Reducing Wind-Turbine Induced Bird Mortality: the Black Blade – Values, Perceived Consequences and Public Acceptance of Wind Parks

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Abstract

Research has identified various factors that could inhibit people from being acceptive of wind energy, the biggest of which seems to be visual pollution. Another related factor, that of wind turbine-induced bird mortality, and its influence on acceptability is still unclear. In order to counter bird fatalities, researchers have come up with an intervention to decrease fatalities by painting one of the wind turbine's blades black and thereby reducing motion smear. The present study investigated how perceptions of bird mortality and visual aesthetics may change between conventional wind parks and wind parks with black blades, how these changes may be related to the values people hold, and how that may in turn influence acceptability of wind parks. We further investigated whether the provision of information on the black blade's benefit would result in different perceptions and acceptability compared to when not providing that information. Our results suggest that, when provided with information on the environmental benefit, participants perceived wind parks with black blades to have more positive consequences for bird welfare and visual aesthetics, as well as a higher acceptability, compared to conventional wind parks. Even without knowing their benefits, wind parks with black blades were not perceived as more harmful or less visually pleasing than conventional wind parks, and participants showed no differences in acceptability. In line with previous literature there was a general relation between biospheric values and the dependent variables, however, all but one change in perceptions and acceptability were irrespective of which values people held.

Key words: Wind energy, Perceptions, Acceptance, Values

Introduction

Human's reliance on and use of fossil fuels for energy generation are the primary drivers of climate change. Although the negative consequences of climate change have been known for decades, and international governments have recognized the need for mitigation of greenhouse gasses, fossil fuels still make up the biggest share of our global energy consumption (IPCC, 2019). As such, society has recognized the need for a shift in the way in which our global energy is generated, giving rise to various alternative renewable energy sources, including but not limited to hydropower, solar energy and wind energy. The latter of these alternatives currently makes up the second biggest share of renewable energy generated in the EU, and wind parks are expected to grow in order for nations to meet international climate goals (EEA, 2023).

The introduction of renewable energies, such as wind energy, have not only altered the way in which society can produce energy, but they have also altered both the appearance and public perception of landscapes. Landscapes, defined as "an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors" (Council of Europe, 2000, p. 9) and which are functioning as a background for everyday experiences and interactions, are important to people. Over the past few decades, changes like the energy transition have led many European landscapes to change. Consequently, there has been a stronger focus on visual landscape quality in both policy and planning.

Wind energy and visual pollution

Wind parks can drastically change the visual appearance of a landscape, and as such, are often met with resistance by the public. The visual impact (i.e.: 'visual intrusion' or 'visual pollution') of wind parks has been widely studied and recognized, and is often found to be among the most significant factors inhibiting public acceptability of wind energy (Bosley & Bosley, 1988; Rygg, 2012; Bush & Hoagland, 2016). In their literature review, Rand and Hoen (2017) identified that visual impacts of wind energy facilities are often related to people's negative perceptions and oppositions, which further urges the importance of addressing these issues in order to prevent or reduce potential conflict between parties. In early studies on public acceptability of wind energy in California,

researchers have found that those who oppose wind energy reported visual impact to be the most serious problem associated with wind energy support (Bosley & Bosley, 1988). Moreover, researchers have found that while participants did not report visual degradation to be their most important concern in regards to offshore wind park constructions, it was found that this factor negatively influenced their wind energy acceptance (Teisl et al., 2014). Further, research on perceptions of renewable energies in Norway showed that about 60 % of participants perceived wind turbines to degrade the landscape aesthetically, and further were unconvinced that land-based wind parks would be a desirable renewable energy source (Klæboe & Sundfør, 2016).

Wind energy and bird mortality

Next to visual impacts of wind parks, wildlife concerns caused by wind turbines, specifically bird mortality, may also influence people's perceptions and acceptability of wind energy. Studies have shown that wind turbines may kill as many as 140.000 to 328.000 birds through avian collisions in the US every year (Loss et al., 2013). However, there is still little known about the influence of bird mortality on wind energy perceptions and acceptance, and any existing literature on this topic is mixed. Survey findings from the US Great Plains show that 18% of respondents agree with the statement that wind parks would be a threat for birds and bats. (Slattery et al., 2012). Another survey from Indiana showed similar results, with around 23 % of respondents agreeing that wind turbines would threaten the survival of birds and bats (Mulvaney et al., 2013). However, these perceptions have not been found to be significantly related to wind energy acceptance. At the same time, in both surveys, around half of the participants indicated they (strongly) disagreed with the notion that wind turbines would harm birds, indicating a majority of people do not recognize wind turbine-induced bird mortality as an issue at all. On the other hand, research conducted on the Cape Wind offshore wind farm found that 48% of respondents believed that wind turbines would harm birds, which did significantly influence people's acceptance (Firestone et al., 2008). It is possible that this association has been found in this study, but not in the previously mentioned ones, due to the fact that this wind park was located offshore. Similarly, researchers from Switzerland asked participants to choose between three hypothetical wind parks, each of which have either a small, medium, or large impact on the environment, including birds. Most people report lower acceptance of wind parks with a large

ecological impact, while parks with a small ecological impact receive much higher acceptance (Vuichard et al., 2022). Another finding also revealed that around 28% of participants did not know whether wind turbines would threaten the survival of birds in the first place (Mulvaney et al., 2013), indicating a lack of awareness and knowledge around the issue. Thus, more research is needed to further understand if, why and when bird mortality influences people's acceptance of wind energy.

Countering bird mortality: the black blade

The effects of perceived bird mortality on wind energy acceptance are still rather mixed. However, the ecological impact of wind turbines on bird populations has been repeatedly shown, as previously stated. As such, scientists have worked on possible solutions to reduce wind turbine-induced bird mortality. A recent study from Norway (May et al., 2020), building on earlier work by Hodos (2003), has proposed a means of reducing collisions by painting one of the wind turbine's blades black. This would reduce motion smear, thereby helping birds to better recognize the structure, and thus, evade it. In fact, in their study, it was found that this black blade reduced bird mortality by 70%. A similar study is now being conducted at RWE renewable's wind park in Eemshaven, the Netherlands, to see if results generalize across settings.

While the positive effect of the black blade on bird mortality has been empirically shown, it is also of importance to understand how this change in landscape may be perceived by the public. As previously mentioned, visual aesthetics play a key role when it comes to wind energy perceptions and acceptance. As such, it is possible that the modification of wind turbines in this way may have an impact on public visual landscape perceptions, and also influence people's acceptance of wind parks as a whole. The key question in this Master's thesis is how painting the blade black would influence people's perceptions of landscape impact, as well as of bird mortality, and acceptance of such wind parks.

Values, Perceived Consequences and Wind Energy Acceptance

Previous research has identified that people's values may be of particular relevance in explaining public perceptions and acceptability of energy sources, including sustainable solutions such as renewable energies (Bickerstaff et al., 2008; Bidwell, 2013; Perlaviciute & Steg, 2015). Values can be defined as a person's guiding principles in life, which steer individual's cognitions, decision-

making and goals. More specifically, two types of values– egoistic and biospheric values – have been found to be particularly important in explaining people's evaluations of wind energy (Perlaviciute & Steg, 2015). Egoistic values are what have been termed a type of self-enhancement value, in which people primarily consider individual costs and benefits of a behaviour, with the goal of increasing personal resources such as money. Similarly, hedonic values are also a type of self-enhancement value where individuals are primarily concerned with improving one's current emotional state, for instance by increasing pleasure or reducing effort. It can be assumed that those holding strong hedonic values will be more likely to perceive the individual consequences of wind energy similarly to those holding strong egoistic values, namely as negative. Specifically, factors that may reduce an individual's positive experience may influence hedonically and egoistically oriented people, for instance the perceptions of visual pollution. Biospheric values, on the other hand, are a type of self-transcendent value where costs and benefits for the environment are prioritised. Those who endorse biospheric values are concerned for the quality and well-being of nature and the environment. Participants who held biospheric values were more likely to perceive that wind parks can have positive environmental consequences, such as the mitigation of climate change or the protection of the environment. In turn, biospheric values were associated with higher acceptability of wind energy, probably because the consequences for the environment were perceived as positive, and the environment is of high value to these individuals. In contrast, those with strong egoistic values were more likely to perceive wind parks as having negative individual consequences, such as visual pollution or higher energy prices (Perlaviciute & Steg, 2015). In turn, these individuals were less accepting of wind energy, probably because the consequences for themselves were perceived as negative, and personal factors are of high value to these types of individuals.

Because those holding strong biospheric values tend to prioritize environmental consequences in their evaluations of wind energy, and the black blade is an intervention that would reduce bird mortality (an environmental consequence), it can be assumed that, when informed about the intervention's benefits, these individuals will perceive wind parks with black blades as more positive for bird's welfare.

H1a: When informed about its benefits, those holding strong (vs. weak) biospheric values will perceive wind parks with black blades to be more positive for bird's welfare compared to conventional wind parks.

The provision of information on the black blade's positive environmental consequence, namely reducing bird mortality, may therefore also be especially relevant for those holding strong biospheric values. Research has shown that providing people with information about an environmental problem, or with solutions on how to behave pro-environmentally, in regards to a certain problem, can increase their knowledge of said problem behaviours and thus, may be facilitated to change them (Schultz, 2002). Therefore, we will also explore differences in perceptions of black blade wind parks with additional information and without additional information.

H1b: Those holding strong (vs. weak) biospheric values will perceive wind parks with black blades to be more positive for bird's welfare when providing information about the benefits compared to not providing information.

It can further be assumed that those holding strong biospheric values will also have a higher level of acceptance for wind parks with black blades, as long as they are informed about their environmental benefits (see Figure 1 for a semantic overview of hypotheses H1a, H1b, and H1c).

H1c: Those holding strong (vs. weak) biospheric values will have a higher acceptance of wind parks with black blades compared to conventional wind parks, but only if their benefits are explained.

In contrast to those holding biospheric values, people endorsing strong egoistic or hedonic values tend to prioritize individual consequences in their evaluations of wind energy. Because the black blade changes the visual appearance of a wind turbine, and visual appearance has been found to be an important factor in wind energy acceptance, the black blade could potentially, but necessarily, form a negative individual consequence for these individuals. Due to the black blade's primary function of reducing bird mortality - an environmental consequence - we do not expect this intervention to be effective for those holding strong egoistic or hedonic values and their evaluation of wind energy. Instead, we expect those holding strong egoistic or hedonic values to either perceive the black blade in

the same way as a conventional blade (namely as visually disturbing) or they may even find the black blade to be less visually pleasing than the conventional blade.

H2a: Those holding strong egoistic or hedonic values will perceive the visual aesthetics of wind parks with black blades equally or more negatively compared to conventional wind parks.

In turn, those endorsing a self-enhancing value orientation are expected to have the same or a lower acceptance of wind parks with black blades. Further, information provided on the black blades benefits is also likely to be uninfluential on their level of acceptance. We expect acceptance for those individuals to either remain unchanged or to decrease, as the black blade may further pollute the visual landscape aesthetics, but not offer any positive consequence (see Figure 2 for a semantic overview of hypotheses H2a and H2b).

H2b: Those holding strong egoistic or hedonic values will have the same or lower acceptance of wind parks with black blades compared to conventional wind parks, no matter if their benefits are explained.

Figure 1

Moderation of Biospheric Values and Experimental Conditions on Perceived Bird Welfare and Acceptability of Wind Parks

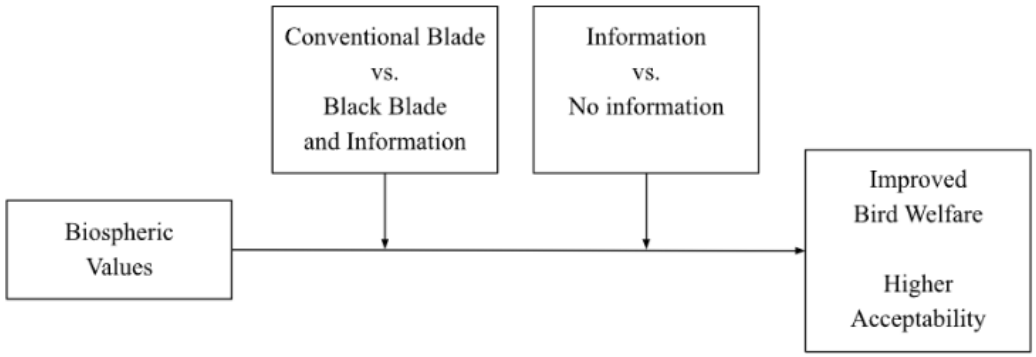
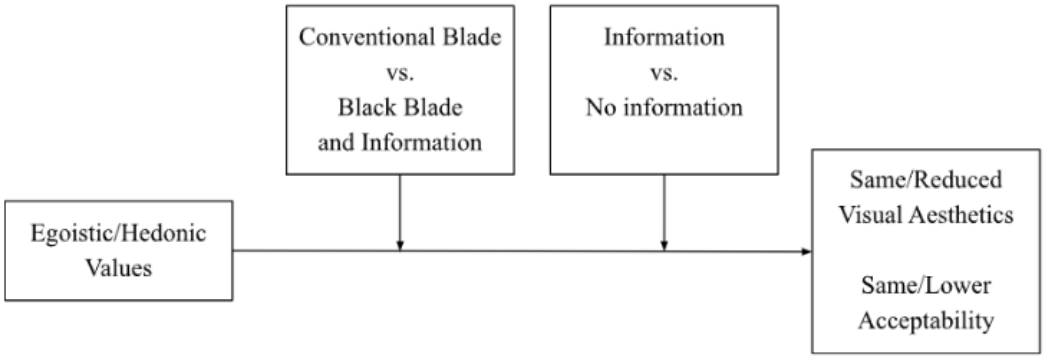


Figure 2

Moderation of Egoistic/Hedonic Values and Experimental Conditions on Perceived Visual Aesthetics and Acceptability of Wind Parks



Method

Research Design and Procedure

This study employs a mixed between- and within-subjects design exploring the relation between values, perceived consequences, and acceptance of conventional wind parks versus wind parks with black blades. More specifically, we wanted to investigate the potential influence that painting the blades of wind turbines black would have on people's perception of both bird mortality and visual aesthetics, as well as their acceptability of wind parks. In addition, we investigated whether the black blades are perceived differently depending on whether or not people receive additional information about their environmental benefits.

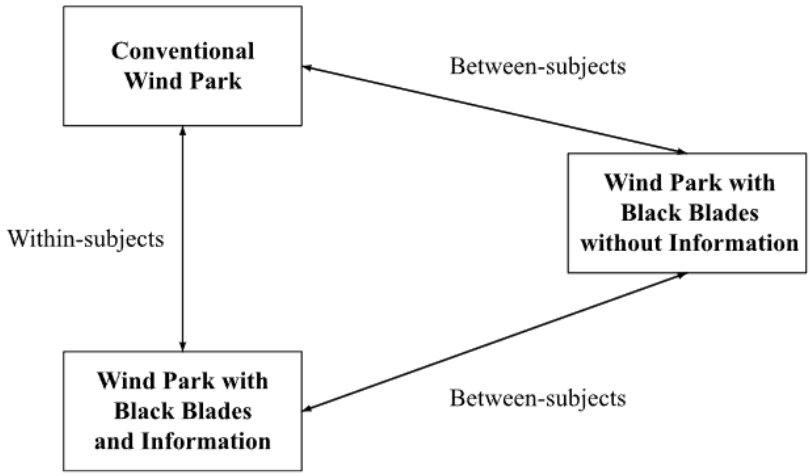
To test this, participants were assigned to one of two experimental conditions: 1) *conventional blades/black blades with information*, and 2) *black blades without information*. These experimental conditions differed in the way in which wind parks were presented to participants in the form of photos, as well as the extent to which the environmental benefits of the black blades were described. Prior to manipulation, participants in both conditions were asked to report on their general values. Next, in the first experimental condition, participants were shown photos of a conventional wind park and wind turbine, after which the perceived bird welfare and perceived visual aesthetics were assessed, as well as participant's acceptability of wind parks. Afterwards, the same participants were shown

photos of a wind park and wind turbine *with* black blades, along with a description of the intervention and its benefits. Again, participants reported on the perceived bird welfare and perceived visual aesthetics, as well as their acceptability of wind parks with black blades. This first experimental condition thereby entails a within-subjects condition with two levels, namely wind parks with conventional blades versus wind parks with black blades and information. In the second experimental condition, participants were only presented with a photo of a wind park and wind turbine with black blades, without any additional information about the environmental benefits, after which perceived bird welfare and perceived visual aesthetics, as well as acceptability of the wind park were assessed. Comparing wind parks with black blades and information versus black blades without information will thereby define the between-subjects condition, also containing two levels. Lastly, participants in both experimental conditions were asked to report on some socio-demographic variables, including age, gender, educational level, as well as their perception of the area they live in (natural, industrial, and/or urban).

This research design not only allows us to compare how perceptions of wind turbines without black blades and wind turbines with black blades may change within individuals, but also whether perceptions of wind turbines with black blades differ depending on if the benefits of the interventions are explained or not (See Figure 3).

Figure 3

Research Design of Within- and Between-Subjects Comparisons



Participants were only considered for this study if they were 16 years of age or older, resided in the Netherlands, and understood written Dutch. Before participants filled out the main survey as described in the previous section, a general introduction to the study as well as information on the study's purpose were provided. Moreover, it was communicated that participation was both voluntary and anonymous, and that the withdrawal from the study was possible at any moment without negative consequences for the participant. The time needed to take part in this study was estimated to be around 10-15 minutes and was communicated to participants prior to the survey.

At the end of the questionnaire, participants were debriefed. This process offered an explanation for the study's deception, provided information on the full extent of the study's purpose, and informed participants as to which condition they had been randomly assigned to.

Sampling involved the recruitment of a representative Dutch sample via the online recruitment service Thesis Tools Pro. Participants received an e-mail with a link to the survey, after which they had two weeks to fill out the questionnaire (see Appendix B for e-mail invitation via panel company). As compensation, participants were offered a one-euro voucher for a popular online shop (*www.bol.com*) in exchange for participation in the study.

Participants

An a priori power analysis was conducted for a repeated measures ANOVA, with a medium effect size (f =.25), and an alpha level of .05, using the program G*Power 3.1.9.7. The analysis revealed a total of 299 participants are needed to achieve a minimum power of .80. In total, 467 participants were recruited. After excluding those who did not consent to take part in the research, a total of 462 participants remained and were included in the statistical analyses. Roughly 40% of participants identified as female, while around 60% identified as male, and no participant identified as diverse (N=398). Moreover, around 4% of participants were aged 16-35, 21% were aged 36-55, 60% were aged 56-75, and around 15% were aged 76-95. The majority of Dutch participants (39%) held a degree of higher professional education (HBO), followed by those holding a university degree (17%), those holding an MBO 2, 3 or 4 diploma (16%) and those holding a HAVO, VWO or propadeuse HBO/WO (12%). 7% of participants reported to hold a degree higher than a university degree, while around 9% reported to hold a degree lower than MBO. Furthermore, approximately 60% of

participants perceived the area they live in as natural, while around 40% perceived it as urban. Only two participants perceived the area they live in to be industrial. Given the demographic characteristics of this sample, it was not entirely representative of the Dutch population (www.cbs.nl). The sample was slightly overrepresented by those identifying as male and older people, particularly those aged between 56 and 75.

Materials

Description of Stimulus Materials

Participants were randomly assigned to one of the two experimental conditions. In the first condition (conventional wind park/wind park with black blade and information), participants were presented with two rounds of stimulus materials, shown one after another, allowing for the assessment of within-subject variance of acceptability of wind parks both with and without black blades. The first stimulus material included two photos, the first of which pictured a conventional wind park, and the second of which pictured a single conventional wind turbine (see Figure 4 and 5). The second type of stimulus material in this condition included two photos, the first of which pictured a wind park with black blades, and the second of which pictured a single wind turbine with black blades, as well as a short description of the environmental benefits of black blades (see Figure 6, 7 and 8).

Figure 4

Figure 5

Conventional Wind Turbine

Figure 6

Wind park with black blades

Figure 7

Wind turbine with black blade

Figure 8

Additional information on the black blade

"We now present you with another pair of photos from a slightly different wind park. In this wind park, one blade of each wind turbine is painted black. Research has shown that painting one blade black can help birds better recognize and avoid the turbines, resulting in about 70% fewer bird deaths."

In the second experimental condition, participants were solely exposed to one round of stimulus material. This included two photos, the first of which pictured a wind park with black blades, and the second of which pictured a single wind turbine with the black blade (see Figure 6 and 7). This time, participants were not informed about the environmental benefits of the intervention.

Description of Measures

In the following, all measurements taken in the survey that are relevant to testing the study's hypotheses are presented (see Appendix A for scales used).

Values. Participants' values were measured by using a shorter version of the widely-used value scale as developed by Schwartz (Steg et al., 2014). A list of 16 value items, including egoistic, hedonic and biospheric value items, along with a short description, were presented to participants, after which they were asked to rate how important they perceive the different values 'as a guiding

principle in their lives' on a scale from -1 (opposed to my principles) to 7 (extremely important). Egoistic values were represented by five items, those being social power, wealth, authority, influential, and ambitious, and were averaged to form a composite scale for egoistic values (*a* [401] = .73, *M* = 1.76, *SD* = 1.22). Hedonic values were measured using three items, namely pleasure, enjoying life, and gratification for oneself, and were averaged to a composite scale (*a* [401] = .84, *M* = 4.32, *SD* = 1.44). Lastly, biospheric values were assessed with four items, namely preventing pollution, respecting the earth, unity with nature, and protecting the environment. This was also averaged to form a composite scale (*a* [401] = .88, *M* = 5.15, *SD* = 1.40). Values were measured before participants were exposed to the experimental conditions.

Perceived Consequences. The perceived consequences of wind energy were assessed by asking participants to rate how negatively or positively they perceived different consequences of wind parks. To measure this, were asked to imagine a wind park would be built in the area they lived in, after which they were presented with a list of both environmental and individual consequences of wind energy, and asked to report how they perceive these consequences on a scale from 1 (very negative) to 7 (very positive). Three items represented individual consequences, namely the effect of wind parks on the landscape's visual aesthetics, energy prices, and quality of life of those living in the area of the potential wind park. Four items represented environmental consequences, namely the effects of wind parks on bird's welfare, mitigation of climate change, nature, and the environment. In the analysis, only the items pertaining to bird's welfare (*M* = 4.78, *SD* = 3.09) as well as of perceived visual aesthetics (*M* = 4.21, *SD* = 2.73) are relevant and will be used in the analysis. The higher the reported score, the more positive one perceives the consequences of the shown wind park to be for bird's welfare and visual aesthetics respectively.

Acceptance of Wind Parks. Acceptance was represented by four items, each of which measured how participants would evaluate a wind park being built in their area. The first item's scale ranged from 1 (very unacceptable) to 7 (very acceptable), the second item's scale from 1 (very negative) to 7 (very positive), the third item's scale ranging from 1 (very bad) to 7 (very good), and lastly, the fourth item's scale ranging from 1 (very unnecessary) to 7 (very necessary). Acceptance items were averaged on composite scales for each wind park shown: no black blades (*a* [193] = .97, *M*

= 3.97, *SD* = 1.77), black blades with info (*a* [186] = .98, *M* = 4.11, *SD* = 1.87) and black blades without info (*a* [191] = .96, *M* = 3.98, *SD* = 1.69).

Statistical Analysis

To process the data and to perform the statistical analyses, IBM SPSS Statistics, Version 28.0.1.1 (15) was used.

In this study I tested the effects of values and condition, both within-subjects (conventional blade versus black blade and information) and between-subjects condition (black blade with information versus black blade without information) in a step-wise way, by first looking at the main effects of condition and values respectively, and then by looking at their interaction effects.

To assess the hypotheses pertaining to the within-subjects condition, various repeated measures ANOVAs were conducted with condition (conventional blade versus black blade and information) as the within-subjects factor, values as covariates, and perceived bird welfare, perceived visual aesthetics, and acceptance of wind parks as respective dependent variables.

To assess hypotheses pertaining to the between-subjects condition, separate one-way ANOVAs were conducted with condition (black blade with information versus black blade without information) as the between-subjects factor, values as covariates, and perceived bird mortality, perceived visual aesthetics, and acceptance of wind parks as respective dependent variables.

Additional Analyses

To further investigate the sample and possible differences in perceptions and acceptability of the black blade, we will also investigate how one's perceived living area (industrial, natural, or urban) may relate to these factors. Previous research has shown that wind turbine's impact may be perceived particularly negative in natural settings (Lothian, 2008). Due to the black blade relating to the environmental impact of wind parks, it may be of interest to explore this factor here too. To do this, a two-way between-subjects ANOVA will be conducted with perceived living area and condition (no black blade vs. black blade) on perceptions and acceptance respectively.

Results

H1a: When informed about its benefits, those holding strong (vs. weak) biospheric values will perceive wind parks with black blades to be more positive for bird's welfare compared to conventional wind parks.

To test this hypothesis, we conducted a repeated measures ANOVA with condition (conventional versus black blades with information) as the within-subjects factor, biospheric values as the covariate, and perception of bird welfare as the dependent variable. We found a main effect for the within-subjects condition, namely $F(1,198) = 85.24$, $p = <.001$, meaning participants perceived the consequences of wind parks with black blades and info (N=199, *M:* 4.02, *SD:* 1.86) on bird welfare significantly more positively compared to wind parks with conventional blades (N=199, *M:* 2.86, *SD:* 1.49). We further found a significant main effect for biospheric values, namely $F(1,197) = 10.74$, $p = .001$, indicating that, in general, strong biospheric values are significantly related to the perception of bird welfare. Contrary to our hypothesis, our results do not suggest an interaction effect between the within-subjects condition and biospheric values, $F(1,197) = 2.73$, $p = .100$. This means that we did not find support for the idea that changes in perception, such that they are more positive for wind parks with black blades and information compared to conventional wind parks, are stronger for those who hold strong biospheric values.

H1b: Those holding strong (vs. weak) biospheric values will perceive wind parks with black blades to be more positive for bird's welfare when providing information compared to not providing information.

To test this hypothesis, we conducted a one-way ANOVA with condition (black blades with information versus black blades without information) as the between-subjects factor, biospheric values as the covariate, and perception of bird welfare as the dependent variable. We found a significant main effect for the between-subjects condition, namely $F(1,400) = 53.89$, $p = <.001$, meaning participants perceived the consequences of wind parks with black blades and explained benefits (N=199, *M:* 4.02, *SD:* 1.86) on bird welfare to be significantly more positive compared to wind parks with black blades and no explained benefits (N=203, *M:* 2.79, *SD:* 1.48). As in the previous hypothesis, we also found a

main effect of strong biospheric values, namely $F(1,398) = 13.51$, $p = <.001$. There was no interaction effect between the between-subjects condition and biospheric values, $F(1,397) = 2.62$, $p = <.107$.

H1c: Those holding strong biospheric values will have a higher acceptance of wind parks with black blades compared to wind parks with conventional blades, but only if their benefits are explained.

To investigate this third hypothesis, another repeated measures ANOVA was conducted comparing acceptance scores of wind parks with black blades and information with acceptance scores of conventional blades. The ANOVA included condition (conventional versus black blades with information) as the within-subjects factor, biospheric values as the covariate, and acceptance of wind parks as the dependent variable. The main effect of the within-subjects condition was significant, $F(1,196) = 7.05$, $p = .009$, meaning participants were more accepting of wind parks with black blades and information (N=199, *M:* 4.11, *SE:* .13) compared to wind parks with conventional blades (N=199, *M:* 3.97, *SE:* .13). We also found a main effect for biospheric values, $F(1,195) = 17.23$, $p = <.001$, such that there was a significant relation between biospheric values and acceptance. Similarly to the previous hypotheses, there was no interaction effect of the within-subjects condition and biospheric values on acceptance, $F(1,195) = 2.94$, $p = .088$.

A one-way ANOVA showed there was also no significant interaction effect of the between-subjects condition (black blade and information versus black blade without information) on acceptance of wind parks, $F(1,397) = .57$, $p = .452$.

H2a: Those holding strong egoistic or hedonic values will perceive the visual aesthetics of wind parks with black blades and information equally or more negatively compared to conventional wind parks.

To investigate this hypothesis, another repeated measures ANOVA was conducted with condition (conventional versus black blades with information) as the within-subjects factor, egoistic and hedonic values as covariates in two respective models, and perceptions of visual aesthetics as the dependent variable. We found a significant main effect of the within-subjects condition on perceived visual aesthetics, namely $F(1,197) = 9.59$, $p = <.002$, meaning that all participants had a more positive perception of the visual aesthetics of wind parks with black blades and benefits explained ($M = 2.98$,

SE: .12) compared to wind parks with conventional blades (*M* = 2.72, *SE:* .10). We did not find significant main effects for either egoistic, $F(1,196) = .20$, $p = .656$, nor hedonic values, $F(1,196) = .13$, $p = .724$. There was also no significant interaction effect between the within-subjects condition and egoistic values, $F(1,196) = .65$, $p = .422$, nor between the within-subjects condition and hedonic values, $F(1,196) = .69$, $p = .404$, on perceptions of visual aesthetics of the wind parks. This is in line with our hypothesis predicting that there may be no change in perceptions of visual aesthetics in wind parks with conventional blades to wind parks with black blades and explained benefits for individuals strongly endorsing egoistic or hedonic values. The black blade does not seem to be an influential negative consequence for people in terms of visual perceptions, irrespective of their egoistic and hedonic values.

H2b: Those holding strong egoistic or hedonic values will have the same or lower acceptance of wind parks with black blades compared to conventional wind parks, no matter if their benefits are explained.

To test this hypothesis, another repeated measures ANOVA was conducted with condition (conventional blades versus black blades with information) as the within-subjects factor, egoistic and hedonic values as covariates in separate models, and acceptability of wind parks as the dependent variable. There was a significant main effect of the within-subjects condition, namely that the entire sample showed a significant increase in acceptance of wind parks with black blades and benefits explained compared to wind parks with conventional blades, $F(1,96) = 7.05$, $p = <.009$. Both egoistic, $F(1,195) = .06$, $p = .804$ and hedonic values, $F(1,195) = .19$, $p = .664$, had no significant main effect on acceptance. Further, neither egoistic values, $F(1,195) = .15$, $p = .701$, nor hedonic values, $F(1,195) = .07$, $p = .794$, had an interaction effect with the within-subjects condition.

To test for the between-subjects condition, a one-way ANOVA was run with condition (black blades and information versus black blades without information) as the between-subjects factor, egoistic and hedonic values as covariates in separate models, and acceptability of wind parks as the dependent variable. We did not find significant main effects for the between-subjects condition, $F(1,397) = .57$, $p = .452$, egoistic values, $F(1,394) = .2.16$, $p = .139$, nor hedonic values, $F(1,394) = .2.98$, $p = .085$. Further, there was so significant interaction effect of the between-subjects condition

and egoistic values, $F(1,394) = 2.95$, $p = .087$. However, we did find a significant interaction of the between-subjects condition and hedonic values, $F(1,394) = 5.12$, $p = .024$, indicating that those with strong hedonic values had a higher acceptability of wind parks when their benefits were explained compared to when they were not explained. See Table 1 for a summary of all mean scores on the dependent variables across the different within- and between-subjects conditions.

Table 1

Mean Scores on Dependent Variables Across Conditions

Condition	Mean Score DV		
	Bird welfare	Visual aesthetics	Acceptability
Conventional Blades	2.86[a]	2.72[a]	3.97[a]
Black blades and information	4.02[b]	2.98[b]	4.11[b]
Black blades without information	2.79[a]	2.83[ab]	3.98[ab]

Note. Different letters indicate significant differences, while shared letters indicate insignificant differences.

Additional results

We further wanted to explore whether other variables, namely perceived living area and age, would influence perceptions and acceptability of the black blade. Results from our analysis show that neither of the investigated variables had a significant influence on people's perceptions and acceptability of black blades, nor did they have an impact on the changes in perceptions between normal and black blades.

Discussion

In this study, we investigated how the black blade – an intervention to mitigate wind turbine-induced bird mortality – would influence people's perceptions of visual landscape impact, as well as of bird mortality, and acceptability of wind parks. In the following, I will discuss the study's results along with the its limitations and possible future directions.

The main focus of this study was to find out how people's perceptions and acceptability of wind parks with black blades differ in comparison to wind parks with conventional blades. We have

found that, when informed about the black blade's benefits, people perceived wind parks with black blades to be less harmful for bird's welfare compared to wind parks with normal blades as well as wind parks with black blades without the additional information. Moreover, participants perceived wind parks with black blades and their explained benefits to be more visually pleasing than wind parks with conventional blades. Similarly, participants also reported a higher acceptability of wind parks with black blades when the benefits were explained compared to wind parks with normal blades. Interestingly, even without information on the black blade's benefits, wind parks with black blades were not perceived as less visually pleasing and did not result lower levels of acceptance compared to conventional wind parks.

Theoretical Implications

All but one (hedonic values and black blades with information vs without information on acceptance) of the significant effects found in this study were irrespective of the participant's endorsed values. Previous research suggests that, when people hold strong biospheric values, they tend to prioritize environmental consequences when evaluating wind energy. In contrast, those holding egoistic values have been shown to prioritize individual consequences when evaluating wind energy (Perlaviciute & Steg, 2015). Based on the literature, we expected the black blade and its environmental benefits only to be relevant for improving perceptions and increasing acceptability for those with strong biospheric values. Meanwhile, those with strong egoistic or hedonic values were expected to have no changes to or reduced perceptions and acceptability. Because these individuals tend to care more about individual consequences, the black blade may be less relevant in increasing their perceptions and acceptability. Our data, however, shows that when informed about the black blade's benefits, all participants perceived wind parks with black blades to be more positive for bird's welfare and all participants found them more acceptable than conventional wind parks, irrespective of their values. Thus, all participants found the information on the environmental benefit of the black blade relevant and effective in their perception of bird's welfare and their acceptability in wind parks with black blades, not just those holding strong biospheric values. While these *changes* in acceptability were irrespective of which values people held, we did replicate the general finding that those with

strong biospheric values tend to evaluate renewable energy sources more positively. That is, generally, strong biospheric values were associated with a higher acceptance of all wind parks (conventional wind parks, wind parks with black blades with information, and wind parks with black blades without information).

Further, because those holding egoistic or hedonic values tend to care more about the individual consequences of an energy source and less about the environmental consequences (Perlaviciute & Steg, 2015), we expected those individuals to perceive wind parks with black blades to be equally visually pleasing or less visually pleasing than conventional wind parks. Visual pollution seems to be one of the most influential factors in inhibiting people's acceptance of wind energy (Bush & Hoagland, 2016; Rand & Hoen, 2017). Altering a wind turbines' appearance, and inevitably that of an entire wind park, may have influenced people's perception of visual aesthetics, especially if they hold strong egoistic or hedonic values. Similarly, we also expected these visual perceptions to either result in a lower acceptance of wind parks with black blades or not influence acceptance at all. Interestingly though, participants perceived wind parks with black blades and explained benefits to be more visually pleasing, which was irrespective of one's values, and a higher acceptance was also found for such wind parks compared with conventional wind parks. Generally, just as the black blade did not increase any perceptions and acceptability for those holding strong biospheric values, the black blade also did not decrease any perceptions or acceptability of those holding strong egoistic or hedonic values. Another interesting finding is that there was a change in acceptance from wind parks without information to wind parks with information for those holding hedonic values, but not for other individuals. This indicates that the information provided on the black blades' benefits may be particularly relevant for these individuals in their evaluation of the wind park. This is in contrast with previous findings which have shown those with egoistic values (another type of self-enhancing value) do not prioritize the environmental consequences in their energy evaluations, but rather care about individual consequences (Perlaviciute & Steg, 2015). While hedonic values are also a type of self-enhancement value, these individuals may prioritize individual and environmental consequences differently to those that have strong egoistic values. More specifically, these results suggest those with

strong hedonic values may care about the environmental consequences in their acceptance of wind energy more than those with strong egoistic values.

One reason why we did not find values to have an impact on most black blade perceptions and acceptance could be that this sample was one that held strong biospheric values across all participants. Indeed, when looking at the sample, 233 out of 462 reported biospheric values to be very or of utmost importance in their lives. This could explain why statistically, all participants had more positive perceptions and a higher acceptability of black blades and benefits explained. Laypeople often believe that only few people find biospheric values very important and that a lot of people endorse egoistic values, because many people still engage in environmentally harmful behaviours. However, most people, but especially the Dutch population, strongly endorse biospheric values throughout the population (Bouman & Steg, 2019). This suggests that, besides values, there are various other relevant factors that may promote or inhibit perceptions and acceptability of wind energy. In their literature review on wind energy acceptance in the US, Rand and Hoen (2017) provide a few factors especially relevant in wind energy acceptance, including economic aspects (i.e.: perceived reduced property values), lack of fairness (i.e.: the perceived inability of local community members to share ownership of wind facilities), sound pollution, perceived adverse health effects, or a lack of inclusion in the planning process. Merely painting one of the wind turbine's blades black does not seem to decrease people's perceptions or acceptability, probably because some of these other related factors are not influenced by the black blade and are still too important for people, thus inhibiting their support. This study shows us that the black blade is one factor that can promote positive perceptions and heightened acceptability in individuals that are informed about its benefits, and that, even without knowing the intervention's benefits, does not result in more negative perceptions or lower acceptability.

Practical Implications

Participants in this study perceived wind parks with black blades and explained benefits as least harmful for birds, as most visually pleasing, and also reported the highest acceptability of said park when compared to conventional wind parks or wind parks with black blades without explained benefits. When participants were not informed about the environmental benefits of the black blade,

participants perceived these wind parks to be more harmful for bird's welfare compared to wind parks with black blades and benefits explained, and about equally harmful as conventional wind parks. This indicates that, when people know about its benefits, the black blade can add to people's perceptions and acceptability of wind parks, such that they are perceived as more positive for bird's welfare, more visually pleasing, and more acceptable, compared to conventional wind parks. An equally important finding in this study is that, when people do not know about the black blade's benefits, they do not perceive this wind park to be any more dangerous to bird's welfare, any less visually pleasing, or any less acceptable, than wind parks with conventional blades. Therefore, these findings suggest that, from an environmental psychological point of view, introducing the black blade to wind parks across the Netherlands does not yield negative consequences, as it does not decrease perceptions or acccetpability. However, we do advise policy makers to emphasise the environmental benefits of the black blade when introducing it, as this achieves a positive impact on individuals who endorse all three value types studied and results in more positive perceptions and higher acceptability.

While we did find significant effects, such that all participants perceived the black blade and information more positive for birds, more visually pleasing, and were more acceptive of it, the overall effects were rather small. Further, the final perceptions and acceptability scores were, while slightly better than conventional wind parks, still rather low. On a scale from 1 (very negative) to 7 (very positive), perceptions of bird's welfare in wind parks with black blades and information averaged on 4.02, while visual aesthetics average 2.98 on the same scale. On a scale from 1 (highly unacceptable) to 7 (highly acceptable), acceptability scores averaged on 4.11.

Limitations

As mentioned before, the sample recruited in this study was not entirely representative of the Dutch population. As such, the study's external validity is somewhat reduced and it is important to not blindly generalize the results the entire population. Nevertheless, even when accounting for demographics such as age or gender, the results and their effects do not change, indicating that perceptions and acceptability are quite similar across the entire sample. At the same time, we used real

life images when exposing participants to the different wind parks, thereby increasing the study's external validity as well.

Moreover, the data analysed in this study relied on participant's self-reports. These reports are often subject to biases and come with restrictions. For instance, respondent characteristics such as socially desirable responding may influence people's reports, or introspective inability may keep individuals from accurately assessing themselves in the first place. Besides self-reports, one could have also studied real-life cases of people supporting and/or opposing wind parks.

Future Directions

Future research may explore the difference in perceptions and acceptability between moving and still turbines. Generally, some literature suggests people prefer still turbines, because they are quieter, motionless, or perceived as more beautiful (Gipe, 1995; Rand & Hoen, 2017). Other findings propose that rotating turbines are perceived more positively because they give people an impression of productivity (Fergen & Jacquet, 2016; Rand & Hoen, 2017). Considering the black blade creates a motion smear when moving, and thus, a change in the turbine's visual appearance, motion may be an influencing factor. Because the literature on this topic is still mixed, it may be worth exploring further for wind parks with conventional blades, not only in general, but especially in relation to the black blade and its impact on turbine's appearances when in motion.

Conclusion

In this study, we investigated people's perceptions and acceptability of three different wind parks: conventional wind parks, wind parks with black blades and information, and wind parks with black blades without information. We further explored how changes in perception and acceptability between these wind parks may relate to whether people hold strong biospheric, egoistic or hedonic values. We found that, when information on the black blade is provided, people perceived these wind parks as more positive for birds' welfare, more visually pleasing, and also reported a higher acceptance compared to conventional wind parks. Even without knowing its benefits, the black blade was not perceived as more harmful for birds, less visually pleasing, or less accepted by participants

compared to conventional wind parks. However, besides the change in acceptance between wind parks with black blades and information and wind parks with black blades without information being stronger for those with hedonic values, all other effects were irrespective of which values people endorsed strongly.

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Appendix A

Research Instruments

Values

Voordat we uw mening vragen over windenergie, willen we graag weten wat u in het algemeen belangrijk vindt in het leven. Hieronder vindt u 16 waarden. Achter elke waarde staat een korte uitleg over de betekenis ervan. Geef voor elke waarde aan hoe belangrijk deze is als leidraad in uw leven. De betekenissen van de scores zijn als volgt: -1 betekent dat de waarde tegen uw principes ingaat 0 betekent dat de waarde niet belangrijk is; de waarde is niet relevant als leidraad in uw leven 3 betekent dat de waarde belangrijk is 6 betekent dat de waarde zeer belangrijk is 7 betekent dat de waarde voor u uiterst belangrijk is als leidraad in uw leven. Gewoonlijk heeft iemand niet meer dan twee waarden waaraan een 7 wordt toegekend.	**Gaat in tegen mijn principes**	**Niet belangrijk**	**Belangrijk**					**Zeer belangrijk**	**Uiterst belangrijk**
1. GELIJKHEID: gelijke kansen voor iedereen	-1	0	1	2	3	4	5	6	7
2. RESPECT VOOR DE AARDE: in harmonie leven met andere soorten	-1	0	1	2	3	4	5	6	7
3. MACHT: controle over andere mensen, dominantie	-1	0	1	2	3	4	5	6	7
4. PLEZIER: genot, vervulling van verlangens	-1	0	1	2	3	4	5	6	7
5. EENHEID MET DE NATUUR: je verbonden voelen met de natuur	-1	0	1	2	3	4	5	6	7
6. EEN VREEDZAME WERELD: vrij van oorlog en conflict	-1	0	1	2	3	4	5	6	7
7. RIJKDOM: materiële bezittingen, geld	-1	0	1	2	3	4	5	6	7
8. GEZAG: het recht om te leiden of op te dragen	-1	0	1	2	3	4	5	6	7
9. SOCIALE RECHTVAARDIGHEID: herstel van onrecht, zorg voor zwakken	-1	0	1	2	3	4	5	6	7
10. GENIETEN VAN HET LEVEN: van eten, seks, ontspanning, etc.	-1	0	1	2	3	4	5	6	7
11. BESCHERMING VAN HET MILIEU: behoud van milieukwaliteit en de natuur	-1	0	1	2	3	4	5	6	7
12. INVLOEDRIJK: invloed hebben op mensen en gebeurtenissen	-1	0	1	2	3	4	5	6	7
13. BEHULPZAAMHEID: werken voor het welzijn van anderen	-1	0	1	2	3	4	5	6	7
14. MILIEUVERVUILING VOORKOMEN: natuurlijke hulpbronnen beschermen	-1	0	1	2	3	4	5	6	7
15. JEZELF VERWENNEN: aangename dingen doen	-1	0	1	2	3	4	5	6	7
16. AMBITIEUS: hardwerkend, eerzuchtig, strevend	-1	0	1	2	3	4	5	6	7

Perceived Consequences

Wij presenteren u nu enkele foto's van een windpark en een windturbine. Stel dat zo'n windpark zou worden gebouwd in het gebied waar u woont. Wij willen u vragen hoe u denkt over een aantal gevolgen van zo'n windpark op een schaal van 1 (zeer negatief) tot 7 (zeer positief). Bekijk de foto's en vul dan onderstaande vragen in. Ik vind de gevolgen van windmolens in mijn omgeving op...	Heel negatief						Heel positief
…het verminderen van klimaatverandering	1	2	3	4	5	6	7
…het milieu	1	2	3	4	5	6	7
…de natuur in de omgeving	1	2	3	4	5	6	7
…het welzijn van vogels	1	2	3	4	5	6	7
…de aantrekkelijkheid van de omgeving	1	2	3	4	5	6	7
…de lokale energieprijzen	1	2	3	4	5	6	7
…de kwaliteit van leven van mensen in de omgeving	1	2	3	4	5	6	7

Acceptance:

Wij willen graag weer weten wat u in het algemeen vindt van de mogelijkheid om zo'n windpark in uw gebied te ontwikkelen. Ik vind het ontwikkelen van zo‘n windmolenpark in mijn omgeving…								
Heel onacceptabel	1	2	3	4	5	6	7	Heel acceptabel
Heel negatief	1	2	3	4	5	6	7	Heel positief
Heel slecht	1	2	3	4	5	6	7	Heel goed
Heel nodig	1	2	3	4	5	6	7	Heel onnodig

Appendix B

E-mail Invitation to Participants via Panel Company

TARGETED ADVERTISEMENT VIA RESEARCH PANEL WEBSITE
VERSION FOR PARTICIPANTS

"REDUCING WIND-TURBINE INDUCED BIRD MORTALITY: THE BLACK BLADE – VALUES, PERCEIVED CONSEQUENCES AND PUBLIC ACCEPTANCE OF WIND ENERGY"
PSY-2223-S-0179

Participants are recruited by the panel company ThesisToolsPro. Since the sample is one that needs to nationally representative of the Netherlands, the panel company will choose suitable participants based on this criterium. Participants will then be invited to take part in the survey by sending out invitations via e-mail.
To do this, the following information will be sent out to participants:

> **Invitation Online Survey Master Thesis**
> In dit onderzoek onderzoeken we de menselijke perceptie van windenergie. Deelname aan dit onderzoek duurt ongeveer 10-15 minuten.
>
> **Details van het onderzoek:**
> In dit onderzoek wordt u gevraagd een vragenlijst in te vullen over uw persoonlijke percepties van windparken en windenergie. Wij willen u ook vragen naar enkele gegevens over uw persoon, zoals uw leeftijd, geslacht, opleiding en woonplaats. Om de anonimiteit van uw antwoorden te waarborgen, zullen deze gegevens nooit worden gebruikt om u persoonlijk te identificeren.
> Dit onderzoek wordt uitgevoerd in het kader van het afstudeerproject van de Master Omgevingspsychologie aan de Rijksuniversiteit Groningen en wordt daarmee gebruikt voor zowel wetenschappelijke als educatieve doeleinden.

https://rug.eu.qualtrics.com/jfe/form/SV_a4yWs7fWJ96VYY6