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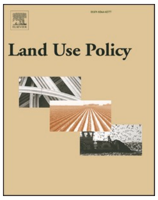

What really undermines public acceptance of wind turbines? A choice experiment analysis in Israel

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A R T I C L E I N F O

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A B S T R A C T

As of 2020, there are only 27 MW of installed wind capacity in Israel. Yet, the country's northern region is expected to soon become the site of numerous additional wind farms. The externalities associated with wind turbines frequently arouse concerns and objections among the general public. The relative apprehensions about different external effects remain poorly characterized. Moreover, the associated environmental costs with different effect are difficult to assess, especially for populations unfamiliar with turbines' environmental impacts. The study involves a choice experiment survey among Israelis living in the country's northern region. The questionnaire evaluated perceptions of five environmental impacts caused by wind turbines: *noise, visibility; bird mortality, land use* and *shadow flickers*. Results indicate high rates of public support for wind power. Significant concerns emerged about noise pollution from turbines. Reasonable setback distances and attention to avian populations also appear necessary to assuage public opinion. Evaluation of demographic characteristics reveals disparate preferences in different populations. Findings are relevant for policy makers in ongoing efforts to design more precise environmental standards for wind power and ensure appropriate utilization of land resources. Greater attention to environmental impacts promises to improve social acceptance of wind turbines, ensuring their optimal location and ultimate contribution to reducing greenhouse gas emissions.

1. Introduction

In recent years, wind power has emerged as the major, installed renewable energy resource for supplying electricity worldwide. For most countries seeking clean electricity sources, it has become the "go-to" option, whose contribution to climate change is substantial (REN, 2019). With increasing numbers of onshore WT (wind turbines) in many countries, wind now offers a technology that is not only significantly less expensive than fossil fuels (IRENA, 2020a,b) but also environmentally preferable.

After increasing by more than 10 % annually for a decade, however, WT have become controversial in many countries due to external environmental implications (Firestone et al., 2015). WT generate noise and can cause shadow flickers; their visual impact is often extremely dominant (Henningsson et al., 2013; Dai et al., 2015; Ólafsdóttir and Sæþórsdóttir, 2019) In addition, WTs can endanger wildlife, especially birds and bats, who are exposed to the risk of avian collisions where any contact with the blades can increase mortality (Rydell et al., 2012; Dai et al., 2015).

As there remains uncertainty about the external costs, assessment of monetary values will be necessary to better characterize the relationship between renewable power and social wellbeing. Indeed, previous research suggests that the social acceptance of wind power is a function of technological concerns and also reflects a strong socio-economic component. The development of distinguishable sub-functions, in particular the environmental implications associated with new crucial technologies is important for creating more favorable institutional conditions as well as facilitating extensive social learning (Wolsink, 2012).

In Israel, the total installed capacity of wind power is only 27 MW. But this is starting to change: Israel's Ministry of Energy has declared its intention to develop WT that will generate hundreds of additional megawatts. The new wind farms for the most part are slated to be sited in Israel's northern periphery. Overall, Israel's government has set a goal of achieving 17% renewable energy nationwide by 2030 Israel's Ministry of Energy. (2019). By 2025, some 730 MW of this power is

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supposed to come from wind. But it is not at all clear that these objectives will be realized. WT programs increasingly face objections from local citizens, local government authorities, as well as environmental NGOs due to concern about their externalities (Gorodeisky, 2018; Israel Planning Authority, 2018; Israel Planning Authority, Northern Region, 2019).

As Israel is a small country, many projects are planned near residential settlements and natural habitats. Israel case is unique: A society with little experience in wind technology lives on a complex terrain, with a high density of human settlement, nature reserves as well as religious and historic sites. Notwithstanding the understandable emergence of NIMBY-Not In My Back Yard (Devine-Wright, 2005; Rand and Hoen, 2017) forces in recent campaigns, there are many legitimate concerns forwarded by opponents to wind power. The complexity of the zoning and siting dynamics requires that rigorous analytical tools and new perspectives for assessing WT environmental implications and public perceptions be applied.

Appropriate siting and operational adjustments can mitigate many of these negative impacts. The favorable deployment of wind power, therefore, entails distributional effects that must be monitored and moderated by policy makers (Zerrahn, 2017). Developing a regulatory approach that can address community objections through evidence-based, management strategies constitutes a paramount objective for ecological, climate change and public health advocates alike. For example, concerns for bird populations can be solved by operating regimes which shutdown WT during times when birds are in proximity. Operation of radar and observation technology, combined with enforcement authorities to limit threshold values, can serve to bring collateral damage to the minimal levels (Tomé et al., 2017). If the marginal costs of associated environmental effects can be fully integrated into the feasibility evaluations associated with site-selection and decision-making for establishing WT and their operation, the process is likely to be more transparent and comprehensive. This will also increase the potential for engendering public support for new renewable energy projects.

We conducted a Choice Experiment (CE) survey in the north of Israel. The study examines public opinion among residents about wind energy and its external effects, with the objective of assigning marginal cost values to the different impacts of WT. Assessing the *specific* contribution of *different* external effects of WT, while teasing out their separate environmental costs enables a richer understanding of wind power's environmental impacts.

The insights from the present research are intended to contribute to more rational decision-making and more effective management strategies. Results of this study can help policy makers and planning authorities develop an optimal wind power strategy. As wind power expands, a more nuanced quantitative analysis of its environmental attributes is vital for meaningful and holistic cost-benefit calculations. This is the first study in Israel that seeks to measure the external effects of WTs and the environmental impacts that they impose in the unique conditions of a crowded country with an unusually high concentration of historic and ecologically rich sites. Deconstructing and quantifying social perceptions about WT externalities constitute the main objective in this study: The research seeks to better characterize the interplay between public support for WTs and renewable energy development alongside the social's concern for environmental quality and conservation.

2. Literature review

Non-market valuation is the most used technique to estimate environmental impacts of wind power. For example, several studies estimated the monetary value of WT along with their environmental and social costs. Methods include hedonic pricing studies (Lang et al., 2014; Gibbons, 2015; Heintzelman et al., 2017; Jensen et al., 2018) as well as contingent valuation studies (Groothuis, 2008; du Preez et al., 2012d) in order to characterize the external costs.

CE is another non-market valuation approach used with increasing frequency. The approach was first proposed by Lancaster (1966), utilizing survey questions to construct hypothetical markets and elicit participants' willingness to pay (WTP) for reducing the external effects. In the case of wind energy, CE methodology presented multiple wind farms as different combinations of defined attributes at different levels and intensities (e.g, distance from the wind farm to residential areas or number of WT in the wind farm).

Participants are asked to state their preferences for competing wind farm alternatives through a rigorously designed, recursive procedure. By attaching a monetary value to particular wind farm, CE studies can estimate the WTP for specified changes in environmental conditions. The marginal values of the non-monetary attributes can thus be derived.

Previous WT CE studies have focused on a range of attributes. The most common one is the examination of individual WTP for distancing WT from settlements, adjusting the number of turbines, and turbine height (Álvarez-Farizo and Hanley, 2002; Meyerhoff et al., 2010; Drechsler et al., 2011; Vecchiato, 2014; Mariel et al., 2015; Brennan and Van Rensburg, 2016). Other attributes assessed in the literature assign a price to wildlife impacts (Bergmann et al., 2006; Meyerhoff et al., 2010; Liebe et al., 2012; Aravena et al., 2014; EK and Matti, 2015). Visual and spatial location impacts have also been quantified (Bergmann et al., 2006; Strazzera et al., 2012; Aravena et al., 2014; Vecchiato, 2014; Arnberger et al., 2018; Lee et al., 2020).

Another cluster of research characterizes local involvement in the planning process or the implication of community rewards towards public attitudes to WT (Álvarez-Farizo and Hanley, 2002; Bergmann et al., 2006; Dimitropoulos and Kontoleon, 2009; EK and Persson, 2014; Brennan and Van Rensburg, 2016; García et al., 2016). Research also analyzed comparable aspects of attributes for offshore wind farms (Ladenburg and Dubgaard, 2007; Krueger et al., 2011; Westerberg et al., 2013; Lutzeyer et al., 2018). Due to the increasing prevalence of WT and the rising resistance in many countries to their construction, CE surveys and multi variate analyses studies have been carried out to identify explanatory variables for the differences among valuation results (Dachary-Bernard and Rambonilaza, 2012; Mirasgedis et al., 2014; Bigerna and Polinori, 2015; Mattmann et al., 2016; Wen et al., 2018).

Previous studies emphasized the ability of key attributes to produce substantial negative externalities. Particularly, it has been shown that residents confirm the intuitive assumption that WT be located farther away from dwellings. At the same time, a *distance decay effect* is a factor common to perceptions of WT location: the marginal benefit of moving WT away decreases with distance (Bigerna and Polinori, 2015; Wen et al., 2018). Empirical research has demonstrated citizens' WTP significantly more for the first kilometer from dwellings, with subsequent values dropping as proximity decreases. There does not appear to be a significant preference for a given number of WT or wind farm size. While some studies found a preference for larger wind farms with more WT (Vecchiato, 2014), others showed the opposite, with smaller wind farms and fewer WT enjoying greater local support (Mariel et al., 2015). Previous studies also reflect inconsistencies regarding turbine height preferences (Liebe et al., 2012; Vecchiato, 2014). Indeed, only five case studies out of nine obtained statistically significant estimates regarding perceptions of turbine height (Wen et al., 2018).

Biodiversity is another important category for which public preferences have been elicited. Studies that investigate wind energy's wildlife impact tend to focus on concern for potential bird mortality. An important finding in several studies involves WT' visual impact and the frequent expression of a significant preference to locate WT offshore to decrease visibility (Aravena et al., 2014: Vecchiato, 2014), as some individuals consider the visual or "aesthetic" aspects more important than the social health or ecological consequences (Lee et al., 2020).

Research that focuses on the involvement of local communities demonstrates greater WTP values that that when the local community is engaged in the planning process (Dimitropoulos and Kontoleon, 2009; EK and Persson, 2014; Brennan and Van Rensburg, 2016). García et al.

(2016) reported that in Norway, households prefer *public* compensation to *private* returns, while Bergmann et al. (2006) found the negative environmental impact from WT was more significant than any utility gained from hypothetically expanded employment among residents.

According to Lee et al. (2020), in South Korea, the public reported a perceived 1% improvement of visual impact of WTs ($0.17), as opposed to a 1% reduction, when responding to possible ecosystem destruction ($0.12), as well as to exposures to a 1 dB reduction in noise levels ($0.06). Despite these findings, no explanations are offered about the participants general attitudes towards wind power and the impact of the socio-demographic characteristic.

In the current study, we use the CE technique to single out all of the WT impact attributes that the literature suggests significantly increase WTP. It is important to continue the comparison between the anthropocentric impact of WT to ecological effects, these two categories receive significant attention in the literature. A specific values of the WTs' primary externalities is especially valuable when some impacts only affect residents living near the proposed site, while others are relevant for the population at large.

To our knowledge, none of the aforementioned WTP studies deconstruct the distance effects into separate attributes. In other words, participants presumably preferred moving WT further away because of the *aggregate impact of* a range of several different externalities (such as noise, shadow flickers, and visual impact). All of these attributes are associated with distance. But separate monetary values have never been calculated for the disparate contributors to the overall distance effect associated with turbine location. Noise, for example, is perceived quite differently in rural areas than in urban settings, while the visual impact of a turbine can be reduced when it is hidden by objects that function as landscape barriers. This can also affect the reaction to shadow flickers that are largely a function of the angle of the sun. This is why on the one hand, the focus of the study's attributes relates to the distance effects (noise, shadow flickers, and visual impact), while on the other hand, we assess the ecological implications of bird mortality and land use. Combining these attributes into a single CE model has not been undertaken heretofore. This evaluation provides important insights about public preferences and the external costs of WT technologies. Also, the article provides findings about a population, the majority of whom still lack meaningful experience with WT facilities, offering important insights about social acceptance for renewable energy in new markets.

3. Methodology

3.1. Design of choice experiment

To create a CE model, we designed a survey for the northern regions of Israel, Fig. 1 presents the map of the study area. The regions span 5337 square kilometers and have a population of 2.5 million inhabitants (Israel's Central Bureau of Statistics, 2019). All of Israel's wind power is presently located in the northern region (27 MW). Moreover, hundreds of upcoming additional megawatts are currently in the planning process there. The survey was conducted through a professional surveys company via the internet between July and September 2019. Overall, 644 participants responded to the study. The sample was designed to represent the region's population, urban and rural settings together. Therefore, we tracked participants' personal characteristics via an

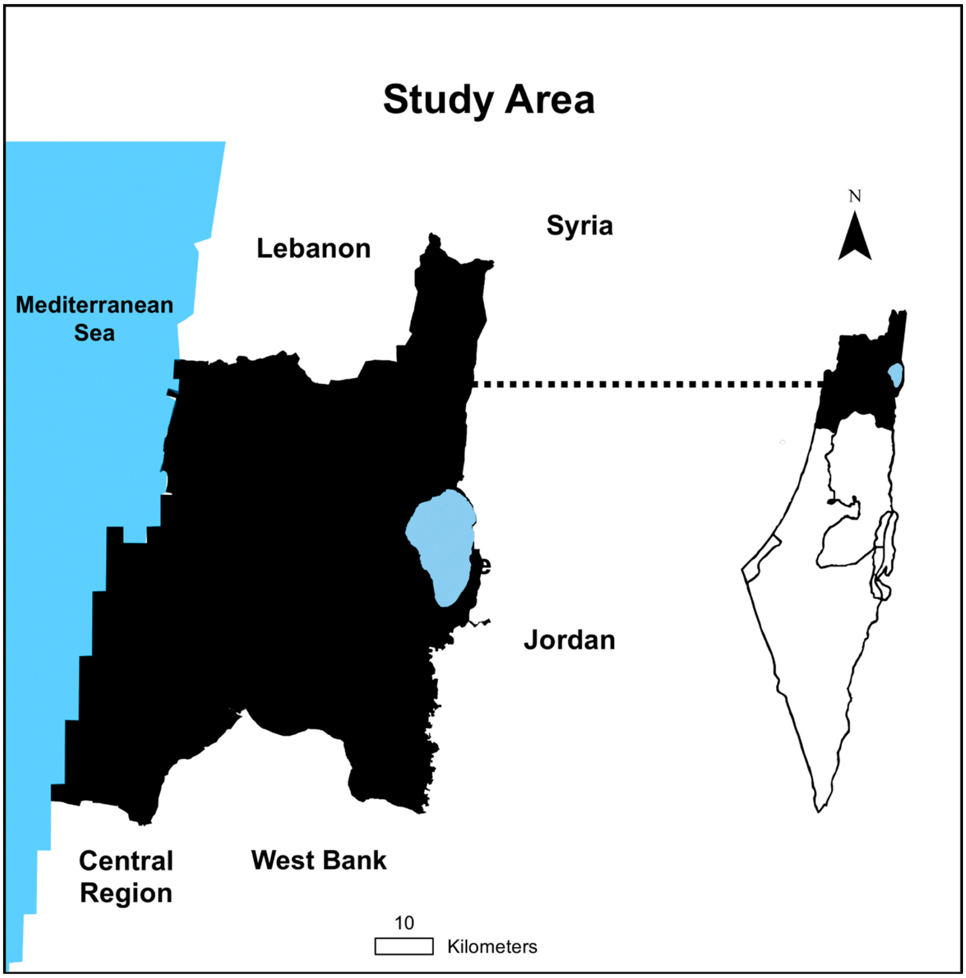

Fig. 1. A map of the study region in Israel and it is boundaries.

internet survey company. To ensure a representative distribution of respondents, the survey also conducted focus groups in selected settlements. It assured that the survey sample contained responses from rural areas and from adults who are not inclined to participate in internet surveys. At last, 584 participants responded online and 60 completed the full sample via focus groups. The survey was presented in Hebrew and Arabic, given the ethnic mix of the population living in Israel's northern region.

One of the key survey research challenges associated with distributing a complex survey through the internet is ensuring that participants read and understand the questions, especially when relatively technical topics are involved. Moreover, in our case, much of the public in Israel still lacks experience with WT' external effects. To overcome this challenge, we added illustrations and explanations about WT characteristics along with information about wind power in general. The survey then checked respondent literacy in key areas. Participants who failed to answer 'vigilance questions' correctly were eliminated from the sample. For example, after a video display of an examined attribute, we asked a question that assessed whether the participant watched the video. Participants who answered the internet survey too rapidly were also automatically omitted. Because the survey design began with an unnecessarily high number of participants, it allowed for applying severe criteria for exclusions, ensuring that one of the major problems of internet surveys was appropriately addressed.

The survey itself is divided into four sections: The first section explores respondents' general attitudes towards environmental issues and wind power experience. Environmental behavior was normalized to three levels according to responses for behavioral habits such as dedication to cycling or membership in environmental organizations. Similar categorization was performed according to the level of familiarity with WT. As such, participants were asked to report how often they have encountered WT in their lifetime: Never encountered or only a few times normalized to a 'low familiarity' group; tens or more times is defined as 'medium', 'high familiarity' involves participants who had lived or currently live close to WT.

The second section provides information regarding the pros and cons of wind energy and demonstrates environmental attribute levels. This section includes vigilance questions about the different attributes. Also, at the end of the second section, respondents are asked to rank the priority of the attributes based on their opinions. The third section contains the choice experiments. The final section elicits socioeconomic information about individual respondent characteristics (residence, gender, age, education, religion, household income).

3.1.1. *Attribute levels*

To estimate the respondents' WTP, we create three hypothetical referenda in our model. Two options (B and C) locate WT with different levels of visual impact, noise, shadow flickers, land use, and damage to birds. The hypothetical scenarios present WT impacts under different conditions, producing relatively high-resolution information about participants' individual preferences and their WTP. While in some cases, noise and shadow flickers both are associated with distance, it is important to separate them if we are to isolate specific externality costs. The third option offered respondents involves maintaining the status quo, where no WT is established. Under this scenario, the country continues to produce most of its electricity from natural gas and coal. This alternative approach is used frequently in CE models (Bergmann et al., 2006; Brennan and Van Rensburg, 2016; Dimitropoulos and Kontoleon, 2009; García et al., 2016; Krueger et al., 2011; Vecchiato, 2014). Table 1 shows the attributes and level values.

The first attribute, the distance from dwellings, is aimed at understanding the visual impact. Many studies rely on the cognitive skills of the respondents to imagine WT of different sizes and at different locations (Firestone et al., 2015; Hevia-Koch and Ladenburg, 2019). This point is particularly important in cases (as in Israel) where many participants are unfamiliar with WT' visual impacts. Fig. 2 presents images of open landscapes from the northern region produced by standard imaging software (Adobe Photoshop CC 2018); we displayed a single WT with a height of 150 m at three levels of distance (500 m, 1000 m, 2000 m). The turbine size was selected based on conventional present technology.

Table 1
The model attributes and their levels.

Levels	Attribute
500, 1000, 2000	Visual Impact (Distance in Meters)
Natural, Disturbed	Land Use
None, 0.5, 1	Shadow Flickers (Hours Per week)
None, Low, High	Noise Intensity
3, 10	Birds (Damage per year)
10, 20, 40, 60	Willingness to Pay (NIS Per Month)

The images created on contrasting landscapes illustrate the land use attribute. Israeli planners typically prioritize conservation of open spaces without human interventions. Accordingly, zoning infrastructure as near as possible to existing human facilities, ostensibly, is preferable. *Option B* simulates a turbine on a disturbed agriculture landscape, while in *Option C*, the turbine is in a natural land setting.

The next attribute involves shadow flicker frequency. Rotating blades interrupt the sunlight, producing an unavoidable flicker. This light is bright enough to pass through closed eyelids. Furthermore, moving shadows cast by the blades on windows can affect illumination inside buildings. To illustrate this phenomenon, we linked a 30 s video showing WT shadow flickers on the living room of a house. In each scenario the participants had different levels of flicker frequency per week (every hour, every half hour or no flickers at all). Those levels were selected due to spatial tests of the average weekly effect at 500 m and 1000 m using WindPro 3.2 software.

To explain the noise attribute, we composed a short paragraph describing WT noise effects, with a comparison to other familiar sounds (for example, it emphasized that normal conversation overcomes turbine noise at standard level and the noise is emitted only when WT operate). At every choice set, the level of the noise attribute ranged between 'no noises at all', 'low intensity,' and 'high intensity'.

In presenting the Birds attribute, participants read a few sentences explaining the potential damage to avian populations. The average mortality for avian populations is estimated to be 5.2 cases per turbine (Henningsson et al., 2013). Therefore, the selected range of values in the choice set presented involved relatively minor damage (3 birds per year) and large damage (10 birds per year).

The final attribute, electricity fee, is used as a payment component in participants' monthly electricity bills. The questionnaire clarifies that the hypothetical payment would be required for electricity transmission and technological improvements to reduce the external effects. The final bid levels that were chosen are 10, 20, 40 or 60 ILS per month (1 NIS = 3.6 US dollars) or fees of $2.77, $5.55, $11.11, $16.66 respectively. The status quo *Option A* requires no payment as it does not involve any WT. The range of electricity fee values was determined based on the results of pretesting with focus groups and the literature review.

3.1.2. *Design of attributes and choice sets*

To produce an optimal choice design for the six attributes being evaluated, we created combinations of choice sets: one with four level alternatives, two with two level alternatives and three with three level alternative each, As in previous studies, a fractional factorial design consisting of 48 choice sets was made (Kuhfeld, 2007). The survey includes a "business as usual" /status quo option in all sets, while the other two options alternates between different sets. Finally, all options contain a balanced weight for the five-attribute combination. For example, if the electricity fee increases, the external effect of some attributes decreases respectively, leaving the option weight equal to the alternative. The sets

Fig. 2. Wind turbine simulation at different distances and land uses.
A-Disturbed 500 m, B- Disturbed 1000 m, C- Disturbed 2000 m, D- Natural 500 m, E- Natural 1000 m, F- Natural 2000 m.

were blocked into eight subgroups with six choice sets; each block was presented to at least 50 respondents. Fig. 3 shows a sample of one choice set. In the six choice sets, a "vigilance choice set" was intentionally added to identify lack of cooperation among the respondents.

3.2. *Choice experiment analysis*

The analysis presented here is based on the analysis presented by W. Kuhfeld in his summary of research methods in SAS (2007). In

Option 1

Business as usual

No wind turbines

Producing power from coal and natural gas

My selection is: ☐

Option 2

Attribute	Level
Distance to settlement	1,000 m
Noise	No noise
Shadow flickers	No flickers
Birds mortality	10 per year
Land use	Disturbed
Electricity fee per month (NIS)	60

☐

Option 3

Attribute	Level
Distance to settlement	500 m
Noise	Low
Shadow flickers	One hour per week
Birds mortality	3 per year
Land use	Natural
Electricity fee per month (NIS)	20

☐

Fig. 3. Example of choice experiment question.

particular, the methodology follows the vacation choice example, in which there is always the choice: "Stay at Home" which is analogous to the option of "No Wind Turbines" presented in each choice set in the current research. Kuhfeld provides the appropriate options for applying the multinomial logit model using SAS®'s "PHREG" procedure. Rather than use multilevel class variables for the various attributes, in our implementation, each attribute was specifically coded using one or two zero-one indicator variables.

For a given population, or sub-population, the primary analysis includes only the indicator variables for the design factors: Wind (= 1 for WT, 0 for no WT), Distance (two indicators), Noise (two indicators), Flickers (two indicators), Birds (one indicator), Land Use (one indicator). Cost is entered as a continuous variable, so its estimated coefficient corresponds to the loss of utility for every extra shekel of monthly cost. Marginal willingness-to-Pay (MWTP) in shekels, when comparing to two levels of a design factor, is then obtained as the ratio: (difference in utility) / (difference in utility per shekel cost).

The secondary analysis includes interactions between attitudes and/or demographic information and between the design factor indicators used in defining the choice options. For each population, all possible interactions were entered into the SAS PHREG procedure, which then "selected" those that had a significant effect on the choice decisions for the population under consideration. Observing the resulting model with its selected significant interactions, one can ascertain both qualitatively and quantitatively the extent to which attitudes or demographics change the utilities associated with various choice parameters. It also becomes possible to see to what extent these interactions change the WTP associated with reducing negative impacts of the various choice parameters.

The results from analyzing the choice design that are reported were all conducted using the PHREG procedure. In order to ascertain whether there might be any sensitivity to the model assumptions, an alternative analysis using the BCHOICE procedure of SAS® was also conducted. The latter uses a Bayesian analysis approach, incorporating the Markov Chain Monte Carlo (MCMC) methodology. It requires more computation time to run, particularly if many interactions are included. For the primary analysis models, the results of the BHOICE procedure were largely indistinguishable from the primary analysis results reported here, and it was therefore decided not to present them separately.

4. Results

4.1. Supporting wind power

In the opening question of the survey, participants were asked to indicate to what extent they support wind power as a renewable energy source in Israel. Some 79 % of the sample was completely or partly in favor of wind power, while 16 % did not express a coherent opinion. Table 2 presents the demographic characteristics of the sample according to levels of support expressed. Only 5% of the participants were completely or partly opposed.

It is particularly interesting to note that in comparing demographic groups' perspectives to that of the total sample, identical levels of

Table 2
Respondent characteristics and support rate related to wind power in Israel.

	N (total sample %)	*Completely Opponents N (%)*	*Partly Opponents N (%)*	*Partly Advocates N (%)*	*Completely Advocates N (%)*	*No Opinion N (%)*
Environmental Behavior						
Low	100 (15.5)	2 (2.0)	2 (2.0)	30 (30.0)	36 (36.0)	30 (30.0)
Med	355 (55.1)	7 (2.0)	13 (3.7)	105 (29.6)	170 (47.9)	60 (16.9)
High	189 (29.4)	2 (1.1)	6 (3.2)	46 (24.3)	121 (64.0)	14 (7.4)
Familiarity with WT						
Low	390 (60.6)	5 (1.3)	8 (2.1)	107 (27.4)	185 (47.4)	85 (21.8)
Med	211 (32.8)	3 (1.4)	11 (5.2)	61 (28.9)	122 (57.8)	14 (6.6)
High	43 (6.7)	3 (7.0)	2 (4.7)	13 (30.2)	20 (46.5)	5 (11.6)
Residence						
Cities	367 (57.0)	3 (0.8)	8 (2.2)	99 (27.0)	193 (52.6)	64 (17.4)
Arab villages	80 (12.4)	2 (2.5)	2 (2.5)	29 (36.3)	38 (47.5)	9 (11.3)
Kibbutzim	71 (11.0)	3 (4.2)	5 (7.0)	19 (26.8)	35 (49.3)	9 (12.7)
Family Farms	58 (9.0)	1 (1.7)	2 (3.5)	14 (24.1)	30 (51.7)	11 (19.0)
Rural communities	68 (10.6)	2 (2.9)	4 (5.9)	20 (29.4)	31 (45.6)	11 (16.2)
Gender						
Female	325 (50.5)	4 (1.2)	11 (3.4)	82 (25.2)	154 (47.4)	74 (22.8)
Male	319 (49.5)	7 (2.2)	10 (3.1)	99 (31.0)	173 (54.2)	30 (9.4)
Religion						
Jews	494 (76.7)	8 (1.6)	20 (4.1)	131 (26.5)	250 (50.6)	85 (17.2)
Muslims	92 (14.3)	1 (1.1)	1 (1.1)	29 (31.5)	50 (54.4)	11 (12.0)
Others	58 (9.0)	2 (3.5)	0 (0.0)	21 (36.2)	27 (46.6)	8 (13.8)
Education						
Low (< = 12 years)	238 (37.0)	5 (2.1)	6 (2.5)	68 (28.6)	108 (45.4)	51 (21.4)
High (>12 years)	406 (63.0)	6 (1.5)	15 (3.7)	113 (27.8)	219 (53.9)	53 (13.1)
Age						
18-28	158 (24.5)	0 (0.0)	7 (4.4)	38 (24.1)	79 (50.0)	34 (21.5)
29-38	165 (25.6)	2 (1.2)	3 (1.8)	55 (33.3)	80 (48.5)	25 (15.2)
39-48	133 (20.7)	4 (3.0)	3 (2.3)	37 (27.8)	61 (45.9)	28 (21.1)
49-58	87 (13.5)	5 (5.8)	2 (2.3)	22 (25.3)	48 (55.2)	10 (11.5)
59-68	67 (10.4)	0 (0.0)	6 (9.0)	15 (22.4)	41 (61.2)	5 (7.5)
>68	34 (5.3)	0 (0.0)	0 (0.0)	14 (41.2)	18 (52.9)	2 (5.9)
Income (household p/m)						
<6,000INS	115 (17.9)	2 (1.7)	2 (1.7)	30 (26.1)	60 (52.2)	21 (18.3)
6,000–12,000	219 (34.0)	2 (0.9)	9 (4.1)	64 (29.2)	104 (47.5)	40 (18.3)
12,000–20,000	251 (39.0)	7 (2.8)	7 (2.8)	67 (26.7)	137 (54.6)	33 (13.2)
>20,000	59 (9.2)	0 (0.0)	3 (5.1)	20 (33.9)	26 (44.1)	10 (17.0)
Type						
Internet	584 (90.7)	8 (1.4)	18 (3.1)	161 (27.6)	303 (51.9)	94 (16.1)
Field	60 (9.3)	3 (5.0)	3 (5.0)	20 (33.3)	24 (40.0)	10 (16.7)
Total	**644 (100.00)**	**11 (1.7)**	**21 (3.3)**	**181 (28.1)**	**327 (50.8)**	**104 (16.2)**

Note: Each line of support rates is calculated from the total N of the sub-population examined.

support were found across different communities. Nonetheless, some cohorts showed a greater tendency to oppose WT. For instance, respondents with “high familiarity” were more likely to oppose WT than the general population – but even in this group, opposition was extremely moderate: only 7% were completely opposed and 4.7 % partially opposed. A relatively high rate of opposition was also found among residents of rural areas, especially residents of ’Kibbutzim’ (a communal rural settlement) with 4.2 % ’completely opposed’ and 7% only ’partly’. The last category of opponents was categorized as ’field survey participants’, referring to individuals who participated in focus groups, 35 % of whom were kibbutz residents. Only two sub-groups (those included in the ’field survey’ and respondents who revealed ’low levels of environmental behavior’) expressed no more than 40 % support for ’fully advocated’ wind energy.

As mentioned, most respondents stated that WT should be a vital source of energy for Israel. Statistically, some groups emerged as more avid advocates of this alternative energy. The sub-population with the highest percentage of support for wind power was among individuals who were defined as exhibiting a ’high level of environmental behavior’: 64 % of who expressed ’complete support’ and additional 24.3 % partial support for WT. Other groups that showed relatively high levels of support were Muslim Israelis, respondents with ’high education’, individuals with ’medium familiarity’ of WT and participants over 48 years old (especially those over 68 years old who expressed 94.1 % support). Younger respondents disproportionately expressed partial support and ’no opinion’ relative to adults. Other categories without a clear opinion included respondents with a low level of education, low familiarity with WT and people exhibiting low environmental behavior. Urban residents and males showing a slightly more favorable opinion than respondents in small settlements and female respondents, respectively.

4.2. *Concerns about external effects*

Table 3 summarizes the ranking of environmental impacts by respondents. A rank of ’one’ represents the impact of highest concern; a rank of ’two’ represents the second concern for an individual etc.

As can be seen, over 50 % of the respondents ranked ’Noise’ as their *first concern* while only 4% ranked ’Noise’ as the *last concern*. Thereafter, ’Visibility’ was rated by 50 % of respondents as the first or the second concern. At the bottom of the list, 64 % declared ’Land Use’ as fourth or of least importance. Only a modest proportion of respondents ranked ’Shadow Flickers’, ’Birds’ and ’Land Use’ as their greatest concern (13 %, 11 % and 7%, respectively).

To estimate the odds ratio between respondent categories, ordinal logistic regression was conducted for each external effect as a dependent variable (five levels of priority) and different respondent categories as an independent variable, separately as univariate model. Table 4 presents the results of *significant effects between categories* when calculated for the five environmental impacts assessed. Individuals from cities show relatively significant concerns for ’Noise’(OR-1.29) and ’Shadow Flickers’(OR-1.25), while individuals living in small settlements attribute greater importance to ’Birds’(OR-0.78) and ’Visual Impact’(OR-0.82). Arab villages expressed significantly less concerns for ’Shadow Flickers’(OR-0.39) and greater concerns about ’Land Use’ than others (OR-1.40). Residents living on a kibbutz ascribe higher weights to ’Birds’ and ’Visibility’ than to ’Noise and Land Use’.

Assessing results according to religious/ethnic grouping suggests that Israeli Jews have significantly greater concerns about ’Shadow Flickers’ than do Israeli Muslims (OR-3.29) and other religious communities (OR-0.27) who rank ’Birds’, ’Land Use’ and ’Visibility’ more highly. Another difference between demographic categories was found in the income, age and ’familiarity with WT’ categories: low-income individuals assigned a relatively high importance to ’Noise’(OR- 1.16) in contrast to ’Land Use’(OR-0.83); younger respondents tended to attach greater importance to ’Visibility’(OR-1.12); and citizens who reported familiarity with WT selected ’Noise’ more regularly as well (OR-0.84). Finally, a statistical association was found for respondents who oppose WT: their concerns were more likely to be centered on ’Birds’(OR-1.75) than ’Shadow Flickers’(OR-0.44).

4.3. *Choice experiment model output*

The “status quo” option was selected by 15 % of the overall sample, regardless of the combination of attributes offered. This default resistance to any change was even more pronounced in the focus groups (25 %). Of the 85 % that chose to select a particular ’turbine’ tradeoff alternative (Wind1), only 27 % selected the option that contained the "High Noise" variable when it was presented in the choice sets.

Table 5 outlines the results. The coefficients for each single attribute are presented for two models, with and without interactions. The left column estimates the utility coefficients of each attribute separately, and the right column contains their estimates while the model also includes the selected (significant) interactions between attributes and individual factors. It is important to analyze the overall coefficients separately in order to tease out which factor influences the actual selection of attributes. Table 6 details the second model output further, reporting the significant interactions between attributes and individual factors, based on the results of overall interactions for each single independent attribute. The table summarizes only those interactions that were found to be significant in our model. Further analyses examined the factor variable differences compared to reference points as shown in Table 6. In this case, the model was able to identify which variable behaved differently as a result of the interaction with a given attribute, and which group was more likely to select or unselect specific attributes.

The “reference point” represents the variable with the most minimal external effect. Accordingly, without exception, all attribute utilities increase negatively from the reference point. The model demonstrates that the attribute of *Noise* has a larger effect than other variables. At the same time, the increase in the attribute is not linear as a

noise ’decay effect’ can be clearly identified close to the Reference Point. This implies that respondents enjoy a higher positive utility if the hypothetical WT creates a relatively ’low intensity noise level’ instead of ’high intensity of noise level’. Alternatively, the utility decreases if a turbine produces ’no noise at all’ instead of a ’low intensity of noise level’. The *Bird Coefficients* emerge as the second most important environmental consideration among respondents, when faced with a likely damage scenario of 10 birds per year. This attribute corresponds to only two levels of concern based on an arbitrary ecological outcome.

The results suggest that the greatest concern by respondents involved

Table 3

External effect concerns rank from 1-5. R1 represent the highest priority; R5 represents the lowest priority of the environmental concerns.

	R1 N %		R2 N %		R3 N %		R4 N %		R5 N %	
Noise	325	50.5	151	23.4	87	13.5	55	8.6	26	4
Visibility	117	18.2	193	30	185	28.7	98	15.2	51	7.9
Shadow Flickers	84	13	153	23.8	108	16.8	111	17.2	188	29.2
Birds	72	11.2	93	14.4	131	20.3	184	28.6	164	25.5
Land Use	46	7.1	54	8.4	133	20.7	196	30.4	215	33.4
Total	644	100.0	644	100.0	644	100.0	644	100.0	644	100.0

Table 4
- The logistic regression procedure between attributes and individual categories. * P < 10 % ** P < 5% *** P < 1%.

		Noise		Land		Birds		Visibility		Flickers	
Effect		Odds Ratio	P-value	Odds Ratio	P-value	Odds Ratio	P-value	Odds Ratio	P-value	Odds Ratio	P-value
Support	Opponents vs Advocates	1.00	NS	1.11	NS	1.75	0.085*	1.42	NS	0.44	0.015
Environmental Behavior	L EB vs H EB	1.12	NS	1.00	NS	0.90	NS	1.31	NS	0.80	NS
Familiarity with wind turbines	L Familiarity vs H Familiarity	0.84	0.044**	0.91	NS	1.15	0.089*	1.14	0.106	0.95	NS
Residence	City vs All Others	1.29	0.087*	1.00	NS	0.78	0.083*	0.82	0.158	1.25	0.119
	Arab Villages vs City	1.05	NS	1.35	0.177	1.40	0.125	1.35	0.180	0.39	<.0001
	Arab Villages Vs Kibbutzim	1.85	0.042**	1.86	0.035**	0.95	NS	0.88	NS	0.40	0.002
	City vs Kibbutzim	1.77	0.016**	1.38	0.172	0.68	0.089*	0.65	0.068	1.04	NS
Gender	Female vs Male	0.85	NS	1.02	NS	1.02	NS	0.87	NS	1.26	0.096
Religion	Jews vs All Others	1.17	NS	0.57	0.001***	0.63	0.005***	0.70	0.031	3.29	<.0001
	Muslims vs Jews	1.47	NS	1.74	0.006***	1.8	0.004***	1.56	0.030	0.27	<.0001
Education	L Education vs H Education	1.09	NS	0.95	NS	0.80	0.101	1.03	NS	1.15	NS
Age	L Age vs H Age	0.97	NS	0.93	0.123	0.99	NS	1.12	0.018	0.99	NS
Income	L Income vs H Income	1.16	0.065*	0.83	0.017**	0.88	0.108	1.08	NS	1.12	0.146

Table 5
The logistic regression procedure between attributes and individual categories.

Attribute	*Parameter Estimate*	*Standard Error*	*Pr > ChiSq*	*Parameter Estimate*	*Standard Error*	*Pr > ChiSq*
Wind0 (RP)	–	–	–	–	–	–
Wind1	3.91	0.42	<.0001	1.71	0.51	0.0009
Dist2000 (RP)	–	–	–	–	–	–
Dist1000	−0.30	0.08	0.0002	−0.32	0.08	<.0001
Dist500	−0.99	0.14	<.0001	−0.44	0.25	0.0864
NoNoise (RP)	–	–	–	−0.40	0.08	<.0001
NoiseL	−0.40	0.08	<.0001	−0.68	0.22	0.0022
NoiseH	−1.62	0.14	<.0001			
NoFlickers (RP)	–	–	–	–	–	–
FlickersL	−0.40	0.08	<.0001	−0.30	0.09	0.0016
flickersH	−0.93	0.15	<.0001	−0.67	0.16	<.0001
Birds3 (RP)	–	–	–	–	–	–
Birds10	−1.00	0.08	<.0001	−0.87	0.08	<.0001
LandUseD (RP)	–	–	–	–	–	–
LandUseN	−0.47	0.08	<.0001	−0.49	0.08	<.0001
Cost	−0.03	0.006	<.0001	−0.04	0.007	<.0001

avoiding a turbine at distance of 1000 m or less. Accordingly, the utility associated with avoiding WT sited at a closer distance is far greater than the utility gained between moving a turbine from one kilometer (*Dist1000)* to two kilometers (*Dist2000)*. Results for *Shadow Flickers* were more linear as the increasing of the utility was found to be similar for both levels of environmental effects- half hour/ week and one hour/ week (*FlickersL* and *FlickersH*, respectively*)*. The linearity of flicker duration may well explain the utility function for shadow flickers' effect on dwellings. Even though landscape background was repeated with every choice set with images, the importance of the land use for WT siting emerged as less significant, according to the selections made in the choice experiment and participants' statements in semi-structured interviews.

The estimates appearing in Table 6 reflect the selection preferences of different sub populations. As expected, WT opponents demonstrate an affinity for the status quo option. In contrast, respondents who exhibit high level environmental behavior as well as Muslims (relative to Jews) show a marked preference for the wind power option. These two groups also emerged as major advocates according to their support rates *(*See Section 4.1- Table 2*)*. Residents of kibbutzim selected the WT option as well, despite their generally negative opinion of this alternative at the beginning of the survey. Prioritization for distancing WT from homes (Dist500) had a positive relationship with individuals who were familiar with WT.

A similar inclination was found among Jews (relative to Muslims) as well as among residents of agricultural communities (who tended to be more familiar with WT). Noise pollution proved to invoke greater opposition among females and respondents with high incomes, albeit this concern about noise was not initially apparent when females and high-income respondents ranked environmental priorities *(*See Section 4.2- Table 4*)*. Not surprisingly, two groups that showed a generally lower WTP to reduce environmental impacts from WT were respondents with low educational level and young respondents, presumably reflecting their economic capabilities.

4.4. WTP estimates

Marginal WTP values were generated as the choice experiment model output analyzed the five environmental attributes with coefficients entitled "*COST*". Fig. 4 indicates the resulting WTP amounts for the external effects. As expected, all values were found to be positive, since they represent negative environmental scenarios relative to the reference points. Aggregated, individual preferences indicate that developing WT in disturbed areas would be worth $4.7 per month per household rather than locating them on pristine or natural lands. Reducing an hour of flickers per week emerged as being valued at $9.4/ month whereas reduction of bird mortality from ten to three per year was worth $10.1. The value of physically distancing WT one kilometer instead of 500 m from dwellings was assessed at $7 while respondents on average were willing to pay an additional $3 to locate a turbine two

Table 6
Interaction parameter estimates.

	Multinomial Logit Parameter Estimates		
Interaction	*Parameter Estimate*	*Standard Error*	*Pr > ChiSq*
*Support*Wind1*			
Opponents (RP)	–	–	–
Advocate	1.554	0.173	<.0001
No opinion	1.076	0.196	<.0001
EB Wind1*			
L EB (RP)	–	–	–
H EB	0.076	0.021	0.0003
*Residence*Wind1*			
Rural Communities (RP)	–	–	–
City	0.057	0.162	0.7243
Arab Villages	0.324	0.276	0.2407
Kibbutzim	0.714	0.223	0.0014
Family Farms	0.098	0.214	0.6477
*Religion*Wind1*			
Jews (RP)	–	–	–
Muslims	1.187	0.232	<.0001
Familiarity* Dist500			
L Familiarity	–	–	–
H Familiarity	−0.136	0.061	0.0264
*Residence*Dist500*			
Rural Communities (RP)	–	–	–
City	−0.103	0.175	0.5540
Arab Villages	−0.390	0.267	0.1449
Kibbutzim	−0.547	0.229	0.0167
Family Farms	−0.495	0.236	0.0359
*Religion*Dist500*			
Jews (RP)	–	–	–
Muslims	0.474	0.180	0.0083
*Gender*NoiseH*			
Male (RP)	–	–	–
Female	−0.242	0.107	0.0236
Income NoiseH*			
L Income	–	–	–
H Income	−0.183	0.060	0.0023
*Education*Cost*	0.022	0.009	0.0181
L Education	–	–	–
H Education (RP)			
*Age*Cost*			
18-28	0.014	0.005	0.0031
29-38	0.013	0.005	0.0089
39-48	0.003	0.005	0.5027
49-58	0.006	0.005	0.2468
59-68	0.005	0.005	0.3157
>68 (RP)	–	–	–

kilometers away. Consistent with the earlier responses that ranked environmental impacts, the greatest modification for which the public is willing to pay involves moving from a higher to lower noise intensity. A decrease from high to moderate noise levels was valued at $12.4 while an additional reduction to “no risk of noise” was $16.4.

5. Discussion

As was expected from the literature, the perceived impact from visibility attracts more attention and invokes greater opposition in the first kilometer between homes and a new, proposed WT installation (Wen et al. 2019). An important new finding from our study indicates that the general public is more concerned with noise issues than impaired visual impacts or shadow flickers. It can be inferred that citizens prefer nearby but silent WT to distant and noisy ones. The significant decrease in the public’s WTP to move from moderate noise intensity to zero-noise WT indicates that social concern is particularly focused on high noise levels and is concerned with the most powerful nuisances.

Lee et al. (2020) conducted a CE analysis that revealed noise annoyance to be the last (lowest) preferences among the participants, after visual impacts and ecological effects were ranked. Cultural disparities and the very different survey designs can explain the contradictory results. In the Korean model, the noise level was presented in decibel units along with an explanation of a typical sound of the same decibel unit. For example, to illustrate noise level of 40 dB(A), noise levels were compared to sounds heard in a library, which represents a quiet, internal environment. In the case of the routine sounds of WTs, frequently this level of noise is that noticed by neighboring residents (Pedersen et al., 2009). Indeed, there are many countries that limit the noise levels from turbines to around 40 dB(A) (Dai et al., 2015). In other words, illustration of WTs noise via comparisons to a library or other sounds, is likely to affect the participant perceptions and influence the results.

However, the comparison between the public perceptions in South Korea and Israel suggests that less experience with WTs leads to greater concerns about noise. Accordingly, South Korea wind power is home to 1500 MW installed capacity of WTs while Israel is still in its nascent development stages with only 27 MW (IRENA, 2020a,b). Significant segments of the population in the northern region is familiar only with the *proposed* renewable energy projects in their vicinity. The percentage of respondents that actually live close to wind farms remains relatively minor. Present concern, therefore, is largely based on "the unknown" without little or no actual experience with WT.

This provides new insights and perspectives about social acceptance (Wolsink, 2012). Previous questionnaires found evidence of an association between knowledge / experience and local acceptance. Accordingly, an increase in knowledge contributes to greater acceptance of wind energy infrastructure; community members with limited knowledge may incorrectly assume that such a large, moving structure will be quite loud and constitute a nuisance (Langer and Wooliscroft, 2018; Cranmer et al., 2020).

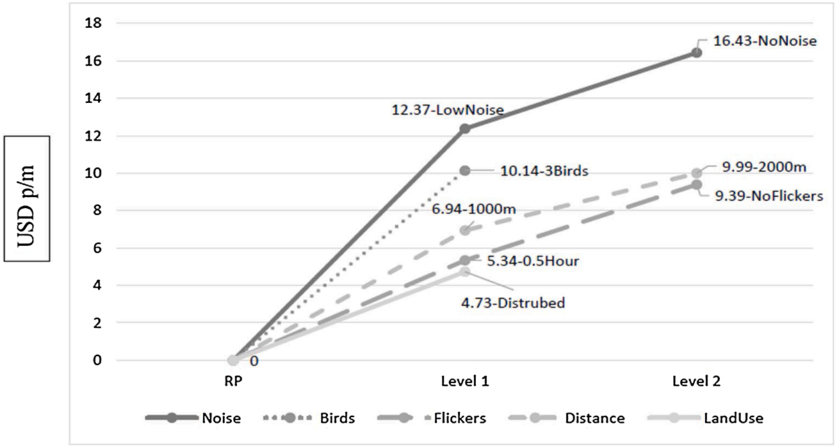

Fig. 4. Willingness to pay amounts of the five wind turbines external effects.

Admittedly, the general opposition to wind power is comparable to the percentage of rejections found in surveys in Germany (Meyerhoff et al., 2010), Ireland (Brennan and Van Rensburg, 2016), and New Zealand (Langer and Wooliscroft, 2018).

Nonetheless, survey participants' concern about externalities show a more nuanced and richer range of perceptions than has been reported in the literature about CE and social preferences. Visibility, noise, and flickers can be seen as anthropocentric effects while bird mortality and land use attributes represent effects that correlate with concern for wildlife and ecological values. Although the public expresses *lower* concern for *ecological* impacts than for other *anthropocentric* impacts, it is important to discuss the cumulative marginal costs of the current model. We assume that birds and land use increase the cumulative WTP for more environmentally friendly WT, as they are associated with a far greater number of individuals, including passive users of these environmental goods (Becker et al., 2009). It would be interesting to see whether more nuanced and diverse ecological variables would produce different outcomes. For instance, perhaps some bird species would evoke greater concern than others.

As for the demographic characteristic, residents of the collective kibbutzim communities demonstrate a relatively negative opinion toward WT, although this group selected the WT option frequently. One possible explanation for this finding is that in earlier years, kibbutz residents were not expected to pay an individual electricity bill. In some kibbutzim this norm has changed. Nonetheless, one compelling explanation for the kibbutz members' opinions and WTP is an ingrained expectation, that their community is responsible for covering the costs of energy payments instead of individuals.

The low support rates among Jews, relative to Muslims reflects statistically significant ethnic differences, especially with regards to greater Jewish proclivity for nature conservation, rather than for rural development by WTs. A similar insight was also reported by Negev et al. (2019). The apprehensions of Jewish Israelis are largely focused on shadow flickers – at least when compared to other religious groups that rank land use and bird impacts as being of greater concern. It begs the question of whether higher opposition rates to rural development among Israel's Jewish citizens are based primarily on pure ecological issues or whether they may be due to more narrow individual interests and a perception that the impacts will take place in their "backyard".

6. Conclusions

Because it produces electricity with zero greenhouse gas emissions, wind power can provide a vital source of renewable energy as part of a climate change mitigation strategy. At the same time, there are legitimate concerns about WT's external, environmental effects. The research seeks to better characterize the interplay between public support for WTs and renewable energy development in the face of the growing concern about wind turbines' adverse impacts on environmental quality and conservation. This was done through a choice experiment survey conducted in the northern region of Israel. This region is characterized by its many diverse rural settlements, iconic natural and heritage sites, along with a massive population of migrating birds. The local residents' experience with WT facilities is very limited, as to date, only three small wind farms exist in the country (producing a total of 27 MW).

In the past few years, many proposals for additional wind facilities have been submitted to planning authorities, as the government strove to increase the share of wind power in the country's north region. As addressing climate change becomes a more salient socio-political challenge, such efforts can be expected to increase. Accordingly, it is important to characterize the perceived concerns among the general public about WT, including noise, shadow flickers and visual impacts, together with effects on land uses and birds.

The study concludes that noise pollution is considered to be the most significant anticipated impact among the public when it considers the full effects of WT. Among the various CE surveys of WTs preferences published to date, this study constitutes the first model that deconstructs the distance effects into separate attributes. The importance of high noise levels, relative to other attributes that correlated with distance (visual impact and shadow flickers) emerges as one of the main outcomes in our results. This point is especially relevant in places with a dearth of meaningful experience with operational wind farms where planners are considering optimal locations for siting WT.

Various countries have established guidelines for setback distance to avoid noise (Dai et al., 2015), but they are hardly uniform. While noise and setback distance generally are correlated, noise levels can also be influenced by background noises, wind direction and geographic conditions (Alberts, 2006; Wagner et al., 2012).

A flexible policy approach should therefore define threshold values for noise limits and consider location parameters inside settlements. Guidelines based solely on setback distance to avoid noise emission might miss these particularly salient environmental nuances, compared to a more narrow regulation and enforcement of WT noise levels. Using the findings from this research can contribute to sustainable policies, that maximize wind energy without degrading quality of life in surrounding communities. Paying attention to the site-specific nuances and what really undermines the social acceptance of wind turbines can lead to greater public tolerance and support.

In addition, the study reveals new perspectives about local acceptance in regions where wind energy has not yet penetrated the local markets. The lack of familiarity appears to inform our participants' responses, magnifying their anxiety about certain environmental impacts. It would be prudent for planning authorities and entrepreneurs to adopt an "overly-cautious" approach, especially for noise parameters, when they design and present new projects in communities unfamiliar with wind energy.

It would also be valuable if future studies enrich the discussion about public concerns and use the same methodology to focus solely on populations that live in close proximity to wind farms. Cognizant of the diverse factors that inform individual perceptions of WT, wind farm advocates, along with government planners and regulators should be committed to conducting on-site measurements in applying the precautionary principle' to address social concerns. Moreover, integrating the disparate responses of groups with contrasting demographic characteristic according to their perceptions can offer a richer basis for decision making and contribute to develop better public discourse and social acceptance.

The present study is of interest to countries whose planners are confronting the challenge of optimization of wind turbine locations. In jurisdictions like Israel, with tremendous access to the sun and only limited land resources, similar assessments of characterizing the externalities of solar power generation, would also be of great interest. Future research should characterize and contrast between the choice preferences of the public for the full range of renewable energy alternatives. This would provide decision makers with important information as they design climate change mitigation programs and set priorities.

Declaration of Competing Interest

The authors reported no declarations of interest.

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