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NAVIGATIONAL ASPECTS OF OFFSHORE WIND FARMS CONSTRUCTION IN THE POLISH EEZ

ABSTRACT

The paper presents methodology for determination of areas suitable for high power offshore wind farms in the Polish Exclusive Economic Zone of the Baltic Sea. Possible conflicts between different sea users and ways of their minimization are considered, especially in the aspect of navigation.

Keywords:
wind farms, offshore navigation, hazard.

INTRODUCTION

Increasing power demand recorded worldwide during the last few decades and rising deficiency of conventional power sources at the same time, as well as pursuit in CO_2 emission limitation all contribute to the necessity of energy sources diversification. For this reason more and more global attention and significance is given to renewable sources of energy with wind energy on the first place. Wind power plants are erected in numerous countries all over the world, mostly in Europe. Favourable climate conditions, especially strong winds from the Atlantic blowing in western and northern Europe for most of the year, are conducive for wind power industry development.

Interest in investment in offshore power industry worldwide including the North and Baltic Seas has been dynamically growing in the recent years. In comparison to coastal land areas offshore wind turbine location has a number of advantages:

— winds are much stronger and more stable in comparison with adjacent inland areas, which allows for a more efficient energy use;
— on the sea, the wind velocity increases relative to altitude much faster than inland and its force intensifies significantly further from the shoreline, which allows for high power turbine implementation;

— due to larger and less intensively used space, on the sea the erection of large energy farms is possible, which enables optimum utilization of wind energy;
— sea space has no inhabitants, so the adverse effects of wind farms such as noise, vibrations or seascape changes are less controversial.

Due to the above advantages, marine wind power industry is standing on the threshold of highly dynamic growth. High initial investment cost in comparison to onshore is a drawback of offshore wind farms, however, the time of investment refund can be relatively short.

European countries currently exploit or prepare for exploitation offshore wind farms with power exceeding 100 MW. Estimations by the European Commission show that facilities of 70 GW may be implemented in Europe until 2010, 14 GW of which in coastal offshore areas [12]. EWEA report [2] indicates that European coastal waters may reach production capacity of 40 GW in the year 2020, which corresponds with 4% of European Union electric energy demand (currently approx.1,1 GW has been implemented at sea).

Commission's Action Plan for offshore wind will be published as a result of broad consultations in November 2008. It is a significant step for indication of legal action needed at EU level for offshore power industry development to produce 20% of renewable energy until the year 2020.

The actions indicated above facilitate more and more intense offshore wind farm construction within European sea areas and coastal waters in particular. It will create a new situation for navigation and make special safety requirements necessary.

WIND ENERGY RESOURCES ASSESSMENT FOR POLISH SEA AREA

Within Polish Exclusive Economic Zone there are areas with valuable wind resources and water depth not exceeding 40 m (which is the current technical and economic limiting condition for offshore windmills' foundation), which create favourable conditions for wind farms' construction. Assessments carried out so far by the Maritime Institute in Gdańsk [9] assume the potential energy yield of these areas for approximately 18 TWh annually for depths between 20 m and 30 m and 28 TWh annually for depths between 30 m to 40 m. Considering that the predicted national demand for renewable energy in the year 2020 is around 25 TWh electric energy delivered to final consumers (15% of renewables ratio in overall energy production is a Polish obligation), it creates a situation where utilization of these resources is not only beneficial but also necessary for Polish economy [4].

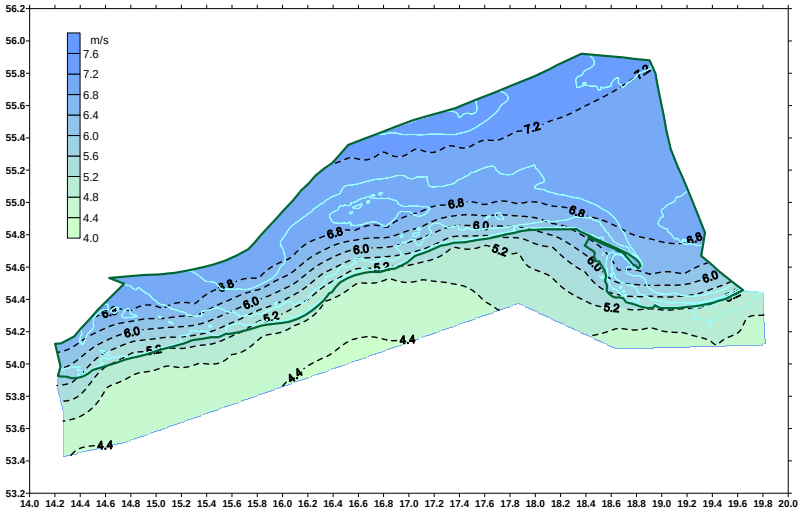

Fig. 1. Annual average wind velocities at sea and inland coastal areas for altitude of 10 m AMSL (as for 1998–2007); indication of 10, 20, 50 and 100 m depth contours

Due to lack of regular meteorological stations at the Polish sea, wind conditions assessment for these areas requires data taken from numeric models for weather forecast [6]. The analysis [8] showed conformity of these wind parameters with the ones observed at the sea. Also the average annual wind velocities (fig. 1) are in a good agreement with analysis based observation data from coastal stations [10].

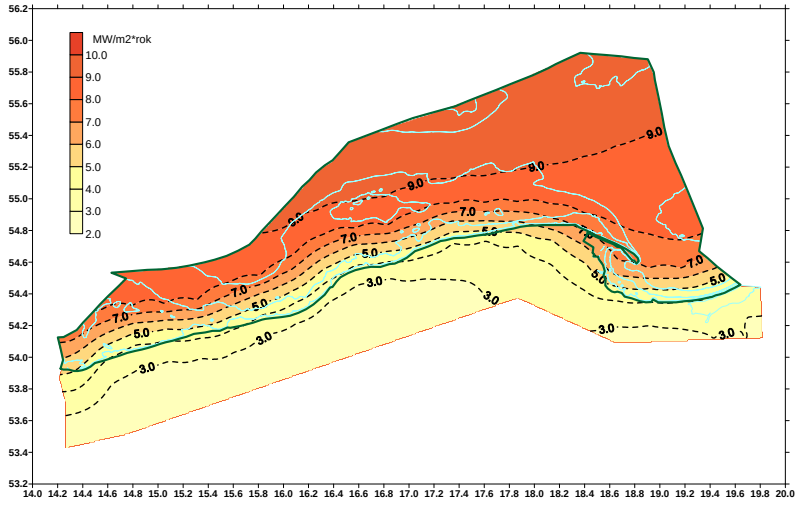

Fig. 2. Annual average potential for exploitable wind energy at sea and inland coastal areas (in MW/m^2/year) calculated for the altitude of 100 m AMSL (for 1998–2007)

Annual average wind velocities indicated in figure 1 both for Polish maritime and adjacent inland areas prove the relevance of wind power development at sea. It is confirmed by calculations of potential annual wind energy (fig. 2). However, the amount of actually produced energy will be smaller than the wind power potential, dependent on the type of implemented generators as well as their location on the farm.

MAJOR NAVIGATION ROUTES ON POLISH SEA WATERS

There are two major navigation routes in Polish sea areas in the southern Baltic: the far-sea and the coastal route. Among with other sea uses they determine the location of potential wind farms within the 40 m depth contour (fig. 3). In terms of their influence on navigation safety, it is necessary to consider the anticipated increase of cargo and passenger traffic. For example, according to one of the most professional studies [11], in the Gulf of Gdańsk, predicted volume of cargo shall increase from 47,7 million tons (Gdańsk) and 8,4 million t (Gdynia) in 2001 to respectively 65 million t and 14 million t in 2015; increase in passenger transport in both ports is predicted in the same study to 2,4 million passengers in 2015 compared to 1,6 million in 1998.

Navigation routes at open sea, shipping lanes and traffic separation zones at the ports are designed and controlled by the Polish maritime administration in cooperation with IMO (International Maritime Organisation).

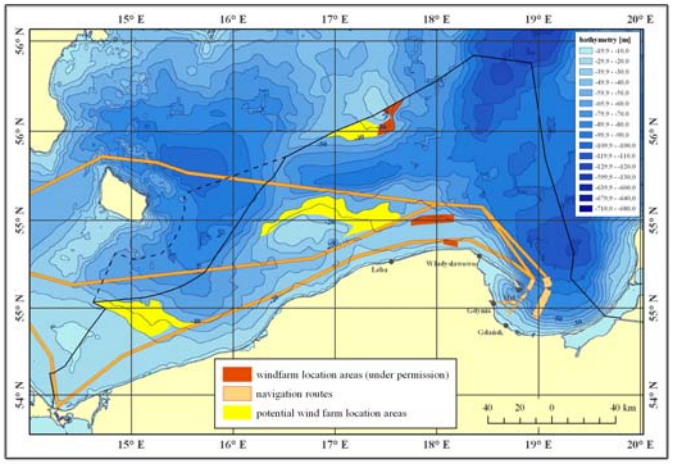

Fig. 3. Navigation routes in the southern Baltic near Polish shore and some of the proposed locations for offshore wind farms

A sea going route in the southern Baltic is, according to the NP19 — international navigation scheme, the route no 8.14. It goes from the Danish Straits, passing Bornholm from the southern side, the Słupsk Bank from the northern side to the ports of the Gulf of Gdańsk and further to Russian ports. The route is considered a major communicational artery designed for Baltic navigation in the southern region. It is significant as it enables traffic of vessels with large dimension and submergence independent of time of the year. It's also especially important during winter season, when ice may hinder or even prevent safe navigational use of the route north of the Bornholm Island. In the area to the north-east of Rozewie it is linked with sea going route to the Pomeranian Bay ports south of the Słupsk Bank.

According to the NP19 navigation scheme it is advisable for coastal navigation to use route no 8.301, which turns into route 8.330. It stretches approximately 4 sea miles from Polish shore. It is designed for vessels of smaller size, submergence and speed i.e. small commercial, passenger, fishery vessels, yachts etc.

Offshore power plant locations in vicinity of navigation routes should ensure free navigation and access to ports, unrestricted use maritime signalisation and lighthouse lights within boundaries of indicated range. These issues have been described in detail in the publication [3].

Estimation of impact of an offshore wind power plant on the existing shipping and navigation regime shall specify:

— potential impact on navigation safety on adjacent routes, taking into consideration also terrestrial navigation;
— preliminary risk estimation of vessel collisions;
— potential quality changes for sport and tourist navigation (yachting);
— threats to navigation during the construction and deconstruction stages;
— conditions of access for maritime rescue units within of close to the offshore wind farm area;
— recommendations on risk management and minimization of navigation disturbance.

EXAMPLE OF NAVIGATION MARKING OF OFFSHORE WIND FARM

Offshore power plant area is regarded as a navigation barrier closed for normal traffic (with exception of service vessels and farm maintenance). For this reason is shall be marked in conformity with effective international (IALA 0-117 [7]) and national guidelines and regulations. Marking methods of offshore wind power plants are regulated by the Ministry of Infrastructure Ordinance from 29.10.2002 concerning methods for navigational markings in Polish marine zone [1].

Therefore, in accordance with the foregoing guidelines the area of potential offshore wind farm Rozewie (fig. 3) shall be marked so it was easily visible day and night [5]:

— turbines on corner surface shall be marked using yellow flashing lights of 'special sign' characteristic so it is visible from all directions and has range of at least 5 sm;
— borders shall be marked in the middle of distance between the corner lights (at distance shorter than 2 sea miles to the corner), yellow flashing light of different characteristics and range from the light restricted for the 'special sign';
— navigation lights shall be located at the very top over the largest observable water level below the lowest arc made by the rotor blades, and the towers shall be painted in yellow form the highest noticeable water level up to light location height;
— in order to provide good radar visibility of the farm in all weather conditions, additional radar reflector shall be assembled in every corner pole of the farm surface;
— with regard to farm proximity to recommended sea going route, a fog signal shall be assembled in the surface centre operating within the range not shorter than 3 sm;
— as to enable unified identification of this navigational barrier, the Automatic Identification System (AIS) transmitter shall be assembled;
— for navigational safety level improvement (lowering collision threat for vessels in motion or leeway with wind power plant poles) a restricted zone within 500 m within the farm surface shall be implemented;
— every pole shall be marked with a number, which explicitly identifies turbine number; every of the number shall be illuminated by low intensity light in order to be visible from sea direction, which shall allow for its reading (in normal visibility conditions) from the distance of 300 m.

Offshore wind farm erection within regions of intensive navigation routes requires carrying out of a risk assessment. Therefore, it is possible to identify level of the collision and other navigation risks in the farm vicinity for:

— vessels using proposed navigational routes as well as those beyond these routes;
— vessels in the leeway;
— fishery vessels;
— sporting and recreational boats.

Methods for collision risk assessment are based on statistic methods, which determine probability of collision by vessels, which use areas in direct vicinity of offshore wind farms [3].

CONCLUSIONS

The increasing power demand of Polish industry including renewable energy sources focuses the attention of growing number of investors. Wind power collection on the sea is regarded more promising than on the land. On account of this, there appears a new significant sea user, whose activity may cause specific limitations and obstruction for present users including shipping.

On the other hand, there is a growing demand for maritime transportation services with regard to increasing cargo mass, an extensive amount of which is hazardous cargo as well as dynamically growing passenger transport. Therefore, there is a need for designing proper spatial plans for marine regions in Polish EEZ in order to avoid possible conflicts, maintain safety conditions and tap beneficial economic effects. Presently these works are being conducted by Maritime Institute in Gdańsk.

Offshore wind farms are regarded navigation barrier for vessels in their vicinity. Therefore proper marking as well as restricted security zones shall minimise collision threat with the towers.

As there are no operating wind power plants in the Polish marine zone at present, their design, erection and exploitation stages will require application of experience gathered by other countries and their adjustment to current Polish legal regulations. Navigation activity in regions, where offshore plants are located shall be thoroughly monitored at construction and exploitation phase to provide appropriate means of navigation security and collision threat limitation.

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