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Offshore wind farms development in relation to environmental protected areas

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ABSTRACT

The potentiality of offshore wind energy development in the western coast of Greece in relation to all the protected areas in this region was investigated. Major factors such as minimum distances from constraining the offshore wind farm installations, ports and Natura sites were analyzed as environmental constraints in the region. The results indicate that even if all the protected areas are excluded as well as places of economical activity like ports, the available surface is adequate for the massive development of the alternative energy source of offshore wind.

1. Introduction

Renewable energy sources (RES) are viable forms of energy which derive from various natural processes such as wind, geothermal, water circulation and others. Two key features of these resources are:

i. it is not required any active intervention, such as mining, extraction or burning for their exploitation
ii. they are clean sources of energy, very environmentally friendly, which do not release hydrocarbons, carbon dioxide or toxic and radioactive waste.

During the last years, RES interest has been strongly revived due to the question of energy security (the two oil crises of 1973 and 1980), which made the industrially developed countries dependable on oil mainly and secondly, and the greenhouse effect, which led to the total recall of RES.

Wind energy is a practically inexhaustible source of energy. The exploitation of the high potential in countries like Greece, combined with the rapid development of technologies incorporated in modern efficient wind turbines, is of paramount importance for the sustainable development, the saving of the energy resources and the protection of the environment. In recent years, the cost of constructing wind turbines has significantly been reduced and it can be considered that wind energy is going through the period of maturity, as it is now competitive with conventional forms of energy.

As the high mainland wind energy resources are being covered with wind turbines installations, offshore wind farms have been started to be considered, since specific locations like North Ionian, Cyclades, the Aegean Sea, the Southern Crete, and the southeast of the Dodecanese have many advantages to those on land. Sea winds are more intense and with energy output dependable on the cubic power of the wind speed. It is estimated that each sea wind turbine produces enough energy in a year to meet the needs of about 1.500 households, while at the same time it reduces the production of carbon dioxide by about 35.000 tonnes. Bearing in mind their life duration in the sea of higher than 25 years, the great importance of exploitation of wind energy for the protection of the environment comes in the first place.

Recent energy estimates show that in a country like Greece, 500 large wind turbines can cover at least 10% of its energy needs with further increase from the high potential of the islands. However, the proper location of a wind farm at sea requires the installation of wind turbines at a remote distance from the shoreline and in shallow depths of the sea, with the criteria of thriftiness (cost of construction preservative), the avoidance of environmental impacts and the public acceptance, ensured by maximizing the distance from populated coastal areas from coastal recreational areas, shore bathers etc. The most essential prerequisite for efficient operations and economic viability of a wind farm is a high and exploitable wind potential. The size and the periodic fluctuations of the wind are key factors, related to the function of the marine park. The coastal areas are rich in natural resources while most of them host important habitats and species protected by international conventions and European directives. However, due

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Table 1
Major effects of offshore wind farms installations on the sea environment.

Impacts of OWF installations
- Acute noise-related impacts during construction phase (driving, drilling and dredging operations)
- Disturbance during exploration, construction and maintenance
- Generation of polluted sediments during construction and their re-suspension.
- Collisions of birds and other organisms with OWF structures
- Creation of the artificial reef, with concomitant impacts on biodiversity
- Chronic impacts due to continual operational noise and vibrations emanating from OWF
- Electromagnetic impacts (underwater cable networks) that may interfere with animal navigation
- Thermal impacts that may aggravate the impacts of other stressors on the benthos
- Impacts of episodic traffic increase for troubleshooting
- Impacts during physical decommissioning (particularly with the use of explosives)

to the accumulation of human activities, coastal areas are threatened by thoughtless development and environmental problems, such as pollution and climate change.

Offshore wind parks can influence the marine environment by a number of ways (Table 1). Monopiles can cause sediments removal, loss of substrate and changes in the water currents. During functioning, the marine bird populations are vulnerable to collisions while noise and vibration disturbs aquatic communities, fish and marine mammals. However, offshore piles, as artificial structures, may favour the settlement, reproduction and growth of aquatic species. Wilson et al. (2010) discussed in detail the potential impacts arising from offshore wind farm construction, and how these may be quantified and addressed through the use of conceptual models. They concluded that while not environmentally benign, the environmental impacts are minor and can be mitigated through good siting practices. In the Netherlands, an extensive monitoring programme was executed at the first offshore wind farm at Egmond aan Zee, (Lindeboom et al., 2011). Impacts were expected from the new hard substratum, the moving rotor blades, possible underwater noise and the exclusion of fisheries. It was found that the OWEZ wind farm acts as a new type of habitat with a higher biodiversity of benthic organisms, a possibly increased use of the area by the benthos, fish, marine mammals and some bird species and a decreased use by several other bird species. Since the construction of wind parks introduces a hard pillar on a soft bottom, it can seriously affect existing seabed habitats. The effect of Scroby Sands offshore wind farm to harbour seal (a species of conservation concern), was studied by Skeate, Perrow, and Gilroy (2012). An aerial survey programme conducted during a five-year period spanning wind farm construction, revealed a significant post-construction decline in haul-out counts. A lack of full recovery of harbour seal during the study was also linked to their sensitivity to vessel activity and/or rapid colonization of competing grey seal. Any impact of offshore wind farm development upon pinnipeds would be much reduced without pile-driving. In an experimental study conducted in the Tunø Knob offshore wind park in Denmark, common eiders were found to avoid flying close to or into the wind park (Larsen & Guillemette, 2007).

In a recent study, a surveillance programme was performed at the Lillgrund wind farm in Sweden in order to investigate the integrated effect wind turbines on the abundance and distribution patterns of benthic fish communities. The studies revealed no large-scale effects on fish diversity and abundance after establishment of the wind farm when compared to the development in two reference areas (Bergström, Sundqvist, & Bergström, 2013).

Moreover, extensive modelling and life cycle assessment has been performed on offshore wind farm development. The impact of the first German offshore wind farm alpha ventus in the North Sea was investigated by Wagner et al. (2011). In a life cycle assessment, its environmental influence was compared to that of Germany's electricity mix. They found that alpha ventus had better indicators in nearly every investigated impact category in comparison to the mix. They proposed that additional research should be performed by considering the backup power plants as well as increasingly required energy storage systems into account. Moreover, Burger et al. (2011) conducted a hazard and risk evaluation for three species of US list threatened birds, or candidates for listing, and that might occur offshore on the Atlantic Outer Continental Shelf (AOCS) where wind power facilities could be developed. They concluded that risk to this species is likely to be low from turbines located far from land as this species migrates mainly along the coast. Further validated information on exact spatio-temporal migration routes, flight altitudes (especially during ascent and descent), and behavioural avoidance of turbines by birds will improve the risk evaluation. Recently, Bergström et al. (2014) presented the current state of understanding on the effects of offshore wind farms on marine wildlife, in order to identify general versus local conclusions in published studies. The results were translated into a generalized impact assessment for coastal waters in Sweden, which covers a range of salinity conditions from marine to nearly fresh waters. The studies showed a high level of consensus with respect to the construction phase, indicating that potential impacts on marine life should be carefully considered in marine spatial planning. Potential impacts during the operational phase were more locally variable, and could be either negative or positive depending on biological conditions as well as prevailing management goals. There was paucity in studies on cumulative impacts and long-term effects on the food web, as well as on combined effects with other human activities, such as the fisheries.

However, there are also positive environmental effects due to offshore wind farms development. In the study of Wilson and Elliott (2009), it was found that the placement of offshore wind turbines gives the potential for habitat creation, which may thus be regarded as compensation for habitat lost. According to their analysis, the net amount of habitat created by the most common design of offshore wind turbine, the monopile, is positive, thus providing a net gain even though the gained habitat may be of a different character to the one that lost. Summarizing, the environmental impact of offshore wind farms installations and functioning on the local ecosystems is presented in Table 2. In order to minimize the environmental impact, Greek Law 2742/1999 "Spatial planning and sustainable development", paragraph 10, sets out mandatory criteria for the siting wind farms at sea and uninhabited islets as the following:

- The siting of wind facilities in all sea areas of the country is allowed, which have conditions of wind exploitation and which they do not become part of a particular institutional regime with a prohibition in the installation or which they do be part of the exclusion zone, like statutory or underwater parks or established lines passenger navigation.
- The clearances for the turbines installation in order to ensure the functionality and performance of wind farms should be minimized according to the provisions of land.
- The installation of wind turbines in a distance less than 500 m from organized or formed shores bathers or other remarkable coasts and beaches (e.g. sandy) is prohibited.
- Small-enclosed bays with opening width of less than 1100 m should be left free of wind turbines.
- Minimum installation distance from areas and items of cultural heritage and settlements should be considered in accordance with the provisions of the land.