DTU Library

Environmental and social impacts of wind energy

Borch, Kristian; Clausen, Niels-Erik; Ellis, Geraint

Published in:
DTU International Energy Report 2014

Publication date:
2014

Document Version
Publisher's PDF, also known as Version of record

Chapter 12

Environmental and social impacts of wind energy

By **Kristian Borch**[1], **Niels-Erik Clausen**[1] and **Geraint Ellis**[2],
1) Technical University of Denmark, 2) Queens University Belfast

The most common reasons for non-technical delays to wind energy projects are local resistance and poor strategic spatial planning. This chapter looks at the environmental and social impacts of wind energy and discusses how the public can gain trust in the public planning and private project management processes.

Wind farms' compliance with local and regional environmental requirements, and their social acceptance, is prerequisites for meeting the ambitious targets that have been set for wind energy.

While the nominal cost of obtaining an environmental permit for a wind farm might be just a few percent of the total project cost, it is clear that the planning and environmental permitting process can influence the project's schedule, and hence indirectly its cost. A delay of only a few months can have a significant impact on the project economics, since it delays income from the sale of electricity. In the worst case, a court case or other conflict may lead a project to be cancelled all together.

A recent example of a project that was seriously delayed and finally cancelled is the London Array offshore wind farm in the UK, which was planned in two phases with a final capacity of 1,000 MW. The first phase, rated at 630 MW, entered operation in 2013. In February 2014 the consortium behind London Array Phase 2 (370 MW) cancelled the project after having worked on it since 2003. The failure was mainly due to planning uncertainty related to the red-throated diver, a protected seabird. Previously, planning issues related to two other seabirds, the Sandwich tern and the common scoter, led respectively to the cancellation of the Docking Shoal and Shell Flat projects (Jensen, 2014).

For land-based wind farms, the environmental impact assessment carried out before construction begins falls into two parts. On one hand we must consider the impact on people and the landscape; on the other, the effect on flora, fauna and biodiversity. The following sections discuss three particular concerns:

- visual and landscape impact;
- noise; and
- shadow flicker.

Visual impact

Of all of the issues involved in siting a wind farm, none seems to be argued more strongly than that of landscape. Perhaps this is not surprising, because from both environmental and socioeconomic viewpoints landscape is considered one of the most important natural resources (Bishop *et al*., 2007). This trend has been noted worldwide and the strongest opinions voiced are usually those related to protecting the scenic qualities of the landscape (Bishop *et al*., 2007, Lothian, 2008).

This issue has gained momentum in recent years mainly because of the growing number of wind power developments (as a consequence of government renewable energy targets) and the increasing size of wind turbines. It is also more hotly contested than in the construction of traditional thermal power plants because the lower energy density of wind farms requires them to be spread over larger areas.

To date there has been only a limited amount of research on the aesthetic impact of wind turbines on landscapes, but the preferred approach has been assessment through photographs, visualisations from points of interest, and verbal descriptions (*Figure 36*) (Bishop *et al*., 2007).

Noise

Noise is defined as any unwanted sound (Rogers *et al*., 2002). As with visual impact, the effect of noise is partly subjective because it affects people and their perceived quality of life. The environmental impact of noise depends upon many parameters and physical effects, and as such it is difficult, though not impossible, to model. The difference between visual and audible impact, however, is that a definite threshold can be established for noise impact, and this has been done in many countries. In 2011 Denmark became the first country to establish a separate limit for low-frequency noise (below 160 Hz), as measured inside homes (Danish Environmental Protection Agency, 2014).

There are two potential sources of noise associated with wind turbines: aerodynamic and mechanical. Aerodynamic noise is now the more important of the two.

Figure 36 – Visualisation of 1.75 MW (93 m) and 3.6 MW (150 m) turbines.

Mechanical noise is created by the machinery inside the nacelle of the turbine. Although this includes components such as yaw drives, cooling fans and hydraulics, the dominant sources of noise are the gearbox and the generator (Pedersen *et al*, 2003). These noises are usually of constant frequency, since they are generated by rotating equipment, and they are transmitted along the structure of the turbine (the tower and nacelle) before being emitted from its surface (Rogers *et al*., 2002). Occasionally this may create pure tones, in contrast to most noise emitted from wind turbines, which is a mixture containing a large range of frequencies ("white noise"). For noise containing pure tones the Danish regulations impose a penalty of 5 dB(A).

During the last 20 years, mechanical noise in wind turbines has been reduced to the point where it is no longer the dominant source of wind turbine noise (Pedersen *et al*, 2003, Rogers *et al*., 2002). This has mainly been done through improved acoustic insulation (Leloudas *et al*, 2007) and component mountings, but also through technological innovations such as low-speed cooling fans and changing the finish on gear teeth (Rogers *et al*., 2002). Another reason that mechanical noise is now less important than aerodynamic noise is a consequence of the increased size and especially tower height of wind turbines.

Noise impact is modelled and evaluated against national requirements using commercial software packages such as WindFarm, DNV-GL Windfarmer and WindPro.

Shadow flicker

Shadow flicker describes the pulsing change in light intensity that is observed when the blades of a wind turbine pass periodically through sunlight in front of an observer. Obviously this requires a clear sky, a low sun, wind to turn the blades, and a particular wind direction in relation to the position of the sun and the observer. Levels of shadow flicker are generally not regulated explicitly but guidelines do exist in most countries, either for acceptable maximum levels of flicker or for the distance within which any flicker effects must be mitigated. In Denmark there is no firm rule, but the guideline states that shadow flicker should be evaluated for observers between 500 m and 1,000 m from any turbine, and that any particular house should see no more than 10 hours of flicker per year. It is generally considered that observers further than 1 km from the turbine see the turbine as just another static obstacle in front of the sun, so shadow flicker is not an issue at this distance.

Social acceptance

For land-based developments, governments have tended to focus their attention on overcoming the initial and obvious challenges of designing an appropriate support system, securing grid access, simplifying planning procedures, and dealing with technical risks. However, this approach can only deliver so much.

Visualisation of 1.75 MW (93 m) turbines (**left**) and 3.6 MW (150 m) turbines (**right**) from a Danish project in Gisselbæk Danish Energy Authority (2010).

Renewable development actually takes place in a society made up of people – people who may be suspicious of new technologies, feel sceptical of the motives of developers, or see the changes to cherished landscapes as too high a price to pay for the benefits of wind energy. Indeed it appears that the consequences of this have not been fully grasped.

Governments and developers have often not felt it necessary to consider the social dynamics around wind energy projects, largely because opposition groups in the past have been small, scattered and ineffective. Many anti-wind groups are now becoming more broadly organised, however, and in some cases they are beginning to influence national energy policy. Indeed, in many countries it is now becoming clear that it will be social acceptance that determines the ultimate scale of the onshore wind industry.

We are now seeing the implications of this across the northern hemisphere, with some local and national contexts – political, social and cultural – proving particularly challenging to the social acceptance of new wind energy projects. Opposition may take on different dynamics and characters according to the type and location of the proposed project, though the largest projects seem to offer the greatest challenges. Sometimes local objections may be stimulated by a lack of trust in consenting authorities. Opposition may be the result of a poorly designed or located project, or it can arise because host communities think it is unfair that the places they love will be spoiled, while the project owners will derive the monetary benefit.

This is becoming a major challenge in many countries with major wind energy schemes, from the US to Japan. In Australia, local concerns were the driving force for the state of Victoria to adopt a new 2 km setback distance that has crippled the wind industry there. In the UK, while the country forges ahead with ambitious offshore schemes, the ruling Conservative party has pledged to remove all support from onshore wind farms after the next election, having judged this to be a key voting issue for many of its supporters.

Ireland has been developing onshore wind as a key element in its economic recovery, with the ambitious intention of becoming an energy-exporting nation. However, the country had a major setback recently after a massive wind scheme planned to generate electricity for the UK market attracted a storm of objections. The adverse publicity was so great that it may have damaged national perceptions of the wind industry and spurred objector groups throughout the country.

There are therefore major challenges to the rollout of onshore wind, and while different countries will continue to experiment with the best models for extending their renewable energy capacity, the extent of onshore wind will ultimately depend on how host communities relate to new projects. While this may never be an easy process, there are ways in which relations can be improved. These include more open and transparent decision-making, community investment in renewables, devolving carbon budgets to individual communities, and enhanced community input to national energy strategies.

One would expect that many of the problems discussed above could be solved by offshore developments, because of their relatively remote location (Scott, 2007; Strachan *et al*., 2006). However, offshore wind projects have seen considerable opposition from a range of individuals and organisations in Northern Ireland, the Republic of Ireland (Ellis *et al*. 2007), and Cape Cod in the US (Kempton *et al*., 2005). Apparently noise is the only problem that vanishes at sea (Hagget, 2008).

The case of Denmark

Denmark is approaching saturation point for onshore wind, given current technologies and procedures for public involvement. One would expect the industry to have foreseen this situation, since this is not the first time in history that a technology has encountered opposition from the public (Gibbons, 1999; Borch *et al*.3 2003). However, an unpublished survey carried out at the recent wind power summit in Barcelona (EWEA, 2014) revealed that the industry has only a weak analysis of risk of social acceptance or social impact. Some developers and operators even refuse to talk about social acceptance.

Nonetheless, the industry has made some attempts to address the opposition. Examples are the work to reduce noise emissions from turbines, and wind acceptance campaigns such as actonfacts.org (international), Vindinfo.dk (Denmark) and yes2wind (UK). While innovations to reduce the environmental impact of wind farms are always welcome, however, it is doubtful whether "rational" information campaigns improve acceptance by people who oppose wind power projects. They may even have the opposite effect. People's opinions of wind turbines are highly subjective and are influenced by numerous factors (Ladenburg, 2009).

But as mentioned previously, lessons learned from poorly designed or badly located projects can be used constructively to increase local involvement. In turn, this can help to earn their recognition of wind power as a better alternative to fossil fuels – even if this is only until new renewable energy technologies are mature enough to supplement wind power on a large scale and at reasonable cost.

Recent research (wind2050.dk) is looking towards new opportunities to understand and improve the democratic processes linked to the construction of large wind farms and other renewable energy plants. A new method of clarifying public concerns and bringing new perspectives to the fore has recently been applied: a web crawler searches the Internet for websites that mention wind turbines – such as debate forums and feature articles – and charts the points of view expressed, from generalities all the way down to individual wind farms. This can help to paint a full picture of the considerations that need to be shown in the planning and project management of wind farms and the organisation of public consultation meetings.

Recommendations for science, industry and policy

In a modern and democratic society people need to be not only informed but also empowered in making decisions that they believe have consequences for their daily lives. Public participation is often believed to be "the solution" in gaining social acceptance for technologies. However, public participation and the empowerment of local communities can easily be counterproductive if ambiguity is mistaken for uncertainty.

Uncertainty can be addressed through information and technical problem solving. Ambiguity is a completely different matter: rational argument is ineffective here because the problem is a fundamental difference in values. Unfortunately for the progress of wind power, developers and governments tend to neglect many views and concerns of society as a whole, beyond a narrow scientific approach or the business models favoured by industry.

A more constructive approach would be to give consideration to these concerns rather than simply to dismiss them as nonsense. The question for science, industry and policy is thus not whether to empower the public, but how.