Opportunities for co-utilization of infrastructures for wind energy generation

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Abstract: The co-utilization opportunities of different infrastructures for wind energy generation will be investigated in this paper. Information is derived from previous research and discussions with Finnish wind energy companies as well as with authorities, environmental organizations and local inhabitants in the Ostrobothnia region of Finland. Wind power can be built in areas where there are already other business activities. These co-utilization areas include harbours, industrial sites, roads, railways and existing masts and towers. Moreover, both natural and cultivated environments have vast co-utilization potentials for wind energy offshore, near shore and onshore like in fields, forests and swamps and on hills and islands. The environmental and socio-cultural considerations are of crucial importance when planning co-utilization in natural environments, and very important also in cultivated environments. Industrial areas are the least environmentally and socio-culturally vulnerable, but the potential partners there are businesses that demand substantial financial benefits from co-utilization cooperation, hence making the economic considerations decisive. Co-utilization projects can mitigate or prevent many undesirable environmental, socio-cultural and economic impacts of wind turbines, if they are holistically and carefully planned. Furthermore, wind turbines as structures can serve numerous environmentally, socio-culturally and economically beneficial purposes.

Keywords: *Wind energy, Co-utilization, Infrastructure, Life cycle assessment, Social acceptance*

1. Introduction

Wind turbines can be short, medium-sized and tall, are they can be located off shore, near shore and on shore. They have a variety of environmental, social, cultural and economic impacts, both positive and negative, which depend on the areas they are built in.

Wind turbines can be built in areas where there are already other business activities, and not only in locations where no other human activities take place. These co-utilization areas include e.g. harbours, industrial sites, roads, railways and existing masts and towers. Wind turbines and wind farms can also be built in cultivated environments, i.e. on fields and fallows. In addition, natural environments, such as forests, fields of flowers, arctic hills, swamps, islands and offshore sea areas, are increasingly used as wind farm building sites.

The environmental and socio-cultural considerations of wind turbines are of crucial importance when planning co-utilization in natural environments, and very important also in cultivated environments. Industrial areas are the least environmentally and socio-culturally vulnerable, but the potential partners there are businesses that demand substantial financial benefits from co-utilization cooperation, hence making the economic considerations decisive.

The starting point of this research is the compiling of a sustainability assessment, i.e. an environmental, social, cultural and economic life cycle assessment (LCA) of wind turbines from previous economic and environmental impact and social acceptance studies on wind power and discussions with Finnish wind energy companies and their interest groups. The opportunities for co-utilization will then be mapped in cooperation with Finnish wind energy companies and their interest groups. Wind turbines as structures can serve numerous environmentally, socio-culturally and economically beneficial purposes.

2. Methodology

This is an exploratory study, which derives its information from previous research[1,2,3,4,5,6,7,8] and discussions with wind energy companies, authorities, environmental groups and local inhabitants of Ostrobothnia at a wind energy seminar organized by the Regional Council of Ostrobothnia in Vaasa, Finland, on 30 September 2010, to discuss regional wind power planning. The author of this paper is a member of the CLEEN WIPO research group with 26 Finnish wind energy companies and seven Finnish research institutes. This research group is currently planning a major research project to enhance wind power (WIPO) building and exports. The CLEEN Ltd is the Finnish energy and environment strategic centre for science, technology and innovation with 44 shareholders (major Finland-based companies and national research institutes) established in 2008 to facilitate and coordinate research in the field of energy and environment. This paper analyses current knowledge of wind power impacts and co-utilization, and maps out some research cooperation possibilities for the WIPO project.

3. Results

Table 1 compiles environmental, social, cultural and economic impacts of wind turbines.

Table 1. Environmental, social, cultural and economic impacts of wind turbines.

Environmental impacts	**Social impacts**	**Cultural impacts**	**Economic impacts**
POSITIVE: +Renewable, natural energy production method +Rescue nature from harmful options +Hardly any CO_2 or other emissions +Hardly any hazards to humans or nature +Compensate within 3-6 months the energy used during their whole life-cycle +Nearly all parts of turbines are recyclable	POSITIVE: +Boost local employment: planning, construction & maintenance +Boost entrepreneurship +Boost research & development +Farmers: can lease land, generate small-scale power for their farms and become large-scale wind power producers	POSITIVE: +Traditional; long experience from windmills +Use and upkeep of local knowhow +Could be integrated into contemporary culture, like windmills were: parts of cultural heritage	POSITIVE: +Plenty of business opportunities +Innovation opportunities for many businesses +Major growth opportunities home & abroad +Low maintenance costs +Give nations a great chance to improve their energy self-sufficiency in the most renewable and least harmful way +Help meet CO_2 targets
NEGATIVE: -Wind turbine construction and infrastructure building on natural sites disturb flora and fauna, damage their habitats, and destroy forest, flower field and sea bottom ecosystems, diminishing biodiversity -Propellers and power lines are hazardous to birds, bats and insects -Radar impacts on bats disturb their orienteering - CO_2 & other emissions from parts production and transportation -Noise causes danger (cannot hear predators) and stress to animals	NEGATIVE: -Cause “not in my backyard” (NIMBY) syndrome -Cyclic noise causes stress & stress-related illnesses to humans -Hinder visibility -May spoil visual landscape -Cause light and shadow reflections -May cause accidents to people -May impact real estate values and prices	NEGATIVE: -May upset current cultural landscapes	NEGATIVE: -Local resistance inhibits or slows down investments -Require often many permits and environmental impact assessments (EIAs) with long, exhaustive application procedures -Winds change, challenging even energy supply -Possible radar impacts on military monitoring sensors and air & sea monitoring radars

Table 2 maps co-utilization opportunities of wind turbines in different areas and elaborates on the way they decrease malignant and increase benign environmental, social, cultural and/or economic impacts of wind power.

Table 2. Some co-utilization opportunities of wind turbines.

Co-utilization	Benefits for environmental, social, cultural and/or economic impacts
Industrial sites, warehouse areas, harbours	+Infrastructures are already in place; hence there is no need to cause ecological harm by building them. +Usually far away from natural sites and residential areas; hence propeller noise does not disturb nature or humans. +Visual disturbance is minimized by already spoilt scenery and long distance to natural and residential sites. +Require fewer permits & no environmental impact assessments (EIAs). +Wind power generation can be integrated into the site's business operations, thereby giving both energy & financial benefits to companies. +Easy to supply energy to cities and residential areas because of the established grid and power line connections. +Companies on the site can invent multiuse purposes for wind turbines. +The jungle of turbines of wind farms can breed novel business ideas. +Rebuilding power lines underground prevents birds, bats and insects from flying into them.
Roadsides and railway banks	+Propellers' noise is hidden by traffic. +Visual disturbance is lessened by already spoilt asphalt, metal and concrete constructions. +Turbines have tall towers that can be used for traffic control, other surveillance and storage. +Wind energy generation by roads and railways could allow recharging the batteries of electric cars and novel electric trains during the journey. +The jungle of turbine masts can inspire novel means of transportation (e.g. postmodern Tarzans). +Wind farms in public areas will attract extreme sports enthusiasts with their creative inventions. +Building power lines underground prevents birds, bats and insects from flying into them.
Masts and towers	+Radio masts, telecommunication masts and many different kinds of towers can act also as wind turbines. +Possible added negative environmental, social, cultural and economic impacts of attaching propellers to these masts and towers can be easily analyzed and minimized, taking the special characteristics of the location into account. +Both the infrastructure and the turbine trunks are ready-made. +These second-hand wind turbine masts and towers save plenty of steel, fibreglass and metal-plastic composites normally needed to build the turbine trunks. +The trunks could serve also as habitats and nesting places for animals, particularly if they are covered by moss, lichen and other plants. +Building power lines underground prevents birds, bats and insects from flying into them.

Farm fields and fallows	+Little ecological disturbance or damage, as farm fields are typically monocultures with diminished biodiversity. +Farming and wind power generation can be done simultaneously. +Farmers earn either from leasing land and doing turbine maintenance, from generating the energy they need through small-scale wind power, or from becoming large-scale wind power producers and sellers. +Social nuisance is minimized: farmers who benefit do not suffer from the NIMBY syndrome and tolerate the visual harm and noise stress caused by the turbines. +Distance to neighbours is often quite long. +Building power lines underground prevents birds, bats and insects from flying into them.
Swamps	+Swamps that are already in commercial peat energy production are suitable for wind power generation, as they have already been ruined ecologically, socially, culturally and visually, and are plagued by noise from heavy work machinery. +Building power lines underground prevents birds, bats and insects from flying into them. -However, swamps still in their natural state should not be disturbed or damaged by wind power developments, which would destroy their fragile ecosystems and biodiversity once and for all.
Islands	+Wind turbines could be built on the hilly centre of an island with fishermen and/or summer residency, so that they will not disturb the coastal fishermen's houses, summer cottage owners, tourists or nature. +The island's commercial activities (shops, bank, post-office, car battery recharge, etc.) could also be built in the centre. +Building power lines underground prevents birds, bats and insects from flying into them.
Offshore (and near-shore) areas	+The adverse ecological impacts of dredging, building infrastructure and setting up turbines in marine ecosystems can be mitigated by turning the concrete and steel foundations into artificial reefs by erosion protection. +The reefs would attract fish, plants and other marine life, and could develop into holistic ecosystems, thereby preserving biodiversity. +Blocks built from rocks of different sizes can muffle turbine noise that drives fish away. Strong fish populations enhance fishing as a natural livelihood of the area. +Near-shore and offshore wind farms can be built to accommodate research platforms for marine life, weather and tidal energy research. +Shark nets could possibly be attached to the below sea-level turbine constructions of near-shore wind farms. +Building power lines underwater prevents birds from flying into them.

4. Discussion and Conclusions

There are many co-utilization places for wind turbines in which they would not cause much environmental, social or cultural harm and could be made economically profitable.

Industrial sites, warehouse areas, harbours, roadsides and railway banks are environmentally, socially, culturally and economically best places for wind turbines. There they do not damage

nature or disturb humans; their building expenses are low because of the ready-made infrastructures, and profit opportunities are great due to the easy supply of energy to local businesses and residents.

Using existing, i.e. second-hand, masts and towers in these areas would cut down the turbine construction expenses to the minimum and save plenty of unrenewable building material.

Farm fields and fallows are also environmentally, socially, culturally and economically rather benign areas to build wind turbines since they are monocultures, lie often away from residential areas, and wind power generation provides several livelihood opportunities for farmers.

Swamps exploited for peat energy production, are already environmentally, socially and culturally ruined, and therefore, would not suffer much from wind turbines, which would add to the high profits derived from peat energy production. Untouched swamps should be left alone.

Islands are often ecologically valuable areas, but islands with a commercial centre in the middle would not be too much hurt by wind turbines, if they were also built in the centre, which would leave the ecologically fragile and socially important coastal areas untouched.

Offshore wind farm building has several environmentally damaging impacts, but they could be mitigated by turning the concrete and steel foundations into artificial reefs, which would attract fish and other marine life. This could lead also to a beneficial effect on the livelihoods of fishermen. Offshore wind farm platforms could be used by researchers. Near-shore wind farms are more malignant environmentally, socially and culturally, but could possibly be used e.g. for attaching shark nets to.

There are some areas where the malignant environmental, social, cultural and/or economic impacts outweigh the benign ones.

Arctic hills have plenty of space and plenty of wind. In wintertime the colour of wind turbines and snow is synchronized, making a visual match. However, infrastructure building and turbine construction rape virgin land. Moreover, reindeer herders oppose arctic wind farms because they endanger the winter pastures of reindeer. And ultimately, since climate change causes trees to migrate north, plenty of space must be left for the arrival of trees.

Forests of any kind are not suitable or economically profitable places as trees muffle wind. Furthermore, infrastructure building, turbine construction and propeller noise cause such massive disturbance and damage to flora, fauna, soil, rocks, and to the whole forest ecosystem that wind turbines should not be built in forests.

Wind power should not be built in nature protection areas or bird and other animal sanctuaries, on the migration routes of birds, fish and sea mammals, or on environmental or cultural heritage sites. An ample buffer zone between these areas and wind farms should be reserved to prevent any environmental, social or cultural disturbance against these most valuable assets of the humankind.

The findings of this research are based on previous studies of the impacts of wind turbines (which themselves have taken account of hundreds of studies) and on the partially conflicting views of wind energy companies, authorities, environmental organizations and local inhabitants of the Ostrobothnia region of Finland gathered together at a wind power seminar.

This study adds to the knowledge of previous wind turbine impact research through the empirical study. The most important value of this research comes from exploring and mapping out novel empirical findings for a new research area of co-utilization impacts of wind power.

This research has not critically evaluated any of the conflicting views of the seminar participants but listed them all as positive and negative impacts of wind turbines and their co-utilization. The number of participants at the wind power seminar was 63, which is not a representative sample of the population of the city of Vaasa (59,633 inhabitants on 31.10.2010) or the Ostrobothnia region (about 1 million inhabitants during the early 2000s). Those who attended the seminar were more interested in wind power than an average citizen of the city or region, but the participants (wind energy companies, authorities, environmental organizations and local inhabitants) represented the different views and perspectives to wind power development well enough to give a rather balanced account of the positive and negative impacts of wind turbines and their co-utilization.

Similar studies could be conducted at other wind power seminars and at wind farm planning meetings collecting together people with different backgrounds and interests. New issues to address and ideas to solve them would no doubt emerge in such gatherings as wind farms become more widespread and people gain more experience on their impacts.

5. Recommendations

Co-utilization is an effective way of enhancing the social acceptance of wind power. Participation at every stage of the planning process in close cooperation with the wind energy companies tends to make local people, farmers, environmental organizations, authorities and businesses adopt a very positive attitude towards wind power. They appreciate the wind energy companies' respect for their expertise and creativity in mapping out co-utilization possibilities and planning continuous cooperation.

The active involvement in the projects and the resulting structures in turbines that for example, protect nature or collect data, satisfy the needs of most local people, environmental organizations and authorities. Farmers and companies want also business opportunities from co-utilization. The others often shy away from the profit-maximizing limited liability type market economy in co-utilization, but show great interest in socio-culturally beneficial co-op type co-utilization. This poses both an opportunity and challenge for the limited liability type wind energy companies: can they set limits to their short-term profit greed in order to secure long-term survival and success?

These issues are worth contemplating, as wind power is one of the few energy businesses that are strongly supported by environmental organizations. One of the most radical environmental organizations, Greenpeace, estimates that 20 per cent of the world's energy could be produced by wind power by 2030.[6] Such encouragement should be taken advantage of by solving the negative environmental, social, cultural and economic impacts of wind power through co-utilization and other measures.

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