Nawigacja,
Bezpieczeństwo żeglugi

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NAVIGATIONAL ASPECTS OF MARITIME SAFETY IN OFFSHORE INSTALLATIONS AREAS -WINDFARMS

Article in short form presents some problems of maritime safety in such offshore installations as windfarms are. Some economic aspects of windfarms exploitation are shortly sketched at the beginnings. Next, such navigational issues as an identification, marking, boundaries and effects on routing are touched on by authors. The form of an article restricts authors to present only the main problems in a wide-ranging of subject such a maritime safety in windfarms is.

NAWIGACYJNE ASPEKTY BEZPIECZEŃSTWA ŻEGLUGI W REJONACH FARM WIATROWYCH

Artykuł w skrótowej formie porusza problem bezpieczeństwa żeglugi z rejonie instalacji offshore jakimi są farmy wiatrowe. We wstępie nakreślone są ekonomiczne aspekty eksploatacji farm wiatrowych; w dalszej części takie elementy nawigacyjnego bezpieczeństwa jak oznakowanie, strefy bezpieczeństwa, wpływ na środowisko oraz linie żeglugowe.

1. PREFACE

As commonly known, the total wind power resources available offshore are vast and should certainly be able to supply a significant proportion of electricity need in an economic manner. Several studies concluded that a large proportion of power could be supplied from offshore wind turbines.

Apart from various lobbying organizations, there are some oppositionists which indicating some conflicts of interest concerning: ship and air traffic, defense, fishing and special fauna species. Following them, some areas should definitively be excluded from consideration for use as offshore wind power stations at the pre-planning phase. These are e.g. major ship lanes, areas close to airports, oil & gas pipelines, cable routes, raw material deposits, military restricted areas and areas of importance in relation to fauna. Nevertheless, there are a lot of offshore areas where all above mentioned conflicts do not exist and that

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are the areas which should be eventually considered for achieving power from windfarms. [1]

In this short article authors would like to focus on some navigational aspects referring to maritime safety in offshore installations areas as windfarms are. These aspects are e.g.: charting, identification, markings, boundaries and effects on routing.

2. WINDFARMS ECONOMICS ASPECTS

Looks like an offshore windfarms will become an important source of energy in the near future; it is expected that wind parks with a total capacity of thousands of megawatts will be installed in the seas all over the world. This will be equivalent to several large traditional coal-burn power stations. Plans are currently advancing for large-scale wind parks e.g. in Swedish, Danish, British and Irish waters and the first such parks are currently working e.g. in U.K. [6]

As in all undertakings these are some advantages as well as disadvantages of an investment.

Major advantages which are taking into consideration thinking about an offshore windfarms are:

- availability of large areas suitable for major projects;
- higher wind speeds, which generally increase with distance from the shore;
- less turbulence, which allows the turbines to harvest the energy more effectively and reduces the fatigue loads on the turbine;
- lower wind-shear (i.e. the boundary layer of slower moving wind close to the surface is thinner), thus allowing the use of shorter towers.

But there are very important disadvantages of the additional capital investment necessary e.g., for:

- marine foundations;
- installation procedures and restricted access during construction due to weather conditions;
- integration into the electrical network and in some cases a necessary increase in the capacity of weak coastal grids.

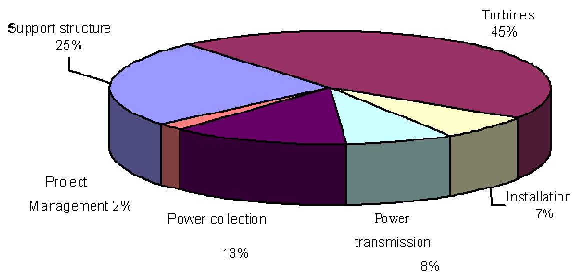

Figure 1: Typical distribution of costs for offshore windfarm [1]

There are many wind farms in operation or under development in the UK. (British Wind Energy Association) e.g.: Barrow, Blyth Offshore, Kentish Flats, North Hoyle, Scroby

Sands, and Burbo Bank. A further are reported to be under construction. To date there have been no recorded incidents for a ship collision with a wind turbine structure, but on the other hand, there are a lot of efforts for researches on navigational risk assessment. [3]

3. WINDFARMS NAVIGATIONAL SAFETY ASPECT

Identification - all windfarms are charted by the UKHO, either by a group of black wind turbine chart symbols or by encircled black wind turbine symbol. The outer limit is a black dashed line or a magenta T shape dashed line. Submarine cables associated with windfarms are charted depends upon the scale of the chart.

The turbines typically consist of a foundation below sea level, a yellow transition section not less than 15 m height measured above HAT (highest astronomical tide), above which is a platform forming the base of the turbine tower – usually 70 ÷ 80 m in high. All above, cause that windfarms in good meteorological conditions are without difficulty identifiable both visually and by radar from a considerable distance.

At the top of the turbine tower is a nacelle - a box shaped structure housing the generator. The turbine blades are located opposite the nacelle. Each turbine blade can be more than 60 m in length. The structures above the yellow transition section are usually painted matt grey. The total high of a turbine and rotors can be up to about 150 m.

Theoretically an observer with a high of eye of 3 m should be able to see the tips of the blades at the distance of 28 miles. Nacelle larger than 70 m high should be visible to the same observer at 20 miles in clear visibility.

The foundations of a single turbine may be either mono-pile sunk into the seabed, a basket filled with aggregate or a tripod anchored. Inseparable parts of the turbine are electrical cables located on the seabed. The network of cables from individual turbines may be connected in some cases to separate platform containing electrical switchgear, transformers and other equipment for transition along a cable an onshore substation.

Windfarm boundaries marking matter – Following IALA Recommendation 0-117 /may 2000/ offshore wind generators have to be marked so as to be conspicuous by the day and night with consideration given to prevailing conditions of visibility and vessel traffic. In central cases the cardinal marks should be permanently placed adjacent to windfarms. During construction standard cardinal marks have to be used around the area.

A corner structure or other significant point of the windfarm boundary is called Significant Peripheral Structure /SPS/.

Every SPS is marked with lights visible from all directions in the horizontal plane. These lights are synchronized to display an IALA “special mark” characteristic – flashing yellow with a range of not less than 5 miles. Aids to navigation on individual structures are typically placed below the arc of the rotor blades – at the top of the yellow section. Additionally, as a minimum each SPS must show synchronized flashing characteristics. In some cases there may be synchronization of all SPSs. In the case of the large or extended windfarm the distance between SPSs should not normally exceed 3 miles.

Selected Intermediate Peripheral Structures /IPS/ on the boundary of a windfarm between SPSs, should be marked with flashing yellow lights which are visible from all directions horizontally. As directed, the characteristics of these lights should be distinctly different from those displayed on the SPSs with a range not less than 2 miles. The distance between such lit structures should not exceed 2 miles. The characteristics of the lights and marks will be shown on the chart.

Additionally IALA permits: illuminating of peripheral structures and all structures within the windfarm Racons with Morse characteristic “U”, Radar reflectors and radar target enhancer. AIS as an aid to navigation /IALA recommend. A-126/. Sounds signals – where windfarm is equipped, should be not less sound range than 2 miles – details should be given on the chart as well. [5]

Other issue is *single structure marking*. Individual turbines will be marked with a unique alphanumeric identifier which should be clearly visible at a range of not less than 150m. At night should be lit discretely /e.g. with down lighters/ enabling to be seen at the same range. So turbines should be clearly visible in good visibility but may be reduced in poor visibility conditions and at night.

Fixed red aviation lights on the top of the nacelles have to be visible to surface craft and care must be taken not to confuse these with vessels sidelights or marine navigational aids, despite the possibility of them appearing to have a flashing characteristic when seen through rotating turbine blades. According to IALA recommendation 0-114 a single structure /not a part of a turbine group/ should be marked with a white light flashing Morse code “U”.

Windfarms and turbines effects on routing. Currently a large study and collision risk analysis is being carried out and in general, such risk studies and additional information on damage mechanisms are called for in order to investigate the issue of marine traffic safety and offshore wind farms more closely. Even where careful planning is carried out, and the farm is not placed near major navigation routes, or routes have been altered in order to minimize collision risk, there will still exist a risk of severe environmental damage in case of ship collisions with wind turbines, e.g. an oil carrier collision, furthermore, locations where ships may lay the anchor /close to harbors entering and anchoring areas/ must be avoided. On the other hand, when wind farms are to be located on reefs, banks and other shallow water areas, which in themselves constitute a risk for ship collisions, well-planned offshore wind farms can contribute to maritime safety.

Especially vessels involved in turbine maintenance and safety duties /small crafts/ may be encountered within or around a windfarm. Fishing vessels may also be operating in the area. Therefore all should be conscious of a possibility of presence such a vessels and aware that the structures may occasionally obscure them. This is particularly relevant at night. Large vessels may become obscured as well. A good lookout should be therefore maintained by mariners at all times by all available means /as required by COLREG/.

Additionally, in coastal areas *shore marks* may also be obscured by windfarm structures. Particularly, the characteristics of lights at night need careful verification if turbines temporary mask them. Following a good marine practice, vessels position should be checked by all available means continuously.

In or adjacent to larger windfarm offshore electrical *transformer stations* may be present. These stations are of similar appearance to small offshore production platforms. Submarine cables link turbines to this transformer stations from where the generated power is exported to the shore. As already mentioned, whether all submarine cables are charted depends on the scale of the chart. Therefore, small craft operating within the windfarm should avoid anchoring except in emergencies as the anchor can easily become fouled.

Zones totally excluded for any vessels movement except special support or safety vessels are defined as *Safety Zones*. Temporary safety zones may be established during construction as and when required. Such a safety zones are promulgated by Notices to Marines and Navigational Warning broadcast. Permanent Exclusions Zones – are expected to be established around windfarms, if compelling risk-assessed arguments are presented. The nominal safety zone around an operational single wind turbine is expected to have a 50 m radius.

The UK introduced new regulations regarding safety zones around or adjacent to an offshore renewable energy installations. Following these new regulations standard dimension of the safety zone is 500 meters during construction (which is the maximum permissible under international law), and 50 meters during the operational phase of an installation's life (Department for Business Enterprise & Regulatory Reform, 2007). The requirement for a larger safety zone should be considered as part of the navigational safety assessment. [7]

In sudden emergencies, such as engine or steering failures, close to or within windfarm installation, the standard procedures for mariners should be to inform immediately appropriate authorities and be prepared to use anchors if necessary, being aware of the likelihood of presence of submarine cables and other seabed obstructions. General rule for voyage planning through windfarms waters should be to avoid the area completely. Where there is sufficient sea room, the prudent option is to navigate around the edge of the farm.

Considering *air traffic*, the main problem does not appear to be the civil air traffic.
The requirements posed by helicopter teams seems to be the most important concern, e.g. rescue helicopter teams, who might have to access the offshore wind farms in heavy weather. As the sites are covered by quite heavy turbulence, helicopter maneuvers within the area are difficult, making marking lights and ability to switching off all turbines immediately is a really serious safety issue.

Next few navigational safety aspects concerning windfarm are spacing, depth of water, seabed changes and influence of the turbines on the radar and radio signals.

Spacing turbines within windfarm depending on the size of the turbine but generally are spaced 500m or more apart. In order to make best use of the wind resource, turbine spacing is proportional to the rotor size and the down-wind wake effect created. General rule is larger rotor, greater spacing. Small craft may be able to navigate safely within the windfarm boundaries, while larger craft will need to keep clear.

Offshore wind turbines located around the UK are required to have the lowest point of the rotor sweep at least 22 meters above MHWS. This clearance seems be ample for the majority of small craft. Those with a grater masthead height should take appropriate care. It would, in any case, be imprudent for larger vessels to be close to a turbine in situation other than an emergency.

The majority of winds turbines now operating in relatively shallow water e.g. on shoals or sandbanks. The limited *depth of water* therefore provides a natural constraint between larger vessels and turbines. However, is expected that new generations of windfarm will be constructed in deep water, where navigable channels in the vicinity may restrict vessels to a particular route passing close to a windfarm boundary.

Windfarm structures could, over time, *affect the depth of water* in their vicinity. In dynamic seabed areas with strong tidal streams, changes in the scouring of the seabed may occur. This may result in depth information being unreliable. Windfarm developers are therefore required to make an assessment of any potential changes in sedimentation that may occur as a consequence of their plans. Development may be permitted where the assessed effect is considered tolerable.

In practice, the actual effect could differ so it is good to bear this in mind and allow sufficient under-keel clearance with a suitable margin of safety. Some wind turbines have scour protection in the form of boulders or concrete mattresses placed around their base. Windfarm structures may obstruct *tidal streams* locally as well, creating eddies nearby. Mariners should be aware of likelihood of such eddies which are likely to be significant very close to the structures.

The turbines produced strong radar echoes giving early warning of their presence. The movements of the turbine blades are registered by the radar as false echoes, presented as several dots on the operators’ screen, which may be confused with the echoes from an aircraft. They may produce multiply reflected and side lobe echoes that can mask the real targets. These develop at about 1.5 miles with progressive deterioration in the radar display as the range closes. Target size of the turbine echo increases close to the turbine, with a consequent deterioration of target definition and bearing discrimination. This effect we can observe on both 3 and 10 cm radars.

Radar antenna which is sited badly with respect to items of the vessels structure can enhance this effect. Adjustment of radar controls can suppress some of these spurious radar returns but operators should be conscious that there is a consequent risk of losing targets with a small radar cross section, such as buoys or small craft. /e.g. yachts/. Care must be taken during such adjustments.

As an example of measures to mitigate wind turbines effect on radar systems and decrease the collision risk, it should be mentioned that in the UK, whenever relevant, wind farms will be equipped with radar reflectors/intensifiers and fog signaling devices, as specified by the Department of Environment, Transport and the Regions. [4]

Researches shows that are a minimal impact on VHF radio, GPS receivers, cellular telephones and AIS. UHF and other microwave systems suffered from the normal masking effect when turbines where in the line of the transmissions. The disturbance of radio signals is primarily caused by reflections from the tower and is depending of the frequency band of the radio links; influence from wind turbines may deteriorate the performance for radio relay links for frequencies between 2 and 10 GHz. The potential disturbance effect of radar and radio signals increases with the number of turbines. [7]

Harvesting energy, turbines “de-power” the wind. Researches indicate that we can even expect 10% reduction in wind velocity. This *wind-shadow effect* is predicted to exist within the vertical air column up to heights of 15 m. The impact of the wind shadow reduces with distance in the lee of the turbine.

The effect of the turbine rotor harvesting the wind can be pictured as a horizontal cone, centered on the rotor hub with the approximate diameter of the rotor. The cone extends down-wind attenuating to the point at a distance proportional to the wind velocity. This down-wind effect also depends upon the azimuth of the rotor. The impact on the vessel is proportional to its wind age area and for a sailing vessel the mast height. Especially yachtsmen need to be aware of this effect. By day the normal visual clues should be noted and changes in leeway or the balance of the tidal stream to wind power anticipated. Extra care should be taken at night, when clues are not so easily detected.

4. CONCLUSION

Despite economic reasons for construction and development offshore windfarms, we should be conscious of their influence on to date human activity at sea – shipping. Expansion such constructions in offshore areas inevitable enforce support and service using special vessels witch proper navigational supported area. This is not a simple issue and need a sophisticated risk analyses for each location separately. In this article, authors tried to outline the matter and touched only a few aspects of navigational safety in these areas.

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