Energy Policy 122 (2018) 601–611

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Seeing clearly in a virtual reality: Tourist reactions to an offshore wind project

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ARTICLE INFO

Keywords:
Offshore wind energy
Virtual reality
Tourism

ABSTRACT

Most research to elicit citizen's reactions to proposed windfarms use either no visuals (relying on text) or static representations (e.g., 2-D photos or drawings); we develop and test a virtual reality (VR) tool to determine whether increased information – in the form of VR – alters tourists' perceptions, attitudes, concerns and behaviors related to a proposed siting of wind turbines. Tourists using the VR were better at evaluating the impact of wind turbines on their experience and forecasting how their behavior may change. Also the VR caused respondents, on average, to have more negative reactions.

1. Introduction

To meet the increasing demand for energy while reducing dependence on fossil fuels, many areas in the world have been heavily investing (US$ 110 billion in 2015) in both onshore and offshore wind; these investments increased global wind power capacity by 64 GW in 2015, a 17% increase (WEC, 2016). However, the impact of these newly sited technologies on the quality of life of local residents and visitors can be incredibly difficult to envision yet this understanding is crucial, given the importance of local visual impacts in focusing opposition to wind farms in locations across the globe (Phadke, 2010). A research tool allowing local stakeholders to experience a project's visual impact on the local context could: reduce stakeholder misperceptions (leading to buyer's remorse[1]), identify visual adjustments to reduce stakeholder concerns and identify populations who may be more open to new information about the project.

Most research to elicit citizen's reactions to proposed windfarms have used either no visuals (relying on text descriptions) or static representations (e.g., 2-D photos or drawings).[2] However, recently computer simulations are being used in wind planning (see Fooks et al., 2017; Ribe et al., 2018; Maslov et al., 2017) so it is relevant to test how computer simulations impact viewer responses.[3] We contribute to this nascent literature on computerized information provision by testing tourists' responses to a virtual reality (VR) or static picture (SP) rendering of a proposed offshore wind facility. We find VR respondents felt they had more information and less decision uncertainty than those seeing a SP. VR respondents also held relatively more negative or more extreme views of the wind turbines, and on average, reduce their stated intention to visit. This suggests that non-VR studies may collect data based on stakeholders' (overly optimistic) misperceptions of the visual impacts of the wind project on their visitation experience; which would lead proponents and developers to underestimate potential future resistance to the wind project. In addition, once the wind farm is realized, stakeholders would update their perceptions and have buyer's remorse. We suggest the VR is a better visualization tool as it situates the windfarm within the local context.

2. Previous research

2.1. Wind energy and visualization

Although visual aesthetics are the primary driver of wind energy acceptance (Wolsink, 2007, 2010; Betakova et al., 2015; Molnarova et al., 2012), many previous acceptance studies have not used visuals (Mirasgedis et al., 2014; Georgiou and Areal, 2015), relying on text and the ability of respondents to imagine turbines, or to apply previous experience to the current situation (Hevia-Koch and Ladenburg, 2016; Firestone et al., 2018). However, this lack of visual aids may be

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[1] Suggested by an anonymous reviewer.
[2] Visual impact assessment is often used in environmental impact assessment (Chias and Abad, 2013).
[3] Even if we are unable to determine the mechanism underlying these response differences.

https://doi.org/10.1016/j.enpol.2018.08.018
Received 12 December 2017; Received in revised form 6 August 2018; Accepted 7 August 2018
0301-4215/

problematic because wind turbine acceptance is driven by a number of project-specific attributes, including number, size and density of turbines, distance from viewpoint, features of the landscape and the location of the turbines within the landscape (Bishop and Stock, 2010; Bishop and Miller, 2007; Hevia-Koch and Ladenburg, 2016; Firestone et al., 2018; Filova et al., 2015; Svobodova et al., 2015). Indeed, even the composition of the photo can affect preferences (Svobodova et al., 2014).

Static renderings (site specific see Knapp et al., 2013; artistic rendering see Strazzera et al., 2012) may not provide full information to participants as human sight responds more to moving objects (Franconeri and Simons, 2003) and turbines in motion are viewed as more beautiful and more economically productive than those not in motion (Fergen and Jacquet, 2016). The literature also suggests multiple mechanisms or explanations for why responses to a static picture would differ from VR. Heft and Nasar (2000) note that generally "perceivers are moving with respect to, and often through, the environment" (pg. 302), making a dynamic presentation more consistent with lived experience. Thus, static imagery may be insufficient when presenting moving elements within an environmental context (Hetherington et al., 1993), particularly with respect to wind energy installations (Jallouli and Moreau, 2009). Kaplan and Kaplan (1989) identified coherence, legibility, complexity and mystery as factors impacting preference for nature information. Heft and Nasar (2000) interpret the implications of this work by noting that "a scene is high in mystery….if it draws the perceiver into the scene with the prospect of more information" (pg. 305). Given that people generally experience motion in their environment interactions, the dynamic nature of the VR representation of the wind turbines and surrounding environs, may project the potential for more information. Psychological Distance (PD) is an individual's mental representation of resources and their perceived distance to those resources. PD is not often used in the natural resource literature (exceptions, see Spence et al., 2012; Huff et al., 2017) but is traditionally captured using four dimensions: spatial, temporal, social, and uncertainty, where PD is measured from abstractness to concreteness (Trope and Liberman, 2010). Two of these dimensions are particularly relevant to the current work: spatial and uncertainty. PD in the spatial domain is the level of abstraction when an object is physically distant (Fujita et al., 2006), while in the uncertainty domain is an individual's ability to integrate knowledge about novel concepts to create a mental representation (Trope and Liberman, 2010). Research in the environmental perception literature have noted that "static displays invite a detached viewpoint" (Heft and Nasar, 2000 pg. 317) providing further evidence of the potential for greater psychological distance from the static photo. Hevia-Koch and Ladenburg (2016) calls for rigor and care in the use of visualization, noting visualization is a "powerful tool to increase the level of information among respondents but …. (has the) potential to generate distortion" (pg. 9). Thus the use of visualization has important implications for siting of wind energy as residents and visitors may differ in their evaluation of similar visual information (Firestone et al., 2018).

People's *a priori* reactions to windfarms change as they are constructed and become fully operational (Wolsink, 2007; Ladenburg, 2009; Devine-Wright, 2005; Pasqualetti et al., 2002), where the visual impact on the local context is the dominant factor (Wolsink, 2007, 2010; Molnarova et al., 2012). This suggests *a priori* perceptions may not adequately take into account the visual impacts of a wind project (perhaps biased toward economic and environmental benefits).

2.2. Tourism and wind energy

Several authors highlight the lack of research focused on understanding tourists' reactions to offshore wind turbines (e.g., Lutzeyer et al., 2016; Ladenburg, 2010; Landry et al., 2012; Lilley et al., 2010; Westerberg et al., 2013; Broekel and Alfken, 2015), where many of the studies are in the "grey literature" (e.g., Braunová, 2013; Business and Damsbo-Andersen, 2013; Fáilte Ireland, 2012; Albrecht et al., 2013; Tourism Research Centre, School of Business, University of PEI, 2008). The studies examining tourist reactions to proposed wind turbines may (or may not) include a visual in their surveys[4] (e.g., see Landry et al., 2012; Westerberg et al., 2013; Betakova et al., 2015; Molnarova et al., 2012; Abromas et al., 2015; for a review of visualization efforts see Hevia-Koch and Ladenburg, 2016). This approach may not provide the observer with a realistic first-person perspective of how the scene would actually look which makes it cognitively difficult to imagine a proposed site. This is particularly important given visuals are key predictors of tourist visitation (MacKay and Fesenmaier, 1997), and tourists seek out rural landscapes (Devlin, 2005) and associate these areas with less technological or modern intrusions (Urry, 1992).

These studies typically show tourists are generally negative in their reactions to wind turbines, but results are not uniform (Lutzeyer et al., 2016; Riddington et al., 2008; Landry et al., 2012; Lilley et al., 2010; Fooks et al., 2017; Firestone et al., 2018), given the differences in the projects' contexts (e.g., populations and landscapes). However, studies have found between 6% and 31% of tourists stating wind turbines would change their travel destination (see Broekel and Alfken, 2015 for a review). Offshore turbines generally have a negative effect on attractiveness to tourists (Landry et al., 2012; Gee, 2010; Lilley et al., 2010; Lutzeyer et al., 2016), and can disrupt long-standing visitation patterns (Lutzeyer et al., 2016). Other studies have shown tourists are attracted to areas with wind turbines (Eltham et al., 2008; Frantál and Urbánková, 2014) in part because they may fit into the existing landscape (Frantál and Kunc, 2011). Finally, recent studies have found tourists are split; some like, while others dislike, windfarms (Fooks et al., 2017; Firestone et al., 2018). Thus we are left with an open question of how proposed offshore wind turbines would impact visitors perceptions and behaviors.

3. Conceptual framework

We assume tourist reactions to a proposed wind project reflects their prior knowledge and the experimental treatment information. The literature suggests the visual impacts of windfarms are influenced by the characteristics of the farm *and by the setting in which the farm is located*. Providing a realistic visualization of the project (blades spinning) *and* of the local setting may improve individuals' ability to update their perceptions to take the aesthetic dimension into account.

To provide a modeling framework to measure changes in tourists' reactions to the information treatments (e.g., satisfaction with the information) and to the wind project (e.g., attitudes, concerns, behaviors), one first needs to know how information enters into an individual's reactions. The reaction (RXN) function can be represented as:

$$RXN = f\ \{I_j, \mathbf{P}, \mathbf{K}, \mathbf{V}, \ \mathbf{D}, \ \mathbf{S}\} \tag{1}$$

where I_j is the information treatment (j = VR or SP), **P** is a vector of pre-existing psychometric factors (e.g., perceptions, motivations), **K** is a vector of pre-existing knowledge of, and experience with, windfarms, in general, and of the specific project, **V** is a vector of pre-existing visitation characteristics (e.g., frequency, types of trips), **D** is a vector of individual characteristics (e.g., gender, age, education), and **S** is a vector of the survey administration characteristics (e.g., who/when/where surveyed, adequate random assignment) that may explain differences in tourist reactions. The cognitive process that extracts and translates information into a reaction to the project's (information's) impact can be viewed as a 'household production' process by which an individual uses her priors (**P, K, V, D**) and the information presented during the survey. Assuming there are no survey administration issues (i.e., no surveyor, time, location or random assignment issues), then the

[4] Although use of viewsheds is increasingly critical for impact analyses & meeting regulatory guidelines.