# The Properties of Visual Disamenity Costs of Offshore Wind Farms – the Impact on Wind Farm Planning and Cost of Generation

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**Introduction**

Global offshore wind power capacity has expanded rapidly in the last few years, with unforeseen rates of planning and construction of new wind farms.

Offshore wind farms typically offer the benefits of both stronger and more consistent wind resources than are found onshore. Moreover, large scale offshore wind projects (100MW+) will often be less intrusive – both from a visual and a noise perspective – than their onshore counterparts. When asked, people thus typically express preferences for offshore rather than onshore wind farm development (Campbell et al., 2011; Ek, 2006), suggesting that the non-monetary or 'external costs' borne by the consumers and society are smaller for offshore wind energy development.

The main disadvantages of developing wind energy offshore are higher investment and generation costs. These can be substantial, and increase as development sites are moved further from the coast or into deeper waters (with deeper waters often accompanying further distances from the shore). For example, keeping distance from the shore constant, investment costs of a specific project can increase by up to 25% when water depth is increased from 10-20m to 30-40m (European Environment Agency, 2009). Given the multibillion dollar nature of the investments needed for offshore wind farm construction, 25% higher investment costs are far from being trivial. Investors, therefore, have a strong incentive to push development agendas that increase the probability of near shore development. Similarly, in an effort to attract investors and keep consumer utility prices low, energy authorities might also have a relative preference for near shore locations.

While consumers naturally prefer lower utility costs, near shore locations might not be an optimal solution for the consumer. The reason is that near shore wind farms are more visible from coastal landscapes that in most cases have previously been undisturbed by wind turbines. The location of an offshore wind farm close to shore might thus be seen as an intrusive and unwanted element (Bishop and Miller, 2007) and thus cause external costs to society.

The energy planner will thus have to trade-off the benefits of lower investment and utility costs resulting from near-shore locations with the benefits of greater public acceptance and reduced external costs accompanying locations further offshore. In order to accurately weigh these trade-offs, and find the optimal distance to locate wind farms from shore, the different costs described above need to be defined on the same, monetary scale. This in turn necessitates that the visual impacts resulting from offshore wind farm development are quantified in economic terms and that the true marginal external cost function is identified. If this is not done, the missing information on the benefits of reducing the visual cost of offshore wind farms could lead to inefficiently high costs associated with sub-optimal wind farms locations. The areas A and B in Figure 1 illustrate the welfare losses that would accompany suboptimal location choices (in this case at distances of *a* or *b* km from the shore) resulting from incorrect expected marginal benefits functions.

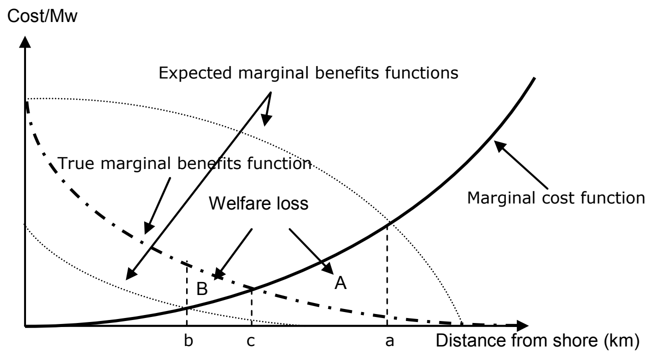


*Figure 1: Comparison of the welfare effects associated with the assessment of the true and false benefit function (based on Ladenburg 2007).*

The present article focuses on economic studies that have assessed the external costs of the visual impacts from offshore wind farms and will bring forth the most relevant highlights.

**Visual Disamenity Costs from Offshore Wind Farms**

To date, all published economic studies strongly indicate that given the choice, consumers, on average, prefer offshore wind farms to be located at larger dis-

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tances from the coast and in some cases completely out of sight. More specifically in two studies from Denmark (Ladenburg and Dubgaard 2007;2009; Ladenburg et al. 2011), one from France (Westerberg et al. 2011) and two from the USA (Krueger et al. 2011; Landry et al. 2012), samples of respondents are asked to state the preferences in terms of willingness to pay for reducing the visual impacts from offshore wind farms. This is done by presenting survey respondents with different visualizations in which wind farms are located at different distances from the shore, and pairing these visualizations with different prices the consumer would face for each scenario. Though the studies are relatively different in terms of the number of turbines, number of wind farms and the distances to the shore, all studies suggest that general public preferences are positively influences by locating a wind farm at a larger distance from the shore. These preferences are expressed either as a willingness to face higher electricity prices when wind farms are moved further offshore, or as a need to be compensated in terms of lower prices of beach recreational activities if wind turbines are located closer to shore.

For example, a study surveying North Carolina coastal tourists (Landry et al. 2012) finds that building an offshore wind farm at 1 mile rather than at 4 miles from the shore would reduce the propensity of visitors travelling to the particular beach from which the wind farm would be visible. This would reduce the economic activities in the specific area, and would result in a loss of revenue and consumer welfare. Similar conclusions can be drawn from the other studies.

Another element common to most studies is that visual impact costs of offshore wind farms decrease at an increasing rate as wind farms are moved further from shore (Krueger et al. 2011; Ladenburg and Dubgaard 2007; Ladenburg et al. 2011). In other words, consumers are willing to pay more to move a wind farm location from 5 miles to 8 miles from shore than they are for moving a wind farm from 12 to 18 miles from shore. This suggests that while society at large might be best served by moving wind farms further offshore than might be in the interests of investors, the increasing infrastructure costs, and decreasing visual impact costs accompanying a movement further offshore might result in a situation where the optimal location for a wind farm is indeed within visible range.

While, as discussed above, the studies reviewed here come to similar conclusions, the same studies also suggest that preferences for reducing the visual disamenities are very different between consumers. Some consumers have very strong preference for visual impact reductions and are willing to pay considerably higher energy prices for the wind farms to be located at large distances from the shore. The same consumers would require a considerable reduction in the costs associated with beach recreational activities if wind farms are built close to shore. In contrast, some consumers are apparently indifferent to the visibility of offshore wind farms and apparently do not perceive the wind farms as a visual intrusion. Still others view wind farms as a visually positive element in the coastal landscape. For this group of consumers, locating wind farms relatively near shore might increase the propensity to visit a specific beach, thus acting as a tourist attraction and not a repellant. Interestingly, in studies in which positive preferences for near shore locations have been found, approximately 20% of the sample seems to hold such preferences (Ladenburg and Lutzeyer 2012). These results clearly indicate that the size of the welfare costs associated with the visual impacts of offshore wind farms are far from being uniformly distributed among the population.

The studies examined have also found some interesting correlations between preferences for reducing the visual impacts of offshore wind farms and specific demographics (such as age, sex and education) as well as factors accounting for experience with different wind farm establishments. The most policy relevant correlations found of are those of age as well as wind farm experience.

The "age effect" is identified in three of the above papers (Ladenburg and Dubgaard 2007,Krueger et al. 2011; Westerberg et al. 2011). More specifically, these papers find that younger respondents appear to hold weaker preferences for reducing visual impacts. The interesting question in this regard is whether the age effect is permanent (a generation effect) or not. If the age effect is permanent, the external cost of locating wind farms at near shore locations will be smaller in the future. Accordingly, if the location decisions of offshore wind farms are based on the preferences of the current generation only, the wind farms might be located further from the shore than would be optimal if future generations are also considered, resulting in utility prices that are inefficiently high. Consequently, it would be beneficial from a power generation point of view, to take this into account when placing future offshore wind farms.

Finally, studies have also found that preferences differ depending on previous experience with offshore wind farms. In general, people who live close to wind farms located onshore, express a stronger preference for siting turbines offshore (Krueger et al. 2011). Moreover, those people who live close to existing offshore wind farms express a stronger preference for moving wind farms to locations further from shore, than those without such experience (Ladenburg and Dubgaard 2007). This suggests that optimal wind farm placement depends strongly on the experiences impacted populations have with wind farms – both on- and offshore. Accordingly, the external cost in the longer run might not just be a simple function of the distribution and the demographic characteristics of the relevant population, but also a function of the choice of the onshore and offshore wind power development mix.

**Conclusion**

Results from existing studies suggest that higher levels of visual impacts can be expected to have a negative influence on both the direct and welfare economy. As a result, an economic analysis of these costs is critical when evaluating the trade-offs associated with finding the optimal location for future offshore wind farm development. The results also suggest that while, on average, consumers prefer siting wind farms further from shore, these preferences become weaker at further distances from the shore, suggesting that optimal wind farm locations are likely to be within view. Moreover, preferences differ significantly among the population, implying that the optimal location of offshore wind farms depends, among others, on the age structure of the affected population as well as the population's previous experience with existing wind energy structures. This heterogeneity makes generic policy prescriptions difficult, and demonstrates the importance of extensive economic analysis by offshore wind energy developers.

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## Council Announces Dues Increase

At its June ?? Meeting the IAEE Council voted to increase regular Affiliate and Direct member dues $15.00, Student member dues $5.00, and Institutional Member dues $500.

This is the first dues increase in five years and reflects the ever increasing costs of operating the Association as well as the costs of bringing on the new publication, *Economics of Energy and Environmental Policy.*

The dues increase is effective immediately, however, outstanding dues invoices will be honored at the old rate.