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Exploring landowners' post-construction changes in perceptions of wind energy in Michigan

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ABSTRACT

Researchers have suggested that residents' acceptance of wind turbines follow a U-shaped curve over time, starting with generally positive attitudes about wind energy, dipping once a project is proposed, and then rebounding after construction. This research considers how residents' perceptions of the benefits and negative impacts of wind turbines shift post-construction by surveying the same individuals (n = 520) at two time periods after a nearby wind project became operational. We find that residents' perceptions follow two separate trajectories based on their perception of the fairness of the wind siting planning process and—to a lesser extent—whether they have a direct financial stake in the wind project. Residents who perceived a fair planning process tended to perceive greater benefits of wind turbines, job creation, and revenues for landowners specifically, while residents who perceived an unfair process perceived significantly greater negative impacts, including visual and noise problems, reduction of nearby property values, and human health problems. These results suggest that while energy business models that extent direct financial compensation to more landowners impact the attitudes of residents in the short-term, resident attitudes about procedural justice may have implications that extend well beyond the project planning stage, impacting long-term support for adding new and repowering old turbines.

1. Introduction

One could reasonably assume that, like living near railroad tracks, residents in communities that host wind turbines may grow accustomed to the technology, and concerns expressed during the project's planning stage may dissipate once the project is built. Here we test this assumption by surveying the same set of respondents at two different points following nearby windfarm construction. In doing so, we add to a small but growing literature that traces the attitudes of residents living near windfarms over time, and account for how the perceptions of impacts and procedural justice and direct financial compensation may alter attitude or acceptance trajectories in the longer term.[1]

Understanding community perceptions post-development and how they impact acceptance is particularly important as wind developers often return to these communities to add additional or repower aging turbines (Frantál, 2015). Additionally, the experiences of individuals and communities that have undergone wind development are increasingly being sought by others to either encourage or oppose their own local wind development. As such, how existing wind projects are perceived years after development may have a serious impact on future development.

2. Literature review

There is no shortage of literature contrasting the general population's broad support for wind power and the strong opposition and negative attitudes regarding wind turbines amongst locals (Bell et al., 2005; Larson and Krannich, 2016; Wolsink, 2007a,b). As part of the case suggesting that this is not just NIMBYism (Not In My BackYard), some of the early community acceptance literature argued that acceptance, or "attitude development" (Wilson and Dyke, 2016: 289), likely follows a U-shaped curve (Devine-Wright, 2005; Gipe, 1995; Krohn and Damborg, 1999). While local support for wind energy begins at the same high level as the general population, it likely decreases following a project's proposal as residents more seriously consider the potential

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[1] It should be noted that these terms "support," "opposition," "acceptance," "attitudes," and "perceptions" of wind energy projects are not synonyms, and yet are often used interchangeably in the literature (Warren et al., 2005; Devine-Wright, 2005; Groth and Vogt, 2014; Kontogianni et al., 2014; Rand and Hoen, 2017). Here we adopt Rand and Hoen's (2017) approach of using "support for" or "opposition to" when discussing *proposed* wind projects and "attitudes toward" when discussing *existing* projects, noting that both broadly fall under the umbrella of "acceptance" research. We also replicate the original authors' terminology whenever possible.

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impacts of development (Wolsink, 2007a). Once the project is implemented, the U-shaped curve theory suggests that acceptance returns as a result of residents either finding that their fears about the project were unfounded (Warren et al., 2005), or more simply that acceptance comes with familiarity (Devine-Wright, 2005; Parkhill et al., 2010).

There is little empirical research however testing this theory, and even this limited set suggests that the curve may not be perfectly U-shaped in all communities or when considering all potential impacts. Eltham et al. (2008), for example, found that most residents supported local wind development before its construction and demonstrated similar levels of support fifteen years hence. Changes were identified in citizens' perceptions of the noise and visual intrusion of wind; however, these changes were not significant. Wilson and Dyke (2016) found that post installation, positive acceptance regarding the visual intrusion and property price impacts of wind turbines fully rebounded; however, concerns remained regarding noise, economic benefits, and environmental impacts, suggesting a slightly flatter right arm of the U-shaped curve. Groth and Vogt (2014) call into question the U-shaped curve, finding that 20% of residents who lived in a community with a wind farm reported a more positive attitude toward wind farm development one year after construction, 29% felt more negative, and 51% reported no change in attitude following construction. Warren et al. (2005) show that in three years nearby residents' attitudes toward local wind farms became more positive, with those living closest to the wind farm showing the strongest support. Frantál (2015) and Frantál et al. (2017) show similar results with residents reporting greater acceptance following operation and a positive effect of residents' proximity to wind farms on their acceptance before, during, and after construction. The author also showed that in the Czech municipalities sampled, positive perceptions dominated negative perceptions, and positive perceptions regarding economic benefits predicted acceptance, while perceptions of landscape disruption and noise annoyance predicted nonacceptance. Kontogianni et al. (2014) showed that following construction respondents reported increases in the perceived impact of wind turbines on noise, visual intrusion, roads, and real estate, and increases in the perceived benefits regarding employment, roads, and tax revenues. Perceiving wind turbine noise and aesthetics as pleasant along with being provided reliable information by the government and involvement in the decision-making process predicted wind farm acceptance.

Though they examine offshore wind and capture attitudes at two points *pre-construction*, Firestone et al. (2012a) suggest both negative and positive attitudes may harden over time. In their surveys of communities within the viewshed of two proposed offshore wind projects, the authors find that residents who opposed the projects at the time of the first survey were more strongly opposed at the time of the second, and likewise, those supporting the projects at the time of the first survey were more supportive at the time of the second. In a companion paper by the same authors (Firestone et al., 2012b), the level of project support (and positive feelings) or opposition (and negative feelings) is positively correlated with feelings of procedural fairness or lack of fairness, respectively. This supports a caveat to the U-shape curve posed by Wolsink (2007b) that attitudes in windfarm host communities will only return to pre-construction levels if the local community feels that their concerns were acknowledged during project planning, mirroring the importance that procedural justice plays in the community acceptance literature more broadly (Rand and Hoen, 2017; Jami and Walsh, 2017; Loring, 2007).

Another potential explanation for the partial return in support for the local wind farm is a lack of distributive justice (Rand and Hoen, 2017; Walker et al., 2014; Gross, 2007). For instance, Wilson and Dyke (2016) write that perceptions regarding the lack of community-wide financial benefits help to explain mixed post-construction attitudes in Cornwall, UK. While much of the community acceptance literature has found that providing sufficient compensation to community residents increases the likelihood of wind development acceptance (Groothuis et al., 2008; García et al., 2016), including residents early on in determining what that compensation looks like may be key (Aitken, 2010).

2.1. Research hypotheses

This study aims to make two primary contributions to the existing literature drawing on the basic 'U-shaped curve of acceptance' model first employed by Gipe (1995). First, it provides evidence of the shape of the right arm of the curve, but with specific regard to how *perceptions* of residents near windfarms change post-construction rather than how *acceptance* changes. While the existing studies compare attitudes pre- and post-construction (Wilson and Dyke, 2016; Eltham et al., 2008) or at two periods pre-construction (Firestone et al., 2012a), this study compares perceptions of residents near the windfarm at two distinct points post-construction. We hypothesize that perceptions regarding wind energy's benefits and impacts will become more positive as the project becomes a part of their environment (H1). This would be consistent with findings of previous studies examining residents' acceptance of turbines that have been operating for some time (Warren et al., 2005; Wilson and Dyke, 2016; Krohn and Damborg, 1999).

The second contribution made by this study is to account for how procedural justice and direct financial compensation affect residents' perceptions of wind farm benefits and impacts, and how those perceptions affect attitudes, specifically respondents' beliefs about the wind farm contributing positively to the overall quality of life in the area, and support for siting additional turbines. Given Wolsink (2007b) and Firestone et al. (2012a), we would expect that satisfaction with the planning process for siting the initial windfarm would predict positive perceptions, which continue to improve over time, while seeing the process as unfair would predict more negative perceptions that do not improve or even degrade with time (H2). This, effectively, would be a branching of the U-curve for these two groups. Furthermore, given Wilson and Dyke (2016), we anticipate that the perceptions of those respondents who receive direct financial compensation from the wind developer will continue to improve over time, while perceptions of those who are uncompensated will not change or will degrade over time (H3). We also expect that how residents perceive the impacts, benefits, and procedural justice along with whether or not they receive financial compensation will affect their attitudes toward existing wind farms and their support for siting additional turbines.

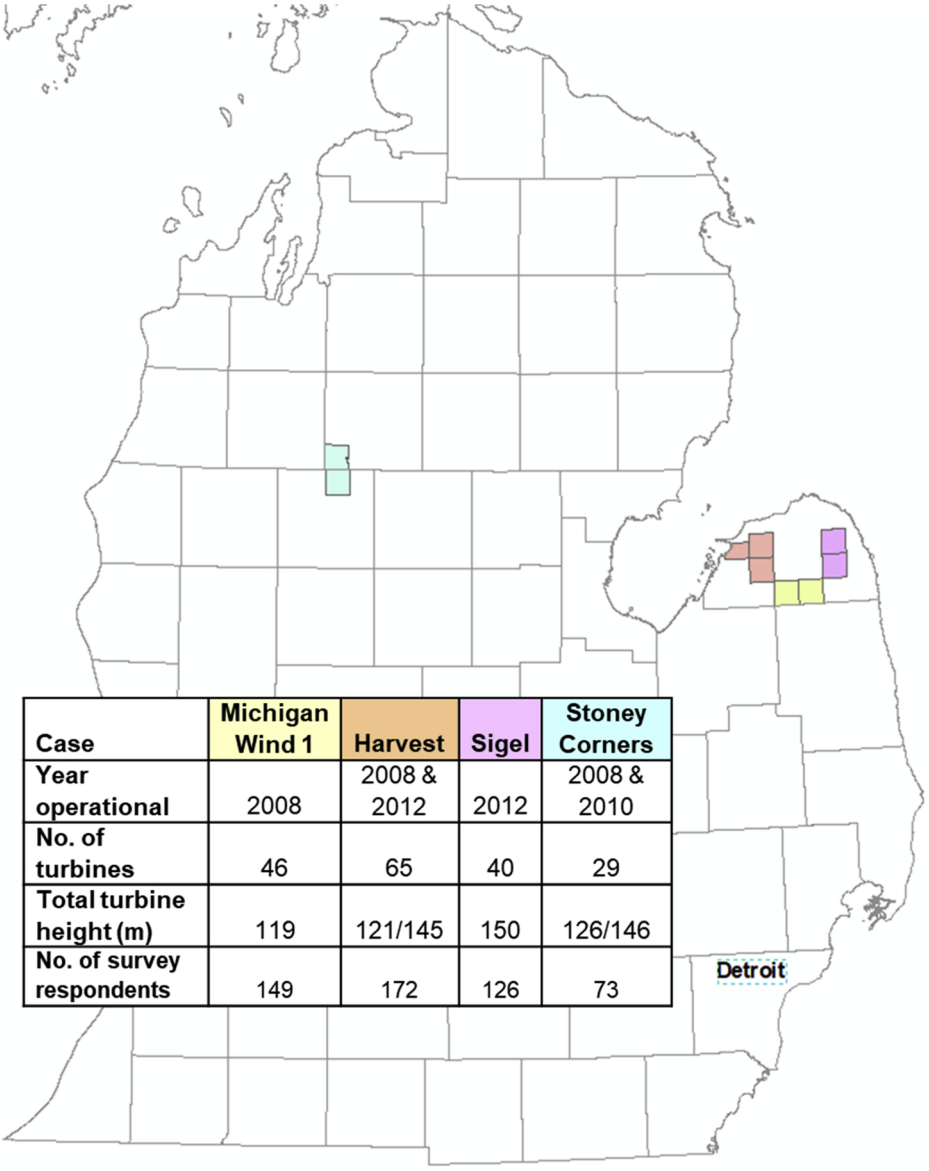
3. Methods

This research draws on data from two surveys, the first sent in 2014 and the second in 2016, to the same landowners in nine Michigan townships with operational windfarms (see Fig. 1). Because the 2014 survey aimed to understand the connection between wind energy and agricultural land use, it was sent only to owners of agricultural land in these townships.[2]

Because sampling from small populations can lead to greater error than sampling from larger populations (Isaac and Michael, 1995), the survey was sent to all landowners in these townships—a census, rather than a traditional sample survey. Of the 1028 landowners contacted in the 2014 survey wave, 712 responded for a response rate of 69% (using AAPOR's RR2 methodology (Definitions, 2015)). The subsequent survey was mailed in June 2016 to any of the landowners in the initial study who still owned farmland in the study area. This survey went to 964 respondents, with 520 responding, for a response rate of 54% (AAPOR RR2). This paper only considers the responses of those landowners who responded to both surveys.[3]

[2] In these communities—as is true in many windfarms—all turbines are sited on agricultural land. Limiting the respondent pool to owners of farmland rather than including all residents or owners of all types of land increases the proportion of respondents who have a direct financial relationship with the windfarm. Thus, the respondent pool is not representative of all residents surrounding the windfarm, but only of farmland owners in these communities.

[3] Note that both surveys were addressed to the family name of the property owner (e.g., The Jones Family). There is some possibility that the same person did not fill out both surveys. Yet, some respondents did provide an email address to receive summary research results—80% of these were identical matches and another 13% appeared to be the same individual but just at a different domain (e.g., Gmail vs. Yahoo).



Case	Michigan Wind 1	Harvest	Sigel	Stoney Corners
Year operational	2008	2008 & 2012	2012	2008 & 2010
No. of turbines	46	65	40	29
Total turbine height (m)	119	121/145	150	126/146
No. of survey respondents	149	172	126	73

Fig. 1. Map and Characteristics of Case Study Windfarms.

The high response rates were achieved by conducting the survey according to best practice with multiple contacts, personalized communications (Dillman, 2011), a pre-paid incentive (Groves and Couper, 2012), and strategic timing based on the schedules of the target population—i.e., avoiding sending a survey to farmers during planting or harvesting times (Pennings et al., 2002). Because this was a census rather than sample-derived survey (or an oversample) and because of the high response rates, the responses were not weighted.[4] One limitation of the survey is that the only demographic data it captured were respondents' age and occupation. Other questions regarding income, gender, and political orientation were removed due to previous interviews and pre-tests with individuals in communities showing these questions discouraged participation. Regardless, previous research of this type, including two key studies (Wilson and Dyke, 2016; Eltham et al., 2008), did not report demographic data and neither age nor occupation had significant effects on the results described below.

The 2014 and 2016 survey instruments both included a range of content, but each began with the same battery of 10 questions about the perceived impacts and benefits of wind projects.[5] Both the impacts and benefits had been used by opponents and proponents of wind energy development and cover wind farms' economic, environmental, aesthetic, and health impacts. On both survey instruments, the positive and negative statements were interspersed and presented in the same order; here, they are rearranged for clarity. Respondents were asked to rank their level of agreement or disagreement with each of the 10 statements on a 4-point scale: "strongly agree," "agree," "disagree," and "strongly disagree." These 10 statements serve as the dependent variables in H1, H2 and H3, but as independent variables in examining residents' attitudes and support.

[4] Surveys are often weighted based on demographic factors to account for sampling error or to compensate for over- or under-sampling specific groups. Because this is a census, neither of these is necessary. There may be concern about non-response bias—that those who responded are somehow different from those who didn't. There is a low likelihood of this being the case as the 2014 survey was also sent to "control" respondents—landowners in communities without wind turbines—who responded with a nearly identical (70%) response rate compared to 69% of those in the windfarm communities reported here.

[5] Both survey instruments are included in the Supplemental Materials.

Table 1
Principal Component Analysis of Procedural Justice Items. Table show loadings of each statement onto a single factor.

Question	Component Loadings
I had ample opportunity to provide input during the wind project planning stage.	.836
The wind project developer acted openly and transparently throughout the planning process.	.893
Community input influenced the outcome of the wind project (e.g., the location or number of turbines).	.716
Local government officials' decisions about the wind project were in the best interests of our township.	.754
The wind developer did not keep the promises they made during the planning process (inverted).	−.741

To test the second hypothesis about procedural justice, an index variable was created using principal component analysis (PCA) of responses to five items about the planning process included on the 2016 survey. These five items (see Table 1) all reduced to a single factor with a Cronbach's Alpha of 0.848. The index was created by taking the mean of each response (inverting the last item), resulting in a scale of 1–4 with a lower score corresponding to more positive perceptions about procedural justice. Since the hypothesis suggests discontinuity—that there would not be a linear relationship across this scale—respondents were reclassified into two groups. Those with scores less than 2.5 (n = 316)—the halfway point on the scale—were coded as having perceived the process to be just. Those with a score of 2.5 or greater (n = 169) were coded as having perceived the process as unjust.

To test the third hypothesis about financial compensation, a binary variable was created based on whether or not the respondent indicated on the 2016 survey that they received any direct payment from the wind developer. 247 respondents (48%) said they had received direct compensation; 267 (51%) said they hadn't, and six respondents (1%) left this question blank so were excluded from the analysis.

To examine the effect of both procedural justice and compensation on the change in residents' perceptions of wind benefits and impacts between 2014 and 2016, we conducted paired t-tests, one-way ANOVAs, and MANOVA using the two items as independent variables and residents' perceived benefits and impacts as dependent variables.

In addition to testing the three hypotheses, we also conducted two linear regressions using respondents' perceived benefits, impacts, and procedural justice along with whether or not they received compensation as independent variables and two items from the 2016 survey as dependent variables: i) respondents' *perception* of overall impact of wind turbines on the quality of life in their township, and ii) their *support* for additional wind turbines being sited within 1 mile of the property they own in that township.

4. Results

4.1. Changes in perceived benefits and impacts from 2014 to 2016

Table 2 shows the aggregate means and the number of individuals who agreed with each benefit and impact statement in 2014 and 2016, as well as the number (%) who agreed more or less in 2016. It is important to note that lower means represent greater agreement, meaning a lower score implies a more positively perceived benefit (PB) of turbines and a more negatively perceived impact (PI) of turbines, which are themselves all negative.In aggregate, individuals agreed in both 2014 and 2016 that wind turbines create jobs ($PB_{Jobs'14} = 2.01$, $sd = 0.70$, $PB_{Jobs'16} = 1.97$, $sd = 0.74$) and provide revenues ($PB_{Rev'14} = 1.77$, $sd = 0.62$, $PB_{Rev'16} = 1.75$, $sd = 0.70$) to land owners. However, that is where the agreement ends. For the remaining eight statements, individuals on average disagreed with the statement. Respondents, on average and across both years, disagreed with the notion that wind turbines preserve rural lands ($PB_{Rural'16} = 2.64$, $sd = 0.84$) and help to limit climate change ($PB_{CC'16} = 2.68$, $sd = 0.86$). Regarding impacts, respondents disagreed with the notion that wind turbines disrupt bird migration ($PI_{Migrate'16} = 2.88$, $sd = 0.87$), disrupt local weather ($PI_{Weather'16} = 3.17$, $sd = 0.76$), and cause health problems ($PI_{Health'16} = 2.98$, $sd = 0.87$). T-tests showed that the 2016 means for turbines producing visual problems ($PI_{Visual'16} = 2.51$, $sd = 0.96$), creating noise pollution ($PI_{Noise'16} = 2.55$, $sd = 0.87$), and reducing property values ($PI_{PropVal'16} = 2.56$, $sd = 0.93$) were not significantly different from the midpoint of 2.5, thus residents did not agree or disagree with these three statements.

To test the first hypothesis—that PBs improve and PIs decline over time—we used a paired *t*-test to evaluate respondents' agreement with the PB and PI statements in 2014 and 2016.[6] These tests show that agreement was stable across six of the ten items between 2014 and 2016; however, participants agreed significantly more in 2016 that turbines help to limit climate change ($\Delta -0.19$, $t = 3.94$, $p < 0.001$), disrupt bird migration (Δ -0.10, $t = 2.50$, $p < 0.01$) and local weather patterns ($\Delta -0.08$, $t = 2.16$, $p < 0.01$), and cause human health problems ($\Delta -0.11$, $t = 2.85$, $p < 0.01$).

Six of the mean PI and PB did not change between 2014 and 2016; only one PB improved, and three PIs increased rather than decreased. As such, we reject H1.

4.2. Procedural justice and changes in perceived benefits and impacts

To examine the effect of procedural justice and test our second hypothesis (H2), we divided respondents into two groups based on their perception of procedural justice and conducted an ANOVA on the *change* in agreement for each PB and PI statement between groups. Table 3 demonstrates the mean responses for each statement for both groups and the change in agreement between 2014 and 2016. Here, a clearer pattern emerges, one that supports H2.

Those respondents who perceived a just siting process perceived greater benefits and less impacts than did respondents who perceived an unjust process across all ten statements, both in 2014 and in 2016, respectively, per a one-way ANOVA, $p < 0.05$). Additionally, for those who perceived a just process, three PBs improved by 2016: wind turbines providing jobs, revenues for landowners, and helping to limit climate change; and no PIs increased significantly. For those who perceived an unjust process, no PBs improved and five of the six PIs increased. ANOVA results demonstrate that the 2-year change was significantly different between both groups for 3 PBs and 5 PIs. Put simply, those who perceived an unjust process perceived greater impacts of wind turbines than did those who perceived a just process, while the opposite was true for perceived benefits. Those who perceived a just process were far more likely to perceive greater benefits after two years than were those who perceived an unjust process. As such, perceptions of wind turbines appear to diverge over time. However, as anticipated (Wolsink, 2007a; Firestone et al., 2012a), those who found the process unjust began with more negative perceptions and those perceptions either remain unchanged or become more negative with time. Likewise,

[6] There is an active debate about whether a parametric or non-parametric text is appropriate for Likert data since such data does not conform to the assumption within parametric statistics that the scale be continuous, for instance, see: Norman (2010). We have chosen to use the more common parametric test, but results are similar (in terms of significance) using a Wilcoxon Signed-Ranks Test, the nonparametric version of a paired t-test.

Table 2
Perceived Benefits and Impacts of Wind. Table shows the aggregate means for each statement in each year, change in mean, the number of individuals who agreed with each statement in each year and the number (%) of individuals who agreed with the statement more or less in 2016. The paired *t*-test examines the mean responses for each year on each statement.

	Aggregate Means			No. of Individuals who…			
Perception	2014 Mean[i] (sd)	2016 Mean[i] (sd)	Change in Mean	Agreed[ii] in 2014 (%)	Agreed[ii] in 2016 (%)	Agreed More (%) & Less (%) in 2016	Paired t-test on Means *t*
Benefits							
Wind turbines create jobs.	2.01 (0.70)	1.97 (0.74)	−0.04	404 (83%)	402 (83%)	+111 (23%) −96 (20%)	1.08
Wind turbines provide revenues for land owners.	1.77 (0.62)	1.75 (0.70)	−0.02	439 (93%)	428 (91%)	+88 (19%) −77 (16%)	0.59
Wind turbines preserve rural lands.	2.64 (0.86)	2.64 (0.84)	0.00	208 (46%)	203 (45%)	+111 (25%) −107 (24%)	−0.16
Wind turbines help limit climate change.	2.87 (0.86)	2.68 (0.86)	−0.19	141 (32%)	169 (39%)	+149 (34%) −91 (21%)	3.94***
Impacts							
Wind turbines produce visual or aesthetic problems.	2.56 (0.97)	2.51 (0.96)	−0.05	185 (40%)	204 (44%)	+115 (25%) -94 (20%)	1.30
Wind turbines create noise pollution.	2.60 (0.88)	2.55 (0.87)	−0.05	186 (40%)	193 (41%)	+123 (26%) −106 (23%)	1.24
Wind turbines disrupt bird migration.	2.98 (0.83)	2.88 (0.87)	−0.10	111 (24%)	129 (28%)	+120 (26%) −87 (19%)	2.50**
Wind turbines disrupt local weather patterns.	3.25 (0.75)	3.17 (0.76)	−0.08	50 (11%)	59 (13%)	+112 (25%) −74 (17%)	2.16**
Wind turbines reduce nearby property values.	2.65 (0.94)	2.56 (0.93)	−0.09	181 (38%)	203 (43%)	+120 (25%) −97 (21%)	1.77
Wind turbines cause human health problems.	3.09 (0.81)	2.98 (0.87)	−0.11	79 (18%)	105 (24%)	+119 (27%) −73 (16%)	2.85**

i: Based on response scale of 1 = strongly agree, 2 = agree, 3 = disagree, 4 = strongly disagree.
ii: Number includes individuals who both agreed and strongly agreed.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 3
Procedural Justice and Perceived Benefits and Impacts of Wind. Table shows mean agreement with each statement for residents who perceived a just development process and those who perceived an unjust process, along with the changes in agreement for each group between 2014 and 2016. ANOVA examines the change in agreement for each statement between those who perceived a just process and those who did not.

	Perceive Just Process			Perceive Unjust Process			ANOVA of △ in Participants' Responses by Perceived Justice *F* [iii]
Perception	2014 Mean[i] (sd)	2016 Mean (sd)	△ in Mean [ii] Agreed	2014 Mean (sd)	2016 Mean (sd)	△ in Mean [ii] Agreed	
Benefits							
Wind turbines create jobs.	1.83 (0.60)	1.73 (0.60)	−0.10*	2.35 (0.78)	2.42 (0.81)	0.08	**5.71***
Wind turbines provide revenues for land owners.	1.63 (0.58)	1.55 (0.59)	−0.08*	2.02 (0.66)	2.08 (0.71)	0.06	**3.96***
Wind turbines preserve rural lands.	2.41 (0.80)	2.41 (0.71)	0.00	3.04 (0.84)	3.07 (0.86)	0.03	0.10
Wind turbines help limit climate change.	2.76 (0.88)	2.49 (0.84)	−0.27**	3.01 (0.83)	3.02 (0.80)	0.01	**7.32****
Impacts							
Wind turbines produce visual or aesthetic problems.	2.86 (0.89)	2.90 (0.79)	0.04	2.06 (0.92)	1.87 (0.85)	−0.19**	**7.15****
Wind turbines create noise pollution.	2.83 (0.79)	2.83 (0.73)	0.00	2.19 (0.88)	2.04 (0.86)	−0.15[iv]	2.98
Wind turbines disrupt bird migration.	3.16 (0.74)	3.18 (0.69)	0.02	2.67 (0.88)	2.39 (0.90)	−0.28**	**14.29*****
Wind turbines disrupt local weather patterns.	3.34 (0.71)	3.35 (0.67)	0.01	3.08 (0.80)	2.86 (0.81)	−0.22**	**7.45****
Wind turbines reduce nearby property values.	2.90 (0.83)	2.96 (0.75)	0.06	2.15 (0.94)	1.85 (0.81)	−0.29**	**14.04*****
Wind turbines cause human health problems.	3.28 (0.69)	3.26 (0.69)	−0.02	2.70 (0.92)	2.49 (0.93)	−0.22**	**5.61****

i: Mean is calculated based on response scale of 1 = strongly agree, 2 = agree, 3 = disagree, 4 = strongly disagree.
ii: Between-year means are different based on paired sample t-tests, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
iii: Based on 1-way ANOVA of the difference between participants' 2014 and 2016 response, using perceived justice as independent variable * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
iv: This difference was marginally significant; the result of the paired sample *t*-test was a $t = 1.97$, $p = 0.051$.

those who were satisfied with the planning process had more positive perceptions that either remained constant or became even more positive over time.

4.3. Direct compensation and changes in perceived benefits and impacts

We follow a similar analysis to test H3, that residents having a direct financial stake in the project will perceive greater benefits and less impacts over time. Table 4 divides the respondents into those who received a direct payment from the wind developer and those who did not. Descriptive statistics and ANOVA show a similar, yet weaker, pattern than that which emerged in Section 4.2.

Those respondents who received payment perceived greater benefits and less impacts than did respondents who did not receive payment across nine of the ten statements, both in 2014 and in 2016, respectively, per a one-way ANOVA ($p < 0.05$); however, the difference was only marginally significant for PB_{Rev14} ($p = 0.06$) and PB_{CC16} ($p = 0.06$), and not significant for PB_{CC14} ($p = 0.27$).

Only the PB of turbines to limiting climate change increased; however, it did so for both groups. All six PIs on the other hand increased significantly for those who did not receive payment; no significant change in PIs was demonstrated for those who did receive payment.

ANOVA showed that between those who received payment and those who did not, changes from 2014 to 2016 were significantly different for one PB and five PIs. These results provide partial support for H3.

4.4. Procedural justice and direct compensation

Both procedural justice and direct compensation affect PBs and PIs, both in 2014 and 2016, as well as how those PBs and PIs change over time. To examine their interaction, we conducted a series of MANOVAs using procedural justice and compensation as independent variables and the change in participants' PBs and PIs from 2014 to 2016 as the dependent variables. Table 5 depicts these results as well as how the means change in PBs and PIs for four groups: those who perceived a just process and received direct compensation (Just-Paid), those who perceived an unjust process and did not receive direct compensation (Unjust-Unpaid), and the two groups in between.

It is apparent that the Unjust-Unpaid group demonstrated greater changes in PI from 2014 to 2016 than did the Just-Paid group. The Just-Paid also demonstrated greater changes in PB than did the remaining three groups. MANOVA confirms that changes in 5 PIs and 1 PB were significantly different between the Just and Unjust groups (with the exception of noise pollution) and changes in 2 PIs were significantly different between the Paid and Unpaid groups. No interaction effects between justice and compensation were significant with regard to changes in respondents' PBs and PIs. These results suggest that perceptions about the windfarm siting process are more influential than direct compensation, in particular with regard to PIs changing over time; however, receiving compensation certainly plays a role.

4.5. Perceptions, attitudes, and acceptance

In addition to examining the relationship between procedural justice and compensation and PBs and PIs, we also examined the relationship between these perceptions and respondents' more general attitude toward wind turbines and their support for additional turbines being sited within 1 mile of their home. Table 6 shows the results of these two linear regressions.

These regressions show that perceptions of procedural justice significantly affect respondents' attitudes ($B_{PJ} = 0.24$, $p < 0.01$) and even more so their support ($B_{PJ} = 0.43$, $p < 0.001$) for new turbines. Receiving compensation, however, was not a significant predictor of neither respondents' attitudes ($p > 0.05$) nor support ($p > 0.05$).

Table 4
Direct Compensation and Perceived Benefits and Impacts of Wind. Table shows mean agreement with each statement for residents who received a direct payment from wind developers and those who did not, along with the changes in agreement for each group between 2014 and 2016. ANOVA examines the change in agreement for each statement between those who received a payment and those who did not.

	Receive Payment			Did Not Receive Payment			ANOVA of △ in Participants' Responses by Payment Received
Perception	2014 Mean[i] (sd)	2016 Mean (sd)	△ in Mean[ii] Agreed	2014 Mean (sd)	2016 Mean [ii] (sd)	△ in Mean[ii] Agreed	F[iii]
Benefits							
Wind turbines create jobs.	1.92 (0.64)	1.84 (0.73)	−0.08	2.10 (0.73)	2.09 (0.74)	−0.01	1.49
Wind turbines provide revenues for land owners.	1.72 (0.62)	1.62 (0.63)	−0.10	1.83 (0.64)	1.87 (0.72)	0.04	**4.40***
Wind turbines preserve rural lands.	2.49 (0.86)	2.50 (0.83)	0.01	2.79 (0.85)	2.82 (0.80)	0.03	0.13
Wind turbines help limit climate change.	2.82 (0.86)	2.61 (0.91)	−0.21**	2.90 (0.85)	2.76 (0.81)	−0.14**	0.19
Impacts							
Wind turbines produce visual or aesthetic problems.	2.71 (0.98)	2.80 (0.93)	0.09	2.42 (0.94)	2.26 (0.90)	−0.16**	**10.87****
Wind turbines create noise pollution.	2.74 (0.86)	2.79 (0.84)	0.05	2.47 (0.86)	2.31 (0.82)	−0.16**	**7.83****
Wind turbines disrupt bird migration.	3.13 (0.79)	3.12 (0.85)	−0.01	2.81 (0.83)	2.63 (0.82)	−0.18**	**5.43***
Wind turbines disrupt local weather patterns.	3.32 (0.70)	3.31 (0.75)	−0.01	3.17 (0.79)	2.99 (0.75)	−0.18**	**6.37***
Wind turbines reduce nearby property values.	2.83 (0.91)	2.83 (0.89)	0.00	2.45 (0.93)	2.29 (0.88)	−0.16**	**4.92***
Wind turbines cause human health problems.	3.25 (0.72)	3.21 (0.82)	−0.04	2.90 (0.86)	2.72 (0.85)	−0.18**	2.45

i: Mean is calculated based on response scale of 1 = strongly agree, 2 = agree, 3 = disagree, 4 = strongly disagree.
ii: Between-year means are different based on paired sample t-tests, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
iii: Based on 1-way ANOVA of the difference in participants' responses in 2014 and 2016 using receive payment as independent variable * $p < 0.05$, ** $p < 0.01$.

Table 5
Procedural Justice and Compensation on Changes in Residents' Perceptions of Benefits and Impacts. Table shows the mean change in agreement per response between 2014 and 2016 for each of four groups. MANOVA tests the effect of procedural justice and compensation on the change in response from 2014 to 2016.

	Mean △ in Participants' Response per Group				MANOVA Results		
Perceptions	Unjust, Unpaid[ii]	Unjust, Paid[ii]	Just, Unpaid[ii]	Just, Paid[ii]	Procedural Justice. *F* [iii]	Received Payment *F* [iii]	Interaction Effect *F* [iii]
Benefits							
Wind turbines create jobs.	−0.01	0.19	−0.05	−0.10	3.39	0.77	2.08
Wind turbines provide revenues for land owners.	−0.03	0.07	0.01	−0.12	0.83	0.05	1.97
Wind turbines preserve rural lands.	−0.01	0.02	0.05	−0.03	0.00	0.04	0.29
Wind turbines help limit climate change.	0.01	0.14	−0.24*	−0.27**	**7.54****	0.17	0.38
Impacts							
Wind turbines produce visual or aesthetic problems.	−0.29***	−0.12	−0.11	0.15*	**4.95***	**4.66***	0.22
Wind turbines create noise pollution.	−0.27*	0.00	−0.16	0.04	0.57	**5.33***	0.13
Wind turbines disrupt bird migration.	−0.33***	−0.19	−0.10	0.07	**7.35****	3.00	0.02
Wind turbines disrupt local weather patterns.	−0.30**	−0.09	−0.04	0.03	**4.12***	2.08	0.52
Wind turbines reduce nearby property values.	−0.43***	−0.19	0.02	0.16*	**13.40*****	3.02	0.23
Wind turbines cause human health problems.	−0.27**	−0.16	−0.06	−0.01	**4.22***	0.83	0.10

i: Mean is calculated based on response scale of 1 = strongly agree, 2 = agree, 3 = disagree, 4 = strongly disagree.
ii: Between-year means are different based on paired sample t-tests, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
iii: Based on MANOVA of the difference between participants' 2014 and 2016 response, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Those respondents who perceive more jobs ($B_{Jobs} = 0.14$, $p < 0.01$), less noise pollution ($B_{Noise} = -0.20$, $p < 0.01$) and human health problems ($B_{Health} = -0.16$, $p < 0.01$), and a greater impact to local weather patterns ($B_{PJ} = 0.14$, $p < 0.05$) are more likely to report that wind turbines improved the township's overall quality of life. Respondents who perceive turbines providing more revenues for landowners ($B_{Rev} = 0.23$, $p < 0.01$) and better preserving rural lands ($B_{Rural} = 0.31$, $p < 0.01$), and less visual problems ($B_{Visual} = -0.46$, $p < 0.01$) and noise pollution ($B_{Noise} = -0.25$, $p < 0.01$), along with a greater impact to local weather patterns ($B_{Weather} = 0.23$, $p < 0.05$) were more likely to support additional turbines.

5. Discussion

This is the first study in the US to compare residents' perceptions of wind turbine impacts at two points post-construction. Its hypotheses largely extend the logic of existing studies: that with experience comes acceptance, and that over time, residents would perceive greater benefits and less negative impacts over time (Warren et al., 2005; Frantál, 2015; Eltham et al., 2008). However, this was not the case overall. Residents on average did agree that wind turbines create jobs and provide revenues to landowners—with the former predicting positive attitudes toward wind and the latter predicting support for new turbines. However, residents disagreed that wind turbines preserve rural lands and limit climate change—though turbines' perceived benefit in limiting climate change did significantly increase over the 2 years.

Residents also tended to disagree that wind turbines disrupt bird migration and local weather patterns and cause human health problems; however, residents perceived these impacts significantly more in the second reporting period than they did the first. Residents were split on wind turbines producing visual or aesthetic problems, creating noise pollution, and reducing property values, and the overall mean response for each of these impacts did not shift over time. Perceiving visual problems and noise pollution did however reduce support for additional turbines, as reported by Kontogianni et al., 2014.

Analyzing the data in aggregate may obscure the differences between distinct constituencies and thus the shape of any prospective U-curve. Respondents who had positive recollections about the windfarm planning process perceived greater benefits in the second reporting period and perceived no greater negative impacts on average. Those residents who were financially compensated by the wind developer perceived slightly greater benefits, though only the perceived benefit to climate change increased significantly. The perceived negative impacts of turbines for this group did not shift positively or negatively between the two reporting periods.

By contrast, those landowners who felt negatively about the windfarm planning process perceived far greater impacts in 2016 than they did in 2014. This group reported the most dramatic increases in the study, and across nearly all of the turbine impacts (even perceived noise pollution demonstrated a marginally significant increase). Most notable is the difference between this group's perceptions that wind turbines produce visual and aesthetic problems and reduce nearby property values, and the overall sample's perceptions. Remember that on average the overall sample was ambivalent about each impact, and those who perceived a just process on average disagreed with each impact statement. Given that the individuals who perceived an unjust process tended to perceive greater impacts on the first survey, this result suggests that these residents became increasingly embittered to wind turbines over time; a result reported by Firestone et al. (2012a) as well. Even so, these results make clear the importance of not only acknowledging the concerns of, but meaningfully incorporating members of the community into the planning process (Rand and Hoen, 2017; Wolsink, 2007b; Jami and Walsh, 2017; Loring, 2007)

We see similar trends in the perceptions of landowners based on direct financial compensation, but not with the same strength as the analysis based on procedural justice. Those individuals who receive compensation saw no significant increase in perceived impacts and yet no perceived increase in benefits either, with the exception of climate change mitigation: results similar to those who perceived the siting process to be fair. By contrast, those individuals who do *not* receive a payment perceive significantly greater impacts, but not to the same extent as those who perceived an unjust planning process. The MANOVA results confirm this finding (see Table 5), namely that landowners' perceptions of procedural justice are far more associated with perceiving negative impacts than is receiving compensation.

This is a key result for developers, utilities, and wind-power advocates more generally; positive perceptions of wind turbines may be less affected by the specific amount or distribution of lease payments

Table 6
Perceived Benefits and Impacts, Procedural Justice and Compensation on Residents' Attitudes and Acceptance. Table shows 2 linear regressions, first on residents' attitude toward existing wind turbines, and second on their support for additional turbines, each using residents' perceived benefits, impacts, and procedural justice, and compensation (yes/no) as independent variables.

	Attitude		Acceptance	
	Wind turbines have improved the quality of life in ___ Township overall		Assuming there were suitable locations, how much would you support *additional* turbines being sited within 1 mile of your property	
Mean (*sd*)	3.04 (0.87) [i]		2.87 (1.53) [ii]	
No. of Participants reporting positive (%)	101 (19%)		225 (43%)	
Perceptions [iii]	**Model 1**		**Model 2**	
Benefits	*B*[iv]	*S.E.*	*B*[iv]	*S.E.*
Wind turbines create jobs.	**0.14****	0.05	0.07	0.08
Wind turbines provide revenues for land owners.	0.08	0.06	**0.23****	0.09
Wind turbines preserve rural lands.	0.06	0.05	**0.31****	0.08
Wind turbines help limit climate change.	0.08	0.04	0.05	0.06
Impacts				
Wind turbines produce visual or aesthetic problems.	−0.07	0.06	**−0.46****	0.09
Wind turbines create noise pollution.	**−0.20****	0.06	**−0.25****	0.09
Wind turbines disrupt bird migration.	−0.06	0.06	0.09	0.10
Wind turbines disrupt local weather patterns.	**0.14***	0.06	**0.23***	0.09
Wind turbines reduce nearby property values.	−0.08	0.06	−0.17	0.09
Wind turbines cause human health problems.	**−0.16****	0.06	−0.17	0.10
Procedural Justice	**0.24****	0.07	**0.43*****	0.11
Received Payment (yes/no)	0.07	0.07	0.01	0.10
Constant	2.78	0.38	2.14	0.60
R^2	0.56	0.59	0.64	0.94

i Calculated based on response scale of 1 = Greatly improved, 2 = Somewhat improved, 3 = Neither improved nor worsened, 4 = Somewhat worsened, 5 = Greatly worsened, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
ii Calculated based on response scale of 1 = Strongly support, 2 = Somewhat support, 3 = Neither Support nor oppose, 4 = Somewhat oppose, 5 = Strongly oppose, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
iii Perceptions are based on participant's 2016 response, on a scale of 1 = strongly agree, 2 = agree, 3 = disagree, 4 = strongly disagree.
iv Unstandardized coefficients are reported.

and benefits packages and more affected by the fairness and inclusivity of decisions that lead to them. Whereas increasing compensation is sometimes seen as bribery (Cass et al., 2010; Walker and Baxter, 2017), few baulk at the notion of improving the fairness of development processes or further empowering communities. Indeed, we are not suggesting that providing sufficient compensation is unimportant (Groothuis et al., 2008; Aitken, 2010; Isaac and Michael, 1995), merely that a justly perceived planning process is unlikely to result in anything but.

Regarding a clearly discernible U-curve, we see the perceptions of different groups heading in opposite directions and even accelerating downward for those most upset by wind development. As depicted in Table 5, those residents who were both paid and perceive a just process perceive greater benefits and less impacts (note the nearly entirely green column) over the 2-year period, whereas those residents who are both not paid and perceived an unjust process perceive far more impacts and minimal increases in benefits over that same time period. While the right leg of the U-curve may slowly be approaching the general public's positive attitudes toward wind for the former group, the right leg continues downward for the latter.

While our study is the first to examine the perceptions of residents living nearby wind turbines twice post-construction in the US, there are aspects of the surveys that warrant improvement in subsequent work. Our index variable measuring procedural justice was a component of the second survey rather than the first. This increases the likelihood that respondents' reported perceptions of the planning process were influenced by the benefits and impacts they perceived and vice-versa. While certainly a concern, this remains a problem of most, if not all, survey research.

Additionally, we captured only each individual's direct financial compensation, not respondents' feelings or beliefs about whether the outcome of the process or the resulting community benefit was justly distributed. Furthermore, by treating financial compensation dichotomously, we lose the ability to differentiate between large landowners with multiple turbines who may be receiving tens of thousands of dollars a year and smaller landowners who entered into participation agreements given their proximity to the turbines, but who may be receiving as little as a hundred dollars a year. Even with these limitations, our results are intriguing in that they show that the receipt of direct compensation had much less effect on perceived benefits and impacts—and ultimately on acceptance of additional turbines—than did perceiving the process to be just. This is encouraging and suggests that residents may be open to the siting of additional turbines and the repowering of old turbines as long as there are expectations that the decision-making process will be fair and inclusive. Nevertheless, subsequent work should examine a broader conception of distributive justice, but also make sure to account for direct payments as well as the size of those payments.

Finally, our study lacked analysis of demographic data for reasons stated in Section 3 and did not capture respondents' distance from the nearest turbine. Identifying the latter has become increasingly important as studies report conflicting results regarding distance, attitudes and support (Warren et al., 2005; Swofford and Slattery, 2010; Baxter et al., 2013).

6. Conclusion

This was the first study to examine how residents' perceived benefits and impacts of nearby wind turbines change between two time periods post-construction. The data in aggregate show little change between response periods; however, when controlled for, those landowners who both perceived a procedurally just process and—to a lesser

extent—those who receive financial compensation not only perceive greater benefits and less impacts, but both perceptions were trending positively. Furthermore, perceptions of a just planning process also predicted both positive attitudes toward wind turbines' effect on overall quality of life and support for siting additional wind turbines. Only concerns regarding the visual and aesthetic problems of wind turbines had a stronger, and negative, effect on support for additional turbines.

In terms of policy implications, these results suggest that actions taken during the wind project planning process by local government officials, planning consultants, and wind developers have impacts that extend well beyond the final project approval meeting. When residents feel the siting process is fair, their perceptions of wind turbines remain steady or improve with time. By contrast, when residents feel they are not given a chance to participate in planning decisions or that their voices are ignored, their perceptions of wind turbines begin to—and continue to—erode. While energy business models that provide a larger percentage of landowners a direct financial stake in the wind project are certainly important, engaging residents early and often during the planning process may lead to more positive outcomes and an invitation to return.

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Declarations of interest

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