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Spoiled darkness? Sense of place and annoyance over obstruction lights from the world's largest wind turbine test centre in Denmark

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ABSTRACT

The relation between wind power development and local communities has received considerable attention in literature and practice. Relatively few studies, however, have provided evidence about how local citizens perceive enduring environmental impacts such as aviation obstruction lights installed on wind turbines or on wind farm light masts. Evidence regarding people's perceived annoyance over obstruction lights is of increasing importance as wind turbines become taller, thus potentially affecting more people in the future. The paper conducts individual web-based surveys and interviews with local residents around the world's largest onshore test site for tall wind turbines in Denmark – the national test site in the rural area of Østerild. The aim is to explore the nature and extent of perceived annoyance over aviation obstruction lights from the test site and the efficiency of different coping strategies. In particular, the discussion focuses on the perceived annoyance in relation to the perceived changes in sense of place, hereunder the loss of the area's unique night darkness. We argue that perceived annoyance can only be mitigated through coping strategies to a limited extent, as a) perceived effects on sense of place are distinctive in shaping annoyance, and b) an internalisation of planning-related inequities persists.

1. Introduction

A significant number of researchers have studied the relations between wind power development and citizens' reactions, with a special focus on social acceptance [e.g. [1–5]]. Paradoxically speaking, while research supposes that initial concerns and resistance wane after the realisation of wind farms, and that the majority of residents appear to at least tolerate the projects if impacts are adequately dealt with [5,6], relatively little is known about how the enduring impacts may pervade people's everyday lives after the construction of wind farms [7]. It is crucial to develop a better understanding of the factors shaping people's responses to wind farm development by not only examining the concerns and envisioned impacts at the planning stage, but also once infrastructures have been constructed and become operational [8].

One particular type of impact from wind power that has received less attention is aviation obstruction lights. Requirements regarding obstruction lights differ across countries, e.g. in terms of colour, light source and flash frequency [9]. Research in Germany and Switzerland has documented a substantial annoyance caused by different aviation obstruction light technologies [10–12], which demonstrates a potential conflict between wind power ambitions, flight safety and the values and health of local citizens. In order to manage the trade-offs between wind power, aviation safety, health impacts and social acceptance, it is important to investigate and document the impacts of different obstruction light technologies and solutions on local citizens.

As wind turbines are consistently increasing in size and height, obstruction lights will always be required for flight safety, and will thus be visible from a greater distance; indeed, this could potentially annoy more inhabitants [13]. Given this development, obstruction lights on wind turbines are likely to become increasingly important in terms of citizens' perception and reaction. This paper adds to the limited existing knowledge about enduring impacts from obstruction lights by reporting on perceived annoyance among local citizens from what is termed the world's largest test site for large wind turbines [14]. Located at an onshore test site in Østerild, Denmark, these wind turbines have an installed capacity of up to 8 MW and a current height of up to 222 m. The Østerild test site is unique insofar as it is a nationally designated test site designed for testing prototypes of large (up to 250 m tall) offshore wind turbines on land. Thus, the wind turbines are gener-

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ally taller than seen at other wind farms on land, and consequently the required level of obstruction light markings for aviation safety is more demanding, demanding white flashing lights mounted on to two light masts, making it an interesting site for a study. Moreover, the planning process of the test site was characterised by a top-down approach, leaving very little leeway for actively taking into account people's concerns other than upfront concessions based on compensatory measures. Furthermore, the test site's location in a largely rural area which benefits from unique characteristics such as an unspoiled, dark night sky, implies that the impact of the obstruction lights may be seen as more intrusive and detrimental to the sense of place than in other areas. The unique case of the test site for large wind turbines in the rural area of Østerild is therefore interesting due to its particular technological, institutional, and place-based characteristics, but also reflects the importance of that issue.

The aim of this paper is to explore the nature of local perceptions regarding the impacts of the aviation obstruction lights from the test site for large wind turbines through individual web-based surveys and interviews with selected local residents. While it provides a unique case, the study adds to the limited knowledge base regarding perceived annoyance and coping strategies from obstruction light technologies, particularly in regard to the effects of flashing lights during night time from very large wind turbines. The study furthermore contributes to the understanding of the concept of annoyance and the relation between perceived annoyance and sense of place. As part of this relation, the paper focusses on the issue of the loss of night darkness as a perceived deterioration of uniqueness and distinctiveness of the place [15], and how the lost quality of darkness adversely impacts the efficiency of coping strategies.

2. Obstruction lights, annoyance and local responses

The relationship between visual impacts of obstruction lights on wind farms, sense of place, and perceived annoyance has rarely been considered. This section positions our study of obstruction lights in these notions, and provides a framework for the empirical analysis.

2.1. Research pertaining to aviation obstruction lights on wind turbines

Research regarding the visual impacts of wind turbines has predominantly focussed on individual perceptions of turbines [e.g. [16,17]] and the assessment of the visual presence of wind turbines in the landscape and seascape [e.g. [18–21]]. Obstruction lights on wind turbines or wind farm light masts are generally only indirectly considered as part of visual impacts [e.g. [16,17]].

So far, only a group of German researchers has extensively studied the significance of visual disruptions through light pollution from wind turbines and analysed the perception of and annoyance resulting from wind turbine obstruction lights [11,12,22]. They compared the stress impacts of different aviation obstruction markings on people living in the vicinity of several wind farms in Germany and Switzerland by using the survey methodology. While their survey did not find any evidence for disease-promoting stress effects induced by obstruction markings, it did reveal differences in the nature, quality, and extent of annoyances, disturbances, and coping strategies related to certain types of obstruction markings [11]. The visibility of the lights due to changing weather conditions and natural light during day and night were also identified by the group as a key factor for eliciting annoyances, as the lights were perceived as more disruptive on cloudless nights than on misty days. Light intensity adjustments were also identified as another factor affecting the degree of perceived annoyance.

Obstruction lights have furthermore been explicitly considered in studies concerning the detrimental effects of wind turbines on animals, particularly with regard to attracting lights as a cause of collision fatalities for birds and night-migrating bats [23–25]. This is an issue that has also been discussed in relation to the lighted markings of other infrastructures, such as communication towers [26]. More generally speaking, research on aviation obstruction lights relates to studies of artificial light sources as environmental problems [27–29]. This field of research points to the perceived value of experiencing darkness and lightless places in a world which is becoming increasingly over-illuminated [30].

2.2. Sense of place and darkness

Places do not have an inherent meaning, but gain significance through various meanings ascribed to them by humans. Therefore, places not only become relevant as the spatialised setting or physical location for social activities, but also incorporate values, emotional attachments, social relations and identity. The notion of *sense of place* captures 'the conscious awareness of locatedness and distinctiveness between places' [31,p.63] that is 'embedded within the social, economic, and cultural relations that provide the setting for everyday experiences on a more local level' [32,p.91]. A focus on sense of place allows for a better understanding of how technical activities, such as the siting of energy infrastructures and their associated implications, can encroach upon people's feelings and perceptions about where they live and potentially affect certain values ascribed to this place [32]. Changes of sensory and aesthetic experiences may alter or threaten the meanings ascribed to places depending on the underlying individual and symbolic meanings associated with these places and envisioned changes [33,34]. The visual impacts of wind farms are generally seen as a factor that can change the relationships between certain landscapes and the people who occupy, cherish, value or appropriate them [19,35,36]. Expected or feared visual intrusions have become a common argument underlying protests [37], as they may alter sensory qualities of places by creating unwanted sights and views and thus disrupting a place-related continuity and familiarity of individuals [33]. This can then not only lead to disruptions of the positive emotional ties of the self with familiar places, such as home and neighbourhood [38], but can also be projected onto expected reactions of others, especially the place-related aspirations of tourists [39].

However, visual impacts have not yet been explicitly put into the context of obstruction lights as a potential interference and disruption of place-based relations. While the perception of obstruction lights has remained largely disregarded, the meaning of darkness has gained more importance in place-related research, with many describing it as a powerful agent in the production of atmospheres [40]. The role of a dark night sky has also been highlighted as a central element when it comes to sensory and affective experiences of landscapes and places [30,41,42]. Shaw [43] has provided an overview of the breadth of nocturnal social sciences and stressed the multiplicity of lived and experienced nights by conceptualising the night as a frontier. He argued that the gradual return to darkness has a transformative potential for understanding the self and landscape, and also hinted at the place-shaping capacity of representations of darkness.

2.3. Citizens' perception and annoyance of wind power

As the previous subsections indicate, annoyance has been referred to as a central term in describing the perceived impact of wind farms in general and obstructions lights in particular. However,despite extensive research on annoyance, including degrees of