

**Review
Article**

Stated Public Preferences for On-land and Offshore Wind Power Generation—A Review

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With the increasing number of on-land turbines and the increasing size of the individual turbines, on-land locations for wind power development have become more difficult to find in an increasing number of countries. In the literature and the public debate, these on-land siting difficulties are often put forward to be related to the perceived environmental costs of wind turbines. However, offshore wind power generation might be a solution to this problem, if the perceived environmental costs are smaller offshore compared with on-land. Based on a review of seven papers focusing on the preferences and willingness to pay for different wind power development sites, people in different countries generally seem to hold significant preferences of offshore wind power development when compared with different types of locations on-land. However, the preferences for offshore wind power development seem to be dependent on the specific place of location offshore. This points towards the fact that offshore locations potentially can have higher environmental costs than on-land locations. However, the preferences for offshore locations strongly indicate that the environmental costs can be significantly reduced by the location of offshore wind farms at large distances from the coast. Copyright © 2008 John Wiley & Sons, Ltd.

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Introduction

As a consequence of the ratification of the Kyoto Protocol, a substantial number of countries are committed to reduce the emissions of greenhouse gases. Aside from actual reductions in the consumption of energy, one of the strategies to achieve the reductions is the investments in the renewable energy sector, such as wind power development. However in some countries it is difficult to find appropriate locations for on-land development of wind farms without compromising the well-being of the population living in the areas designated for wind turbine development.

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* Furthermore, with the rapid change in technology and especially turbine size, this problem might also become evident in countries/regions with presently few on-land turbines. On the other hand, based on the positive experience from offshore wind farms in the 1990s and the beginning of the new millennium in the UK, Denmark, Holland and Sweden, offshore wind power generation is expected to have a large if not a dominant role in the future wind power development.

The overall choice of on-land and offshore development strategy must naturally be seen in relation to the costs and benefits to society associated with the specific choice of location. In a welfare economic perspective, these costs and benefits do not only cover those associated with actual transaction between agents in the economy, such as development, generation and other capital costs. The costs and benefits also include external costs and benefits to society, which—though not supplied through a regular market—have a significant influence on the wellbeing of people.^{3,4}

More precisely, even though wind power from a life-cycle analysis point of view is a cleaner technology,^{5–7} wind power generation is associated with potential impacts on the environment, such as landscape disamenities,^{8,9} impacts on the wildlife¹⁰ and noise effects,¹¹ i.e. external costs.

Accordingly, alternative locations and settings (size and grouping of turbines) will probably differ not only with regard to the capital costs of wind power generation, but also with regard to the external costs. As such, the dimension of the external costs can have a strong influence on the economic attractiveness of wind power generation.¹² Consequently, different wind power development locations will have different economic profiles. Therefore, the assessment of the optimal locations of wind turbines might not be clearly evident without an in-depth analysis of the capital costs and benefits as well as the monetized measures of the externalities.

In the literature, questions regarding the feasibility of offshore compared with on-land development and where and how to develop offshore have emerged both in the political and the public debates. As a response, several studies have analysed the attitudes and perceptions towards wind power in general and towards wind power on-land and offshore, specifically see studies by Bishop and Miller, Firestone and Kempton, and Ladenburg,^{13–16} and, for a good review of the literature, Krueger.¹⁷ However, in a welfare economic framework the assessed level of attitudes and perceptions are very hard, if not impossible, to convert into monetary measure and thereby use them in an economic analysis of optimal locations for development.[†]

The aim of the present study is therefore to give a novel contribution to the literature by a review of the economic valuations studies available, which focus on the demand and willingness to pay for locating wind farms at different on-land and offshore locations. The study is structured as follows: first, a short introduction is to be given to economic valuation of non-market goods with a focus on the impacts from wind turbines. This is followed by the review, discussion and concluding remarks.

Economic Valuation of the Disamenities from Wind Power Generation

Unlike ordinary goods, external impacts from wind power generation, such as a decrease in the environmental quality, cannot be purchased on a regular market. As a consequence, the demand for reductions in these impacts

*As remarked by one reviewer, this problem might also be related to the reduced possibilities to own a wind turbine (at least in Denmark).¹ These statements are supported by Krohn and Damborg,² who reported, from an attitude study carried out in an area in Denmark with a high density of wind turbines, that co-owners of wind turbines were more positive towards wind turbines when compared with people with no economic interests. Accordingly, benefits (good feelings from producing renewable energy, economic incentives, feeling of community spirit, etc.) from owning/co-owning a wind turbine might increase the acceptance of the environmental benefits. Consequently, ownership as a means to reduce the sensitivity towards environmental impacts might have a positive influence on the attitude and acceptance of wind generation projects. However, unless the influence of ownership with regard to the acceptance of wind turbines is site specific, the 'ownership effect' would be expected to be constant between locations and thus 'cancel out' in the assessment of potential differences in the environmental costs between different locations, as carried out in the studies in the present review. Though, the issue is highly relevant from a policy and implementation point of view and calls for future research, it is beyond the scope of the present review to go further into detail on this subject.

[†]In this line, Ladenburg¹⁸ finds that stated *attitudes* and *preferences* towards visual impacts from offshore wind farms appear to reflect different levels of perceived visual disamenities in the sample population.

cannot be extracted from the observed market transactions. In the field of environmental economics, solutions to this problem have been previously explored by the development for different types of economic valuation techniques.^{3,4} These techniques have been applied in many different settings to elicit individuals' (latent) willingness to pay (WTP) for non-market goods, such as environmental quality and landscape amenities, or, as in the focus of the present paper, the avoidance of disamenities such as the visual intrusions from wind turbines.

Generally, the methodological approaches to economic valuation can be divided into methods relying on observed behaviour on a market where a market good is confounded with one or several environmental goods, also known as revealed preference methods (RPM) and methods based on stated hypothetical behaviour, i.e. stated preference methods (SPM).

With regard to wind power development, the RPM studies in the literature have mainly focused on the relation between property price and the density of turbines in the neighbourhood, referred to as the house price method (HPM). In the HPM studies, it has been tested if the presence of wind turbines in the landscape is reflected in terms of differentiated residential property prices on the market.^{19–21} These investigations did not reveal unambiguous statistically significant effects on property prices from adjacent wind turbines.^{20,21} The results from the HPM studies all relate to on-land turbines. The HPM studies are therefore perceived to be less relevant in relation to the present review.

Focusing on the SPM, the contingent valuation method (CVM) and choice experiments (CE) are the most applied methods. In short, CVM stipulates a hypothetical scenario for the preservation or provision of a non-market good. Having explained the characteristic of the service, the rules of provision, method of payment, etc., respondents are asked to state their willingness to pay (e.g. through taxes) for the benefit in question. Whereas CVM has a holistic focus on specific scenario, CE examines the response of individuals to changes in the attributes of a scenario—for example, different layouts of a wind power programme with respect to size and siting of wind farms. CE then examines the trade-offs made by individuals when choosing between different attribute profiles including electricity prices or taxes to be paid.

Both methods have been used to estimate the demand for environmental qualities in relation to on-land wind turbine projects.^{8,9,22,23} Together with the RPM studies, they have given some important insights of the type and level of the potential external costs associated with on-land turbines. However, as in the case of the RPM studies, it might not be valid to generalize the results also to cover the external costs of offshore wind farms. In the following section, the studies relating offshore wind farms are reviewed.

On-land versus Offshore Wind Power Generation

In the literature three studies have analysed the preferences for location of wind turbines offshore compared with different types of on-land locations in three different countries. In the next three subsections, these will be presented and their results discussed subsequently.

***Aravena et al.*²⁴**

The economic valuation study was carried out in Chile. Using the economic valuation method CE, the primary aim of the paper was to test the impact on preference by different specification of the price vector using the case of the preferences for wind farm projects located at different sites in the VIII administrative region. In the survey 300 respondents from the metropolitan area of Concepcion (south of the capital Santiago) were randomly sampled. To elicit the preferences for different sitings, each of the respondents were asked to make 12 pairwise choices between different wind power projects. The wind power projects differed with regard to the location of the wind farm, i.e. offshore, along the coast, inland and in the mountains. With this set-up, it would be possible to test if the location of the wind power project affects the choice of project and thereby the potential difference in perceived environmental costs between locations. Besides the label of location (offshore, along the coast, inland or in the mountains), the locations were *not* geographically specified to a

specific area. To the author's knowledge, pictorial stimuli were not used to guide the respondents with regard to the landscape impacts of the four types of location, though the use pictorial stimuli to increase the realism of the hypothetical scenario are highly recommend in studies focused on for example air visibility levels.²⁵ The economic valuation of the preferred location of the wind power projects was thus based solely on the respondents *prior* information[‡] regarding the perception of the environmental impacts associated with wind turbines at different locations. In addition to the location attribute, the wind farm projects also varied with regard to the total area covered by wind turbines (300, 500 or 800 football pitches), impact on bird population (1, 3 or 5% of the population) and the costs of electricity. The costs were defined as being a fixed monthly payment. To the author's knowledge the wind power projects were not specified with regard to the wind power capacity (kW, MW).

It would have been interesting to test for potential site specific effects relating to the total area covered and impacts on the bird population. However, in Aravena *et al.*²⁴ the impact on the birds and total area covered attributes were not interacted with the location attribute. It is therefore not possible to infer to the potential influence of the total area covered and impacts on the birds on the preference for locations. These attributes are therefore reported further on.

Applying an analytical model, which can handle variance in the preferences, i.e. random parameter logit model,²⁷ the results demonstrate that, when controlling for potential impacts on birds and the area total covered, offshore locations significantly are preferred to coastal, inland and mountain locations, respectively. Or stated differently, the respondents are willing to pay an extra premium via an increase in the electricity bill for having the wind farms located offshore as opposed to on-land locations. This premium was estimated to be between 340–356 Chilean pesos[§] (CLP) for locating the wind farms offshore compared with on-land, 373–436 CLP for locating the wind farms offshore compared with locations in the mountains and finally 367–490 CLP for locating offshore compared with coastal location. Assuming that these differences in costs are correlated with the differences in perceived environmental impacts, the estimated levels of WTP suggest that environmental costs of offshore wind power are smaller compared with on-land locations.

Ek²⁸

The focal point of Ek²⁸ is how consumers' demand for different wind generation alternatives is sensitive with regard to the environmental quality and costs of the wind generation. Using CE, the demand for the environmental quality was decomposed into the attributes, level of noise (30 dB or 40 dB), the height of the turbines (lower or equal to 60 m or higher than 60 m), the grouping of turbines (separate turbine, 2–9 or 10–50 turbines in a group) and the location of the turbines.^{**} As in Aravena *et al.*,²⁴ the latter was represented by geographical unspecified locations in the mountains, on-land and offshore. To guide the choice of the respondents between different locations, pictorial stimuli were presented in the questionnaire. The economic frame of the choices was set by adding a hypothetical change in the costs of electricity as an attribute. Based on an effective sample of 488 residential homeowners, who were randomly drawn from the Swedish Official Register of Persons and Addresses, preferences for wind generation offshore, on-land and in the mountains were elicited. The results show that after controlling for noise levels, height of the turbines and the type of grouping, the homeowners on average would be willing to pay between 0.035 and 0.057 Swedish Kroner (SEK)/kWh for having wind farms located offshore compared with that of the on-land and in the mountains, respectively. Depending on the type of heating system in the respondent's home, this equals an annual WTP between 166 and 833 SEK, and 271 and 1356 SEK, respectively.^{††} Again, this suggests that everything else kept

[‡] See Hoehn and Randall²⁶ for a detailed presentation of prior and new information effects on the preference formation in economic valuation surveys.

[§] At the time of the survey \$1 ≈ 523 CLP.

^{**} As in Aravena *et al.*²⁴ the other attributes are not interacted with the location attribute. These attributes are therefore not reported further on.

^{††} At the time of the survey \$1 ≈ 9 SEK.

equal, offshore wind farms are associated with fewer environmental costs when compared with on-land locations.

McCartney²⁹

In contrast to Aravena *et al.*²⁴ and Ek,²⁸ McCartney²⁹ estimated the demand for wind power development sites in a geographical specified area. The area of choice was the Jurien Bay Marine Park (JBMP) in Western Australia, which is an area with high social value and very little development. The ocean and coastal interface views in JBMP are thus considered to be pristine. In the survey, the hypothetical scenario stipulated that wind turbines could be located at an inland location, on the beach/in the dunes and offshore. Both local residents and tourists visiting the area for vacation were sampled, a total of 96 respondents. Using the economic valuation method CVM, the respondents were presented to the hypothetical scenario and subsequently asked to state their preferences for developing wind turbines on-land compared with coastal and offshore locations, respectively. To guide the respondents, pictorial stimuli of the visual changes at the different sites were provided. To estimate the stated preferences in terms of the WTP, a temporary lump-sum payment over the next 12 months was used as a payment vehicle. The stated WTPs strongly indicated that the on-land location was preferred compared with coastal and offshore locations. Expressed in monetary figures, the preferences translate into an average WTP of 36–43 Australian dollars (AUD) for developing wind turbines on-land compared with that along the coast, and 34–44 AUD for developing on-land compared with offshore.^{‡‡} Consequently, the environmental costs of on-land development is estimated to be significantly larger compared with the environmental cost of offshore and coastal development in the JBMP. Furthermore, the results also indicate that in the case of JBMP the respondents seem to be indifferent between offshore and coastal locations of the wind turbines.

Discussion I

The stated preferences of the respondents in Aravena *et al.*²⁴ and Ek²⁸ point towards the conclusion that individuals are willing to pay more for having wind farms located offshore compared with on-land. Stated differently, assuming that the differences in WTP between locations can be interpreted as differences in environmental costs between locations, this denotes that offshore wind farms are associated with lower impacts on the environmental qualities compared with on-land turbines, i.e. lower environmental costs. This appears to be evident independent of the type of on-land location. Accordingly, the estimated lower environmental costs of offshore wind power generation suggest that it would be social optimal to have wind farms located offshore, everything else kept equal. However, besides the label of the location (offshore, on-land, etc.), Aravena *et al.*²⁴ and Ek²⁸ do not specify the exact geographical locations of the wind farms. This means that potential site specific attributes on-land and offshore are not accounted for in the two studies, which potentially could have an influence on the elicited demand relations. As such, some on-land location could be preferred to offshore locations. As it will be presented further, preferences for offshore location are found to covariate with the level of usage of the coastal zone in Dubgaard and Ladenburg.³⁰ Consequently, on-land development might actually be preferred if the only option for offshore development is in areas with intense recreational coastal activities. These view points are supported by McCartney,²⁹ who, contingent on that the offshore wind farm could be seen from a pristine natural site,^{§§} finds that an on-land location was preferred to an offshore location. Preferences are thus not unambiguously in favour of offshore locations.

As a consequence, policy-makers might be tempted to increase public acceptance of future offshore wind farms by locating them at large distances from the coast and thereby reduce the visual disamenities from the

^{‡‡} At the time of the study \$1 ≈ 1.33 AUD.

^{§§} Even though the present paper is not a review of wind power attitude studies, a similar difference in wind power perception can be observed. More specifically, there seems to be strong differences in attitude, whether the respondents are asked to state their attitude towards a specific project or wind power development in general (see Krueger¹⁷).

wind farms. However, the costs per kWh produced rise as the distance from the shore increases.³¹ With only information on the relative preference for offshore wind farms compared with other locations, the choice of optimal locations of the future offshore wind farms can only be made as some subjective judgements with regard to preferences and costs for locating offshore wind farms further from the coast and reductions in visual disamenities.

As discussed in Ladenburg,³² lack of information on marginal value of moving offshore wind farms further from the coast could potentially lead to inoptimal offshore locations. This would be the case if the expected (assessed by the social planner) marginal benefit function for reducing visual disamenities is notably different from the true marginal benefit function and would lead to welfare losses.

In Krueger,¹⁷ Dubgaard and Ladenburg,³⁰ Ladenburg and Dubgaard,³³ and Ladenburg,³⁴ the issue of identifying the true marginal benefit function of reducing visual disamenities from offshore wind farms is directly addressed. The results from these surveys are presented in the following section.

Offshore versus Offshore

Dubgaard and Ladenburg,³⁰ Ladenburg and Dubgaard,³³ and Ladenburg³⁴

These papers^{30,33,34} are all based on the same preference and attitude survey carried out in the period 2003–2005; see Ladenburg *et al.*³⁵ Besides auditing the attitude towards wind energy, the primary aim of the survey was to assess the preferences for reducing the visual disamenities from offshore wind farms among the general population^{30,33} and the population in two areas close to the two large scale offshore wind farms Nysted and Horns Rev in Denmark.³⁴ More specifically, it was the purpose of the surveys to identify/assess whether there was an impact and, if so, how much people would be willing to pay in order to reduce the visual disamenities from offshore wind farm by moving them to larger distances from the coast. This requires the assumption that people see the wind farms as a visual disamenity and if so that they are willing to pay to reduce the impact. Accordingly, the survey was split in three smaller (sub-) surveys: National; Nysted; and Horns Rev, respectively. In all three sub-surveys, an identical questionnaire was used and the economic valuation method CE was applied to estimate the demand for reductions in visual disamenities from offshore wind farms.

In the CE, the respondents were asked to choose between alternative layouts for future offshore wind farms in Denmark with 5 MW turbines and a total development of 3600 MW offshore wind. The alternative offshore layouts were visualized in a coastal landscape with wind farms at distances 8, 12, 18 and 50 km from the coast. At 50 km, the wind farms would technically be invisible from the coast, though in the real world invisible at distances nearer to the coast depends on the weather conditions. Furthermore, as a proxy of the size of the wind farm, the wind farms could have 49, 100 and 144 wind turbines per wind farms. The location of the future offshore wind farms was not specified in the survey, except for that the respondents were given the information that future offshore wind farm would be located at sites, which would have a minimum impact on the biodiversity and the landscape. Based on the choices of the respondents, the preferences and thereby the levels of WTP for locating offshore wind farms at different distance was estimated; see Table I

Starting with the national survey,^{30,33} 362 (of 700) respondents returned the questionnaire satisfactorily. The expressed level of WTP showed that people in general hold preferences for reducing the visual disamenities from offshore wind farms by locating them at larger distances from the shore. More specifically, the average respondent was thus willing to pay 47, 98 and 125 EUR/household/year for having the wind farms located at 12, 18 and 50 km when compared with the location at 8 km, respectively.^{***}

However, the papers also find that preferences are not uniform in the sample. First of all, preferences seem to covariate with the usage of the coastal zone, such as the number of visits to the beach, whether you are an angler, recreational boater or can see offshore wind farm from your residence represent usage of the coastal zone. Accordingly, frequent users of the coastal zone were found to have a significantly higher level of WTP

***At the time of the survey \$1 ≈ 0.80 EUR.

Table I. Willingness to pay (WTP) (EUR/household/year) for locating offshore wind farms further offshore compared with 8 km from the coast (adapted from Dubgaard and Ladenburg³⁰ Ladenburg and Dubgaard³³ and Ladenburg³⁴)

Distance	WTP _{National}		WTP _{HornsRev}		WTP _{Nysted}	
12 km						
Sample average	47	[11.8] ^a	30	[7.5]	75	[18.8]
User	67	[16.8]	—	—	—	—
Less frequent users	27	[6.8]	—	—	—	—
18 km						
Sample average	98	[8.5]	81	[8.5]	91	[2.7]
User	129	[10.3]	—	—	—	—
Less frequent users	69	[7.0]	—	—	—	—
50 km						
Sample average	125	[0.8]	75	[-0.2]	147	[1.8]
User	165	[1.1]	—	—	—	—
Less frequent users	85	[0.5]	—	—	—	—
Number of respondents	365		140		170	

^aThe number in the brackets is the marginal WT/km, estimated as the difference in WTP between placing the wind farms at 8 and 12 km, 12 and 18 km, and 18 and 50 km from the coast divided by the difference in kilometre.

compared with less frequent users. As such, these results suggest that frequent users of the coastal zone perceive the visual impacts from offshore wind farm to be stronger/having a more negative influence on the coastal landscape compared with less frequent users. Second, the preferences also co-variated with the age and income of the respondents.^{†††} In line with the attitudinal literature with regard to wind power, younger respondents are found to hold significantly weaker preferences for reducing the visual disamenities when compared with older respondents.^{13–15} More specifically, respondents younger than 30 years have stated indifference with regard to the distance. Strictly interpreted, this puts forward that contingent on the size of the turbine used in the CE scenario (5 MW) and that a 5 MW turbine is invisible at 50 km from the coast; the younger respondents do not find offshore wind farms located at 8, 12 and 18 km to generate *any* visual impacts. Finally, respondents from households with medium and higher levels of income have stronger preferences for moving offshore wind farms further away from the coast.³³

Moving on to the preferences for reducing visual disamenities from offshore wind farms in the two local surveys,³⁴ the main result points towards that experience with offshore wind farms influence preferences for reducing the visual impacts from offshore wind farms. Based on 140 responses from the Horns Rev sample and 170 responses from the Nysted sample (of the initially 350 respondents in each sub-survey), the WTP for moving offshore wind farms to 12, 18 and 50 km is estimated to be 30, 81 and 75 EUR/household/year, respectively in the Horns Rev survey; in the Nysted survey the WTP is 75, 91 and 147 EUR/household/year, respectively. Eyeballing the levels of WTP, it seems like the respondents in the Nysted sample find the visual impacts from offshore wind farms to be stronger compared with the respondents in the Horns Rev sample ($WTP_{Nysted} > WTP_{Horn Rev}$).

When interpreting these differences in WTP, it is important to take into account that the offshore wind farm at Nysted is located approximately 10 km from the coastline. In addition, the wind farm can be seen from a considerably large number of permanent residences and summerhouses compared with the wind farm at Horns Rev, which is situated 14 km from the coastline. Finally, the wind farm at Nysted is visible from the town harbour, which is an important meeting place for the local people of Nysted town.³⁶ Everything else kept equal,

^{†††}This is not presented in Table I, for more details see Ladenburg and Dubgaard.³³

these differences create dissimilar visual interferences from the offshore wind farms at Horns Rev and Nysted. Taking this into account, the differences in experience with visual impacts from the two offshore wind farms seem to have caused differences in preferences, in the sense that the prior experience in the Nysted survey seems to entail a higher degree of visual disamenity. Beside the estimated levels of WTP for moving offshore wind farms further away from the coast; the marginal WTP/km is also presented in Table I. The marginal levels of WTP are interesting in the sense that the decision criteria for locating future offshore wind farm in a policy context are expected to be more continuous than the scale applied in the three studies, e.g. 8, 12, 18 and 50 km. These results generally show that the estimated marginal WTPs are decreasing with distance across the three studies. This will be elaborated on in the follow discussion section.

Krueger¹⁷

The aim of the study by Krueger¹⁷ is to assess the demand for offshore wind farms located at three geographically specified areas and a different distances from the coastline along the shore of the state of Delaware in the USA relatively to a new coal-fired power plant. The survey is set up by allowing the hypothetical wind farms to vary with regard to five different characteristics; the geographical location of the wind farm (Delaware Bay, North Ocean (Rehoboth Beach) or South Ocean (Fenwick Island), distance to the shore, type of royalty fond (Beach nourishment fund, Delaware green energy fund or Delaware general fund), renewable payment (\$1 million, \$2 million or \$8 million) and an extra energy fee. In the survey three distinct populations in Delaware were sampled. Two of the samples represented the respondents living in Delaware near the coastline, i.e. Delaware Bay (bay) and the Atlantic (ocean). These two samples consisted of 400 respondents each. The third sample represented the remaining part of the people living in Delaware (inland) and included 1200 respondents. Focusing on the distance, the wind farms could be located at 0.9, 3.6, 6, 9, 12, 15 and 20 miles from the coast. With 0.9 miles as the baseline, the respondents in all of the three samples were found to have significant preferences for locating the wind farms at large distances, suggesting that offshore wind farms have significantly visual environmental costs (see Table II below).

Interestingly, the results strongly indicate that the preferences for moving offshore wind farms further away from the coast are very heterogeneous between the three samples. As such, $WTP_{\text{Ocean}} > WTP_{\text{Bay}} > WTP_{\text{Inland}}$. This implies that the respondents living in the ocean area perceive the visual costs to be relatively larger, and that they would gain more utility by moving offshore wind farms further away from the coast. Conclusively,

Table II. Willingness to pay (WTP) for locating offshore wind farms further offshore compared with 1.5 km from the coast (adapted from Krueger¹⁷ table 7.6)

Distance (km) ^a	WTP _{Inland} ^b		WTP _{Bay}		WTP _{Ocean}	
6	9	[3.5] ^c	17	[6.2]	41	[15.1]
10	13	[1.4]	23	[2.6]	56	[6.3]
14	16	[0.9]	28	[1.6]	68	[3.9]
19	18	[0.7]	31	[1.2]	76	[2.8]
24	19	[0.5]	34	[0.9]	83	[2.2]
32	21	[0.4]	37	[0.7]	91	[1.7]
Number of observations	1692		609		546	
Response rate (%) ^d	47		51		46	

^a 1 km = 0.66 mile.

^b The estimated WTP are \$/month for 3 years.

^c The number in the brackets is the marginal WTP/mile, estimated as the difference in WTP between placing the wind farms at 1.5 and 6 km, 6 and 10 km, 10 and 14 km, 14 and 19 km, 19 and 24 km and 24 and 32 km from the coast divided by the difference in kilometre.

^d When accounting bad addresses, deceased and other incapacitated respondents, the average response rate is 52%.

costal area residents thus seem to perceive offshore wind farms to be a visual higher disamenity than inland residents. As in the case of the Danish survey the marginal WTP is also estimated and is found to be decreasing with the distance.

Discussion II

Jointly, the four papers strongly imply that offshore wind farms are associated with visual disamenities and thereby significant environmental costs, which influence the utility of the population. Wind farms located at large distances from the coast are thus significantly preferred to wind farms located at shorter distances and vice versa.

The results also indicate that preferences for reducing the visual disamenities are heterogeneous in the population, especially when accounting for the usage of the coastal zone. People using the coastal zone either directly,³³ as a user³⁰ or by living close to the sea¹⁷ seem to associate offshore wind farms with higher environmental costs compared with respondents with a less strong association to coastal areas. As such, these estimates of environmental costs point out that everything else being equal, offshore wind farms should be located in coastal zone areas with small recreational values, compared with areas with high recreational values, unless the wind farms can be located at large distances at relatively low costs.

Importantly, the results also show that the marginal WTP for moving the wind farms further from the coast is decreasing. This means that the respondents in all the presented studies find it more important that the wind farms are moved from, e.g. 10 to 11 km from the coast compared with 19 to 20 km. Or stated differently, a reduction in the visual impact from an offshore wind farm close to the shore is more important than a reduction from a wind farm far from shore. In wind power development framework these results are very noteworthy. They indicate that unless the marginal costs of moving locating offshore wind farms are small, it might not be socially optimal to completely remove the visual impacts from offshore wind farms at any costs and that a certain level of visual impacts seems to be acceptable.

Concluding Discussion

The optimal location for the future wind power development is naturally a function of many different variables, which jointly rank one location compared with other locations. Some of these variables relate to capital costs of wind power development. In Lemming *et al.*³⁷ it is assessed that on-land installation costs in the UK are between costs 585 and 800 £/kW and 1200 and 1600 £/kW offshore. Everything else being equal, capital costs of offshore locations are almost twice as high compared with on-land costs. If the offshore wind farm is located on deep water and at large distances from the shore, the offshore capital costs might be even larger. These direct costs indicate that on-land development from a purely capital costs of view might be the most economically attractive solution, even when accounting for better weather regimes offshore. However, the potential differences in external costs between different on-land and offshore might change this relation.

In the present paper, a review of the existing studies concerning the preferences for offshore wind power development has been presented. The studies can be divided into two groups of studies. The first group analyses the preference for offshore development relatively to alternative on-land locations, such as in the mountains, on-land and along the shore. Generally the results suggest that the offshore locations might be associated with lower environmental costs when compared with on-land locations. However, as one study suggests, the external costs of offshore wind farms might be larger at specific offshore location. Unfortunately, Aravena *et al.*,²⁴ Ek²⁸ and McCartney²⁹ do not explicitly specify the capacity of the wind power development in the scenario description defining the frame of the economic valuation studies. It is therefore not possible to directly compare the estimated level of WTP with the capital costs of development put forward in Lemming *et al.*³⁷ In this line it is clear that further research in this area is strongly warranted.

In the second group of the studies concerning preference for offshore wind power development, the three studies relating to the Danish consumers' preferences are based on an offshore wind power development

scenario of 3600 MW. Assuming a discount rate of 0.05, a life-year expectancy of 20 years of an offshore wind farm and approximately 2,500,000 households in Denmark, the WTP/kW is between approximately 275 and 800 £/kW for the moving offshore wind farms from 8 to 12, 18 and 50 km for an average sample in Ladenburg and Dubgaard.³³ Though, these numbers should be perceived as rough estimates, they indicate that, potentially, the reduction in environmental costs associated with locating offshore wind farms at relatively large distances might outweigh the capital cost increase compared with on-land development, everything else being equal. However, as mentioned, these values most likely will be dependent on location dependent. Further research is therefore warranted.

As based on the review of the literature available, the stated preferences for location of wind power development point towards that the environmental costs associated with offshore wind farms appear to be smaller compared with the environmental costs of on-land wind farms/turbines. Even though these preferences are sensitive with regard to the specific geographical locations, the results also point towards that the environmental costs of offshore wind farms can be further reduced by locating the wind farms at large distance from the coast, though the benefits of doing so will be marginally decreasing.

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