.00	3.29
6	Pinnebog	51	2016	MI	DTE Energy	30	1.7	6	5.83	3.31
7	Echo	112	2014	MI	DTE Energy	70	2.05, 2.1	7	5.57	3.31
8	Big Turtle	49	2016	MI	Heritage Sustainable Energy	24	2.4	6	5.50	2.88
9	Deerfield	149	2017	MI	Algonquin Power, RES Americas	72	1.79, 2.3	5	5.40	1.67
10	Michigan Wind 1	69	2008	MI	Exelon Wind, Noble Environmental	46	1.8	6	5.33	3.33
11	Sigel Wind Park	64	2012	MI	DTE Energy	40	1.7	6	5.17	2.48
12	Grand Ridge Wind Farm	210	2009	IL	Invenergy	140	1.5	3	5.00	2.65
13	Big Blue Wind Farm	36	2012	MN	Exergy Development Group	18	2	6	4.83	3.60
14	Heritage Garden	28	2012	MI	Heritage Sustainable Energy	14	1.65, 1.8	6	4.83	2.14
15	Pheasant Run	75	2013	MI	NextEra Energy Resources	44	1.6	6	4.83	2.14
16	Bishop Hill I & II	292	2012	IL	Invenergy	183	1.5, 1.62	3	4.33	2.52
17	Wildcat I	203	2012	IN	E.ON Climate & Renewables	125	1.62	9	4.33	1.73
18	Harvest Wind	112	2012	MI	Exelon Wind	65	1.6	6	4.33	3.01
19	Crescent Ridge	54	2005	IL	Midwest Wind Energy	33	1.65	3	4.00	2.65
20	Tuscola II	100	2013	MI	NextEra Energy Resources	59	1.6	6	4.00	1.90
21	Minden Wind Park	32	2012	MI	DTE Energy	20	1.8	6	3.83	3.13
22	Settlers Trail Wind Farm	150	2011	IL	E.ON Climate & Renewables	94	1.6	4	3.50	2.65
23	Stoney Corners	60	2011	MI	Heritage Sustainable Energy	29	1.6	6	3.33	2.88
24	Tuscola Bay Wind	120	2012	MI	NextEra Energy Resources	75	1.8, 2, 2.05, 2.3, 2.5	6	3.17	1.33
25	Shady Oaks	110	2012	IL	Goldwind Americas, Mainstream Renewable	71	1.5, 2.5	3	3.00	1.00
26	Headwaters	200	2014	IN	EDP Renewables North America LLC	100	2	7	2.86	2.79
27	Cross Winds Energy Park	111	2014	MI	Consumers Energy Co.	114	1.7	6	2.83	0.98
28	Pleasant Valley	200	2015	MN	RES Americas	100	2	4	2.75	2.22
29	Pilot Hill	175	2015	IL	EDF Renewable Energy, Orion, Vision Energy	103	1.7	3	2.67	1.53
30	Mendota Hills Wind Farm	50	2003	IL	Navitas Energy	63	0.8	3	2.33	1.15
31	Minonk	200	2012	IL	Gamesa	100	2	3	2.33	1.53
32	Streator Cayuga Ridge South	300	2010	IL	Avangrid Renewables	150	2	3	2.33	0.58
33	Adams Wind Farm	23	2004	MN	Garwin McNeilus	15	1.5, 1.65	4	2.25	2.63
34	Dodge Center	42	2003	MN	Garwin McNeilus	41	0.9, 0.95, 1.5, 1.65	5	2.00	1.41
35	Fenton	206	2007	MN	EDF Renewable Energy	137	1.5	5	1.80	1.48
36	Beebe Community Wind	82	2012	MI	Nordex	34	2.4	5	1.80	0.84
37	Black Oak Getty	78	2016	MN	Geronimo Energy, Sempra Renewables	39	2	4	1.75	1.71
38	Grand Meadow	101	2008	MN	EDF Renewable Energy	67	1.5	4	1.75	1.26
39	Jeffers Wind	50	2008	MN	Edison Mission Group, WED	20	2.5	4	1.75	1.71
40	Gratiot Wind Farm	102	2011	MI	Invenergy	64	1.6	6	1.75	1.94
41	Rail Splitter Wind Farm	101	2009	IL	EDP Renewables North America LLC	67	1.5	3	1.67	1.15
42	Lakefield	206	2011	MN	EDF Renewable Energy	137	1.5	4	1.50	1.00
43	Pioneer Trail Wind Farm	150	2011	IL	E.ON Climate & Renewables	94	1.6	4	1.50	1.00
44	Prairie Star	101	2008	MN	EDP Renewables North America LLC	61	1.65	5	1.40	0.89
45	Lakeswind	48	2014	MN	PRC / WWV	32	1.5	3	1.33	1.15
46	MinnDakota Wind Farm	150	2007	MN	Avangrid Renewables	100	1.5	3	1.33	1.15
47	Twin Groves I & II	396	2008	IL	EDP Renewables North America LLC	240	1.65	3	1.33	0.58
48	Wapsipinicon Wind	101	2008	MN	EDF Renewable Energy	67	1.5	3	1.33	1.15
49	Moraine	101	2009	MN	Avangrid Renewables	67	1.5	4	1.25	0.96
50	Prairie Rose	200	2012	MN	Geronimo Energy	119	1.68	4	1.25	0.96
51	Chanarambie	86	2003	MN	EDF Renewable Energy	57	1.5	5	1.20	0.84
52	Elm Creek	248	2010	MN	Avangrid Renewables	128	1.5, 2.4	5	1.20	0.84
53	Odell	200	2016	MN	Geronimo Energy	100	2	5	1.20	0.84
54	Ridgewind	25	2010	MN		11	2.3	5	1.20	0.84
55	Trimont Area Wind Farm	101	2005	MN	Avangrid Renewables	67	1.5	5	1.20	0.84
56	Beebe	50	2014	MI	Exelon Wind	21		5	1.20	1.30
57	Community Wind South	31	2012	MN	juwi Wind	15	2	6	1.17	0.75
58	Lake Benton I	106	1998	MN	Enron Wind Corp	141	0.75	7	1.14	0.90
59	Amazon Wind Farm (Fowler Ridge)	150	2015	IN	Pattern Energy Group LP	65	2.3	5	1.00	1.22
60	Benton County Wind Farm	131	2008	IN	Orion Energy	87	1.5	6	1.00	1.55
61	Community Wind North	30	2011	MN	Community Energy Developers Board	12	2.5	5	1.00	0.71
62	Lake Benton II	103	1999	MN	Enron Wind Corp	138	0.75	7	1.00	0.58
63	Meadow Lake Wind Farm	501	2010	IN	EDP Renewables North America LLC	353	1.5, 1.65, 2, 2.1	8	1.00	1.31
64	Mower County	99	2006	MN	NextEra Energy Resources	43	2.3	4	1.00	0.82

(*continued on next page*)

Table 1 (*continued*)

	Wind Farm Information (Source WindIQ, EIA)							Contention (0:None to 10: High)		
No.	Master Project	MW	Year Online	State	Project Developer	Turb. Count	Turb. Capacity (MW)	# of Ratings	Mean	St Dev
65	Nobles Wind Project	201	2010	MN	EDF Renewable Energy	134	1.5	5	1.00	0.71
66	Windpower Partners '93	50	2011	MN	NextEra Energy Resources	73	0.36, 1.5	3	1.00	1.00
67	Fowler Ridge 1	600	2009	IN	BP Wind Energy, Dominion Energy	355	1.5, 1.65, 2.5	6	0.83	1.17
68	Hoosier	106	2009	IN	EDF Renewable Energy	53	2	6	0.83	0.75
69	Taconite Ridge	25	2008	MN	Minnesota Power	10	2.5	5	0.80	0.84

attitudes and practices (see Table 2). Survey responses related to underlying community characteristics informed the selection of characteristics and hypotheses stated in the next section, but all responses are shown as they suggest critical areas for future study.

2.3. Independent Variables: Community characteristics

Following the literature review and wind farm contention survey, we identified six parameters that would serve as independent variables. These six agricultural, land-use and demographic characteristics were drawn from publicly available datasets at the most specific or granular unit of geography available, meaning either the county or preferably census-block group level; see Table 3 for a list of these characteristics, their source, descriptive statistics, and spatial resolution. We also included a dummy variable representing the state in which each project was developed. This was intended to collectively capture any state-level differences that might arise due to differences in renewable energy requirements, siting process, and property tax structure (and subsequent local economic impact of projects).

To distinguish communities by farm characteristics, in particular the size of farms and types of farmers (hobby vs. production-oriented), we drew two parameters from the USDA Census of Agriculture: i) *the size of farm* and ii) *the percentage of principal operators not residing on the farm operated*.

From this data we hypothesized that:

H1: Both i) *the size of farms* in a community and the ii) *percentage of principal operators not residing on the farm operated* are negatively associated with contention.

Table 2
Factors Predisposing Community to Support or Oppose Wind Farm Development. Factors identified from the wind farm contention survey (n = 46) open-ended question: "Based on your experience, which factors predispose a community to support or oppose wind development?" Arrows denote expected effect of factor on opposition to development.

	*Count***
1. *Community (underlying)*	28
Farmers vs nonfarmer tension* (↗)	7
Population density* (↘)	6
Presence of other wind development (depends)	6
Political affiliation* (Republican ↘)	4
Farming* (depends)	2
Education* (↗)	2
Place attachment* (↗)	1
2. *Community (mid-development)*	17
Misinformation (↗)	8
Local officials' actions (depends)	7
Level of discussion (depends)	2
3. *Developer attitudes & practices*	22
Engagement (↘)	9
Distribution of benefits (↘)	9
Transparency (↘)	3
Developer reputation (↘)	1

* denotes a factor that was included either explicitly or as a proxy in the regression analysis** counts do not add to 46 since some respondents offered multiple responses

To distinguish communities based on land-use characteristics, in particular their natural amenities and amenity use, we drew a single parameter from the USDA Economic Research Service [75], namely, the county's iii) *natural amenity rank*.

From this data, we hypothesized that:

H2: the community's iii) *natural amenity rank* is positively associated with contention.

To distinguish communities demographically, in particular their level of education and partisanship, we included two parameters: the first from the US American Community Survey (ACS): iv) the *percentage of the population with a bachelor's degree or higher*, and the second from Townhall Presidential Election Data: v) the *percentage of the population that voted for Donald Trump*.

From this data, we generated two hypotheses:

H3a: iv) *the percentage of the population with a bachelor's degree or higher* is positively associated with contention, and

H3b: v) *the percentage of population that voted for the Republican (Donald Trump)* in the 2016 presidential election is negatively associated with contention.[2]

Finally, in order to determine the amount of individuals in a community working from home—and thus likely to experience the disamenities associated with wind, we drew one parameter, vi) *the percentage of the population worked at home*, also from the ACS (2012–2016).

From this data, we hypothesized that:

H3c: vi) *the percentage of the population working at home* is positively associated with contention.

2.4. Data analysis

In addition to computing descriptive statistics and correlations for each variable, we conduct two separate linear regressions. The first uses the six community characteristics described above and identified in Table 3 as independent variables, along with a state fixed effect, and the contention of each wind farm as our dependent variable. We were limited in the number of independent variables we could include because of the number of wind farms (n = 69) studied and the generally accepted guidance of using no more than one independent variable for every 10 (or preferably more) observations [76]. Our second regression also includes six community characteristics, but exchanges population

[2] Note, in the US, not all states require voters to register by political party and so the common measure of political affiliation is by looking at national elections. Furthermore, we also ran the model using county-level results from the 2012 election in which John McCain was the Republican presidential candidate. There were no differences in terms of which variables were significant, the sign of their coefficients, or in the overall R2, and so we have shown here results using the most recent voting data.

Table 3
Independent Variables: Community Characteristics.

Characteristics	Mean	Min	Max	St dev	Source	Spatial Resolution
Agricultural						
Size of farm (acres)	401.25	180.00	667.00	98.33	Census Agr[1a]	County
Principal operators not residing on farm operated (%)	25.18	12.23	40.50	7.52	Census Agr[1a]	County
Land Use						
Natural amenity rank	2.20	1.00	4.00	0.72	ERS[2]	County
Demographic						
Population w/ bachelor's deg or higher (%)	15.52	3.24	27.86	5.22	ACS[3]	Block Group
Population voted for Trump (%)	63.21	44.72	75.28	6.78	TPED[4b]	County
Population worked at home (%)	7.41	0.56	25.44	5.07	ACS	Block Group
Project Contention						
Level of Contention	2.88	0.83	7.67	1.90	Survey[5]	Mean Center of turbines in project

1: 2012 USDA Census of Agriculture, 2: USDA Economic Research Service, 3: U.S. Census American Community Surveys 5 Year estimates (2012–2016), 4: Townhall 2016 Presidential Election Data, 5: Wind farm Contention Survey
a: 2017 USDA Census data was not available at the time of this study
b: A test of presidential voting data from both 2012 (McCain) and 2016 (Trump) found no difference in results

density for size of farm.[3] Because these two variables are strongly correlated (i.e., farms tend to be smaller where there are higher population densities), it is inappropriate to include them in the same model. Since population density—rather than farm size—is a measure more commonly mentioned on the wind energy contention survey and available at the sub-county level, we test it here in this second regression model.

Finally, because a wind farm is comprised of dozens of individual wind turbines, the Mean Center function in ArcGIS was used to find the geographic center of each wind farm and the wind farm was assigned the community characteristics of the county or census block group in which its mean center fell.

3. Results

3.1. Contention ratings

Responses to the wind farm contention survey demonstrated a low level of contention overall, with a mean level of 2.88 out of 10 (sd = 1.90). The most contentious development project, as rated by energy professionals, was the 2009 218 MW Lee/Dekalb County Wind farm in Illinois (7.67, sd = 2.52), while the least contentious project was the 2008 25 MW Taconite Ridge project in Minnesota (0.80, sd = 0.84). Michigan's 20 wind farm developments were on average rated the most contentious, while Indiana's 7 projects were on average rated least contentious (see Table 4). NextEra Energy Resources, LLC. had two of the five most contentious projects (2009 Lee/Dekalb, IL; and 2014 Brookfield Wind Park, MI) as well as two of the six least contentious projects (2011 Windpower Partners '93, MN; and 2006 Mower County, MN).

Furthermore, the data reveal correlations between some project characteristics and many of the community characteristics of interest and contention. While there is no significant correlation ($p > 0.05$) between the number of turbines or capacity of a wind farm and its contention rating, there is a positive (r = 0.341) and significant (p = 0.004) correlation between the year the wind farm came online and contention. Regarding community characteristics, there is no significant correlation ($p > 0.05$) between contention and either population density or Trump voters, but significant correlations ($p < 0.01$) are demonstrated with all other values. Given the interconnections between many of these characteristics, regression analysis allows us to determine which are most important.

Table 4
Wind farm and Community Characteristic Correlations with Contention.

	Pearson's r	*Sig.*
Wind farm Characteristics		
Year Online	0.341	0.004**
Turbine Capacity (MW)	−0.128	0.293
Turbine Count	−0.169	0.166
Community Characteristics		
Agricultural		
Size of farm (acres)	−0.441	0.000***
Percent operators not residing on farm operated (%)	−0.298	0.013*
Population density	0.016	0.895
Land Use		
Natural amenity rank	0.459	0.000***
Demographic		
Population worked at home (%)	−0.421	0.000***
Population voted for Trump (%)	−0.113	0.354
Population w/ bachelor's deg or higher	−0.337	0.005**
States	Mean Contention	*sd*
Overall	2.88	1.90
IL	3.32	1.73
IN	1.69	1.37
MI	4.59	1.51
MN	1.74	1.29

p-value: ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$, + $p < 0.1$

3.2. Community characteristics and contention

Our first hypothesis related to agricultural activity in a community, both the size of farms (mean = 401.25 acres, sd = 98.33) and the percentage of operators not residing on farms (25.18, sd = 7.52). Our initial regression model showed the size of farms to have no significant effect (p = 0.139) on contention, while the percentage of operators not residing on the farm was highly significantly and negatively associated (B = −0.145, $p < 0.001$) with contention—see Table 5 for results of this regression analysis. Our second model run, which replaced the size of farms with population density (see Table 5), also showed population density to be non-significant ($p > 0.05$), while principal operators not

[3] Initially, we tested a total of 15 different independent variables in various combinations to determine which served as reliable proxies for the characteristics we aimed to study (e.g., various Census of Agriculture characteristics to measuring farm intensity; various measurements of rurality to measure natural amenities; various presidential elections to measure politics). The variables chosen here include those which were supported by the literature or which were mentioned by survey participants (Table 2), and which exhibited consistent behavior (e.g., estimate sign and significance) across models.

Table 5
Results of Farm-Size Model and Population-Density Model.

Characteristics	Farm SizeModel Results			Population DensityModel Results		
	B	*se*	*Sig.*	B	*se*	*Sig.*
Intercept	9.77	1.73	0.000***	7.17	1.82	0.000***
Agricultural						
Size of farm	0.004	0.003	0.139	na	na	na
Principal operators not residing on farm operated (%)	−0.145	0.033	0.000***	−0.101	0.033	0.003**
Population density[a]	na	na	na	−0.001	0.002	0.714
Land Use						
Natural amenity rank	1.599	0.306	0.000***	1.160	0.332	0.001**
Demographic						
Population with a bachelor's degree or higher (%)	−0.049	0.032	0.134	−0.042	0.035	0.235
Population that voted for Trump (%)	−0.077	0.025	0.003**	−0.062	0.030	0.046*
Population that worked at home (%)	−0.073	0.034	0.038*	−0.072	0.038	0.063+
States						
Illinois	2.412		0.000**	2.125		0.001**
Indiana	1.168		0.067	1.289		0.046*
Michigan	0.857		0.160	1.008		0.101
Minnesota	0[a]			0		
R Squared	0.625			0.614		
Adjusted R Squared	0.582			0.555		

p-value: ***p < 0.001, **p < 0.01, *p < 0.05, + p < 0.1
a: Population density replaced Size of farm in Model 2

residing on the farm operated remained significantly ($p = 0.003$) and negatively associated ($B = -0.101$). Thus, H1 was only partially supported.

Our second hypothesis related to land-use characteristics, in particular the effect of natural amenities on contention. Regression showed that communities' natural amenity rank was positively associated with opposition to wind farm development and highly significant in both the Farm Size Model ($B = 1.599$, $p < 0.001$) and Population Density Model ($B = 1.160$, $p = 0.001$). Thus, H2 was supported.

Our third set of hypotheses related to demographic characteristics, in particular community members' level of education, political affiliation, and the extent to which individuals worked from home. Communities varied similarly with regard to the proportion of college graduates and individuals working from home, with the number of college graduates ranging from 3.2% to 27.9%, and individuals working from home making up between 0.6% and 25.4% of the population. The proportion of residents who supported Trump however was far higher, ranging from 44.7% to 75.3%. Regression showed the second and third characteristics, the percentage of Trump voters and percentage of population working from home, to be significantly and negatively associated with contention ($B_{Trump} = -0.077$, $p = 0.003$; $B_{WorkHome} = -0.073$, $p = 0.038$) in the Farm Size Model. The Population Density model showed the percentage of Trump voters to be significant ($B = -0.062$, $p = 0.046$), though not at the $p < 0.01$ level, and the population that worked from home to only be marginally significant ($B = -0.072$, $p = 0.063$). Education was not significantly associated with contention in either the Farm Size or Population Density model, thus hypothesis H3a was neither supported nor rejected; hypothesis H3b was supported, and H3c was rejected.

3.3. *Model fit*

Overall, both models of community characteristics were statistically significant ($F_{Farm\ Size} = 14.539$, $p < 0.001$; $F_{Pop\ Density} = 10.432$, $p < 0.001$; however the Farm Size model explained 62.5% ($R^2 = 0.625$) of the variability of the contention response data, while the Population Density model explained 61.4% ($R^2 = 0.614$). Table 6 shows the difference between the predicted level of contention for the Farm Size model and the level of contention observed. For 51 of the 69 development projects, our primary model predicted a level of contention within 1 point. It should be noted that the dummy variable for State was significant; with Illinois in particular serving as an outlier amongst the four states, significantly and positively affecting contention ($B = 2.41$, $p < 0.001$)

4. Discussion

The intent of this study was to determine the potential for using existing publicly available data to help distinguish between those communities predisposed to support wind farm development and those communities which may oppose it. Using a survey of energy professionals highly familiar with US Midwest wind farm development, we used ratings of the contention associated with existing projects to determine which community-level characteristics were significantly associated with contention, and thus opposition. The characteristics selected were informed by the scholarly literature and the intuitions of energy professionals collected via the wind contention survey.

Much of the existing literature points to the importance of distributional and procedural justice to attitudes toward local wind development [24,25,74,77,78], largely implying controversy surrounding wind energy is the result of wind developers who have failed to provide appropriate community-wide justification, compensation or engagement. Indeed, our wind contention survey finds energy professionals themselves identify wind developer practices as a key component of community responses to wind development. However, energy professionals also assert that there are community-level characteristics that shape how contentious a wind farm proposal may be. Some of these characteristics, like how quickly misinformation spreads or how supportive community leaders are to the project, only appear once a project is actively being discussed. But other characteristics, including demographic, political, and land use characteristics, are present and discernible before a developer arrives in a community. To the extent that these characteristics shape how contentious a wind farm proposal may be, developers can incorporate community characteristics into their prescreening criteria—along with wind resource and access to transmission, for example—to direct their efforts to communities more predisposed to be supportive of wind farm development

Of these underlying community characteristics, our analysis identifies two in particular that may be crucial to community acceptance. The first is linked to agricultural intensity. While the size of farms or population density are sometimes used as short-hand proxies for this measure, population density was not correlated with contention and neither were significantly associated with contention in the regression

Table 6
Farm-Size Model vs. Observed Levels of Contention ($n = 69$).

Wind projects	Difference between modelled and observed level of contention
27	±< 0.5
24	±0.5–1
13	±1–1.5
3	±1.5–2
1	±2–3
1	±3+

models. Instead our model found the proportion of farmers in an area residing on the farm operated as a much stronger correlate with contention. We argue this measure serves as a proxy for the proportion of farmland owners in a community that are either production- or hobby-oriented, with higher levels of production-based farming in communities with more principle farm operators living *off-farm*. In finding that wind farm contention decreases with higher proportions of production-focused landowners, these ag-centric communities likely see wind development as one more way for their land to be productive.

The second underlying community characteristic that is significant in explaining community response measures the degree to which a community has natural amenities. Communities that have higher natural amenities according to USDA's Natural Amenities Index—which accounts for proximity to a water body and topographical variation (the flatter, the less amenable)—also saw more contentious wind farm proposals. To the extent that a wind farm is perceived to be a visual disamenity [79], it may be unsurprising that residents in communities with high natural amenities would have a strong reaction to a change in their landscape.

It should be noted that in much of the country, these characteristics are connected. Most production-oriented agriculture is less conducive in areas with large topographic changes or many water bodies to farm around, while these rural areas with high natural amenities may attract more hobby farmers. There is, however, limited variation in farm intensity or natural amenities in the rural areas in most states. Much of the Great Plains have high levels of absentee landownership [80], but also score relatively low on the Natural Amenities Index [75]. It is unsurprising then that this is the greatest concentration of wind development, in particular where the production- and amenity-based landscape values do not see high amounts of conflict. As wind development expands to other regions of the country however, these values may come more into conflict. The Great Lakes Region, for example, offers a wider variation of communities with both production- and amenity-based landscapes. While the counties that border the Great Lakes rank higher on the Natural Amenity Index, many of these counties also have significant inland agricultural operations. Furthermore, the region boasts many smaller inland lakes in an otherwise relatively flat landscape which allows for small lakeside residential enclaves surrounded by farm fields. Indeed, at one of the first wind farm hearings that the second author attended in Michigan, the author was asked if she was there with "the farmers" or "the lakers" (i.e., owners of homes on a small inland lake), as the former group was in support of a proposed wind farm while the latter group was opposed. Descriptive statistics suggest that the wind farms in Michigan were most contentious; however, the state did not stand out in either regression. This is likely because many of the windfarms in Michigan have been developed in higher natural amenity counties along the Great Lakes coastline. By contrast, the regression found Illinois to have a significant fixed effect, standing out as the most contentious. This could be the result of Illinois' wind development taking place in unexpectedly contentious landscapes, some state level policy variation (e.g., tax or siting policy) that makes Illinois communities less supportive of wind development, or a statistical anomaly resulting from fewer professionals responding to our survey.

While energy professionals suggested that a number of other underlying community factors impacted how contentious a wind farm proposal was, our analysis found these other demographic factors to be weaker within the model. Perhaps inconsistent with previous research [64,71] and even energy professionals' assertions that liberals are more supportive of wind energy, contention was shown to be negatively associated with conservatism. This perhaps counterintuitive result could be true for a number of reasons: first, conservative voters are more likely to be long-standing residents in a community and both seek and frame development in economic terms. Second, rural communities naturally skew conservative and the more politically aligned a community's residents are, the greater that community's cohesion and shared identity. Finally, conservatives tend to place more importance on the value and protection of property rights, which figure prominently in arguments made by wind farm proponents, turbine lease holders, and farmers more generally [66].

Despite the model's ability to identify characteristics that suggest preexisting support or opposition to wind development, it does not and is not intended to capture every aspect and dynamic of a community; to that end it purposely ignores the processes by which wind farms are developed. Both are of course important. Not only are multiple examples provided in the literature [32,52,81], but as noted in Table 2, developers' attitudes and practices play a significant role, in particular the extent to which and when developers engage community members, the transparency with which they conduct business, and their reputations before, during, and after development. As seen in Michigan, poorly perceived developer practices are shared more quickly and fervently between communities than are fairly perceived processes, and may become especially important when developers desire to site additional or repower aging turbines [25]. Additionally, a growing area of research involves examining the role of community benefit packages, tax revenues and structures, and good neighbor payments—referred to as economic benefits in Table 2—in influencing development processes and the favorability of outcomes [12,82,83]. As a result, the findings of this research should not suggest that following best practices for procedural and distributional fairness is unnecessary or unimportant.

However, this research does suggest that following best practices does not guarantee earning community support. A complementary finding of this study is that despite the assumption that each developer relies on consistent practices and is thus often branded as either elevating or eschewing norms of procedural or distributive justice, Table 1 shows that the contention associated with a single developer's projects may vary considerably. NextEra Energy Resources, LLC. was responsible for seven of the 69 projects rated, and those projects range in contention from 1.00 to 7.67. At the same time, EDF Renewable Energy, LLC., responsible (in part) for eight of the 69 projects, saw consistently low contention, never reaching above a mean rating of 2.67. A more in-depth analysis of trends within the project and developer ratings is necessary but outside the purview of this study.

In addition to developers' practices, individuals matter. Less quantifiable aspects like the capacity, resources, and experience of community leaders and development supporters or opponents play crucial roles in either stoking or relieving contention. The amount and accuracy of information shared online and between anti-wind and pro-wind stakeholder groups is a key factor in determining contention and thus the eventual outcome of projects. We note that this model is not intended to replace active community engagement and participatory decision-making processes. Both are key to the successful outcome of a project, whether it be the construction or cancellation of a single turbine or the project en masse.

4.1. Limitations

This study provides actionable results for energy planners and identifies a promising research trajectory but is not without its limitations. Our contention survey only examined existing projects rather than all proposed projects, i.e., both existing and terminated projects. This likely resulted in an overall reduction in contention ratings, as projects terminated as a result of opposition would likely receive a 10 rating. Including terminated projects in future analyses may identify additional community-level characteristics that are even more strongly associated with contention; however, the reverse, identifying characteristics more strongly associated with support, is less likely.

An additional limitation of the study is that the included survey of energy professionals resulted in a sample of 69 wind farms, limited only to four US states. This sample size limited the number of independent variables that could be included in the regression analysis. With more observations, for example, we could include transmission capacity and wind resource potential, both of which could alter community perceptions regarding the viability of projects, the presence of nearby wind farms, the year of the wind farm proposal, and developer leasing and community engagement practices. A larger more nationally representative sample of energy professionals is in the planning phase and has garnered considerable support from government agencies and developer associations; however, we note that such a survey requires building significant trust with developers, regulators and most importantly community members and is a serious undertaking. Nevertheless, the results reported here buoy that effort.

Finally, we found contention to be negatively associated with the percentage of people working from home, which was contrary to our initial analysis (i.e., H3c was rejected). This measure was intended to identify urban transplant telecommuters, who we hypothesized would be more likely to view turbines as a disamenity; however, that measure may have also captured individuals engaged in home-based occupations. As such we ran an additional regression (not reported on here) and included an interaction term including the percentage of population that worked from home and the percentage of the population with a bachelor's degree or higher. This we argue would effectively capture more highly educated telecommuters. That regression resulted in only a marginally significant result and required adding another independent variable; however, the sign of the coefficient was in the direction we hypothesized, with contention increasing as the interaction term increased. As such, we are not outrightly rejecting our hypothesis regarding the role of commuters as much as planning to include this interaction term in future studies where a greater number of observations allow us to include more variables.

4.2. Conclusion

In choosing locations for wind development, energy professionals have historically relied on the technical and resource potential of sites. As technological and economic shifts make more communities across the country economically viable for wind development, it is critical for energy professionals to not only understand, but acknowledge that communities may respond differently to wind proposals and make decisions accordingly. Existing research has used case studies, resident surveys and reviews of development practices and strategies to better understand the social acceptance of wind farms and their development processes. Here we argue that alongside professional surveys, existing public data can be used to assist in the initial selection of sites, identifying agricultural, amenity and demographic characteristics that may predict predispositions to support or oppose wind farm development. Rather than negating the need for employing best practices in community engagement, stakeholder development, and participatory decision-making processes, this work can help prepare developers for the type of reception that might await them in potential host communities and perhaps even direct them to areas where that engagement is most likely to be well-received.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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