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See me, Feel me, Touch me, Heal me: Wind turbines, culture, landscapes, and sound impressions[☆]

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ABSTRACT

Community-based wind energy projects, with their small-scale, yet sizeable presence, provide a valuable opportunity to understand how individuals make sense of changes to their communities and to the surrounding landscape. Here, we examine the results of a 2013 mail survey of individuals residing in the vicinity of a 2 MW wind turbine that is located on the edge of the historic coastal town of Lewes, Delaware in the United States, and adjacent to Delaware Bay and the Great Marsh Preserve. The wind turbine, which was constructed in 2010, primarily serves the University of Delaware's coastal campus, and to a lesser extent the town of Lewes. Seventy-eight percent hold positive or very positive attitudes toward the wind turbine, with only 10% having negative or very negative attitudes, and 82% like the look of the wind turbine. Socially constructed aspects find more resonance than physical ones (e.g., attractiveness) in explaining this latter finding, with the wind turbine being reflective of a transformation to a clean energy future for those residents who like the way the turbine looks. On the other hand, those objecting to its look, find the turbine does not fit the landscape. Policy implications of these findings and others related to wind turbine sound are considered, and recommendations for better understanding of proposed developments from the vantage point of the affected communities, including how a community views itself and its surrounding landscape, are made.

Introduction

Delaware is the second smallest of the 50 United States with a population of less than one million, although it has one of the highest population densities. Delaware is located on the eastern seaboard, with limited economically beneficial land-based wind resources at typical 80 m hub-heights other than those directly adjacent to Delaware Bay or along its 40 km Atlantic ocean coastline. In June 2010, the University of Delaware (UD) commissioned a single 2 MW Gamesa Technology Corporation wind turbine on land directly adjacent to UD's Lewes, Delaware campus. The Lewes wind turbine is the first, and as of the end of 2014, the only utility-scale wind turbine in Delaware; by comparison, the United States as a whole has more than 60 GW (60,000 MW) of wind power capacity. Almost all in-state electricity generation is fueled by natural gas, coal or petroleum, with the Indian River coal plant situated directly adjacent to coastal Delaware, about 25 km from the town of Lewes. The Salem Nuclear Power Plant and the Hope Creek Nuclear Generating Station are approximately 85 km north of Lewes, just across the Delaware River in New Jersey.

Lewes, known as the "First Town in the First State," was settled in the 1600s and has a designated historic district that includes buildings dating back to the 1700s as well as many Victorian homes. The wind turbine is located approximately 0.4 km from the nearest University building, 0.67 km from the nearest home, and about 1.5 km as the crow flies from the closest edge of the historic district (map at http://www.ci.lewes.de.us/pdfs/HPC_User_Guide.pdf). It is also approximately 1 km from Delaware Bay and borders a large wetland complex to the north. The wind turbine's hub is at 78 m, and with a rotor diameter of 90 m, the tip of a blade at its aperture rises approximately 123 m. Although not visible from the historic downtown, it is visible from some parts of the town, including the Lewes Yacht Club, the town beach, and the surrounding area (e.g., from Highway 1). When most people in the town view the wind turbine they are likely oriented with the Great Marsh Preserve in the background. The town of Lewes, Delaware is bordered by Delaware Bay and Cape Henlopen State Park, which fronts the Atlantic Ocean.

Abbreviations: kW, kilowatt; MW, megawatt; REC, renewable energy credit; UD, University of Delaware.

☆ From the song "See Me, Feel Me" written by Peter Townsend, The Who.

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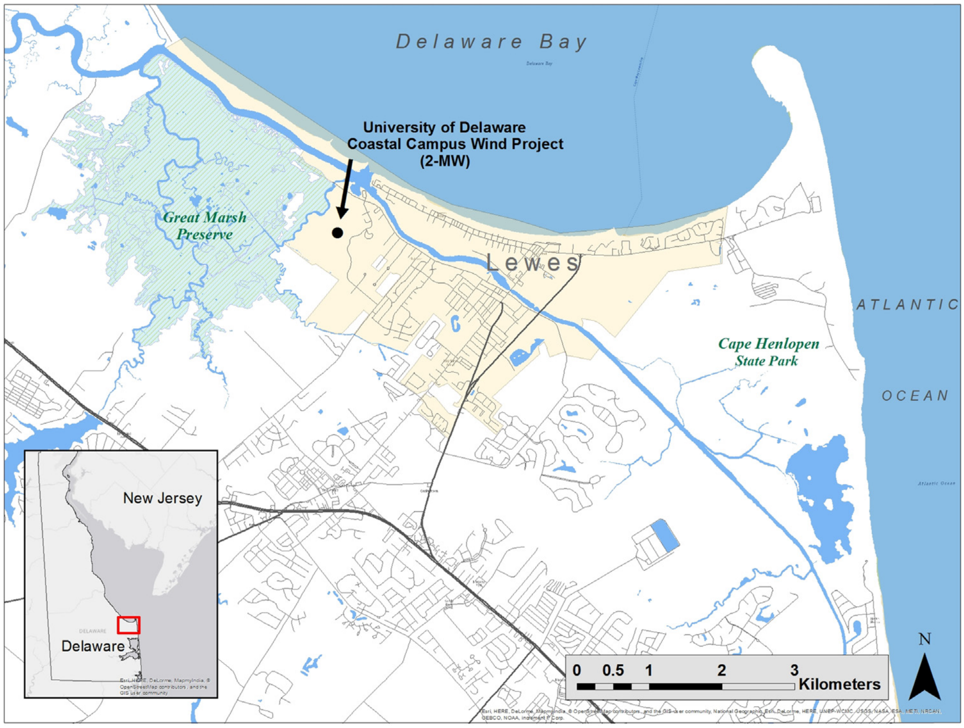

Fig. 1. Map showing the wind turbine and features in the vicinity. Features include the Great Marsh Preserve, the Town of Lewes, Delaware, Cape Henlopen State Park, Delaware Bay and the Atlantic Ocean (Lewes boundary denotes municipal boundaries, not survey sampling area).

With a population of approximately 2750 in 2010, a quaint historic district and coastal location, tourism plays a large part in Lewes' economy, see Fig. 1.

The average age of Lewes residents[1] is approximately 57, with roughly 55% of the population being female and 40% retired. The median household income is almost $54,000, with households averaging just over two members. Lewes is a well-educated population with more than 47% having obtained at least a bachelor's degree. The town voted heavily for President Obama in the last election, with 63% giving their vote to him, 27% to Mitt Romney, and 4% to some other person, with just 6% not voting.

The wind turbine is owned and operated by a joint venture between the turbine manufacturer, Gamesa Technology Corporation (Gamesa), and a UD wholly owned corporation. Revenues from the wind turbine are dedicated toward wind power research and development. UD purchases the bulk of the electricity generated by the wind turbine to power its coastal campus. As part of the transaction, UD also received all of the renewable energy certificates (RECs) generated by the wind turbine. RECs are the "green attributes" associated with renewable generation that regulated utilities in many states are required to hold. In 2013, UD entered into an agreement with the municipal utility of which Lewes is a member, for the re-sale of RECs, with the proceeds going to support graduate scholarships in wind energy.

The town of Lewes is an important partner, although it holds no financial interest. The Lewes Board of Public Works (LBPW) "virtually" net meters six campus buildings (treating them as one and then net metering). The LBPW also purchases electricity not used by UD at avoided cost—that is, Lewes receives wind-generated, clean energy for the same price it pays for electricity generated by an amalgam of sources, which is primarily comprised of fossil fuel-based electricity and nuclear power. Despite its lack of ownership interest, in an acknowledgment of the town, and due to a desire of the Lewes community, the town of Lewes, like Gamesa and UD, displays its name on the nacelle.

In December 2010, Tech Environmental, on behalf of Gamesa, undertook post-installation sound compliance monitoring. The monitoring occurred outdoors on property of one of the very closest residences to the wind turbine. The sound was below daytime and nighttime average sound limits and within the incremental limit of 10 dBA established under state law for residential areas. More specifically, Tech Environmental, Inc. (2011), found the wind turbine to increase ambient sound level by 1.1 A-weighted decibels (dBA) in the daytime and 2.9 dBA in the nighttime, and after binning hub height wind speeds 4.6 dBA (10.0–10.6 m/s bin) and 4.4 dBA (12.4–13.0 m/s bin). The turbine produces maximum sound when the wind speed is above 8.6 m/s. As noted in the report, the subject effect of a difference of 3 dB is "just perceptible"; 5 dB is "noticeable; and 10 dB is twice as loud (decibels being a logarithmic scale).

In 2012, UD commenced a research project to better understand how residents of coastal Delaware and Greater Atlantic City, New Jersey perceive local land-based wind projects, proposed offshore wind demonstration projects and offshore cabling. Semi-structured interviews were undertaken in 2012. These interviews were exploratory in nature and were designed to provide insights to guide the content of the subsequent mail survey, which was disseminated late spring/early summer 2013.

Although we were somewhat limited in the number of questions we could pose regarding the Lewes wind turbine because the survey also sought information on two other topics, we were able to structure the survey around those aspects (visual, acoustic, and socio-cultural) that were of greatest resonance in the pre-survey semi-structured interviews. Given the limited number of probability sample-based surveys on community-developed and community-scale wind turbines/projects—and even fewer still that

[1] We use the term "Lewes residents" or "Lewes" as shorthand for those in the Lewes sampling strata (see methods), although there is not a precise one-to-one correspondence. The demographic figures here are either drawn from census data relevant to the sample or from the survey data itself (e.g., percent retired and Presidential voting).

have uncovered what lies beneath (for example, visual perceptions of residents)—this empirical study fills an important void and helps to validate or repudiate theory.

After detailing the methods and placing the Lewes wind turbine within the context of studies of community wind projects of similar scale (ideally instillations of one or just a few commercial-scale wind turbines, although given the dearth of studies, some projects have turbines that are smaller than one MW and other projects have more than ten wind turbines), we report the survey results of Lewes residents.

Materials and methods

The semi-structured interviews undertaken in 2012, helped guide survey design (and interpretation of the results). The semi-structured interviews played a particularly important role in the design and format of questions related to the relationship between attitudes toward the Lewes turbine and its visual and symbolic effect on the community. Prior to finalizing the survey instrument, it was pre-tested locally and then pilot tested at the Department of Motor Vehicles testing, licensing and vehicle registration facility to minimize bias and ensure the survey was of appropriate length, and understandable. In addition to substantive content related to wind energy, the survey instrument also sought demographic data including age, sex, education and income. This data was used for weighting purposes and to help interpret the results.

In Delaware, we sampled 1250 individuals. Using the smallest unit for which census data are compiled (block groups, when available; otherwise, census tracts), we split the Delaware sample into three groups (strata), sampling 400 individuals in the vicinity to the Lewes wind turbine, 400 along Delaware's Atlantic seaboard and 300 in census tracts and blocks groups that were located just to the south of the Lewes sample and to the west of the Atlantic seaboard sample ("inland"). The random probability sample includes both full-time and part-time residents, homeowners and renters and was drawn by Survey Sampling International (SSI). Almost all of the results discussed are based on responses from the vicinity of the Lewes wind turbine, although we do make comparisons to other regions where appropriate.

We followed Dillman (2007) with slight modifications to obtain a high rate of response, ultimately mailing two rounds of survey packets and two reminder postcards. A total of 458 Delaware surveys were returned and coded. After accounting for undeliverable mail, the response rate in Delaware was 47%. More details on the semi-structured interview process and the mail survey are found in Bates and Firestone (2015).

Theory

Community wind

The term or concept "community wind" largely entails some combination of local stakeholder ownership, decision-making that resides within a local organization, and a large share of benefits distributed to the local, affected community (World Wide Wind Energy Association, 2013), although some would include ownership by local organizations such as schools and universities (Windustry, 2014). Communities can be further broken down into those individuals who live in close physical proximity to the project and more dispersed stakeholders (Walker, 2008). Less monetizable benefits can be derived directly or indirectly from community or individual ownership models (Aitken, 2010) in that they offer community members local project control and management (Walker, 2008); local communities also can benefit from privately owned or operated wind projects, with quantifiable benefits including investment in a community fund, revenues from additional taxes, job creation and new investment opportunities Cowell, et al. 2012; Cowell, et al. 2011 (Cass, 2010; Aitken, 2010; DTI, 2005).

Several community-scale wind project case studies have illuminated positive attitudes and perceived impacts related to local community-scale wind development. In 2008, the German community Zschadraß, through a joint development/ownership model where the community owned 20%, installed a 2 MW turbine, increasing tax revenue for the school system and local electricity production from 24% to over 100% (Musall and Kuik, 2011). Of the total 100 residents surveyed, forty-nine were asked in follow-up interviews the main reason for their opinion of the local wind project and attitudes toward wind; roughly half of the interviewees referred to wind energy as an 'environmental friendly energy source,' and roughly one-fourth cited the community income/benefit (Musall and Kuik, 2011). Half of the respondents indicated that their attitude would be more negative if the local wind turbine was exclusively privately owned (Musall and Kuik, 2011). While some respondents reported having heard sounds from the wind turbine, only 15% found the sound to be a disadvantage while the majority either found it bearable or evaluated it in the context of other impacts (Musall and Kuik, 2011). Importantly, the resulting media attention and recognition as a 'progressive community' brought a sense of pride to the locals while several indicators suggested the turbine helped instill a notion of local 'energy citizenship' (Musall and Kuik, 2011).

In Scotland, Warren and McFadyen (2010) found consistently more positive public attitudes for a 3-turbine (225 kW each) community-scale wind project compared to perceptions of a developer-owned commercial-scale project. For approximately 62% of the residents near the first community-owned, community-scale wind project in Gigha, Scotland, visual assessment was either positive or very positive (Warren and McFadyen, 2010). Interestingly, 65% of the Gigha respondents stated their support would decrease if a commercial company owned the project while 96% supported increased utilization of wind power in Scotland (Warren and McFadyen, 2010). Stated reasons for support of the community wind project included local income generation and community image (green, successful, progressive, and sustainable) (Warren and McFadyen, 2010). Attribution of Gaelic names to each turbine suggests that "[the turbines] are perceived as a physical embodiment of community cohesion and confidence" (Warren and McFadyen, 2010, p. 209). In one final example, the development of a (75 kW) community wind turbine received an 82.6% acceptance within the local community at Bro Dyfi, Wales, and 64.2%[2] of residents were more positive about renewables in general as a result (Devine-Wright et al., 2007).

Property values

One key consideration of wind turbine siting is the potential for negative effects on local property values, with wind turbine proximity and/or visibility being the primary focal points of investigation. This research has primarily employed hedonic modeling, which is a revealed preference econometric technique to measure the effect of an attribute (in this case, the presence of a wind turbine) using actual property sales data (Vyn and McCullough, 2013).

While Heintzelman and Tuttle (2012) (published) and Gibbons (2013) (unpublished) found net negative effects, and Atkinson-Palombo and Hoen (2014) found temporary negative effects, the majority of studies that have examined the question in the long-term have been inconclusive or have found no evidence supporting

[2] Devine-Wright et al. originally reported the figures as 4.13 and 3.21 on a 5-pt scale; they were then converted to percentages.

the claim that wind power projects reduce nearby net property values (Atkinson-Palombo and Hoen, 2014; Hoen, 2006, 2010, 2013; Sternzinger et al., 2003; Vyn & McCullough, 2013). For example, analyzing home transactions within 0.8 km of a 16-turbine wind project, Sims et al. (2008) found no evidence supporting a causal link between home values and home distance. Sims et al. (2008) also found no causal link between home values and the number of turbines in the project, i.e., turbine density. To enhance the robustness of the results and to decrease the probability that the results were a mere artifact of a given model, Hoen (2011) employed eight different hedonic models of 7500 home sales across nine states. He found no evidence that either visibility of or proximity to a wind project reduced values (Hoen, 2011). Most recently, using a robust data set of 50,000 home sales across 67 different wind projects, Hoen (2013) found no statistical evidence to support the hypothesis that home prices decrease after turbine construction. Furthermore, Vyn and McCullough (2013) found turbine proximity and level of turbine visibility, whether analyzed separately or together, resulted in no significant effects (they analyzed over 6000 Canadian transactions in rural residential and farmland landscapes).

On the other hand, Gibbons (2013), analyzing visual impacts of rural wind projects (averaging 11 turbines) in England and Wales found that housing prices were reduced by 5–6% for homes within 2 km of a visible wind project. Similarly, Heintzelman and Tuttle (2012), examining primarily, large commercial wind projects[3], found the magnitude by which wind projects affect home values is a function of distance, with some homes within 4.8 km of a wind project experiencing a decrease in property value of about 2–8%. Given that these two studies are based solely on larger, commercial-scale wind projects, they should perhaps only be considered in the context of larger-scale projects and be interpreted with caution when drawing conclusions regarding price effects of small community-based wind projects.

Of most relevance to the Lewes wind turbine setting, Lang et al. (2014) examined ten sites in urban settings in Rhode Island (a small state like Delaware that hugs the US Atlantic seaboard), nine of which had a single turbine; the other having three wind turbines. All turbines were between 100 kW and 1.5 MW. Compared to houses approximately five to eight km away, they found a significant decrease of 5.7% in the 0.8–1.6 km band, but a positive, yet insignificant increase in the 0.0–0.8 km band in post-announcement, pre-construction sales compared to pre-announcement. When comparing post-construction to pre-announcement sales, neither was significant, leading the authors to broadly conclude that there is no statistical evidence in their data for a finding of negative property value effects (Lang et al., 2014).

Landscapes

A landscape may be an integral part of the local fabric and mark a town as distinctive. As a consequence, it may enter into the every day lives of citizens and the wider community conscience, giving rise to a sense of place and a sense of identity. Thus, even if a given wind energy project has little or no effect on local property values, it may still uncomfortably intrude on landscapes in which residents are immersed (Firestone et al., 2012a; Kempton et al., 2005; Petrova, 2013; Wolsink, 2007).

Pasqualetti (2011, p. 908) has noted: "Whatever we do to make the wind turbines less conspicuous, we can do nothing to make them invisible . . . People see them, hear them, and *even feel them*, and in response they often reject them" (emphasis added). It is thus perhaps unsurprising that some proposed wind energy projects have not been concluded because developers have not sufficiently appreciated the importance of landscapes in quality of life (Short, 2002) or because the projects violated resident expectations that the landscape would remain unchanged (Pasqualetti, 2002). After examining four diverse wind power developments/proposals for development (off the coastal community of Cape Cod in the US, the desert of Palm Springs, California, Isle of Lewis, Scotland and the lowlands of Oaxaca, Mexico), Pasqualetti (2011) identified five core issues that defined those wind energy disputes: immobility of the wind energy site; immutability of landscapes, imposition of "costs" on local people, lack of appreciation (solidarity) for the tie between life and land, and threats to place attachment. Thus, it is not simply the landscape per se, but rather the cultural connection that humans have with them. As a result, the effects of wind turbines on individuals can extend beyond mere physical transformation of the landscape to include symbolic and socially constructed aspects of that transformation (Devine-Wright, 2005, 2009). Most problematically, while environmental and health and safety (e.g., noise) concerns can largely be mitigated or for the most part avoided, there are no technical fixes for changes to landscapes—changes that are all that more important because they can affect an individual's sense of those landscapes, including the relationship of a landscape to farming, solitude, recreation, or history, etc. (Pasqualetti, 2012).

Sound

Wind turbines emit sound from two sources. First, the gearbox emits mechanical sound, but it is of increasingly less importance due to turbine technological advancements. Second, the rotation of the blades creates an aerodynamic noise, which has been the focus of attention (Bolin et al., 2011). For both categories, wind turbine sound dominantly occurs at varying broadband detectable levels in the low frequencies from 10 Hz to 200 Hz (Bolin et al., 2011). Haggett (2012), however, observes that research suggests that the quality and characteristics of the sounds produced by wind turbines may be as, if not more, important than the decibel level.

Of particular controversy is infrasound, low frequency sound emitted from turbines that range from 16 to 20 Hz and lower. The general consensus among acousticians is that infrasound emitted from wind turbines is below an average person's hearing threshold, or 20 Hz, and does not pose a threat for adverse human health effects (Bolin et al., 2011; Jakobsen, 2005). Complicating matters is that public responses describing wind turbine sound are often couched in improper acoustical terminology. For example, respondents have attributed the 'swishing' to infrasound when this type of sound actually occurs at acoustical levels anywhere from 500 to 1000 Hz (Leventhall, 2006). In The Netherlands, Pedersen et al. (2009) found annoyance was strongly correlated with the dominant quality of the sound noted as 'swishing'. Regardless of the quality or description of the wind turbine sound in the audible range (from 20 to 200 Hz), some studies have found correlations between annoyance perceptions and stress-related health responses such as reported disturbances to sleep patterns (Bolin et al., 2011; Leventhall, 2006; Pedersen and Waye, 2007; Pedersen et al., 2009). As general matter, however, annoyance related to wind turbine sound tends to be reported by a minority of residents. Bakker et al. (2012) recently found 14% and 23% of respondents reported indoor and outdoor annoyance, respectively, for nearby wind turbines.

Given that health professionals have opined that the limited levels of sound, notably infrasound, cannot support the extent of turbine noise complaints or annoyance, other non-acoustic factors may influence how nearby residents perceive or interpret wind turbine sound. Thus, recognizing the sound source with a visual

[3] Heintzelman and Tuttle (2012) collected data from six wind projects across New York State. Of the six, only one of these projects can be considered community-scale with 14 turbines while the two largest projects contained 194 and 71 turbines, respectively.

Table 1
General attitude of coastal and Lewes Delaware residents toward wind energy and wind project.

Attitude type	Coastal resident attitude		Lewes resident attitude	
Sample	Wind power in general (%)	Lewes project (%)	Wind power in general (%)	Lewes project (%)
Very negative	<1	1	1	2
Negative	2	2	7	8
Neutral	11	16	13	11
Positive	37	37	29	35
Very positive	49	44	50	43

signal may exacerbate reported annoyance (Pedersen et al., 2009). Pedersen and Waye (2007) found evidence suggesting turbine sound-related annoyance is correlated with (although not necessarily caused by) an ability to view wind turbines, perhaps in part related to increased proximity to the turbine itself, while Pedersen and Larsman (2008) observed a statistically greater chance for negative sound-related perceptions among those that considered the turbines to be 'ugly' or esthetically unattractive (p. 389).

Along these lines, recognition, identification and detection of wind turbine sound either alone or in relation with other visual and/or audible stimuli have been shown to play an important role (Pedersen and Larsman, 2008; Pedersen and Waye, 2007; Renterghem et al., 2013). In a Belgian study, the average annoyance of respondents who were unaware of the source did not increase when they were exposed to sound from a 1.8 MW turbine either by itself or in combination with highway sounds (Renterghem et al., 2013).[4] However, when respondents were aware of the sound sources, they found the wind turbine sound much more annoying when it was combined with road traffic sounds (Renterghem et al., 2013). Annoyance was higher for those respondents able to recognize the sound as coming from a wind turbine, suggesting potential interplay between visual or esthetic signals with wind turbine sound detection and annoyance (Renterghem et al., 2013). In a related context, annoyance with wind turbine sound was found to be correlated with the extent of urbanization and the type of surrounding landscape, with individuals in rural areas compared to urban settings; living in flat terrain compared to hilly landscapes; and being able to see at least one turbine versus having none in their viewshed responding more negatively to wind turbine sound both as a general matter as well as specifically to those sounds that are generated by the blades of a wind turbine ($p < 0.001$) (Pedersen and Larsman, 2008). Finally, no association has been demonstrated between stress-related annoyance and wind project-related infrastructure for navigation, such as obstruction markings, while non-synchronized and (xenon) nighttime lighting has been slightly negatively associated with attitudes (Pohl et al., 2012).

Finally, evidence suggests ancillary economic and social factors are associated with interpretations of or reactions to wind turbine sound. Respondents that economically benefitted from wind turbine rents reported significantly less annoyance (Pedersen et al., 2009). Moreover, in another study, despite both noticing the sound more frequently and experiencing augmented sound levels, respondents that economically benefitted from nearby wind turbines reported significantly less annoyance compared to respondents that did not (Bakker et al., 2012). Most recently, while residents that economically benefitted from a nearby 126 MW wind project were not more likely to report decreased levels of sound annoyance, they were more likely to report satisfaction with his/her total living environment (Magari et al., 2014). Influence of non-acoustical, socioeconomic factors on sound perceptions also appears in other contexts (e.g., airports; see Schreckenberg et al., 2010).

Results

General attitudes toward community wind

It has been said that there is a gap between the high support for wind energy in general, and support for a particular project, and that this gap arises because attitudes toward a given wind project differ fundamentally from those toward wind power in general (Wolsink, 2007). Here, however, while we find some differences, they are not significant[5], with 86% of coastal Delawareans having a positive or very positive attitude toward wind power, and some 81% having a similar positive impression of the Lewes wind turbine; in each case, only about 3% have a negative or very negative impression (the remainder are neutral), see Table 1.

Even among Lewes residents the project is viewed very favorably, with 78% having a positive or very positive attitude and only 10% having a negative or very negative attitude. Seventy-eight percent is just one percentage point shy of Lewes residents' views about wind power in general, thus Lewes residents' opinions specifically and Delaware coastal residents' more generally appear to run counter to a narrative that overall opinion toward specific wind projects differ fundamentally from general attitudes. Part of the explanation may be the opinions that Lewes residents have regarding community wind in general. We asked survey respondents to what extent they believed policymakers should "encourage" the development of various types of energy, including "community-based wind power." Eighty-five percent of those with positive or very positive attitudes toward the Lewes wind turbine agreed or strongly agreed that community wind projects should be "encouraged" and such agreement was strongly correlated with viewing the Lewes turbine favorably. The fact that the local wind project is comprised of a single wind turbine also may be of relevance to the similarities in local and general support.

Prior to the construction of the wind turbine, while undertaking a survey of public opinions on offshore wind power, we asked respondents a slightly different question, whether they would support or oppose placing a wind turbine on UD's Lewes Campus (no other information was provided, e.g., on size, location, etc.). Seventy-three percent answered affirmatively, only 1% registered opposition, with the remaining 26% undecided. Thus, wind turbine support after several years of operation appears to be at approximately the same high level that was evidenced when the project was merely a concept and not yet discussed in the community; however, opposition has grown from essentially non-existent to minimal.

Among Lewes residents, those who hold positive views of the wind turbine are slightly more likely to be "very positive" rather than just "positive" (43 out of 81) in comparison, only 20% (2 out

[4] Actual in situ wind turbine sound recordings were used from collected measurements 30 m downwind during operation in the predominant wind direction.

[5] We use $p \leq 0.05$ as the test for significance and denominate a finding as "borderline significant" if $0.05 < p \leq 0.10$.

Table 2
Level of conflicted opinion among those having positive or very positive attitudes and negative or very negative attitudes in Lewes.

Conflicted attitude	Positive/very positive attitude (%)	Negative/very negative attitude (%)
Strongly disagree	47	18
Disagree	24	1
Neutral	9	0
Agree	10	52
Strongly agree	10	29

of 10) of those who hold negative views are very negative. Not only are those with negative views not as negative as those with positive views are positive, but they indicate that they are more conflicted (81% versus only 20%) in their attitude toward Lewes turbine (Table 2). As well, a higher percentage of those holding negative attitudes have discussed the wind turbine with family and friends (95%) than those with a positive attitude (67%). They also are slightly more likely to feel knowledgeable about sources of renewable energy (60% compared to 54%). Together, these findings imply that those with negative feelings toward the wind turbine are few in number and have less intense and more mixed feelings than supporters. The mixed feelings held by those with overall negative attitudes toward the wind turbine are evidenced by the response to a question asking whether having a wind turbine in the Lewes community was important to them, with 17% answering in the affirmative.

Visual and cultural effects

We next asked the Lewes respondents about the visual effect of the wind turbine. Interestingly, three respondents reported not having seen the UD wind turbine (there were a few very elderly respondents in the sample who might be homebound), although all respondents reported having seen a wind turbine at some point. Eighty-two percent indicated that they like the look of the Lewes wind turbine. Of those with positive attitudes toward the wind turbine, 99% like how it looks, while none of those with negative attitudes like the way the turbine looks.

We then inquired how a respondent evaluated the “look” of the wind turbine, providing one set of options to those who indicated that they like the look of the wind turbine and a different set of options to those who indicated a dislike. These options were based on responses to the semi-structured interviews we undertook in 2012 and thus differed for those who like and dislike the look of the wind turbine. Respondents were asked to “check all that apply.” As detailed in Table 3, for two-thirds of those who like the look of the Lewes wind turbine, it symbolizes progress toward clean energy while slightly more than a third find it unique and a community landmark, with smaller percentages finding it attractive or a work of art. These findings suggest that supporters see the wind turbine as symbolic of a transformative energy future generally and to a lesser extent as a positive reflection of the Lewes community specifically.

Table 3
Evaluation of the “look” of the Lewes wind turbine (ordered by percent in each).

Like look		Dislike look	
Attribute	Percent	Attribute	Percent
Progress toward clean energy	67	Does not fit landscape	70
Unique	36	Disruptive to community feel	54
Community landmark	36	Unattractive	40
Attractive	25	Industrial	38
Work of art	14	Too big	31
Other (Miscellaneous)	12	Other (Miscellaneous)	10

Table 4
Relationship between distance and liking the look of the turbine.

Distance	Residents' distance to turbine (%)	Like look (%)
0.8 km or less	13	84
0.8–1.2 km	15	96
1/2–1.6 km	15	80
>1.6 km	56	77

Although the percentage of Lewes residents who dislike the look of the turbine is small, the majority of those people believe the wind turbine does not fit the landscape (70%) and that it is disruptive to the feel of the Lewes community (54%). Smaller percentages find it unattractive (40%), industrial (38%) and too big (31%). This dichotomy between residents who dislike and like the look of the wind turbine might be best summarized “as a clash between local rights to landscape and the more global logic of progress toward a low carbon economy.” (van der Horst and Vermeylen, 2011, p. 467). Most importantly, while the physical attributes of the Lewes wind turbine find some resonance among those who dislike the look of the wind turbine, it is the “symbolic, affective and socially constructed aspects” of the wind turbine and people's attempt to make sense of the effect of the wind turbine on their community that resonates most strongly (Devine-Wright, 2005, p. 127).

We also examined the relationship between visual perceptions and agreement that policymakers should encourage community wind. Of those who do not like the look of the wind turbine, 43% feel that community wind should not be encouraged compared to 36% who did. This is in contrast to those with positive visual attitudes, as 79% of those individuals believe that community wind should be encouraged compared to just 2% who do not.

In the demographic portion of the survey, we asked people the approximate distance[6] from their home to the Lewes wind turbine, providing the options of less than a 0.8 km (13%), between 0.8 and 1.2 km (15%), 1.2–1.6 km (15%) and greater than a 1.6 km (56%). This allowed us to evaluate whether opinions of the look of the wind turbine were correlated with physical proximity to the wind turbine, but we found none.[7] Among those living greater than 1.6 km, 77% like the look of the wind turbine, while among those living closest (within 0.8 km), 84% like the look of the wind turbine (Table 4). Of note, residents who live 1.2 km or less from the turbine are more likely to like the look of the turbine than those who live greater than 1.2 km away (91% versus 79%), borderline significant ($p = 0.08$). This finding suggests an approach to community wind that is motivated by how individuals and communities come to make sense of a local wind energy development (a “place-based” perspective) rather than one motivated exclusively or even primarily by physical proximity (“siting” perspective) (Batel and Devine-Wright, 2014, p. 4).

We also analyzed the relationship between other demographic variables including age, income, employment, retirement status, sex, level of education, voting preferences, household size, primary versus secondary homeowners, and years owning their property, and whether they liked the look of the wind turbine. We found no statistically significant differences. See Table 5. That said, we did find that 92% of those who voted for Barack Obama indicated that

[6] Given space limitations in a survey instrument where inquiry into opinions of the Lewes wind turbine was just one of three matters on which we sought information, we did not ask whether individuals could see the wind turbine from home.

[7] There is a slight negative correlation (−0.11) between the distance from the wind turbine and attitude toward the turbine, but it is not significant ($p = 0.34$).

Table 5
Relationship between demographic characteristics and liking the look of the turbine.

Variable	Coefficient	Standard error	*p* value
Age	0.009	.024	.712
Income > $100 K	−0.170	.650	.794
Income > $250 K	−1.303	.712	.070
Self employed	−1.059	.806	.191
Work for wages	0.169	.665	.799
Retired	0.244	.597	.683
Male	−0.717	.652	.273
College degree	0.273	.667	.684
Voted for Obama	1.232	.688	.076
Household size	−0.082	.153	.592
Primary residence	0.125	.715	.862
Years owning property	−0.003	.009	.782

they like the look of the wind turbine compared to just 69% who either voted for Mitt Romney or another candidate ($p = 0.066$). Further, when we regressed the variable Obama on liking the look of the turbine, assigned a 1 if the person voted for Obama, and zero otherwise, the variable was borderline significant ($p = 0.076$). While there may be a political orientation gap, overall these findings are consistent with our prior findings that despite the strong partisanship that exists generally in the United States, wind energy finds support across the partisan divide (Firestone and Kempton, 2007).

In an attempt to gain further insight into individuals for whom the socially constructed aspects of the wind turbine had resonance, we examined logistic regression models where the dependent variable was either the categorical variable Like (1) or Dislike (0) the Look of the wind turbine or the categorical variable Evaluated the Look Positively (1) as "Progress Toward Clean Energy" or Not (0). In each case, the independent variables were demographic variables. The independent variables tended to lack significance and therefore the models offer little explanatory power to describe the data and thus, provide little additional insight. The lack of demographic variable influence here and elsewhere suggests that the socio-cultural influences we find in Lewes are not limited to certain segments of the population and either are pervasive or mediated by other characteristics such as values (e.g., humans' responsibility to the environment and future generations), practices (e.g., environmentally friendly behaviors) and beliefs (e.g., role of government generally and financial and policy support for renewable energy specifically). We did not collect data to test these hypotheses and therefore they remain unanswered.

Wind turbine sound annoyance

We next inquired into whether the wind turbine was audible to respondents "from your house" (we did not distinguish among three scenarios: inside the house with the windows open, inside with the windows closed, and in one's yard) and more generally into the effect of the sound of the wind turbine on respondents. Ten percent of respondents indicated that they had heard the wind turbine from home. When asked their "opinion about any noise you have heard from the wind turbine, "from any location?" (emphasis in the survey) and given four options, the majority—60%—indicated that they had never heard the wind turbine, 22% found the sound "not bothersome," and 9% were "not sure."[8] Ten percent found the sound "bothersome." See Table 6. A higher percentage who have heard the wind turbine from home found it bothersome (23%), but

Table 6
Sound annoyance among Lewes residents.

Population	Variable	Proportion	Standard error
All Lewes residents	Never heard turbine sound	.596	.056
	Heard sound, not bothersome	.217	.042
	Heard sound, bothersome	.095	.039
	Not sure	.092	.032
Residents who could hear from home	Not bothersome	.727	.121
	Bothersome	.232	.111

the vast majority, 73%, found it not bothersome, with the remaining 4% unsure.

The findings are based on small numbers, as, for example, only 21 respondents report having heard the wind turbine from home. While nine of these individuals live within 0.8 km of the wind turbine, four live between 1.2 and 1.6 km and another four live more than 1.6 km.

There is a significant, negative correlation between those who can hear the turbine from home and distance from the turbine (−0.34, $p = 0.021$), which makes sense; however, of those that can hear the wind turbine from home, there is no statistically significant correlation between distance and being bothered by the sounds generated by the turbine. This latter finding is surprising given that the wind turbine is louder the closer one is to it.

We also looked at demographic characteristics of those who have heard the wind turbine. Of note, self-employed individuals are significantly more likely to be bothered by the sound than people of other employment (employed for wages, student, retired, homemaker, or out of work) ($p = 0.027$). While one might hypothesize this is because self-employed individuals are in the home and attempting to concentrate, a person is more likely to be able to hear the wind turbine in the evening hours when the ambient noise is lower. As noted, however, we did not distinguish between having the window open or closed, and this could account for the greater level of annoyance. The survey was conducted at a time of year when the weather is generally warm, possibly increasing the likelihood that a response was based on experience with the window open.

The average age of those bothered by sound is 47, younger than the average age in Lewes (56), and non-retirees (26%) are similarly more likely to be bothered than retirees (17%). One might hypothesize that younger people are more likely to be bothered by the sound because they have better hearing; however, neither difference is statistically significant. On the other hand, a significantly higher proportion of small households, that is two persons or less (29%) are bothered by the sound than households with more than two residents (5%) ($p = 0.044$), suggesting that empty nesters and those without children place more value on quiet. Finally, we examined the relationship between being bothered by the sound and income (using an eleven-category variable based on census data) and found that those with lower incomes were more likely to indicate that they were bothered by the sound, borderline significant ($p = 0.078$).

Interplay between noise, attitude and esthetics

Finally, we analyzed the interplay between being bothered by the sound and other measures such as attitude toward the wind turbine and visual/esthetic considerations. Unsurprisingly, there is a positive (0.84), significant ($p = 0.0001$) correlation between being bothered by the noise at home and having a negative or very negative attitude toward the wind turbine. More interestingly, 30% of those bothered by the sound from the Lewes wind turbine nonetheless believe that policymakers should encourage community wind,

[8] It is not clear whether they were not sure whether they had heard the turbine or were not sure whether the noise was bothersome. In the text we use the word sound rather than noise (it would have been better had we also used "sound" in the survey rather than "noise," which generally refers to unwanted sound).

and another 18% are neutral. This finding suggests that, for almost half, whatever negative associations they have with the wind turbine do not carry over to their more general views of community wind.

In addition, we find that there is a positive (0.53), significant ($p = 0.0001$) correlation between a respondent holding the opinion that having a wind turbine in the Lewes community is not important to him/her and being bothered by the sound generated by the wind turbine. The question however becomes whether the feeling of unimportance leads one to be bothered by sound that would otherwise not be bothersome or would be less bothersome or whether being bothered by the sound leads one to discount the importance of the wind turbine, or whether they are jointly determined by other variables.

Of people who are bothered by the sound, two-thirds do not like how the wind turbine looks, suggesting that there may be some interplay between visual and auditory responses to the wind turbine. Each of those individuals feels the wind turbine does not fit the landscape and strong majorities find the wind turbine disruptive to the feel of the Lewes community (87%) and industrial (71%).[9] Forty-one percent find the wind turbine too big and 24% unattractive. Thus, the socially constructed aspects of the wind turbine are prominent among those who take issue with both the visual and auditory aspects of the wind turbine.

Discussion

At the core, the question the United States and other countries face is how will they accommodate large deployments of renewables and respond to the twin imperatives of human health protection and climate mitigation while also recognizing important social and cultural values, which may or may not be in alignment with individual projects. As we document here, community wind poses unique challenges, including the need to be sensitive to community expectations. At the same time, it presents important opportunities. As Jones and Eiser (2009) note, there is a difference between developers showing communities a proposed development and communities showing developers the type and scale of development they would find acceptable.

Certainly one of the biggest challenges that policy makers and developers face is that, given their size, wind turbines may intrude on cultural heritages, norms and landscapes (and for those living proximate to a wind turbine, may result in annoyance from the sounds it produces). Despite the fact that the Lewes wind turbine sits on the edge of town, those with negative attitudes toward the wind turbine indicate that it disrupts a cultural connection they have to the landscape and to their community. Schwahn (2002) has noted that a given project can result in some residents feeling as if they have been driven from their community, and although we do not know whether that has happened in Lewes, it does appear that some view the wind turbine as having infringed on their community (Passqualetti, 2002).

Interestingly, although the Lewes wind turbine appears to generate visual and auditory disamenities for some, it appears to engender positive amenities for many more, although we did not seek to quantify them as you might in a stated preference survey (e.g., Krueger et al., 2011) or measure the relative magnitude of the two. The positive impressions that residents have of the wind turbine that are connected to how it appears, much like the negative ones, are more reflective of socially and culturally constructed aspects associated with the wind turbine than physical ones, with the symbolic attribute—that is, its representation of progress toward clean energy—having the most resonance (Devine-Wright, 2005). We gained little insight by examining demographic characteristics into how, if at all, survey respondents who are moved by socially constructed aspects differ from those who are not. It would thus be useful in future research to examine the relationship of these socially constructed aspects to values, practices and beliefs. Finally, although it is unclear how generalizable the sentiments in Lewes, Delaware are, the community in question has urban (279 inhabitants/km^2), rural (bordered by Great Marsh and part of a rural county) and coastal attributes, and an historic sensitivity, and thus the findings here may have some resonance in other coastal communities in the U.S. and elsewhere (e.g., England and Wales) and perhaps even in enclaves within rural areas.

[9] These findings must be interpreted with some caution because they are based on the opinions of only eight individuals and therefore statistical significance is not reported.

Conclusions

Electricity must come from some source be it coal, natural gas, oil, nuclear, hydro, geothermal, solar, wind, etc. Each source has its own negative externalities, with perhaps the most significant being, in addition to health effects, climate change and ocean acidification. While from a wide policy perspective or environmental justice perspective, one might broaden the inquiry to include the relative impacts on communities that are at risk from various forms on energy generation, most can agree that not every place is appropriate for wind energy development. As well, society also can actively seek technological solutions to externalities of wind power generation such as operational sound and implement policies to minimize opportunities for conflict and disruption to livelihood, community and landscape. Setbacks, for example, can be employed to minimize annoyance associated with wind turbine operation (e.g., sound and shadow flicker).

Developers and regulators would be wise to gauge the sentiment of communities (Firestone et al., 2012b), and work to comprehend how, from a community's vantage point, a proposed development fits within the sense of how the community views itself and the surrounding landscape, for not every community will identify with local wind power as closely as have the residents of Lewes, Delaware. Landscape issues may only become further amplified in a future that will likely witness the continued expansion of wind power into new environs and the movement toward taller towers and longer blades, further underscoring the importance of understanding community sentiment.

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