Solar Parks and Wind Farms Along Inland Waterways – Mitigating Measures Concerning Hindrance for Vessel Traffic

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Abstract. In the search for space for producing renewable energy, possible negative effects of solar parks and wind farms along inland waterways can easily be overseen. This paper provides an exploratory description of effects for navigation like blinding of helmsmen, disturbance of radio communication and exaggeration of vessel's radar images and concludes with a chapter on mitigating measures.

Keywords: Solar parks · Wind farms · Effects for navigation · Inland waterways

1 Introduction

To stop or at least slow down climate change, a world wide pursuit to produce renewable energy instead of using fossiles is high on the agenda. Two ways to produce green energy are booming: solar parks and wind farms. Being quite space consuming, they are often planned along inland waterways as the banks are often free of population, buildings and growth.

The possible negative effects of solar parks and wind farms along inland waterways for vessel traffic can easily be overseen. In the case of solar parks, the installation can cause electromagnetic hindrance (disturbance of radio communication). Also, reflection of the sun in the solar panels can lead to blinding of the helmsman (visual hindrance). Both hindrances can have a negative effect on nautical safety, as recent research from the Dutch Organization for applied scientific research (TNO) shows (Emmerik et al. 2022). This research was ordered by the Dutch main waterway authority Rijkswaterstaat.

In the case of wind farms, each wind turbine reflects the echo of radars, that are installed aboard vessels or ashore, as a part of a VTS system. The wind turbines can produce false echos in the fairway at the radar-screen and thus lead to misunderstanding by the skipper or VTS-operator. Again, this hindrance can have a negative effect on nautical safety.

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2 Solar Parks

2.1 Visual Hindrance

Possible visual hindrance of solar parks for helmsmen starts with the reflection of sunlight by the panels. Reflection is highly dependent on the angle of incidence. In a perpendicular situation, resulting from diffractive indexes of air and glass reflection of sunlight is only 4%, but at larger angles reflection increases up to 100%.

2.1.1 Human Aspect of Reflection of Sunlight

The first definition of nuisance is based on the point when it becomes uncomfortable to perceive reflected sunlight. This can be expressed in many ways, but common reactions are a tendency to turn the head away from the light source or hold the hand above the eyes or in front of the light source.

A second way to define this hindrance is to rely on the process that takes place in the eye. The Solar Glare Hazard Analysis Tool (SGHAT) from Sandia National Laboratories in the US is based on this (Ho et al. 2011). This tool calculates the amount of light that falls on the retina. The angular size of the light source in the visual field of the observer is also calculated. Based on these two measures, it is then calculated how much light falls on the retina and how large the light source is depicted on the retina.

2.1.2 Application of the SGHAT Model on the Dutch Waterway Network

The effects of solar parks along Dutch inland waterways were calculated by making use of an adapted SGAHT model. Parameters of this model are azimuth, angle of inclination, (viewing) direction and orientation of the solar panels.

Being a relatively small country (300 x 200 km), the outcome of the model is the same in the whole of the Netherlands. The outcome of the model is the hindrance of the reflected sun, expressed in the number of hours a year. Emmerik et al. (2022) recommended a somewhat arbitrary upper limit of 100–150 hours annualy.

As an example of this research, Figure 1 below gives an expression of the hindrance for northerly directions of view.

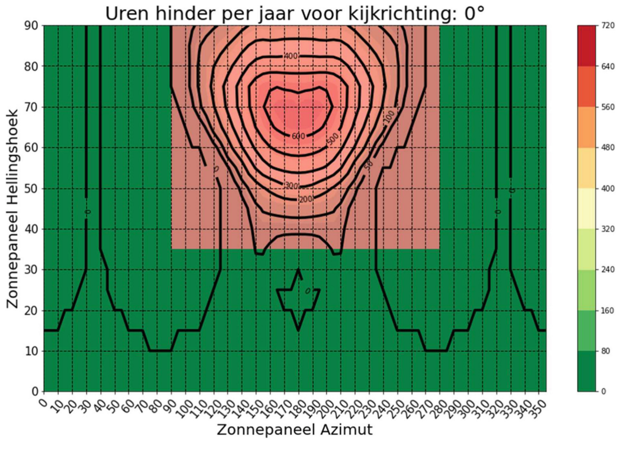

Fig. 1. Riskfull solar panels for northerly directions of view.

Special fairway situations as junctions and trajectories served by operators of locks and bridges can ask for a stricter number of hours of hindrance (up to zero), to be determined by the waterway authority concerned.

The research carried out by Emmerik et al. (2022) is not suitable for movable solar panels, following the sun; it can be assumed that those cause more hindrance than predicted by the SGHAT model.

2.2 Radio Disturbance

Solar parks along inland waterways can possibly cause disturbance of radio communication between vessels or between vessel and operator of lock, bridge or Vessel Traffic Service. Most important communication systems involved in the Netherlands are maritime radiotelephone (VHF), automatic identification system (AIS) and the system used by first responders (C2000).

2.2.1 Cause of Disturbance

The radio disturbance can be caused by the combination of the inverter(s) and the electric wires, connecting the panels. Together they can cause significant high-frequent emissions. In the past, severe degradation of the C2000 network has shown in Dutch residential areas. A recurrence in the VHF, AIS and C2000 networks should be prevented.

Figure 2 below shows emissions of a solar installation -measured by the Dutch governemental Radio Agency- which can reach a level of 14 dB. Emmerik et al. (2022) limit this increase of radio noise of solar systems however to 3 dB.

2.2.2 Rules for Electromagnetic Compatibility (EMC)

In Europe, Guideline 2014/30/EU was published to prevent all kind of electric appliances from radio noise. This EMC-Guideline refers to European harmonized standards NEN-EN 55011:2016 and EN61000-6-4/A1, agreed on by manufacturers and radio users. Appliances that comply to these European standards, are supposed not to disturb and get a CE-label.

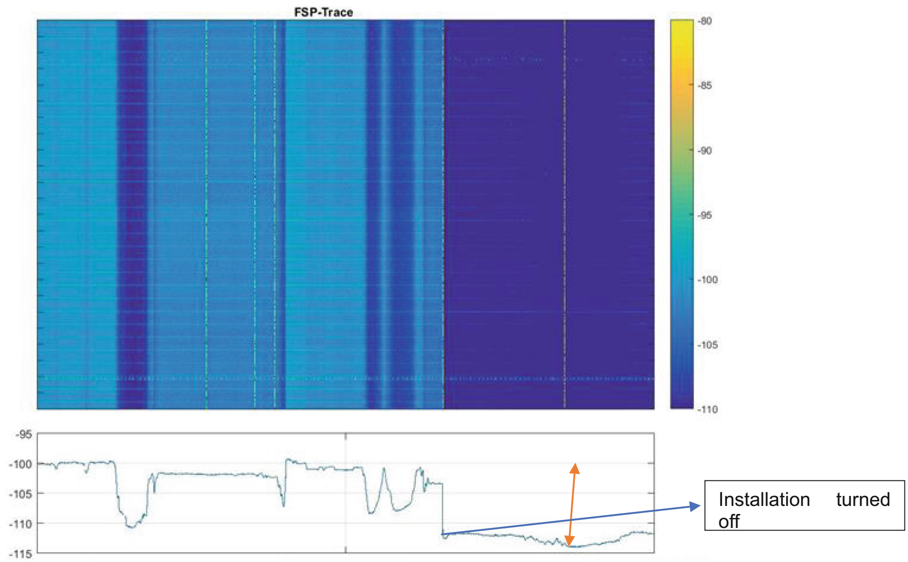

Fig. 2. Noise level of 14 dB (orange arrow), produced by a solar installation. Source: Radio Agency Netherlands.

Emmerik et al. (2022) however, showed that a complete solar installation whose appliances apply to the European standards, can still produce serious radio disturbance and violate the so called essential requirements of the European Guideline 2014/30/EU. The same message comes from Keyer et al. (2014), who state that nearly all European national agencies, responsible for enforcing the law in this matter, are not able to stop this fast growing number of violations.

3 Wind Farms

3.1 Projection of a Windturbine at a Radarscreen

Windturbines are projected at the radar screen of an inland waterway commercial vessel deviant from the real situation in a number of ways. Most important deviation is the exaggerated projection of their width, as a result of the width of the radar bundle. Such radars are certified for an observing distance of 1200 m. At this distance, this wider projection of the windturbine is illustrated in Fig. 3 below.

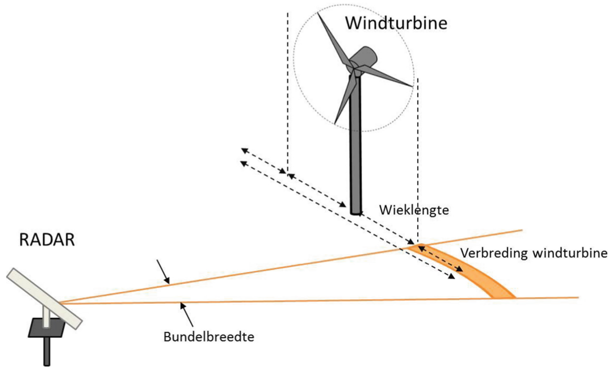

Fig. 3. Principle of the exaggerated width of the windturbine on the radar screen. Source: Rob van Heijster et al. 2016.

3.2 Problem of Exaggerated Width

As a result of the exaggerated with, a windturbine (to be) placed close to the fairway can be projected on the radarscreen as an object laying partly in the fairway. Note that this projected object is at maximum size when -due to the momentary wind direction- the rotor of the windturbine is perpendicular positioned to the fairway. This projection can lead to all kind of misinterpretations of the radar observer (helmsman) and subsequently to riskfull behavior, like navigating around or stopping in front of the would be obstacle in the waterway. An illustration of this deviant image of a windturbine on the vessel's radar screen can be seen in Fig. 4 below, giving the impression of a largely blocked fairway, indicated by the white circle.

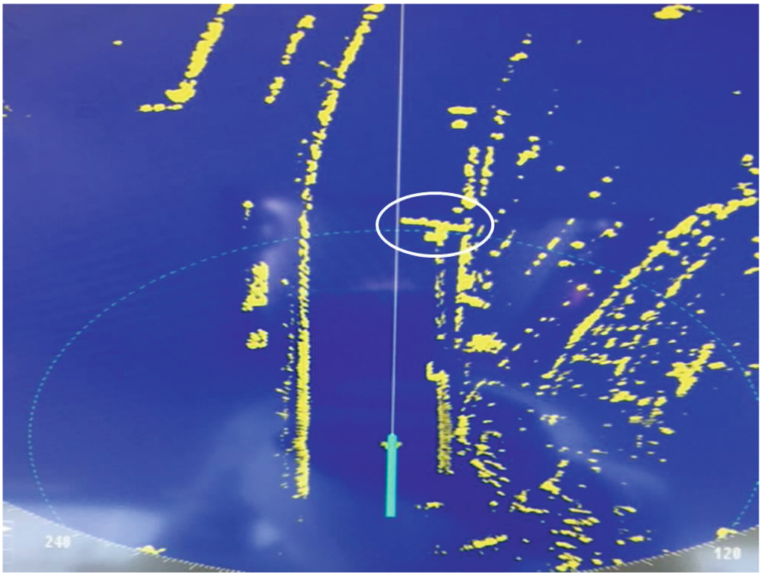

Fig. 4. Image on the radar of a commercial vessel, navigating the Dutch Hartel canal. Source: Rob van Heijster et al. 2016

3.3 Current Dutch Policy on Minimal Distance

In order to avoid images of windturbines at vessel's radar screens in the fairway like in Fig. 4 above, the Dutch Minister of Infrastructure (2015) published his policy concerning applications for permission to place windturbines. The minimal distance from the edge of the fairway should be at least 50 m and in all cases at least half the size of the rotor of the windturbine, to avoid possible collision with vessels.

3.4 Windfarms at Sea

At sea, the number of windfarms is growing rapidly, also in areas of marine traffic. Various effects of the windturbines on the radar at seagoing vessels are addressed recently by the National Academies of Sciences, Engineering and Medicine (2022), but they are out of the scope of this paper, which focusses on inland waterways.

4 Mitigation

This chapter provides points of interest and possible measures to reduce the hindrances previously discussed. The first part concerns diminishing hindrance of solar parks, the second part of wind farms.

4.1 Mitigating Hindrance of Solar Parks

4.1.1 Mitigating Visual Hindrance

The reflection of solar panels can be reduced by the use of coatings or textured glass. For an idea of the reflection by different types of solar panels, see Fig. 5 below. The lowest curve in Fig. 5 concerns deeply textured panels.

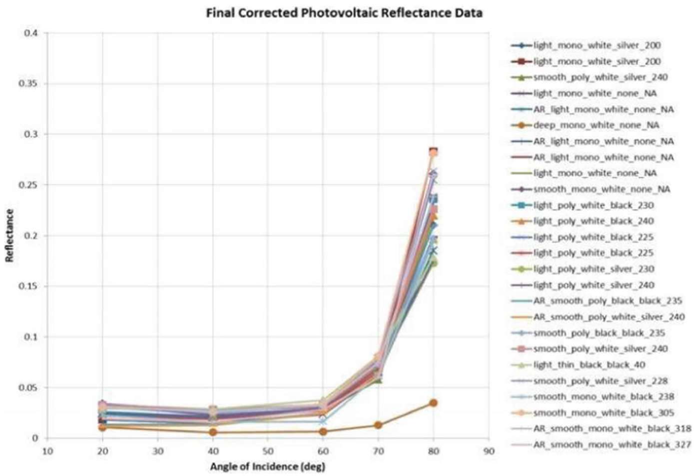

Fig. 5. Source: Ho et al. 2011.

4.1.2 Mitigating Electromagnetic Hindrance

Various measures can contribute to diminish electromagnetic effects and avoid radio disturbance. First of all, electric wires should not form a string and can be put side by side in iron bars or cable trays. Secondly, the right type of EMC/EMI-filters and ferrite beads can be applied (see Fig. 6 below); the latter is often seen in the case of computer devices.

Nonetheless these measures, specialized measurements before and after realization of a solar park are necessary to be certain that no radio hindrance is produced.

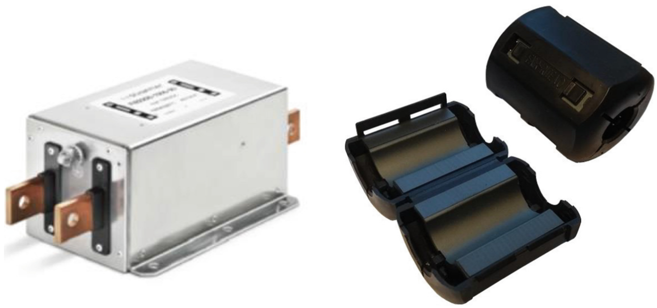

Fig. 6. EMC/EMI filter (left) and ferrite beads (right). Source: Dutch Agency for Telecommunication.

4.1.3 Mitigating Hindrance of Windfarms

Based on the fact, that a windturbine's reflection point is relatively small and concentrated, Heijster et al. (2016) starting from the then current largest windturbines determined the exaggerated width at 30 m at both sides of the windturbine at a distance of 1200 m. This led to the recommendation for the Dutch Minister of Infrastructure to change his policy (see §3.3) into a minimum distance to the edge of the fairway of half the rotor size of the windturbine plus 30 m.

Another direction for a possible contribution to nautical safety is providing a windturbine with an AIS transponder, thus informing the helmsman on the presence of the windturbine, thereby avoiding misunderstanding of it's image at the vessel's radar screen.

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