nature energy

ARTICLES

https://doi.org/10.1038/s41560-019-0347-9

A strong relative preference for wind turbines in the United States among those who live near them

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Studies on social acceptance of wind power projects typically evaluate wind power in isolation, or as a choice between wind and no wind. However, at a societal level, the choice is not limited to whether, how or where wind turbines should be sited, but whether society should generate electricity by wind or from some other source. Consequently, it is important to understand whether those living near local wind projects prefer them relative to other local power projects. Here, we show that approximately 90% of individuals in the United States who live within 8 km of a wind turbine prefer their local wind project to a centralized power plant sited a similar distance away. Wind is also preferred three to one over solar among the approximately two-thirds who have a preference. These results are relatively consistent across states with different characteristics, suggesting a strong social preference for wind turbines among their neighbours.

The United States, and many countries of the world, are in the midst of a burgeoning energy transition from centralized power plants fuelled by coal, natural gas and uranium to more geographically dispersed generation powered by the sunlight or wind[1,2]. This shift was initially motivated by concerns over health and the desire for 'clean' renewable energy, and invigorated by disquiet over a changing climate. It is now driven largely by economics[3,4], at times assisted by government policies[5,6], with the lack of social acceptance of nuclear energy[7] also important in some countries. Accordingly, electric distribution companies and Fortune 500 companies are sourcing wind and solar power in greater quantities[3].

This change in electricity generation follows others in the energy and transportation sectors, including whale oil to kerosene, horses and buggies to electric street cars to bicycles to gasoline-powered automobiles; and small wind turbines to rural electrification[1], as well as those engendered by disruptive technologies in other sectors such as the substitution of digital images for film[8]. Transformations can be accompanied by economic and social disruption in communities previously economically dependent on the manufacturing or processing of older technologies. In the United States, as centralized power plants switch from coal to natural gas as a bridge fuel, coal-mining communities are feeling the weight of this most recent energy sector upheaval[9]. Their plight is of concern, and in a wealthy society their economic transition can be eased[9], although social disruptions may remain.

Coal communities are not the only communities experiencing disruption. Being distributed, and dependent on geographic location, wind and solar have expanded into new environments, with installations becoming neighbours to many whose only previous relationship to electricity generation was occasionally passing by a centralized power plant, flicking a light switch, or switching on an electric-powered device such as a television or window fan. Communities' and their residents' relationship with electricity has changed with the installation of commercial-scale solar projects and modern wind turbines, whether a turbine is a stand-alone installation or 1 of 100 wind turbines in a large wind project.

A modern land-based wind turbine is large—typically 100–150 m to the tip of a blade at its apex—and ranges in rated capacity from 1.5–3.0 MW (compared with centralized power plants of 200 to thousands of MW)[3]. Each wind turbine is typically placed a large distance from all others in a project (roughly 0.5–1.0 km, depending on rotor diameter, terrain and space considerations) to maximize profit through the minimization of wake effects[10]. As a consequence, a wind power project can be seen by many people from their homes and have large effects on the landscape, and more profoundly, on sense of place and community[11–13].

Researchers have understandably dedicated considerable attention to gaining an appreciation for the transition in wind and solar communities[14–17], with research centred around social acceptance[18], place attachment[19,20], process fairness and trust[21–24], the social gap between public support and project approval success rates and the individual gap between levels of general acceptance and active opposition to a local project[25], ownership structure[26,27], compensation and community benefits[28,29], and property value impacts[30]. As electricity generation technologies have social and environmental effects[31,32], research has also considered life-cycle costs[33], as well as values and risk perceptions and knowledge of, and affective responses to, those technologies[34–37].

At a societal (as opposed to community) level, choice is not limited to whether wind turbines should be sited at a preferred location, an alternative location, a preferred location but in a different configuration, or not sited in the vicinity, which is typical of environmental impact assessment. Rather, the question is whether society should invest in efficiency[31] and/or generate electricity by wind, solar, nuclear or hydro power, coal or natural gas, and so on. Thinking about wind power in a comparative framework also brings to the forefront other aspects of distributive justice, including energy justice[38]. The most immediate consideration is perhaps that those individuals who live closer to fossil-fuelled power plants (coal in particular) face increased risk of morbidity and mortality[39,40]. As well, fuels may be mined in communities distant from generation and consumption, and those communities are not typically considered in place-specific, energy-siting analysis. Moreover, fuels such as coal, natural gas and nuclear fuels raise intergenerational equity concerns not present with wind and solar[41].

Despite extensive literature on the social acceptance of wind power[16], attention to whether individuals who live near wind power

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projects would prefer to live near their local wind projects rather than a centralized power plant or a commercial-scale solar installation is lacking. Although a handful of studies consider source preferences, they have typically evaluated distances from a facility—40 (refs. [35,37]), 80 (ref. [42]) and 160 km (ref. [43])—where respondents are no longer considering a 'community' project, blurring the line between a siting enquiry and general attitudes towards electricity sources. Here, moving beyond case studies, which raise the spectre of selection bias[21], we use a national dataset of 1,705 individuals who live within 8 km of a modern wind turbine, to shed light on relative preferences of those who live in wind project communities. By evaluating both the support/opposition question and the question of relative preferences for electricity sources in the same survey instrument, we seek to provide a broader understanding of social acceptance of wind power.

Overall attitudes towards local wind projects

Mean attitudes towards local wind projects are net positive (see Table 1) across a range of respondent characteristics (see Table 2 for definitions of variables). Setting aside those who participate most directly in a wind project by hosting a wind turbine (and thus receive rent and/or royalties), mean attitudes (on a scale from 1–5) range from 3.33 for those who reside within 0.8 km ($t = -3.21$; $P = 0.001$; 95% confidence interval (CI): −0.57 to −0.14; d.f. = 1,696; effect size, eta-squared (η^2) = 0.001, compared with 0.8–8.0 km) to 4.13 for those who rent ($t = 2.31$; $P = 0.021$; 95% CI: 0.084 to 1.02; d.f. = 1,664; $\eta^2 = 0.050$, compared with own). Of note, the mean attitude of individuals who live in one of the top-producing coal states, 3.63, is not statistically different from the mean in non-coal states, 3.70 ($t = 0.43$; $P = 0.664$; 95% CI: −0.215 to 0.338; d.f. = 1,696; $\eta^2 = 0.0004$), and is close to the overall mean (3.69). We also find no difference in mean attitudes between those in highly rural and rural areas compared with those in urban areas ($t = -1.50$; $P = 0.133$; 95% CI: −0.944 to 0.125; d.f. = 457; $\eta^2 = 0.013$ and $t = -0.93$; $P = 0.354$; 95% CI: −0.506 to 0.181; d.f. = 1,537; $\eta^2 = 0.007$, respectively) or between those in red and purple states compared with blue states ($t = -1.75$; $P = 0.081$; 95% CI: −0.733 to 0.042; d.f. = 964; $\eta^2 = 0.018$ and $t = -1.86$; $P = 0.063$; 95% CI: −0.643 to 0.017; d.f. = 1,415; $\eta^2 = 0.022$, respectively), as determined by how each state voted in the 2012 and 2016 presidential elections (red, Republican twice; purple, once each Republican and Democratic; blue, Democratic twice).

Relative preferences for wind versus other energy sources

Next, we examined the preferences for wind power relative to the other means of generation, looking at the effect of attitudes, project attributes and state characteristics (see Methods). We ran a series of correlations using both Pearson's and Spearmen's rank (see Supplementary Table 1). Although a number of correlations are statistically significant, all are weak other than expected correlations between preferring one's local wind power project to another means of generation and having a more positive attitude towards the local project.

The strong preference for one's local wind project is notable (Fig. 1). Approximately 90% of respondents would prefer their local wind project to a nuclear, coal or natural gas plant sited at a similar distance. In contrast, only about 5% would prefer the centralized power plant, with natural gas somewhat more preferred than the other two. In addition, while slightly more than one-third of respondents have no preference between wind and solar at a similar distance, of those who do have a preference, they would prefer their local wind project by about three to one. Each of these comparisons is statistically significant: wind greater than coal (absolute difference: 89.8%; $F = 2,849$; $P < 0.0001$; model d.f. = 1); wind greater than gas (absolute difference: 82.7%; $F = 1,332$; $P < 0.0001$; model d.f. = 1); wind greater than nuclear (absolute difference: 89.8%; $F = 2,079$; $P < 0.0001$; model d.f. = 1); and wind greater than solar (absolute difference: 31.0%; $F = 28.4$; $P < 0.0001$; model d.f. = 1). Even in coal states, only about 8% prefer to live near a coal plant, compared with 86% for wind.

We also investigated relative preferences among subsamples of residents, such as those living within 0.8 km of a wind turbine or in urban areas, red states, farm states and coastal states (Table 3). Irrespective of residency, respondents overwhelmingly would prefer to live near their local wind power project rather than a coal, natural gas or nuclear power plant, as indicated by mean preference ratings greater than 2 (on a scale from 1–3, where 1 indicates preference for the alternative project, 2 indicates indifference and 3 indicates a preference for their local wind power project; see Methods). This was true even among coal-state respondents choosing between their local wind power project and a local coal plant (mean preference: 2.78). As for the relative preferences between wind and solar, only those living in red states (1.96) would have even a slight preference for commercial-scale solar over wind power; indeed, even those in the southwestern states with high solar irradiance would have a slight preference for their wind power project (2.09).

Table 1 | Mean attitudes towards local wind projects by (dummy) variable of interest

Variable category	Variable	n	Mean attitude (1–5)[a]	s.e.
Overall sample	**Overall sample**	**1,698**	**3.69**	
Stratification (distance bins)	Reside <0.8 km	617	3.33	0.07
	Reside 0.8–1.6 km	500	3.70	0.07
	Reside 1.6–4.8 km	318	3.76	0.09
	Reside 4.8–8.0 km	263	3.64	0.14
Stratification (project size)	Large project	1,094	3.52	0.08
	Small project	604	3.76	0.12
Demographic	Female	891	3.66	0.07
	Male	788	3.72	0.15
	College degree	577	3.81	0.10
	No college degree	1,102	3.64	0.12
Residency related	Own	1,519	3.57	0.07
	Rent	147	4.13	0.23
	Moved in pre-construction	1,290	3.53	0.08
	Moved in post-construction	408	3.88	0.16
Project participation	Host wind turbine	104	4.60	0.18
	Compensation	191	3.65	0.27
	Non-participant	1,375	3.69	0.09
State/local characteristics	Red state	281	3.49	0.15
	Blue state	685	3.83	0.13
	Purple state	732	3.52	0.11
	Farm state	780	3.74	0.08
	Range state	304	3.63	0.13
	Coastal state	388	3.85	0.16
	Highly rural	159	3.37	0.22
	Rural	1,239	3.62	0.08
	Urban	300	3.78	0.15
	Coal state	333	3.63	0.10
	Southwestern state	115	3.59	0.18

[a]The scale 1–5 represents very negative to very positive attitudes.

Table 2 | Definitions of main variables of interest

Variable category	Variable	Description/definition	n^a	Full sample weighted means/ proportions (s.e.)	Included in regression models (model)
Wind project attitude	Present attitude	1, very negative; 2, negative; 3, neutral; 4, positive; 5, very positive; "don't know" grouped with neutral	1,698	3.69 (0.09)	(1 and 2)
Relative source preference	Wind–coal	1, prefer hypothetical local coal plant; 2, no preference; 3, prefer local wind power project	1,676	2.90 (0.02)	Dependent variable (1)
	Wind–solar	1, prefer hypothetical local commercial-scale solar project; 2, no preference; 3, prefer local wind power project	1,679	2.31 (0.06)	Dependent variable (2)
	Wind–gas	1, prefer hypothetical local natural gas plant; 2, no preference; 3, prefer local wind power project	1,673	2.83 (0.02)	No
	Wind–nuclear	1, prefer hypothetical local nuclear plant; 2, no preference; 3, prefer local wind power project	1,669	2.90 (0.02)	No
Stratification	Reside <0.8 km	1, live <0.8 km from nearest wind turbine; 0, otherwise	621	0.01 (0.001)	Excluded category
	Reside 0.8–1.6 km	1, live 0.8–1.6 km from nearest wind turbine; 0, otherwise	500	0.04 (0.003)	(1 and 2)
	Reside 1.6–4.8 km	1, live 1.6–4.8 km from nearest wind turbine; 0, otherwise	320	0.37 (0.03)	(1 and 2)
	Reside 4.8–8.0 km	1, live 4.8–8.0 km from nearest wind turbine; 0, otherwise	264	0.58 (0.03)	(1 and 2)
	Large project	1, live near project that has more than 10 wind turbines; 0, otherwise (small project)	1,705	0.29 (0.02)	(1 and 2)
	Dominant project	1, live near under-sampled project; 0, otherwise	1,705	0.23 (0.04)	(1 and 2)
	Case study project	1, live near case study/oversampled project; 0, otherwise	1,705	0.13 (0.01)	(1 and 2)
Demographic	Age	Age in years	1,667	49.1 (1.6)	(1 and 2)
	Female	1, female; 0, male	1,686	0.51 (0.04)	(1 and 2)
	College	1, college graduate; 0, otherwise	1,686	0.27 (0.03)	(1 and 2)
Residency related	Pre-construction	1, moved in pre-construction; 0, otherwise	1,705	0.55 (0.05)	(1 and 2)
	Home owner	1, home owner; 0, rent	1,672	0.79 (0.05)	(1 and 2)
	Years in community	Number of years living in community since wind turbines installed	1,686	4.97 (0.19)	(1 and 2)
Project participation	Host wind turbine	1, host wind turbine on property; 0, otherwise	105	0.005 (0.002)	(1 and 2)
	Compensation	1, receive compensation but do not host; 0, otherwise	192	0.020 (0.004)	(1 and 2)
	Non-participant	1, neither host nor otherwise receive compensation; 0, otherwise	1,380	0.975 (0.005)	Excluded category
State/local characteristics	Red state	1, red state (state voted Republican in 2012 and 2016 elections); 0, otherwise	1,705	0.12 (0.03)	Excluded category
	Blue state	1, blue state (state voted Democratic in 2012 and 2016); 0, otherwise	1,705	0.55 (0.04)	(1 and 2)
	Purple state	1, purple state (state vote switched parties in 2012 and 2016); 0, otherwise	1,705	0.33 (0.04)	(1 and 2)
	Farmland	Proportion farmland of total land in state	1,705	0.36 (0.02)	(1 and 2)
	Farm state	1, >45% of land in state is farmland; 0, otherwise	1,705	0.37 (0.04)	None
	Rangeland	Proportion rangeland of total land in state	1,705	0.10 (0.02)	(1 and 2)
	Range state	1, >10% of land in state is rangeland; 0, otherwise	1,705	0.25 (0.03)	None
	Coastal state	1, border the Atlantic, Pacific or Gulf of Mexico; 0, otherwise	1,705	0.42 (0.05)	(1 and 2)
	ln[state population]	Natural log of state population	1,795	10.83 million[b] (0.68 million)	(1 and 2)
	Highly rural	1, <18 km^{-2}; 0, otherwise	159	0.05 (0.01)	(1 and 2)
	Rural	1, 18–2,590 km^{-2}; 0, otherwise	1,244	0.46 (0.04)	(1 and 2)
	Urban	1, >2,590 km^{-2}; 0, otherwise	302	0.49 (0.04)	Excluded category
	Coal state	1, one of the top five coal-producing states; 0, otherwise	1,705	0.13 (0.02)	(1 and 2)
	Nuclear generation state	1, nuclear power electricity generated in state; 0, otherwise	1,705	0.81 (0.03)	None
	Coal generation state	1, coal electricity generation in state; 0, otherwise	1,705	0.92 (0.01)	(1)
	Natural gas generation state	1, natural gas electricity generation in state; 0, otherwise	1,705	1.00	None

Continued

Table 2 | Definitions of main variables of interest (continued)

Variable category	Variable	Description/definition	n[a]	Full sample weighted means/ proportions (s.e.)	Included in regression models (model)
	Solar generation state	1, utility-scale solar electricity generation in state; 0, otherwise	1,705	0.88 (0.02)	(2)
	Southwestern state	1, high solar irradiance state (AZ, CA, CO, NM, NV or UT); 0, otherwise	1,705	0.15 (0.03)	(1 and 2)
	General attitude towards wind	1, prohibited; 2, neutral; 3, allowed in appropriate circumstances; 4, encouraged and promoted	1,669	3.37 (0.05)	(1 and 2)
	Negative emotion	1, fearful, helpless or angry; 0, otherwise	1,683	0.12 (0.03)	(1 and 2)
	Climate change concern	0, not concerned; 1, slightly concerned; 2, somewhat concerned; 3, concerned; 4, very concerned	1,669	2.41 (0.12)	(1 and 2)
	Turbine look and fit	1, like look and fits landscape; 2, like look but does not fit; 3, neutral or no opinion on look; 4, don't like look, but fits; 5, don't like look and does not fit	1,634	2.14 (0.10)	(1 and 2)
	Place attachment	9-category (2–10) composite variable of 2 5-category (1–5) variables: one measuring whether community is part of a respondent's identity and the other measuring whether the respondent would 'regret' having to move	1,621	7.24 (0.17)	(1 and 2)
	Clean energy progress	1, like the look of the wind power project and indicate that it represents progress towards clean energy; 0, like the look but did not so indicate	966	0.91 (0.04)	(None)

[a]Although there were 1,705 respondents in total, some of these numbers are less either because of question non-response or because they represent a proportion of the full sample. [b]State population in millions rather than natural log of population.

In Fig. 2, we explore in more detail the relationship between negative, neutral and positive attitudes towards one's local wind power project and preferences for two alternative technologies—coal and commercial-scale solar.

Only a small percentage of respondents expressed a negative attitude towards their local wind project in either the full sample (6.8%) or in coal states (9.6%) compared with the approximate 60% with positive attitudes. Looking first at those with negative attitudes, 56% would prefer to live near their local wind project, compared with just 23% near a coal plant. It is noteworthy that even those individuals who live in a coal state and who have negative attitudes towards their local wind project would prefer to live near it rather than a coal plant, although the difference is small (36 compared with 33%). Conversely, those whose attitude is characterized as positive or as neutral or don't know, which altogether make up approximately 90% of the sample, overwhelmingly would prefer living near their local wind project. For example, of those who reside in coal states, and who have positive attitudes or neutral (or don't know) attitudes, a local wind project would be preferred to a nearby coal plant by 98.3 to 0.2%, and 78 to 16%, respectively.

Turning to the wind–solar comparison, more of those with negative attitudes towards their local wind power project would prefer to live near a commercial-scale solar project than their local wind project (42 versus 19%). In contrast, the 47% who are positive would prefer their local wind power project over solar by about 4:1. In addition, those whose attitude is neither positive nor negative would prefer their local wind power project (51 versus 15%), underscoring the general preference for local wind power projects.

Next, we considered relative preferences for wind and solar given differing perceptions of the local wind project's appearance and fit within the landscape, degree of concern regarding climate change, and southwestern location (see Table 4). We found a general preference for wind over solar, with a few exceptions, which are marked by indifference—those who both dislike the appearance of their local wind power project and indicate that it does not fit the local landscape well ($P=0.907$), those living in the southwest ($P=0.714$) and those who are in the middle of the climate change concern scale ('somewhat concerned'; $P=0.327$); all others, including those who are not concerned ($P=0.0008$) and those who are very concerned ($P=0.003$) about climate change would prefer wind. See Table 4 for test statistics, confidence intervals, effect sizes and degrees of freedom. We also found that those with negative emotions (angry, helpless or fearful) towards their local project have significantly different relative wind–solar preferences (mean: 1.65) from those who express other emotions (mean: 2.40) ($t=-3.82$; $P<0.0001$; 95% CI: -1.13 to -0.36; d.f. = 1,658; $\eta^2=0.101$).

It is conceivable that the findings are influenced by the fact that respondents who live near wind turbines are familiar with, or have otherwise habituated to, wind power but are not familiar with the other technologies given that we did not also sample individuals who do not live near a wind turbine. To address this consideration, we first examined whether there is a statistically significant difference between respondents who live in states with and without each alternative project type, other than natural gas, as there is a natural gas plant in every state in our dataset. Pearson's and Spearman's correlations were weak ($<|0.1|$) and not statistically significant (see Supplementary Table 2). We then evaluated correlations between the length of time someone had lived in their community since the wind turbines were installed and relative preferences (see Supplementary Table 2). Most correlations were not significant, and those that were significant had small effect sizes with correlation coefficients $<|0.1|$. These outcomes are generally consistent with those of Ansolabehere and Konisky[35], who found little effect of information on source preferences, other than information concerning nuclear power.

Multivariate analysis

Next, we separately explored the effect of covariates on the wind–coal and wind–solar choice using ordered logistic regression (see Table 5), where the dependent variables are those specified in Table 3 (model variables are defined in Table 2). Turning first to the wind–coal model, it is striking that coal is so disfavoured that measures of project participation (host or compensation) are not significant.

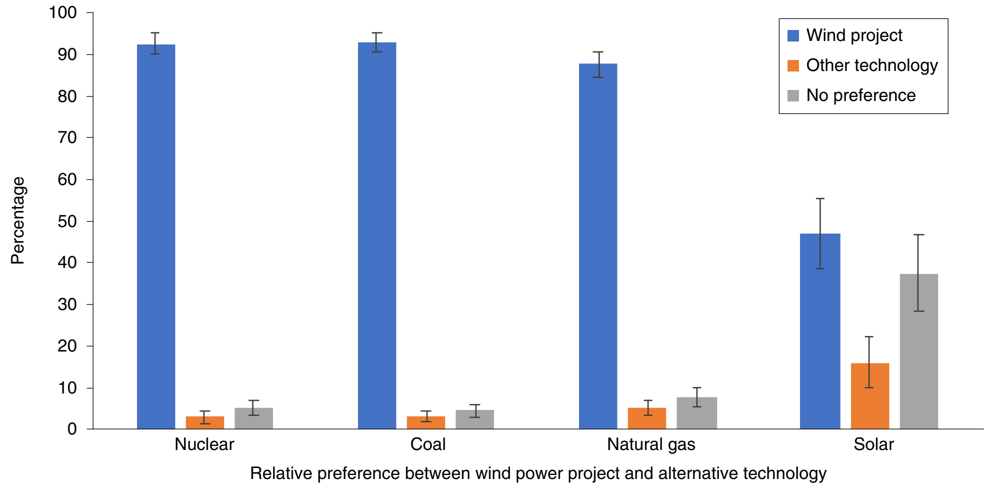

Fig. 1 | Relative preferences between wind power and other means of electricity generation. Percentage of respondents living in the vicinity of a wind power project who indicated a preference for wind versus nuclear (n = 1,669), coal (n = 1,676), natural gas (n = 1,673) and solar (n = 1,679). Error bars represent 95% CIs.

Table 3 | Preferences for wind power relative to other means of electricity generation among specified residents living in the vicinity of a wind power project

Variable category	Variable	Wind–coal (mean)	Wind–gas (mean)	Wind–nuclear (mean)	Wind–solar (mean)
Overall sample	**Overall sample**	**2.90**	**2.83**	**2.90**	**2.31**
Stratification (distance bins)	Reside <0.8 km	2.74	2.64	2.81	2.22
	Reside 0.8–1.6 km	2.87	2.78	2.89	2.36
	Reside 1.6–4.8 km	2.86	2.78	2.91	2.23
	Reside 4.8–8.0 km	2.93	2.86	2.90	2.36
Stratification (project size)	Large project	2.78	2.73	2.80	2.32
	Small project	2.94	2.87	2.94	2.31
Residency related	Pre-construction move in	2.86	2.78	2.85	2.38
	Post-construction move in	2.94	2.88	2.95	2.22
State/local characteristics	Red state	2.84	2.69	2.87	1.96
	Blue state	2.92	2.82	2.89	2.30
	Purple state	2.89	2.88	2.92	2.46
	Farm state	2.88	2.72	2.90	2.29
	Range state	2.87	2.72	2.81	2.13
	Coastal state	2.93	2.86	2.88	2.34
	Coal state	2.78	2.76	2.90	2.29
	Southwestern state	2.94	2.68	2.89	2.09
	Highly rural	2.74	2.51	2.80	2.39
	Rural	2.88	2.80	2.91	2.34
	Urban	2.93	2.88	2.93	2.28

Responses are coded such that 1 indicates preference for the alternative, 3 indicates preference for wind and 2 indicates indifference.

Nor are gender, education, age, distance, home ownership, the political voting pattern of the respondent's state, the local population density, and most geographic and economic characteristics. However, the strong preference for wind increases as the percentage of farmland in a state increases, while it decreases in coal-producing states. It is important to underscore what this last statistic implies—those who live in coal-producing states would be less likely to prefer wind over coal than those who live in non-coal states. As noted earlier, even in coal states, individuals express a strong preference for living near their local wind project. Neither measure of technology familiarity (years in community and coal generation state) is significant.

Four of the attitude perception variables are significant. Unsurprisingly, those who have more negative attitudes regarding (or more negative feelings engendered by) their local wind projects would be more likely to prefer coal compared with those who are more positive. Also as expected, greater concern for climate change predicts local wind power project preference. Finally, those respondents who dislike the appearance and landscape fit of their local wind project would be more likely to prefer a coal plant than those who like the appearance and fit.

Turning to the wind–solar comparison, it is noteworthy that the pseudo-R^2 value for the model (0.108) is smaller than the wind–coal

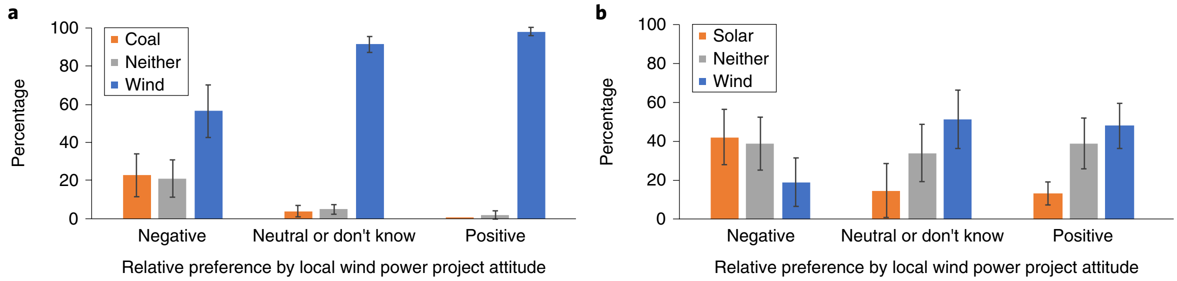

Fig. 2 | Relative preferences for wind as a function of local wind project attitude. a, Percentage of respondents expressing a preference for wind versus coal ($n=1,663$). **b**, Percentage of respondents expressing a preference for wind versus solar ($n=1,663$). Negative and very negative and positive and very positive attitudes towards the local wind project were collapsed into 'negative' and 'positive', respectively. Error bars show 95% CIs.

Table 4 | Percentage of respondents who prefer solar or wind, or who have no preference, given perceptions of the local wind power project, climate concern and geographic location

	Subsample			Preference (%)			Wind–solar comparison		
	Description	*n*	Percentage	Solar	No preference	Wind	Absolute difference (%)	*F* statistic (*P* value)	Model d.f.
Turbine look and fit ($n=1,613$)	Like look; fits landscape	496	40.0	17.1	36.3	46.6	29.5	5.88 (0.015)	1
	Like look; does not fit landscape	489	29.5	10.7	37.3	52.1	41.4	25.1 (0.000)	1
	Neutral; no opinion on look	236	17.7	13.1	42.9	44.0	30.9	9.28 (0.002)	1
	Dislike look; fits landscape	101	4.7	18.6	24.4	57.0	38.4	3.73 (0.054)	1
	Dislike look; does not fit landscape	291	8.2	36.5	28.9	34.7	−1.8	0.01 (0.907)	1
Climate concern ($n=1,651$)	Not concerned	351	13.3	16.9	32.9	50.2	33.3	11.4 (0.001)	1
	Slightly concerned	213	12.3	14.3	36.8	48.9	34.6	5.92 (0.015)	1
	Somewhat concerned	299	22.4	21.7	40.0	38.3	16.6	0.96 (0.327)	1
	Concerned	354	21.8	12.6	31.3	56.1	43.5	19.75 (0.000)	1
	Very concerned	434	30.2	14.8	43.6	41.6	26.8	8.70 (0.003)	1
Southwest ($n=1,679$)	Resident of southwestern state	114	15.0	33.1	25.2	41.7	8.6	0.13 (0.714)	1
	Resident of other state	1,565	85.0	12.7	39.6	47.7	35.0	47.9 (0.000)	1

model's value (0.337), indicating that the predictive capability of the wind–solar model is not as robust. Females have a greater affinity than males for their local wind projects, as do those who are older and those who host turbines on their property. Those who live in red states (excluded category) have a stronger preference for their local wind power project than those who live in blue states, as do those who live in coal states compared with non-coal states. Those in the southwest or utility-scale solar generation states are indifferent.

Having a negative attitude towards one's local wind power project leads to a weaker preference for that local project relative to solar, although the effect of attitude here is about half of that on the relative preference between wind and coal (compare odds ratios). Unlike the bivariate wind–solar analysis, emotions are not significant in the regression equation. One of the measures of technology familiarity is significant: the number of years one has lived in the community since the wind turbines were installed leads to a relative preference for solar, with the effect increasing with each additional year. The other measure—in-state commercial solar generation—is not significant. Those who dislike their local wind project's appearance and landscape fit, and those with climate change concerns, have stronger relative preferences for solar. Regardless of the degree of climate concern, however, local residents prefer their wind power project to a commercial-scale solar project as an absolute matter. Indeed, only those who dislike both the appearance and the fit of their local project within the landscape prefer solar to wind. Even then, it is only by two percentage points (36.5 versus 34.7%; Table 4).

Preference for wind, solar or renewables?

Finally, we looked at the wind–solar data from a different vantage point. Combining those who prefer solar with those who are indifferent (53%; Fig. 1) suggests that many who live near wind turbines might welcome commercial-scale solar development and that positive attitudes towards wind power may in part be mediated by general attitudes towards renewables. When we consider a measure of renewable energy attitudes—first taking the subset who like their wind project's appearance, and then comparing those who indicate that the project symbolizes progress towards clean energy with those who do not—we find stronger relative preferences for the local wind project among the former (mean: 2.39 versus 1.93), although the difference is not statistically significant ($t=1.04$; $P=0.301$; 95% CI: −0.413 to 1.34; d.f. = 986; $\eta^2=0.035$). Considering the question from the other direction, we find that those individuals who indicate that wind power should be prohibited as a general matter have a slight relative preference for solar (mean: 1.96) as the mean is less than 2, while those who are neutral or positive prefer their local project (mean: 2.32), but this difference also is not significant ($t=-1.88$; $P=0.060$; 95% CI: −0.742 to 0.0159; d.f. = 1,667; $\eta^2=0.005$).

Discussion

Researchers have tended to focus either on local opponents of wind power projects or opportunities to enlarge support by overcoming barriers[44] or expanding community benefits[45], rather than focusing on supporters, although there are exceptions. For example, Bates

Table 5 | Linear regression models of relative preferences for a local wind power project relative to coal (model 1) and solar (model 2)

		Model 1				Model 2			
Variable category	Variable	Coefficient	s.e.	*P* value	Odds ratio	Coefficient	s.e.	*P* value	Odds ratio
Stratification	0.8–1.6 km	−0.083	0.248	0.738	0.920	0.238	0.143	0.095*	1.269
	1.6–4.8 km	−0.412	0.279	0.140	0.662	0.214	0.166	0.197	1.238
	4.8–8.0 km	−0.306	0.333	0.358	0.737	0.283	0.192	0.141	1.327
	Large project	−0.477	0.308	0.121	0.621	−0.136	0.161	0.397	0.872
	Dominant project	0.133	0.546	0.808	1.142	−0.254	0.241	0.292	0.776
	Case study project	−0.033	0.216	0.878	0.967	0.125	0.130	0.339	1.133
Demographic (otherwise used in weighting)	Age	0.010	0.007	0.146	1.010	0.009	0.004	0.025**	1.009
	Female	0.103	0.188	0.582	1.109	0.383	0.108	0.000***	1.467
	College	−0.234	0.201	0.246	0.792	−0.180	0.115	0.117	0.836
Residency related	Pre-construction	−0.250	0.267	0.349	0.779	0.162	0.139	0.246	1.176
	Years in community	−0.069	0.050	0.165	0.933	−0.052	0.026	0.046**	0.950
	Home owner	0.466	0.386	0.227	1.594	0.171	0.204	0.400	1.187
Project participation	Compensation	−0.029	0.294	0.921	0.971	0.285	0.183	0.119	1.330
	Host wind turbine	−0.021	0.570	0.970	0.979	0.789	0.276	0.004***	2.202
State/local characteristics	Blue state	0.499	0.448	0.266	1.646	−0.513	0.251	0.041**	0.599
	Purple state	0.172	0.406	0.672	1.188	−0.119	0.257	0.643	0.888
	Farmland proportion	1.113	0.512	0.030**	3.043	0.310	0.333	0.353	1.363
	Rangeland proportion	0.965	1.116	0.387	2.624	−0.578	0.592	0.329	0.561
	Coastal state	−0.178	0.447	0.690	0.837	0.236	0.259	0.364	1.266
	ln[state population]	0.017	0.172	0.920	1.017	0.032	0.092	0.728	1.033
	Highly rural	−0.225	0.441	0.610	0.799	0.498	0.273	0.068*	1.646
	Rural	0.182	0.339	0.590	1.200	0.110	0.174	0.527	1.117
	Coal state	−0.856	0.290	0.003***	0.425	0.364	0.183	0.046**	1.439
	Southwest state	−0.008	0.743	0.991	0.992	0.470	0.364	0.197	1.601
	Generation (coal/solar)	0.408	0.565	0.470	1.503	0.181	0.262	0.491	1.198
Attitudes/perceptions	Local wind project attitude	0.955	0.133	0.000***	2.599	0.233	0.071	0.001***	1.263
	Negative emotion	−0.734	0.277	0.008***	0.480	−0.182	0.194	0.348	0.833
	Climate concern	0.361	0.064	0.000***	1.435	−0.090	0.038	0.018**	0.914
	Dislike look/fit	−0.222	0.088	0.011**	0.801	−0.413	0.055	0.000***	0.661
	Place attachment	0.055	0.043	0.205	1.057	−0.008	0.027	0.776	0.992
Intercepts	Intercept 1	0.823	2.663		0.823	−0.678	1.382		−0.678
	Intercept 2	2.452	2.663		2.452	1.278	1.382		1.278
Log likelihood		−495.9				−1,304.8			
Model *P* value		<0.0001				<0.0001			
Pseudo-R^2		0.337				0.108			

N = 1,418. ***P < 0.01; **P < 0.05; *P < 0.10.

and Firestone[46] posit that individuals support projects that are place consistent. We thus understand less about supporters and their motivations than we do about opponents. In addition, the choice presented to respondents is typically binary—effectively, wind power or not—yet the choice society faces is more complex, involving technology choice. Here, we place positive and negative attitudes towards local wind power projects in a larger societal context that includes electricity generation alternatives. It is striking that in this wider context, wind power appears broadly preferable among wind turbine neighbours.

One might conclude that the issue is not so much the social acceptability of the local wind project as it is the social unacceptability of living near a coal or nuclear power plant, or even a plant powered by natural gas—a transitional fuel. Even in those states that produce coal, local residents prefer to live near their wind power project, rather than a coal plant sited at a similar distance from their home, by more than ten to one. Moreover, even when the comparison is confined to the less <10% who have negative attitudes towards their local wind project, the preference for wind over coal is about 2.5 to 1, with those in coal states having a slight preference for their local wind power project. These preferences suggest that many wind turbine neighbours may grasp the heavy burden (inequity) placed on individuals who reside near thermal power plants.

Despite strong support for utility-scale solar found elsewhere[47], wind power seems broadly acceptable relative to commercial-scale solar among wind turbine neighbours, being preferred by almost three to one among those who have a preference—37% are indifferent. Not surprisingly, those who do not like their wind project's appearance are less likely to prefer it, although this is a relative, rather than absolute, preference. Indeed, even among the 8.2% who dislike the look and landscape fit of their local project, the solar preference is only by the slimmest of margins.

Although solar siting, as for wind siting, is not without conflict[48], when local wind power project perceptions are seen through a wider, comparative lens, a new picture emerges that requires rethinking of previous conceptions of wind power, perceptions and landscape[23]. Although we did not enquire in the survey, we surmise that residents may trade off the greater landscape effect of wind power, given the height of wind turbines, and the much larger footprint of solar, given the small amount of surface land occupied by each wind turbine.

We note a limitation of the findings and a validity threat to the present work. First, the findings are limited to those who live near wind turbines—results that may or may not apply to the broader US public. Future research should examine this question. Second, it is conceivable that many existing wind turbine locations may not support thermal technologies due to landscape (for example, projects on ridgelines) or the lack of proximate cooling water. However, we presume that if the choice presented did not make sense to a respondent because they, for example, knew that the local landscape could not support another technology, they would have skipped the question. Question non-response, however, for the relative source questions was limited, falling between 1.7% (coal) and 2.1% (nuclear). The findings thus appear to support that respondents (even those who have negative attitudes towards their local project) appreciated that matters could be worse from their perspective (that is, they could live near a different type of generation facility).

Elsewhere, researchers have found increased likelihood of support among project opponents, those undecided and supporters if the local project would lead to large-scale deployment, implying that residents would be more willing to accept local development impacts in exchange for a more significant transformation to a clean, low-carbon, renewable energy supply[49]. The research here, which shows broad social preference among wind turbine neighbours for wind power projects over centralized plants powered by coal, natural gas or uranium, in tandem with that earlier finding, is at least suggestive that US residents would welcome faster changes to energy policy than they are seeing.

Methods

Research sample. The sample frame comprised US residences within 8 km of a 'modern', commercial-scale wind turbine, which was defined as having a nameplate capacity of 1.5 MW or greater and being more than 111 m tall (to the tip of the blade) and installed through 2014[50]. The research questions grew out of a large study led by the US Department of Energy's Lawrence Berkeley National Laboratory, where the primary focus was on residents who live near wind turbines. Nearby residents are most likely to experience the effects of sound, landscape changes and/or shadow flicker from their residence, and to undertake coping mechanisms in response to any real or perceived health effects, which formed the basis for central questions in the study. It was assumed that those living nearby are also more likely to participate in the public process leading to project approval—another focus of the research—and to be considered part of a wind project 'community'. A distance of 8 km was thought to capture most of those attributes and to allow comparison with individuals who did not experience any of the effects or participate. With approximately 30,000 wind turbines at 604 projects, almost 1.3 million residences met the criteria.

The sample frame was stratified into small (10 or fewer turbines) and large projects (more than 10), and by distance, oversampling those living closest to the wind turbines (<0.8 km). Homes at a few projects were oversampled where acoustic modelling was planned, to facilitate more granular understanding, and undersampled at a few small projects that were surrounded by large numbers of homes and that would probably have otherwise dominated the sample. A random, stratified probability sample was drawn. The survey and protocol received human subjects review by institutional review boards at the Lawrence Berkeley National Laboratory, University of Delaware and Portland State University, given researcher affiliations. The survey was piloted in December 2015 by telephone to evaluate whether it was comprehensible and of manageable length. After modification and trimming, the final survey was administered between March and July 2016. Individuals were contacted by telephone and/or mail, with agreeable phone contacts taking the survey over the phone and agreeable mail contacts having the option of completing and returning a mail survey or taking it online. The phone, mail and online surveys were identical other than changes dictated by differences in mode. Respondents had their names entered into a random draw for one of 4 US$500 gift cards. Protocols generally followed Dillman et al.[51]. Voxco computer-assisted telephone interview software was used for the phone survey, and Qualtrics software was used for the online survey.

Survey. The survey sought information regarding a respondent's relationship to (for example, see or hear it), perceptions of (landscape fit and emotions) and effects of the local project (for example, caused annoyance), perceived fairness of the public process leading to project approval and demographics along with present attitude towards the local wind power project, attitude more generally towards wind power development, and relative preferences for living near their local wind project or another specified means of electricity generation. The survey enquired into attitudes rather than either support/opposition or acceptance, given the lapse in time since the projects had been in operation and because having to answer questions regarding acceptance might be awkward for respondents. Acceptance also implies mere tolerance[21,52]. A copy of the survey is available at https://emp.lbl.gov/projects/wind-neighbor-survey.

A total of 1,705 valid responses were received, for an effective response rate of 17.9%. For descriptive statistics, the sample was weighted by stratum (for example, distance, project size, and over- or undersampled project), as well as gender, education and age, to address non-response and so that the sample reflects the sample frame (that is, the population that lives within 8 km of a wind turbine). Analyses were conducted using Stata 15. Further details on survey administration can be found in ref. [21].

The attitude question was worded as follows: "What is your attitude toward the local wind project **now**?" (emphasis in the original). The response choice was closed ended and respondents could select "very negative", "negative", "neutral", "positive" or "very positive", along with "don't know". Rather than treating "don't know" responses as 'missing', for analysis purposes, we grouped them with "neutral", as we do know something about these individuals in contrast with those who skipped the question. Not including them in the analysis would have led to a dataset where higher percentages were both positive and negative than in the dataset proper. Because only 24 respondents selected "don't know" compared with 464 who selected "neutral", whether "don't know" responses are included or excluded has only a small effect statistically and does not change intuitions that arise in data analysis.

In addition, in pertinent part, the survey asked each respondent to imagine that rather than the local wind power project, a different kind of power generation facility was located at a comparable distance from that respondent's residence. It stated:

"Now we're going to ask about your preferences for living near the wind project and other energy facilities. Please imagine those other facilities being **the same distance from your home** as the local wind project." (emphasis in the original).

Those two statements were followed up with a series of questions that took the following form:

"Would you rather live near the wind project or a nuclear power plant?"

A respondent could then select among four options: "wind project", "nuclear power plant", "no preference" or "don't know". Similar questions followed, where we substituted, in turn: coal plant; natural gas plant; and commercial-scale solar project for nuclear power plant.

Area classification. Using local population density from the US Census Bureau[53], we classified areas into urban, rural and highly rural[54]. We calculated the percentage of land area in each state that is farmland[55] and rangeland[53,56,57]. Looking for natural breaks, we then classified states as farm states if over 45% of the land is farmland and range states if over 10% of the land is rangeland. We also considered coastal states (bordering the Gulf of Mexico, Atlantic or Pacific Ocean), southwestern states (those six with the highest solar irradiance; Table 2)[58], coal (producing) states (top five producers, although Kentucky is not represented in the dataset)[59] and states that have electricity generated by a specific technology[60] (nuclear, coal, natural gas or commercial-scale solar), as well as how each state voted in the 2012 and 2016 presidential elections (red = Republican twice; Purple = once each Republican and Democratic; blue = Democratic twice)[61].

Analyses. We provide weighted descriptive statistics related to attitudes and respondents' preference between their local wind power project and each of the four alternative projects, followed by unweighted ordered logistic regression for two alternatives (coal and commercial-scale solar) controlled for by stratification/unequal probability of selection and differential rates of response by gender, age and education[62]. We employ *t*-tests (two tailed) to measure the significance of differences between means, providing *t* statistics, *P* values, confidence intervals and degrees of freedom (d.f.) along with η^2 (analysis of variance) as measures of effect size. For comparisons of proportions, we employ an adjusted Wald test rather than a chi-squared test because the data are generated from a stratified random sample rather than a simple random sample. For the adjusted Wald test, we report F statistics, P values and model d.f. We report correlation coefficients (Pearson's rho and Spearman's rho) as measures of effect size for correlations. Lastly, for ordered logistic regression, we report psuedo-R^2 and odds ratios as measures of effect size.

For weighted descriptive statistics, all 1,705 observations are used, accounting for question non-response. For the ordered regression equations, the dependent variables were assigned '1' if the respondent preferred the alternative project, '2' if the respondent had no preference or did not know and '3' if the respondent preferred their local wind power project. We ran both regression models on the same 1,418 respondents who provided a response to each and every survey question that was pertinent to the regression models—that is, for whom there was no question non-response.

Independent variables in the regression models fall into six groups: (1) stratification, which includes geospatial (distance, large/small project, dominant project and case study project); (2) demographic, to control for non-response bias and because they may be correlated with the dependent variable (age, gender and education); (3) residency related (moved in before or after construction of the local wind project commenced to control for Tiebout[63] sorting, whether a respondent was a home owner or renter, and years living in the community since the local wind project was installed); (4) project participation (hosting a wind turbine on one's property or otherwise receiving compensation); (5) state and local characteristics, including political, geographic and economic (voting by so-called 'blue', 'red' or 'purple' state; population density (highly rural, rural or urban); farm, range or coastal state; coal or commercial-scale solar generation state; and whether or not the state is a southwest state or a coal-producing state); and (6) attitudes and perceptions (such as attitude towards the local wind power project; general attitude towards wind power; degree of climate concern; combination of perception of the appearance of the local wind project and its fit with the landscape; place attachment; and emotions engendered by the local wind project). We derived this last measure (emotions) from a survey question that asked: "Which of the following best describes how you feel about the wind project". A respondent could then select one of the following: "prideful", "fearful", "hopeful", "helpless", "angry", "none of the above" or "don't know". After separately combining the negative and positive emotions, statistical analysis related to electricity source choice revealed that positive emotions could be further combined with "none of the above" and "don't know". For reasons of parsimony, we used the reduced form of this variable (see Table 2). In the regression models, as well in descriptive statistics, we thus tested a wide range of factors that might affect wind power attitudes and technology choice.

Reporting Summary. Further information on research design is available in the Nature Research Reporting Summary linked to this article.

Data availability

A copy of the survey and codebook for the database is available at https://emp.lbl.gov/projects/wind-neighbor-survey. A de-identified version of the basic database is available upon reasonable request from the Lawrence Berkeley National Laboratory, with extensions available from the corresponding author upon approval to ensure proper handling of human subjects data.

Received: 29 October 2018; Accepted: 5 February 2019;
Published online: 18 March 2019

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Acknowledgements

The authors thank the United States Department of Energy's Lawrence Berkeley National Laboratory for making the dataset publicly available, and the researchers on that project (in particular, the project investigator B. Hoen) for undertaking the survey and preparing the dataset.

Author contributions

J.F. devised the research question, gathered additional data, performed statistical analysis and interpretation of the data, and wrote the initial draft of the manuscript. H.K. performed statistical analysis, reviewed, commented on and edited the manuscript, and prepared draft figures.

Competing interests

J.F. has held various roles related to a 2-MW wind turbine adjacent to the University of Delaware's coastal campus since its commissioning in 2010, and has been a director of the legal entity First State Marine Wind, which has owned and operated the wind turbine since 2016. The University of Delaware has majority control of First State Marine Wind; Siemens Gamesa, the manufacturer, is the minority partner. The turbine provides electricity to the University of Delaware campus and to Lewes, Delaware. Net proceeds are used for research and graduate fellowships. He has held these positions at the desire of his employer, the University of Delaware, and receives no compensation beyond his regular university salary for this service.

Additional information

Supplementary information is available for this paper at https://doi.org/10.1038/s41560-019-0347-9.

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Last updated by author(s): January 28, 2019

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Software and code

Policy information about availability of computer code

Data collection	Data collection was done by Portland State University's Survey Research Lab (PSU SRL). Phone survey data was collected using Voxco CATI (computer-assisted telephone interview) software to manage the sample and record responses. The file was then download to to SPSS for cleaning and analysis. Online survey data was collected using Qualtrics software. Mail survey data was collected using a paper survey. Paper surveys were reviewed and coded by hand to ensure data was accurate for entry and then entered into SPSS. Data files were then provided by PSU SRL to Lawrence Berkeley National Laboratory, which converted STATA and merged. Other data cells based on CoreLogic data was added to the database and weights (strata, gender, education and age) were created based on ACS data. The corresponding author gathered additional data to support this particular manuscript (e.g., farmland in a state; types of utility-scale generation in a state, etc.) from other sources as noted in the methods section and entered into STATA do file.
Data analysis	STATA SE 15.1 was used in all analysis; the data analysis commands are contained in "do file" maintained by the lead/corresponding author. The figures were prepared using Excel.

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The survey, survey codebook, and the database is available from Lawrence Berkeley National Laboratory (LBNL). Given the involvement of human subjects in the research, LBNL requires an application and approval for access to and use of the database. Subject to approval, extensions are available from the corresponding author. See data availability at https://emp.lbl.gov/projects/wind-neighbor-survey.

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Behavioural & social sciences study design

All studies must disclose on these points even when the disclosure is negative.

Study description	Quantitative data from a random sample
Research sample	Houses within eight km of a "utility-scale" wind turbine, which was defined as greater than 111 meters to a blade tip at its apex and a nameplate capacity of 1.5 MW or greater installed through 2014. More details are under Human Research Participants below. The dataset was from Lawrence Berkeley National Laboratory's (LBNL) National Survey of Attitudes of Wind Power Project Neighbors, https://emp.lbl.gov/projects/wind-neighbor-survey.
Sampling strategy	Using data from CoreLogic, the sample frame included houses within eight km of a "utility-scale" wind turbine, which was defined as greater than 111 meters to a blade tip at its apex and a nameplate capacity of 1.5 MW or greater installed through 2014. Given related acoustic modeling at a few locations, households in the vicinity of fifteen projects, which were selected to capture a diversity of turbine manufacturers, geographies, project sizes, background sound levels, population densities, and topographies, were oversampled. As for the remaining projects, four small projects dominated the sample of homes in one of the four distance strata, and as a result, homes near those projects were under-sampled. The sample also was stratified by project size and, as noted, distance (0-0.8 km, 0.8-1.6 km, 1.6-4.8 km and 4.8-8 km) to facilitate the oversampling homes nearby wind turbines. Descriptive statistics are weighted by strata, age, education and gender.
Data collection	Data were collected by telephone interview, followed by mail contact, with those contacted by mail were provided the opportunity to take the survey by on an enclosed paper survey or on the web using Qualtrics software. There was a survey codebook created and data entered into a database followed by transfer of the data to a STATA database.
Timing	March to July 2016
Data exclusions	24 responses were excluded as further investigation revealed they were not from a home with eight km of a wind turbine.
Non-participation	A total of 875 phone responses out of 3114 resolved (not to be called back because e.g., they completed the survey or asked to never be called back or refused to take part) and 6,332 eligible (resolved plus, e.g., reached voice mail or was asked to call back) phone numbers, for a resolved response rate of 28.1% and an eligible response rate of 13.8%. 483 web and 347 mail responses were received out of a total of 4,637 eligible addresses (accounting for undeliverable mail, etc.), for an effective response rate of 17.9%.
Randomization	Given related acoustic modeling at a few locations, households in the vicinity of fifteen projects, which were selected to capture a diversity of turbine manufacturers, geographies, project sizes, background sound levels, population densities, and topographies, were oversampled. As for the remaining projects, four small projects dominated the sample of homes in one of the four distance strata, and as a result, homes near those projects were under-sampled. The sample also was stratified by project size and, as noted, distance (0-0.8 km, 0.8-1.6 km, 1.6-4.8 km and 4.8-8 km) to facilitate the oversampling homes nearby wind turbines. Descriptive statistics are weighted by strata, age, education and gender; ordered logistic regression is unweighted (Weighting followed the method known as "iterative raking" or "sample balancing"). Ordered logit models are not weighted; however, include dummy variables controlling for differential sampling (strata) and differential rates of response by age, education and gender.

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☒	☐	Palaeontology
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☐	☒	Human research participants
☒	☐	Clinical data

Methods

n/a	Involved in the study	
☒	☐	ChIP-seq
☒	☐	Flow cytometry
☒	☐	MRI-based neuroimaging

Human research participants

Policy information about studies involving human research participants

Population characteristics	Using data from CoreLogic, the sample frame included houses within eight km of a "utility-scale" wind turbine, which was defined as greater than 111 meters to a blade tip at its apex and a nameplate capacity of 1.5 MW or greater installed through 2014. Given related acoustic modeling at a few locations, households in the vicinity of fifteen projects, which were selected to capture a diversity of turbine manufacturers, geographies, project sizes, background sound levels, population densities, and topographies, were oversampled. As for the remaining projects, four small projects dominated the sample of homes in one of the four distance strata, and as a result, homes near those projects were under-sampled. The sample also was stratified by project size and, as noted, distance (0-0.8 km, 0.8-1.6 km, 1.6-4.8 km and 4.8-8 km) to facilitate the oversampling homes nearby wind turbines. Descriptive statistics are weighted by strata, age, education and gender.
Recruitment	An initial random, stratified probability sample of 43,041 homes was drawn, location was verified using two geocoding services (Google and Melissa), keeping those homes with close locational agreement (within 0.4 km), resulting in 26,848 residences. Phone numbers were matched to these homes using MSG Data resulting in 15,455 homes. Random samples in each stratum were drawn, with the objective of loading only as much of the sample as was necessary to reach a goal of 900 phone responses, resulting in a total 7,845 loaded records. An additional 6,000 homes were sampled by mail/Internet. This sample was comprised of 750 phone non-responding homes and 5,250 from records that did not have a phone number, were associated with a non-working phone number or that were earlier screened out because they could not be geocoded with Google, although ultimately geocoded using Melissa alone. Individuals who completed the survey had their name entered into a random drawing for four $500 gift cards. Human subjects review and approval was obtained by Institutional Review Boards at Portland State University (PSU), University of Delaware, and the Lawrence Berkeley National Laboratory, including recruitment scripts and letters and the survey instrument itself.
Ethics oversight	Institutional Review Boards (IRBs) at the University of Delaware, Portland State University and Lawrence Berkeley National Lab approved the study protocol

Note that full information on the approval of the study protocol must also be provided in the manuscript.