Willingness To Accept Local Wind Energy Development: Does The Compensation Mechanism Matter?

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Abstract

Wind power development projects often include compensation for the affected communities, but little is known about the efficacy of the alternative compensation mechanisms. This study addresses this question by examining the relative potential of private and public compensation. We conduct a Choice Experiment (CE) that investigates household preferences of compensation for the local siting of a hypothetical wind park. Households chose among different alternatives, where each alternative was characterized by three varying attributes: the number of turbines, the level of private compensation, and the level of public compensation. Results indicate the wind park imposes welfare losses to local residents and non-local recreational users, with about 35% of these losses corresponding to non-use values. Findings show that households prefer public compensation to private compensation, with household's willingness to accept being lower with public compensation than private compensation. This finding suggests that estimates of local resistance to wind development depends on the compensation mechanism.

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1. Introduction

Wind energy has emerged as an important renewable energy source in recent years: Wind energy generation experienced a five-fold increase worldwide in the period 2005–2012 and currently contributes to about 2% of global electricity supply. In the European Union, 11.4% of electricity consumption was covered by wind energy in 2015 (EWEA, 2014a). Estimates indicate that in 2020 this figure will reach 12.8–17% (EWEA, 2014b). Analyses of greenhouse gases (GHG) concentration stabilization scenarios show that this figure ought to rise to between 13% and 25% by 2050 (Fischedick, 2011; IPCC, AR5). If the world is going to approach the ambitious temperature targets inscribed in the Paris agreement (UNFCCC, 2015), global emissions need to be reduced by between 70% and 95% by 2050 (IPCC, 2014). This will require a substantial increase in the deployment of renewable energy.

Despite fast deployment during the last decade, wind energy faces important challenges (Wiser et al., 2011). First, while production costs have decreased considerably in recent years, more substantial and predictable climate and renewable energy policies are required to spur investment in many regions of the world. Second, the variability and unpredictability of the wind resource, and its localized nature, poses important grid integration challenges. Third, issues related to social acceptance and local opposition continue to impede plans for expanded deployment. This article is concerned with this third challenge.

Whereas there is widespread public support for increasing renewable energy supply generally, and wind power more specifically, wind farm projects are often met with local resistance (e.g. Devlin, 2005 and Wiser et al., 2011). The development of wind power presents a clear conflict between the dispersed societal benefits and the concentrated local costs, and while the general benefits may dominate the local costs, wind development plans are often overturned because of local opposition. Wind farming has well-documented impacts on local communities, including degradation of scenic vistas and landscapes, noise, shadow flickering, as well as impacts on birds, and on other wildlife and ecosystems (Wiser et al., 2011). As wind development continues, it will increasingly encroach upon where people live, thus making local opposition an even greater challenge than it is today.

Environmental valuation studies have attempted to measure the external costs associated with wind development projects. This literature comprises hedonic pricing (e.g. Heintzelman and Tuttle (2012) and Jensen et al. (2014)) and stated preference studies (e.g. Aravena et al. (2014) and Landry et al. (2012)). As discussed in detail in Section 2, the bulk of these valuation studies report local welfare losses due to wind farm development. The derived estimates provide guidance to decision-makers on the local costs of siting decisions and social benefits of wind projects. They also indicate the appropriate level of compensation that developers may provide local residents to offset for the local impacts of a wind project, although navigating the ethical considerations of compensating local residents can be a challenge (Cass et al. (2010)).

Existing environmental valuation studies have a strong focus on the household's tradeoff between the negative impacts of wind farming and private compensation measures. While useful for several purposes, such an approach fails to address some relevant considerations. In particular, compensation to local communities does not have to be limited to individual payments. In some instances, the provision of a local public good can be a viable form of reparation to local communities—e.g., see Cass et al. (2010) and Cowell et al. (2011). Though given little attention in the literature, economic theory provides a rational for such compensation. In fact, public goods and local public goods are often under-supplied due to coordination problems and institutional failures, and it should be unsurprising that some individuals prefer this form of settlement. Compensation in this case occurs at two different levels: first, it corrects an institutional failure that prevents a local public good from being provided and, second, like private compensation, it increases overall welfare.

By implementing a stated preference approach in a local community in western Norway, this study aims to contribute to the understanding of households' tradeoffs between wind farming impacts and private versus public compensation. The paper proceeds as follows. Section 2 presents a discussion of the literature on local impacts of wind energy and the role of compensation to local communities. Section 3 introduces the particularities of our case study and the CE. Section 4 presents the econometric model. Section 5 presents results and Section 6 concludes.

2. Literature review

This section starts by reviewing the economics literature on the effects of wind farming in local communities. The studies include applications of the hedonic price method and stated preference methods. We also review some studies in the geography and environmental planning literatures that provide insights on the relationships between wind farming and local communities, and the role of public compensation as means for easing local opposition.

The literature on the effects of wind farming on property values is relatively recent and scattered. Using a large sample of property transactions, Heintzelman and Tuttle (2012) study the impact of wind facilities on property values in northern New York State in the United States (US). The authors report that proximity to a wind farm consistently reduces property values in two out of the three counties analyzed. The effects in these two counties were large and declined with distance. For a wind farm located 0.5 miles away, the property value is, on average, 8.8–15.8% lower. When the wind farm is located 3 miles away, the negative impact on property values is estimated to be 2–8%. The authors conclude that existing mechanisms, such as easement payments to individual owners, may have properly compensated those who allowed wind farm development on their properties but are unlikely to account for the harm caused to those living in the vicinity.[2] Using detailed data from Denmark on property values and wind turbine location, Jensen et al. (2014) estimate that visual impacts reduce property values by up to 3%, while noise reduces property values by 3–7%.[3] In a similar study using transactions data from Wales and England, Gibbons (2015) finds that wind farm visibility, on average, reduces property values by nearly 6% within 2 km, less than 2% between 2 and 4 km, and less than 1% from 14 km. In a recent study using data from Rhode Island (US), Lang (2014) found no effect of wind turbines on housing prices, though this study only considered single-turbine sites.

Krueger et al. (2011) implement a CE to estimate the costs to the residents of Delaware (US) caused by the eventual deployment of an already planned offshore wind farm. It was found that a near-the-shore development would cause considerable welfare costs to residents, especially those living close to the coastline. Landry et al. (2012) on the other hand implemented a CE experiment in North Carolina (US) and found the effects of coastal wind farming on local recreational visitation to be relatively small. Consistent with Krueger et al. (2011) two CE studies using data from nation-wide surveys in Chile (Aravena et al., 2014) and in Sweden (Ek and Persson, 2014), indicate that individuals prefer offshore, rather than onshore wind energy developments. Álvarez-Farizo and Hanley (2002) and Bergmann et al. (2006) implement CEs in Spain and Scotland and report that wind farm impacts on flora and fauna as well as on wildlife induced considerable welfare losses. A Swedish study that conducts a CE considers earmarking of the revenues for conservation measures (Ek and Persson, 2014). However, the study was targeted to the general public. As we have argued, opposition is most relevant at the community level where the negative impacts of development are salient and where development plans may be halted.[4]

A number of studies outside the environmental valuation literature and within a more qualitative tradition have emphasized that local compensation for negative impacts of wind energy may be private or public. Examples of private compensation are lump-sum payments and share of profits to property owners, and reduced power tariffs to local inhabitants. Cowell et al. (2011)

[2] Hoen et al. (2014) use a large sample of property transactions from nine States across the US and report no effects of wind farming on property values. The authors point out that a proportion of the data used in Heintzelman and Tuttle (2012) come from the period between the announcement of the wind farm and its construction and this ought to be given consideration when interpreting their estimations. Gibbons (2014) questions the conclusions reported in Hoen et al. (2014) the data set included very few transactions in the areas near wind farms.

[3] Sims and Dent (2007) use post-construction data on 919 house sales in three communities in UK and report significant price effects in one of the three communities. In an unpublished study Sunak and Madlener (2012) use data from two communities in Germany and 1405 sales and re-sales and report a reduction in property values within the range 21.5–29.7% for those properties located within 1 km from the wind farm.

[4] Hanley and Nevin (1999) and Bergmann et al. (2008) have considered welfare impacts of job creation in the wind farm construction processes. A number of studies indicate that local opposition and negative attitudes towards wind farming decreased over the operation life of the facilities (e.g. Devine-Wright, 2005). It should be noted, however, that negotiations between communities and developers are over deployment plans, prior to construction when local opposition may be highest and this is likely to have an effect on demanded compensation levels.

introduced the following typology of community benefits: (1) Community benefit fund based on lump-sum or regular payment, (2) direct (in-kind) investments in schools, sports facilities, environmental improvements, etc., (3) community ownership of shares of the wind project, and (4) local contracting and employment during construction and operation. Category 2 explicitly entails the provision of local public goods. Categories 1 and 3 may involve both private and public compensation, while category 4 involves private compensation to a limited number of residents. In a comparative study of six European countries, Toke et al. (2008) report that countries such as Denmark and Germany have been more successful at delivering benefits from wind farming to local communities and this may explain their larger deployment rates. In a study based on interviews in the UK, Cass et al. (2010) conclude that "The normative case for providing community benefits appears to be accepted by all involved, but the exact mechanisms for doing so remain problematic.".

Studies on the siting of waste disposal facilities offer insights that are worth noting. In a survey-based study from Chile, Claro (2007) shows that public support for the siting of a waste disposal facility was lower when cash payments were offered in a referendum question (6.5%), than when no compensation was mentioned (10.5%). Follow up questions indicated that this result was due to a large number of respondents that viewed monetary compensation as a form of bribery. Notably, when compensation in the form of a public good was offered, acceptability was highest (14.9%).[5] While the referendum questions used in this study are rather general, and are of limited applicability to wind farming, the results suggest that reparation may be more acceptable to some people if the compensation is in similar terms as the harm. Claro reasons that public goods – being collective - are more similar to environmental goods than private payments. The author also notes that attitudes may depend on cultural values, implying that the results of the study do not necessarily generalize to other cases.

Given the importance of compensation for acceptability of wind energy developments and the limited knowledge about the efficacy of different compensation schemes, a comparison of public and private compensation schemes is of interest to researchers and practitioners. Even if some studies have discussed the role of public and private compensation, there are, to the best of our knowledge no studies attempting to quantify the merits of these options, and in particular for wind development.

3. Local context: Wind energy in Norway

Due to a favorable topography and abundance of water resources, hydropower has dominated power generation in Norway -hydro accounts for about 97% of total electricity production (NVE, 2013). Norway is a net exporter of green electricity, with about 12% of its production sold to other Nordic countries and Northern Europe (NVE, 2013).[6] With increasing demand for renewable energy in the EU, the Norwegian Government has plans to build two new subsea interconnectors with Germany and the United Kingdom. The plans are, however, highly controversial due to expected higher electricity prices (e.g. Green and Staffell, 2014), and negative effects on local environments (e.g. Gullberg et al., 2014, Solli, 2010, Forum for natur og friluftsliv 2011).[7] Given these particularities, it is somewhat unsurprising that wind energy deployment plans are often met with local opposition.

The share of wind electricity production in Norway in 2013 was 1.5%, while in other Scandinavian countries such as Denmark and Sweden wind accounted for 33% and 7% of total electricity production (IEA, 2013). However, the Norwegian government has started to follow the example set by its Scandinavian neighbors in supporting the development of wind power. The southern and western provinces along the North and Norwegian Seas have considerable wind energy resources (e.g. Hofstad et al., 2005).

Before the introduction of the green certificates market in Norway (in collaboration with Sweden) in 2012, selected wind energy developments in the country received direct support from the government (IEA, 2013). In 2013 Norway had 20 functioning energy farms with 356 windmills (IEA, 2013). Over the years, the Norwegian Water Resources and Energy Directorate (NVE) has kept a detailed register of all windfarm licenses applied for. It shows that about half of wind projects are actually realized. The other half of wind development projects have been declined by NVE or withdrawn by developers due to either local opposition or other reasons. See Fig. 1 for a geographical distribution of existing wind farms and declined wind farm license applications as of January 2016; see also Vindportalen (2014).

4. Choice experiment

To investigate household preferences we conducted a Choice Experiment (CE) that considered the siting of a hypothetical wind park in Sandnes, Norway (see Fig. 1). Sandnes has about 71,900 inhabitants and an area of 286 Km^2. A number of criteria were used to choose this municipality and the exact location of the wind farm. These included, in order of importance, wind farming potential- based on detailed information on wind farming projects in Norway generally and nearby areas especially,[8] viability of the wind farming project so it would appear realistic to respondents, and impact on local communities in terms of visual impacts mainly. The hypothetical wind farm was located in an area that has traditionally been used for hiking and for other recreational purposes by area residents. The wind farm sits in the administrative area of Riska,[9] on the hills to the east of the Frøylandsvatn lake, about 1 km away from road 516. Road 516 connects Hommersåk, Riska´s main urban area with Sandnes´ main urban settlement (also known as Sandnes). Hommersåk is located 2 km north of the wind farm and 12 km north of Sandnes town center. The wind turbines would be visible from this road and from most areas in Hommersåk.

The experimental design was informed by informal discussions with local inhabitants and results from a small pilot survey with 31 respondents. We employed the professional survey company Ipsos to implement an on-line survey on a sample of households located in Sandnes. Our sampling strategy divided the population of Sandnes into two subpopulations: households living close to the wind farm (in Riska) and households living elsewhere (not in Riska). As discussed earlier, the former group (which has a much smaller population) was over-sampled as we sought to get sufficient variation in the data to investigate location effects. Virtually

[5] Kunreuther and Easterling (1996) note that different types of compensations can be effective for siting facilities such as landfills, but do not work well for in the case of nuclear waste repositories.

[6] In short periods of low hydropower production in winter, Norway might have a net import of power.

[7] The Forum for natur og friluftsliv, adopted the following position: "We have enough energy in Norway. The potential for energy efficiency and energy recycling is vastly under-utilized. It is naive to believe that we can be Europe's green battery". It should also be noted that the expansion of hydro capacity has become increasingly difficult due to physical and environmental regulatory constraints.

[8] Confer NVE's database on all existing and planned windfarm projects at https://www.nve.no/konsesjonssaker-og-hoeringer/

[9] Riska has about 6555 inhabitants and is one of the 13 administrative areas of Sandnes.

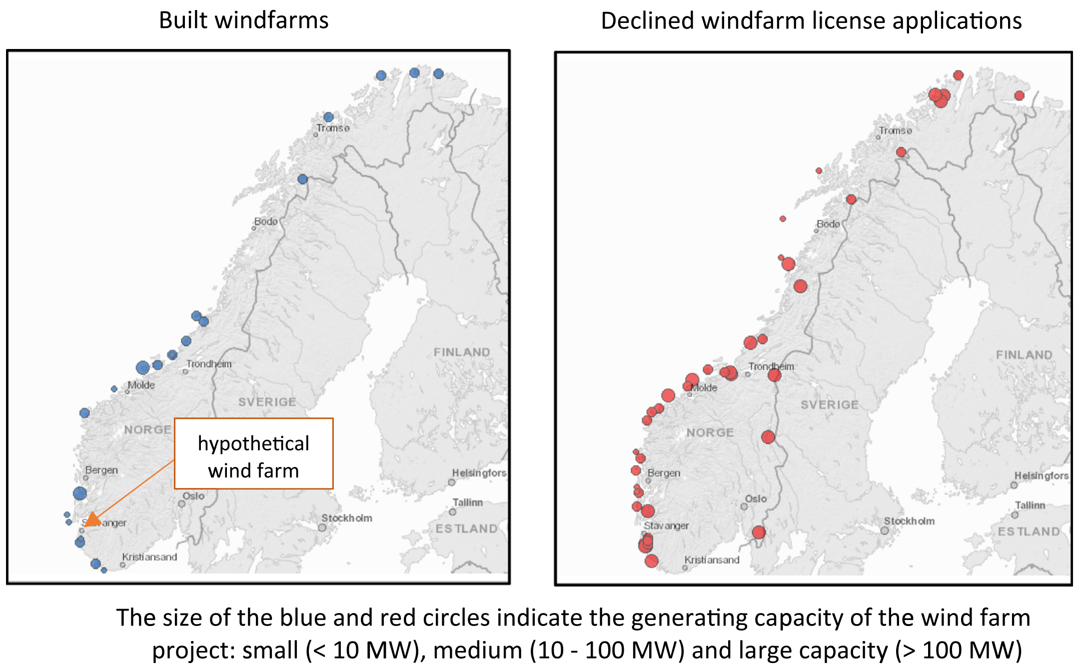

Fig. 1. Location of windfarms in Norway (and location of hypothetical windfarm). Built windfarms. Declined windfarm license applications. The size of the blue and red circles indicate the generating capacity of the wind farm project: small (< 10 MW), medium (10–100 MW) and large capacity (> 100 MW).
Source: Norwegian Water Resources and Energy Directorate (NVE): http://gis3.nve.no/link/?link=vindkraftverk The maps were retrieved in January 10, 2016.

Fig. 2. Example of a choice situation.

all households in Riska were contacted by phone, while recruitment of the remaining respondents was assisted by a random-dialing system.

The questionnaire consists of three sections. The first section starts with demographic questions on general socio-economic characteristics, followed by warm up questions on general knowledge and perceptions of wind power. The second section contains the core of the questionnaire, namely the CE. It starts with a scenario description (see Annex) that contains two maps showing the location of the wind-park as well as written and graphic descriptions of the different attributes of the wind park and the compensation mechanisms that may be implemented. The scenario description makes it clear that the wind farm is hypothetical. It explains that the windmills to be used are 90 m high and that the visual impact they may have will depend on the number of windmills and how they are placed in the terrain. It also briefly mentions that larger wind farms emit more noise and have a greater impact on birds and other wildlife. The scenario is followed by 10 choice situations. The third section contains follow up questions related to the attributes used in the CE.

Each choice situation consists of 2 alternatives, each one characterized by three characteristics: the number of turbines (visual impact), the level of deduction on household electricity bill (private compensation), and the size of community sports facility (public compensation. See Fig. 2 for an example of a choice situation. Given the CE's focus on energy, a deduction of the electricity bill is an appropriate payment vehicle for private compensation. The decision on the type of public compensation was based on an analysis of local needs and a study of the municipality's budget plans. While local governments in Norway have sometimes provided local sports facilities of the type considered in our experiment, it is often the case that existing facilities get overcrowded in peak-hours and the installations and equipment are old -the sports facility is an impure public good but the comparisons public vs private compensation remains..

Construction of the wind project was an alternative in all the choice sets. This design feature emerged from the pilot study, which revealed that only one individual out of 31 preferred the status quo—i.e., no project. The near universal choice for wind farm scenarios may be due to preferences, but considering decisions involving public interests are often centralized in Norway, it may stem from a desire to express preferences for an exogenously determined project. The levels of the private compensation attribute were 0, 400 and 800 NOK reductions in electricity bill per year per household for 20 years (1 USD =6.1 NOK at time of survey). The survey explains that 400 NOK and 800 NOK corresponds, respectively, to about 15% and 30% of the annual electricity expenditure of a typical Norwegian household. The levels of public compensation were *no* sports facility, *small* sports facility and *medium* size sports facility. To recreate the impact of the hypothetical interventions, Photoshop visualizations were used. These recreated what the wind farm would look like from road 516 as illustrated in Fig. 2. The levels of the wind farm development were 9 and 18 wind turbines.[10] With these three attributes and attribute levels, a total of 146 choice sets can be generated. The choice sets were drawn using a complete enumeration method that optimizes orthogonality while ensuring balance and minimizing overlap.

[10] Using information from recently built wind farms in Norway (Vindportalen, 2015) a wind farm consisting of 9 wind turbines would have a capacity of about 30 MW, and can provide 4000 households with electricity. With a 25% utilization rate the windfarm can produce 65 GWh (=30 MW *[8760 h]*[0.25]*[1 GW/1000 MW]) which would be enough to supply 4000 Norwegian households with electricity (=65 GWh *[1′000000 KWh /1 GWh]*[1/16000 KWh] households.

5. Econometric model

The CE experiment methodology relies on the idea that individuals derive utility or satisfaction from the attributes of a good (or an alternative), rather than utility from the good itself (or the alternative itself). This approach to consumer theory was first introduced by Lancaster (1966) and, was later operationalized in econometrics in the Random Utility Model (RUM); McFadden (1974). Using a RUM approach, we assume that the utility of household h from choosing alternative $k = A, B$ in choice set $n = 1,2, \ldots, 10$ is given by the following linear relation:

$$\begin{aligned} V_{hkn} = {} & \alpha_h \times \#\,\text{WIND TURBINES}_{kn} \\ & + \beta_h' \times [D_h \times \#\,\text{WIND TURBINES}_{kn}] \\ & + \gamma_h \times [Y_h + \text{PRIVATE COMPENSATION}_{kn}] \\ & + \delta_h \times \text{PUBLIC COMPENSATION}_{kn} + \varepsilon_{hkn} \end{aligned} \tag{1}$$

The first two terms indicate the household's (dis)utility from wind farming is a function of the number of wind turbines deployed and other observable factors included in vector D_h. Specifically, $\mathbf{D}_h' = \left[d1_h, d2_h\right]$ where $d1_h$ takes the value of 1 when the household is located in the proximity of the wind farm, that is in Riska, and $d2_h$ is 1 when the household uses the development area for recreational purposes. Using a similar notation we have that $\boldsymbol{\beta}_h' = \left[\beta 1_h, \beta 2_h\right]$. The third term represents private consumption and has two components: household's income Y_h and private compensation in terms of reduction of the household's electricity bill. The forth term represents the utility derived from the consumption of a public good, or public compensation which in our case takes the form of a sports facility. The stochastic component ε_{hkn} is assumed to be i.i.d. and to follow a type 1 extreme value distribution. We implement a random parameter logit (RPL) model that controls for unobserved household heterogeneity by allowing the set of parameters $\boldsymbol{\beta}_h$ to vary. The basic presumption is that there is heterogeneity in preferences for wind farming that we are not explicitly controlling for; e.g. Carlsson et al. (2010) and Cherry et al. (2014). Household h chooses alternative A over alternative B whenever $V_{hAn} > V_{hBn}$. The model was estimated using simulated maximum likelihood with Halton draws with 500 replications (see Train, 2003). The econometrics package used was NLogit5.

We estimate the marginal WTA for compensation as the ratio of the relevant attribute coefficients and the marginal utility of income γ (Hanemann, 1984). Specifically,

$$\text{Marg. WTA Private Compen.} = \frac{\alpha + \beta 1 \times d1 + \beta 2 \times d2}{\gamma} \tag{2}$$

$$\text{Marg. WTA Public Compen.} = \frac{\delta}{\gamma} \tag{3}$$

We estimate four Marginal WTA terms for private compensation, depending on whether the household is locate in Riska ($d1=1$) or not ($d1=0$) and on whether the household uses the area for recreational purposes ($d2=1$) or not ($d2=0$). Regarding public compensation we estimate two Marginal WTA terms as our choice experiment includes two types of sports facility, small and medium, and they are included in the econometric model as two dummies.

6. Results

A total of 802 respondents completed the on-line survey, for an overall response rate of 41%. 208 respondents, 25.9% of the sample, were located in Riska and 594 in other areas of Sandnes municipality. 41% of respondents were female while the educational

Table 1
Descriptive statistics. N=802.

Variable	Description	Mean (Standard deviation)		
		Riska N=208	No Riska N=594	Pooled sample N=802
# of Wind Turbines	Number of wind turbines Levels: 9,18	11.41 (3.99)	12.40 (4.36)	12.14 (4.29)
Riska	1 if household is located nearby wind park	1 (0)	0 (0)	0.259 (0.43)
Use area	1 if respondent uses win-park area for recreational purposes such as hiking	0.690 (0.46)	0.522 (0.500)	0.566 (0.496)
Rebate	Yearly electricity rebate Levels: 0, 400, 800 [NOK/yr]	434 (324)	448 (319)	445 (320)
Sports facility small	1 if small size sports facility provided	0.348 (0.477)	0.343 (0.475)	0.345 (0.475)
Sports facility Medium	1 if medium size sports facility provided	0.382 (0.486)	0.400 (0.490)	0.394 (0.488)

Table 2
Results of the random parameter logit model.

Description	Coefficient	Standard error
Constant	0.06830**	0.02974
# of Wind Turbines	−0.03970***	0.00513
# of Wind Turbines × Riska	−0.07441***	0.01952
# of Wind Turbines × Use area	−0.06509***	0.01269
Rebate	0.00078***	0.00008
Sports facility medium	0.75626***	0.07504
Sports facility small	0.47167***	0.05647
Coefficient standard		
# of Wind Turbines	0.01296	0.12477
# of Wind Turbines × Riska	0.10197*	0.05987
# of Wind Turbines × Use area	0.14505***	0.03845
Pseudo R-Square	0.131	
Number of observations	7990	

Note: *Significant at10% level; **significant at 5%. ***significant at 1%.

attainment was 56% university or technical degree, 37% high school, 5% secondary school (1% did not respond).[11] Before a brief introduction to wind energy was provided, individuals were asked about their knowledge of wind energy. 73% of respondents stated that they understood wind energy well or very well, 25% stated that they did not understand it very well, and 2% did not understand it at all. While 24% of the sample indicated to be very worried about global warming, 51% indicated to be a little worried.[12] 92% of respondents stated that they were either always or sometimes in charge of paying the electricity bill in their household, suggesting a high degree of familiarity with the payment vehicle used for private compensation.

Table 1 presents descriptive statistics of the variables used in the empirical analysis. Respondents living in Riska chose the smaller wind park (9 wind mills) over the larger wind park (18 wind mills) more often than respondents located in other areas. 56% of the respondents use the area where the wind park would be located for recreational purposes such as hiking. While 68% of the residents of Riska stated that they used the area for recreation, 52% of the residents of Sandnes not living in Riska also did so. This implies that 71% of the sample is directly affected by the hypothetical wind farm in the sense that they either live in the neighboring area and/or use it for recreation. The data reveals that those living in Riska chose alternatives with lower compensation slightly more often than those not leaving in Riska. However, this cannot be taken as evidence that they would demand lower compensation for a given intervention. As stated above, these households tended to choose options with the smallest wind park development.

6.1. RPL estimations

Table 2 presents results for the RPL model. The CE was generic and the only alternative specific parameter in the model was a constant for alternative A, which always appeared on the left hand side of the choice set. The constant parameter turned out to be positive and significant indicating that individuals tended to choose this alternative more often. All the attributes have a significant effect on choice in the expected direction while two out of three random parameters were significant.

Estimation results show that Sandnes residents prefer wind parks with a lower number of windmills and less visual impact. Preferences, however, vary depending on where the household is located in relation to the wind park and on whether respondents make use of the intervention area for recreational purposes. In particular, those living nearby the wind farm (in Riska) and/or those using the intervention area for recreational purposes expressed stronger preferences against the proposed wind park. At the same time, the parameters of the two suggested compensation mechanisms, namely the electricity bill rebate and the provision of a local public sports facility, are positive and significant. Respondents would thus allow relatively more intrusive wind farm developments if sufficient compensation is provided.

6.2. Willingness To Accept (WTA) wind farming

Tables 3 and 4 present estimated WTA wind farming in terms of private compensation (NOK/year) and in terms of public compensation (sports facility). Standard errors were calculated using the delta method. Table 3 shows that the mean WTA an extra wind turbine in the proposed intervention area is 50.84 NOK per year. This figure applies to individuals that neither live in the nearby area of Riska nor use the affected area for recreational purposes and thus provides an indication of the non-use value of the intervention area to the individual. It should however be noted that most Sandnes residents would occasionally get to see the effects of the wind park on local landscapes, in particularly when traveling

Table 3
Mean Marginal WTA [NOK / Year / Household].

Description	Coefficient	Standard error
# of Wind Turbines	−50.84***	6.611
# of Wind Turbines × Riska	−95.29***	21.576
# of Wind Turbines × Use area	−83.36***	13.350
Sports facility medium	968.46***	80.106
Sports facility small	604.02***	64.230

Note: *Significant at 10% level;**significant at 5%; ***significant at 1%.

[11] According to Statistics Norway the percentage of the population in Sandnes (above 16 years old) in 2015 having higher education (long or short university/college education) is at 32.7%. Thus, there is some bias towards higher education among the respondents. This points out that, as with other online surveys and convenience samples, the survey sample may not be representative of the population along some dimensions. This may affect the absolute point estimates but should not affect the results of interest—the treatment effects and the relative comparison between private and public compensation.

[12] 83% of respondents stated that wind energy was important for Europe while only68% stated that it was important for Norway. Although no question regarding the importance of wind energy for Sandnes was asked, it seems reasonable to expect lower figures in this case.

Table 4
MRS Wind Turbines – Public Compensation.

Description	Coefficient	Standard Error
Sports facility medium	-0.0525^{***}	0.00651
Riska	-0.0984^{***}	0.02216
Use area	-0.0861^{***}	0.01356
Sports facility small	-0.0842^{***}	0.01185
Riska	-0.1578^{***}	0.03732
Use area	-0.1380^{***}	0.02354

Note: *Significant at 10% level;**significant at 5%; ***significant at 1%.

to the northern part of the municipality. As mentioned earlier the wind park lies only 10 Kms north of the most densely populated area in the Sandnes municipality.

If the individual uses the area for recreational purposes (but does not live in Riska) the WTA more than doubles to 134.2 NOK per year. If the respondent lives in the Riska area (but does not use the area for recreation) the WTA is somewhat larger, 146.13 NOK per year. Notably the welfare losses experienced by a recreational user and by a local resident are of the same order of magnitude. The result suggests that the deployment area provides significant recreational services to Sandnes residents and it points to the need to consider factors that go beyond proximity to the intervention area in welfare analyses of wind farming. When the individual both lives in Riska and uses the area for recreational purposes the mean WTA is 229.49 NOK per year, or about 4.5 times the WTA of Sandnes residents that neither live in Riska nor visit or use the area for recreation. This finding provides an estimate of the ratio between the use and the non-use value of the intervention area to the average Sandnes resident.

The lower panel of Table 3 shows measures of WTA in terms of local public sports facility. The two parameters are positive, indicating that this attribute increases individual utility. While the focus of this article is not on these parameters, they offer some insights on whether estimates are reasonable. The sports facility was described as containing a sports field and a gym. The results reveal that respondents, on average, would forgo 968.46 NOK per year to have access to a medium size sports center and 604.02 NOK per year to have access to a small size sports facility. These figures compare favorably to actual gym membership prices. A one-year subscription in a large and fully equipped gym in Sandnes costs about 3000 NOK per year, is consistent with the estimate after considering that our estimates reflect the entire population while membership prices reflect only the residents with the highest values for participation. Since the sports facilities were presented in very general terms in the scenario description, individuals might have also been uncertain about the quality of equipment and service as well as the actual location of the facility. We also note that the attribute sports facility (medium size) was the only attribute with relative large and significant taste heterogeneity; see Table 1.

Table 4 shows that Sandnes residents not living in the Riska area and who do not use the intervention area for recreational activities, would accept the deployment of an extra wind turbine for 5.3% (8.4%) of a medium (small) sports facility. If the respondent uses the area for recreational purposes (but does not live in Riska) he or she would demand 13.9% (22.2%) of a medium sports facility. As a reflection of the fact that the welfare losses of local residents and of recreational users are similar, we find that when the respondent lives in Riska (but does not use the area for recreational purposes) he would demand 15.1% (24.2%) of a medium (small) sports facility. If the individual both lives in Riska and uses the area for recreation he would demand 23.7% of a medium sports facility and 38% of a small sports facility. As expected, the group that is most impacted by the windfarm demands the highest levels of provision of the local public good.

Table 5
WTA an extra wind turbine [NOK/Year/household].

	Riska	No Riska
Private compensation		
Use area	229.49 [n=1486]	134,20 [n=11326]
Don't use area	146.13 [n=699]	50,84 [n=10455]
Public compensation		
Medium size sports facility	59.50 [n=23966]	
Small size sports facilities	33.40 [n=23966]	

Note: WTA measures for private compensation are derived from Table 3 estimates while those for public compensation use Table 4 estimates, population data and costs of providing sports facilities of two sizes.

To draw some comparisons between private and public compensation mechanisms, we monetize the alternatives using some simple calculations (see Table 5). Constructing (including land purchase) and equipping a medium (small) size sports facility in Sandnes would cost around 60 (25) Million NOK -this cost estimate is based on investment plans for sports facilities (halls) of various sizes in a number of Norwegian municipalities. Assuming a standard 20 year operating period with annual operation costs of 3% of initial overnight costs and an annual 3% discount rate, the cost of a medium (small) size sports facility is 5.7 (2.4) million NOK per year. With 23,966 households in Sandnes, the cost per household of a medium (small) facility is 238 (100) NOK per year. From the results, Riska residents (the group most negatively affected) are willing to accept 23% (38%) of a medium (small) sports facility for the deployment of an extra wind turbine. Thus, numbers suggest the cost of providing the marginal increment of a medium (small) facility to offset the deployment of an additional wind turbine is about 59.5 (33.4) NOK per year.

Table 5 shows that WTA in terms of private compensation is typically higher than the WTA in terms of public compensation. Only the group of households living outside Riska that do not use the deployment area for recreation have a lower WTA in terms of private compensation than in terms of public compensation in the form of a medium size sports facility. The apparent preference of public over private compensation is reinforced by the fact that while the estimated private compensations would leave all groups of residents indifferent, public good compensation would leave recreational users living in Riska indifferent while all other Sandnes residents would be better off.

7. Conclusion and policy implications

In this study we used a stated preference approach to examine the welfare impacts of wind farming in the municipality of Sandnes, Norway. We found that the welfare loss experienced by a household located in the vicinity of the wind farm (<4 km) is only slightly higher than that experienced by a household who uses the deployment area for recreational purposes (but lives farther away from the deployment site, typically >10 km, or local recreational users). About 35% of the welfare losses experienced by these two types of households are non-use values. Our results highlight that while there has been an emphasis on impacts on local communities, non-NIMBY (not-in-my-back yard) factors such as recreational and non-use values may be significant and should be given explicit consideration in the welfare analysis of wind farming.

These results are based on willingness to accept measures that are typically used in the environmental valuation literature. We have emphasized and explored the possibility that compensation does not have to be restricted to individual payments (or private compensation). It may also take the form of providing a local public good (or public compensation). We found that local residents would trade lower levels of private compensation for higher levels of provision of a local public sports facility. Further, the cost of compensating for people's welfare loss from an extra wind turbine in terms of the local public good appears to be generally lower than in terms of private compensation. The result is particularly important as it suggests that welfare measures derived in the environmental valuation literature, may over-estimate local resistance to wind energy development.

Among the reasons why compensation in the form of a local public good should be given explicit consideration as a form of compensation in wind farming include: 1) Local public goods are often under-supplied and have the potential to generate considerable individual and communal welfare gains. 2) Reparation may be more acceptable to some people if the compensation is in similar terms as the harm -public goods – being collective - are more similar to environmental goods than private payments-. 3) Open availability to the community of local public facilities allows coverage of a large number of households. 4) Wind energy developers may serve as possible facilitators in the process of coordinating contributions to a local public good or service. Based on the significant economic, social and ethical considerations involved in the choice between providing private or public compensation, we believe the issue should be explored further.

While our study represents a step forward in our understanding of compensation mechanisms in wind energy deployment, it has some limitations. Our estimates are affected by the particular context in which the study was carried out. An important share of additional renewable energy produced in Norway will be exported to Europe and opposition to development plans is particularly high among certain groups. In countries and regions where renewable energy is to be used locally to a larger extent, residents may be more prone to support deployment plans. Thus in order to have a more complete picture on the trade-offs between private and public compensation, it is important to undertake similar studies also in other relevant contexts. Our study used a rather neutral scenario description. It would be interesting to investigate how the results would change when different framings, e.g. an environmental or pro-social frame, are considered. How private and public compensation compare with complementary approaches, such as those including community ownership of shares in the wind projects, may be addressed in future studies. Future efforts may also consider the interplay between compensation mechanisms and the ethical considerations that often exist in the siting processes and decisions.

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ANNEX. Scenario description

First screenshot

This section introduces a **hypothetical case** of a wind farm that is to be built in Sandnes municipality. After an introduction of the hypothetical wind farm, you will be asked to make a number of choices where the characteristics of the wind farm vary.

The wind farm is to be located in the northern part of the municipality (see the red star below in Map 1). Due to favorable wind conditions, the wind farm is to be placed in a steep area to the east of Frøylandsvatnet.

Map 1: Location of hypothetical wind farm (zoomed in)

Visual impact

The windmills to be used are 90 m tall. The visual impact will depend on the number of windmills and the way they are sited in the landscape.

Two alternative development plans are under consideration: The first plan contains **9 windmills** with a relatively small visual impact, whereas the second plan contains **18 windmills** and has a greater visual impact. Larger wind farms are typically noisier and have higher impacts on birds and other wildlife.

Second screenshot

The following three pictures show the view from highway 516 without a wind farm, with a small wind farm (with 9 wind turbines) and a large wind farm (with 18 windmills). The pictures were taken one kilometer from the site of the wind farm.

[The three pictures were included in the survey. See Fig. 2 *for two sample pictures. A map similar to Map 1 above showing where the pictures were taken from was included]*

Third screenshot

Compensation

Wind farms could be well visible in the landscape. In order to compensate the residents of Sandnes for any negative effects that might arise from a wind farm, two compensation mechanisms may be implemented:

a) A yearly **electricity bill rebate** to each household. The electricity bill will be reduced by a fixed amount every year for the following 20 years. The household electricity bill can be reduced by:

400 NOK per year.

800 NOK per year.

For an average Norwegian household consisting of 4 people the amounts correspond to around 15% and 30% of the total annual grid rental.

b) The construction of **a sports facility** for the residents of Sandnes. The sports facility will consist of sports-field and a gym. The sports facility can be of two different sizes:

Small: A small sports-field and gym.

Medium: A medium size sports-field and gym.

[*Sports icons were included in the survey as visual aid. See* Fig. 2].

Fourth screenshot

We would like to study your attitudes towards the construction of a wind farm as described above.

In what follows you will be presented with 10 different choice situations. In each choice situation we will ask you to choose between two alternatives for constructing the wind farm. The two alternatives vary with regard to size of the wind farm and the level of compensation to your household and your community. **Some alternatives will not offer compensation.**

After you have chosen between one of two alternatives for construction, you will be asked whether you would accept the development as described in the alternative you chose.

Important: Please treat each choice situation as being independent from the others.

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