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Visual evaluations of wind turbines: Judgments of scenic beauty or of moral desirability?

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HIGHLIGHTS

- Clarifies what surveys on wind turbines' impact on visual landscape quality measure.
- Compares evaluation of wind turbines, transmission towers and incinerator chimneys.
- Visually similar structures are judged to have different impact on scenic beauty.
- Different visual evaluations are explained by differences in moral associations.
- Statements about visual impact are strongly influenced by implicit moral judgments.

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ABSTRACT

To achieve a transition to renewable energy, large numbers of wind turbines have been built in Germany and in many other countries. Numerous surveys have been conducted to ascertain the subjectively perceived visual impact of wind turbines on the aesthetic quality of landscapes and the underlying factors of this impact. However, the extent to which moral judgments about wind turbines influence their aesthetic evaluation has until now never been studied. To address this issue, we investigated the influence of implicit moral associations and judgments of different large-scale mast-like structures—namely wind turbines, incinerator plant chimneys and high-frequency communication towers—on statements about the impact of these structures on the visual quality of landscapes. We found that mast-like structures which barely differ in visual terms are nevertheless judged to impair the visual quality of landscapes to very different degrees. These correlations held true for both supporters and opponents of wind energy. Furthermore, we looked for correlations between the evaluation of wind turbines and general attitudes towards them, and ascertained that supporters of wind energy tended to rate landscapes with wind turbines substantially higher than non-supporters. A possible explanation for this is the structures' significantly different moral associations. Our findings support the hypothesis that statements about the visual impact of mast-like structures in landscapes are strongly influenced by (implicit) moral judgments on these structures that are driven by their moral associations. Thus, to a considerable extent, such statements reflect not judgments on scenic beauty but moral judgments. These findings have substantial implications not only for the assessment of the impact of wind turbines on the landscapes' scenic qualities but for the interpretation of visual landscape quality assessments in general. We propose a methodological approach to overcome these problems.

1. Introduction

To achieve a transition to renewable energy, a large number of wind turbines have been built in Germany and many other countries, representing one of the main sources of renewable energy (Dai et al., 2015). About 11% of the area of Germany were already classified as wind turbine-dominated landscapes in 2014 (BfN and BBSR, 2014). In principle, the construction of wind turbines and wind farms is welcomed

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by large parts of the population. However, plans to establish wind turbines are increasingly controversial and failing due to a lack of acceptance among the citizens living in the vicinity of projected wind-energy sites (Betakova et al., 2015; Dai et al., 2015; Maehr et al., 2015; Langer et al., 2018; Spielhofer et al., 2021).

The reasons for these acceptance problems are complex. Of particular concern are alleged or actual impacts of wind turbines on (i) human health, particularly from infrasound (Knopper & Ollson, 2011; Langer et al., 2018), (ii) wildlife, especially on birds and bats (Dai et al., 2015; Wang & Wang, 2015; O'Shea et al., 2016), and, foremost, (iii) landscape scenery. The visual impact of wind turbines is often noted as being the dominant factor in explaining why some people are opposed to wind energy (Lothian, 2008; Molnarova et al., 2012; Betakova et al., 2015; Spielhofer et al., 2021). Another reason why visual impacts on landscape scenery play a particularly important role is that wind turbines are visible from afar due to their great construction height and exposed locations so that they have a large-scale area of visual impact compared, e.g., to solar fields (Lothian, 2008; Torres Sibille et al., 2009).

1.1. Empirical studies on wind turbines and perceived scenic beauty

Landscapes are—according to the definition of the European Landscape Convention not objects that exist in themselves independent of observers, but they exist only in human perception. "'Landscape' means 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). Thereby, landscapes represent not only complex visual but complex symbolic and moral objects as well (for a characterization of different concepts of landscape that include ecological landscape concepts as well, see Nassauer, 2012; Trepl, 2012; Kirchhoff et al., 2013; Kühne & Antrop, 2015; Kühne, 2019).

In the last decades, several empirical studies have been conducted to measure the influence of wind turbines or entire wind farms on perceived scenic landscape quality. These studies also investigated the extent to which this influence depends on (i) landscape factors such as landscape type, original landscape beauty or location and arrangement of the turbines in the landscape, (ii) socio-demographic factors such as age, gender, education, place of residence and attitude towards the energy transition, and (iii) structural factors such as construction type, construction height, number and color of the wind turbines (see, exemplifying many, Thayer & Freeman, 1987; Johansson & Laike, 2007; Lothian, 2008; de Vries et al., 2012; Molnarova et al., 2012; Betakova et al., 2015; Maehr et al., 2015; Yu et al., 2017; BfN, 2018; Salak et al., 2021; Spielhofer et al., 2021). Basic findings of these studies regarding impacts of wind farms on perceived scenic landscape quality are:

- Landscape and structural factors are more decisive than socio-demographic parameters (Molnarova et al., 2012).
- There is a positive correlation between the perceived beauty of a landscape and the perceived deterioration caused by a wind turbine or wind farm. The more beautiful a landscape without a wind turbine or wind farm is judged to be, the greater the perceived deterioration caused by its construction, while wind turbines or wind farms in landscapes that are judged to be less beautiful or even ugly without them are perceived as 'neutral' or even as an improvement (Lothian, 2008; de Vries et al., 2012; Molnarova et al., 2012; Betakova et al., 2015; Salak et al., 2021).
- The impact of wind turbines on the landscape decreases with distance within the first kilometers; for longer distances, studies show inconsistent answers or different studies provide contradictory results (Lothian, 2008; de Vries et al., 2012; Betakova et al., 2015).

However, not all of the above results are sufficiently validated to make generalizations. In part, they are based on studies with a relatively small number of participants (Yu et al., 2017: $n = 20$; Johansson & Laike, 2007: $n = 80$; Ribe et al., 2018: $n = 90$; Betakova et al., 2015: $n = 169$). Better substantiated are the results of the studies of Molnarova et al., 2012 ($n = 337$), Lothian, 2008 ($n = 414$) and, in particular, Langer et al., 2018 (n = 1.356), de Vries et al., 2012 (n = 2.008) and Salak et al. (2021) (n = 1.002).

In the current socio-political situation, at least in Germany, an ambivalent attitude towards wind turbines probably prevails. It is true that there are numerous citizens' initiatives with clear positions: on the one hand for and, above all, on the other hand against wind turbines (BfN, 2018). Overall, however, it is not groups with unconditional approval or rejection that dominate, but individuals with ambivalent attitudes. For example, Langer et al. (2018) assigned most of the 1,356 respondents in their study to the acceptance level "ambivalence" (n = 792), but only 225 to "active non-acceptance" and 339 to "active acceptance".

Many people consider an "energy transition", in which wind energy plays a key role, to be necessary and thus welcome the expansion of wind turbines in principle, but at the same time consider their construction to be increasingly problematic, especially with regard to their effects on landscapes' visual or scenic qualities (cf. Molnarova et al., 2012, who, however, speak of "dichotomy" not "ambivalence"). According to this, for a majority of people there is an intrapersonal conflict between a positive energy-political moral evaluation of wind turbines on the one hand and their negative evaluation in terms of impacts on landscapes' visual or scenic qualities.

1.2. Hypotheses and goals

In this situation we hypothesize—against the background of the fact that landscapes represent not only visual but complex symbolic and moral objects as well—that a systematic bias is to be expected for so-called "landscape aesthetic" surveys on wind turbines: answers to questions about whether wind turbines or wind farms affect the scenic beauty of landscapes reflect not only judgments of their impacts on scenic beauty, but also implicitly include judgments of the moral energy-political desirability or necessity of wind turbines or wind farms (for the great importance of such moral judgments, cf. Devine-Wright, 2005; Molnarova et al., 2012; Bidwell, 2013). For many people, their judgment of the impact of wind farms on landscapes' scenic beauty could be influenced by the conviction that wind turbines are necessary to realize the energy transition, and, therefore, must not represent an impairment of landscapes' scenic beauty. If this were the case—and our study is designed to find out if it is the case—then answers to questions about the impact of wind turbines or wind farms on landscape's scenic beauty could systematically turn out more positive than it corresponds to the pure perception of scenic beauty by the respondents. If this were the case, then several of the numerous surveys on the impacts of wind turbines on landscape's scenic beauty were of limited validity as they do not measure what they intend to measure, namely assessments of scenic beauty, but instead measure assessments of moral desirability.

The present study has three main goals: *First*, to investigate the influence of differences in (implicit) moral associations and judgments of physical objects on evaluations of the impact of these objects on landscapes' visual qualities and scenic beauty. This is done with the aim of counteracting misinterpretations of surveys on effects of wind turbines on landscapes' scenic beauty and with the aim of contributing to an improvement of the methodology of such surveys. *Second*, to survey selected attitudes towards wind turbines in a landscape that might influence their evaluation and acceptance. *Third*, the results of these two investigations are examined for correlations between evaluations of impacts of wind turbines on landscapes' scenic beauty on the one hand and attitudes towards them on the other hand. Although we have performed our study in the German-speaking cultural area, its results should be transferable to almost all so-called Western cultures (cf. our "Conclusions").

Please note that we deliberately do not define the ambiguous term "aesthetic". That is mainly for two reasons. The methodological reason is that the aim of our study is to find out what respondents judge when asked to judge the beauty of landscape images and the influence of mast-like structure on it—without us being able (or willing) to dictate what respondents should understand by “beauty” when they give their answer. The practical reason is that choosing a specific definition of “aesthetic” would lead to insoluble complications, because there have been competing theories of aesthetics for hundreds of years (see, e.g., Brady, 2003; Kirchhoff and Trepl, 2009; Shelley, 2022), so that any definition of “aesthetic” would be contestable.

2. Methods

The first and second investigation was operationalized by a survey with an online questionnaire (for details, see below).

2.1. Influence of implicit moral judgments on statements about scenic beauty

Visual assessment of landscapes using photographs or photomontages has been shown in many studies to be a valid surrogate for surveys in real landscapes, provided that highly realistic images are used (Molnarova et al., 2012; Palmer & Sullivan, 2020). Accordingly, to ascertain the influence of implicit moral assessments on statements about the impact of wind turbines on landscapes’ scenic qualities, a visual-textual stimulus of four landscape pictures and descriptions of their content was used.

The pictures and their descriptions were selected and designed so that they would significantly differ from each other in implied moral associations and judgments as denoted by the different types of mast-like structures (cf. below, section 4.1). In addition, the participants were randomly divided into four groups, which were given different textual stimuli while the visual stimulus was identical. All four experimental groups first performed a ranking, then a rating of the four images, each of which were visible during both tasks (see Fig. 1). This survey design was tested in a preliminary study.

2.1.1. Visual stimuli: Four different landscape photomontages

All four stimulus sets contained a completely identical photo of the same landscape. It is well known that wind turbines are strongly rejected in landscapes experienced as very beautiful and attractive, while they are seen by many as relatively unproblematic or even enhancing in landscapes experienced as ugly and unattractive (Lothian, 2008; Molnarova et al., 2012). Relying on our knowledge of many assessments of landscapes’ scenic qualities, a landscape of presumably neither low nor very high visual quality was therefore selected. It is known that wind turbines in the vicinity of one’s own place of residence are judged differently than those elsewhere (Wolsink, 2000)—what is often, but probably too one-sidedly, referred to as the NIMBY effect (Devine-Wright, 2005; Bidwell, 2013; Rand & Hoen, 2017). For this reason, a landscape was chosen whose more precise geographical location cannot be inferred from the photograph. Moreover, an association with the respondent’s own place of residence was made unlikely in showing all the structures in the same landscape, what made at least three of them obviously fictional representations. However, an attempt was made to create an association with the energy policy of the countries in which the respondents presumably reside by selecting a cultural landscape recognizable as Central European to the respondents.

Image A displays a landscape without any built structure. The other three images contain photomontages of different mast-like structures: image B shows an incinerator chimney with exhaust plume, image C a wind turbine and image D a high-frequency communication tower. Minor adjustments to the sky were made to provide a neutral background.

These structures were chosen as stimuli because they differ rather little in visual terms—at least from a distance—with equally large-scale mast-like structures, but relatively large differences in moral associations and normative implications are to be expected for them (postulate: wind turbines are judged as morally better than high-frequency communication towers, and these as morally better than incinerator chimneys; for details see below, section 3.3). In order to minimize the visual differences, the respective mast-like structure was placed in the same position and in the same display size in each image, and a common

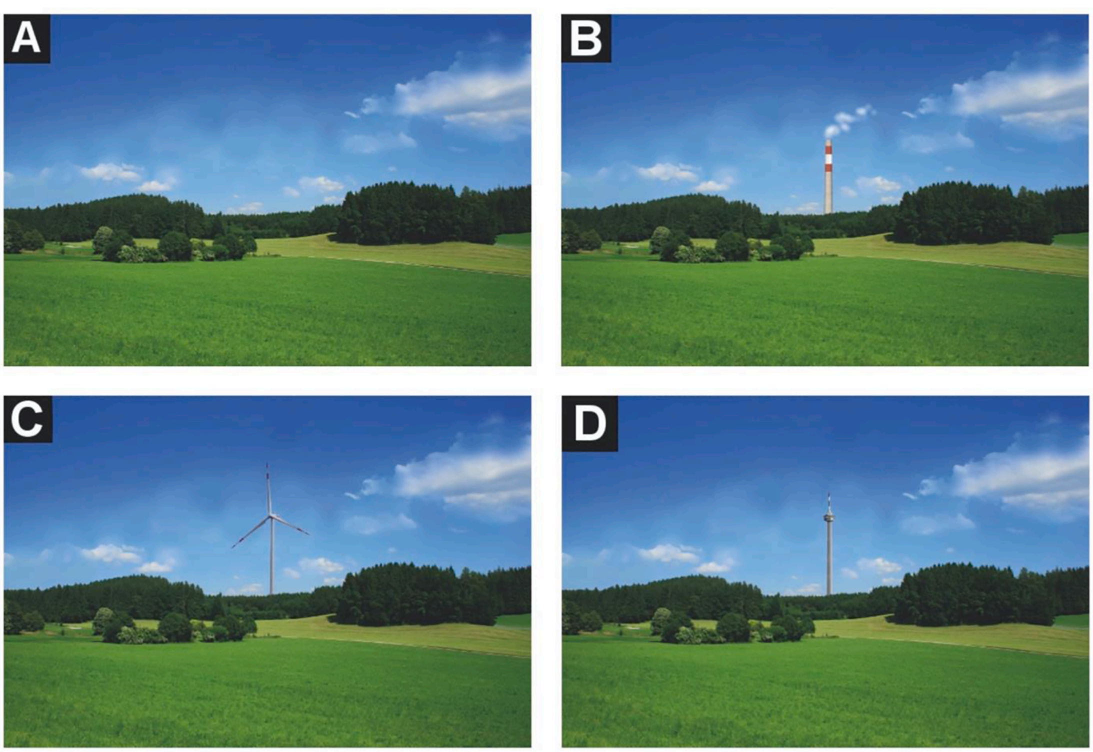

Fig. 1. The four landscape images used in the survey.

location in the background was selected. Differences in the gray values of the structures were reduced by photo editing. To ensure that the incinerator chimney did not look out of place without an associated building (which should not be visible for optimum visual similarity with the wind turbine and communication tower), the base of all structures was placed behind a forest (which would obscure the other buildings of an incinerator in reality).

2.1.2. Textual stimuli: Four different descriptions of the visual stimuli

With an identical visual stimulus, the textual stimuli were varied by forming four respondent groups (cf. below, section 2.4). In group 1, the description did not contain any statement about the mast-like structures seen in the pictures. In group 2, the type of structure was named: "wind turbine" or "high-frequency communication tower" or "waste incinerator chimney". In groups 3 and 4, additional information was provided about the wind turbine's operators: a large company or a local energy cooperative of citizens from surrounding villages (postulating that wind turbines of the latter are evaluated morally as better than those of the former; cf. below, section 4.3).

2.2. Attitudes towards wind energy

Attitudes towards wind energy were surveyed by a set of 12 closed questions (see Table 1) which were believed to highly load on three different factors. These statements were developed on the basis of a previous local case study in Southern Bavaria in 2017 (Suda, 2017). In the context of this study on the evaluation of planned wind turbines, arguments for or against wind turbines were first collected by means of a qualitative content analysis of three types of internet sources. Statements for a quantitative survey were subsequently developed from the following sources:

- Websites of wind power opponents: damage to health, mainly through infrasound; destruction of the landscape; destruction of the native land or home country; impact on bird life; profit of investors; falling property prices; inefficiency of the investment; threat to security of supply.
- Websites of wind power project developers: contribution to climate change; reliable energy source; contribution to the energy transition; increasing the attractiveness of the region; opponents stir up unfounded fears.
- Internet presentations in relation to different forms of citizen participation: consultation of citizens; informing citizens.

Table 1
List of statements about wind energy used in the questionnaire, sorted here by the three factors (risks, opportunities, participation) on which they were assumed to load. The asterisk * marks the two additional statements. For the order of statements used in the questionnaire, see **Appendix A**. Contrary to expectation, the statement "Only investors benefit from wind turbines" is sorted as an opportunity in the factor analysis because the negative value indicates the respondents' opinion that not only investors benefit, but wind turbines create opportunities for everyone.

Risks	Opportunities	Participation
Wind turbines cause property prices to fall. (k = 0.851)	Wind turbines contribute to climate change mitigation. (k = 0.892)	Citizens are sufficiently informed when planning wind turbines. (k = 0.907)
Wind turbines destroy our homeland. (k = 0.825)	Wind turbines are a reliable source of energy. (k = 0.729)	Citizens are sufficiently consulted in the planning of wind turbines. (k = 0.861)
Wind turbines damage health. (k = 0.776)	Wind turbines are important for the energy transition. (k = 0.651)	*Wind turbines should be operated by citizens.
Wind turbines have a negative impact on birds. (k = 0.652)	Only investors benefit from wind turbines. (k = -0.619)	*Wind turbines should not be erected against the will of citizens.

As part of the regional case study (n = 271, March 2017) in three municipalities in the district of Freising (Bavaria, Germany), these statements were examined in more detail using a factor analysis (Promax rotation). The Kaiser-Meyer test (KMO = 0.866) and Bartlett's test ($Chi\text{-}Squared(1\,0\,5) = 644{,}700 p < .001$) provided a 3-factor solution that explained 58,06% of the variance. The three factors describe risks, and opportunities of wind turbines, and participation in their planning.

From this regional preliminary study, those statements with high loading on these factors (k > 0.65) were taken into the actual nationwide study, namely a maximum of 4 statements per factor. To achieve a balance between the representation of the three factors in the statements, two additional statements were added for the factor "participation", which were intended to represent further levels of participation (see Table 1).

2.3. Sample

The participants in the study were recruited by sending a link to the questionnaire to >120 distributors, mainly institutions, who were selected according to criteria of socio-demographically diversity. The distributors neither participated in the survey nor knew about its aim nor received any reward. Thereby people participated from 05.12.2019 to 24.03.2020. In total, n = 1001 participants mostly from Germany (n = 950), further from Austria (n = 9), Switzerland (n = 7) and other or unspecified countries (n = 35), took part in the study. The reported mean age was M = 43.83 years, SD = 17.38. 40% of the participants stated to be female (n = 397), 45% to be male (n = 453), 15% (n = 151) did not report their gender. 42% (n = 421) indicated to have grown up in the countryside, 23% in the outskirts (n = 232), 21% in city environments (n = 214), while 13% did not answer the question on their childhood environment (n = 134). 55% (n = 556) of the participants reported to hold a university degree, followed by applied sciences graduates 11% (n = 115). 13% (n = 134) did not provide answers on their educational background. The remaining 21% responded that they either had other forms of secondary education or no formal education (yet). The results of the socio-demographic data show that the sample was highly diverse, with no indications of a strong under- or overrepresentation of certain socio-demographic groups. Thus, while our survey may not be representative for Germany, its findings are clearly not confined to a special socio-demographic group but widely valid.

2.4. Procedure

The questionnaire was administered in German. The data was collected between 05.12.2019 and 24.03.2020. The online questionnaire was implemented on the platform SoSci Survey (https://www.soscisurvey.de/). The average duration for completing the online survey was (M = 4:39 min, SD = 2:14 min).

The questionnaire started with a short welcome page which did not reveal the actual goal of the survey but instead asserted that the goal was to test different images of landscapes. It was highlighted that the survey was part of a scientific, independently financed research project. Logos of the involved research institutions were displayed to emphasize the scientific nature of the study.

The welcome page (section 1) was followed by four sections of questions: ranking (section 2) and rating (section 3) of four images (see Fig. 1), statements about wind energy (section 4) and socio-demographics (section 5). For visuals of the online questionnaire, please see **Appendix A**.

After the welcome page, during section 2 (rankings), the participants were randomly assigned to one of four experimental groups (G1–G4) following a between-subject research design. This was implemented in the online questionnaire using a SoSci php-module (see https://www.soscisurvey.de/help/doku.php/de:create:questions:random). In all four groups, the participants were asked to rank the four landscape images according to their personal perception of beauty. However, the text describing the images differed among the four groups serving as the independent variable:

- Group 1: “Below you see four landscape images. In three pictures you can see a mast-like structure.”
- Group 2: “Below you see four landscape images. In three of the pictures, you can see a mast-like structure: a high-frequency communication tower (HF transmitter), a wind turbine (WT) and a waste incinerator chimney (WIC).”
- Group 3: “Below you see four landscape images. In three pictures, a mast-like structure can be seen: a high-frequency communication tower (HF transmitter), a wind turbine (WT) of a large company and a waste incinerator chimney (WIC).”
- Group 4: “Below you see four landscape images. In three pictures, a mast-like structure can be seen: a high-frequency communication tower (HF transmitter), a wind turbine (WT) of a local energy cooperative of citizens of surrounding villages and a waste incinerator chimney (WIC).”

After section 2 (rankings) all participants went through the same experimental design. In section 3 (ratings) the participants were asked to rate each of the previous four images individually on a scale ranging from 0 = “ugly” to 10 =”beautiful”. The order of the images was the same as in section 2.

In section 4, the participants were asked to rate to what extent they agree with a set of 12 statements about wind turbines (see Table 1), providing the following scale: ++ “completely agree”, + “agree”, o “neither agree nor disagree”, - “disagree”, -- “completely disagree”. It was explicitly stated to the participants that a “not applicable” or “don’t know” option was deliberately not available as the participants’ opinion and not their knowledge was of interest.

In section 5, socio-demographical information on gender, age, education, the environment where the participants grew up in (countryside/outskirts/city) and in which state in Germany was elicited. The questionnaire ended with the contact information of the researchers (section 6).

The participants were allowed to skip the ranking and the questions concerning personal data. The rating and statements were configured to be not skippable.

3. Results

Due to the conciseness of the study and because there were no indications for systematic distortions (i.e. monotonous response style despite inverted items), it was decided to include all available data sets (complete and incomplete) in the further analyses ($n = 1001$; group 1: $n = 253$, group 2: $n = 257$, group 3: $n = 248$, group 4: $n = 243$). The calculations were computed with JASP (version 0.14) and R (version 4.1.3).

3.1. Rankings

On average, image A without any mast-like structure was ranked by far the most positive (rank 1), followed by image C with a wind turbine (rank 2) and image D with a high-frequency communication tower (rank 3). Image B with an incinerator chimney was rated by far the most negative (rank 4). This pattern was identical across all four experimental groups (see Fig. 2 and Fig. 3).

We found significant differences in the ranking data across all respondents for every image comparison (Friedman test, *Chi-Squared*(3) = 1873.039, $p < .001$; *Kendall’s W* = 0.016, Conover’s post-hoc tests, $p < .001$ level for image A versus image B, image A versus image C, etc.). We found no significant differences among the experimental groups G1 to G4, neither for image A ($H(3) = 5.556$, $p = .135$) nor image B ($H(3) = 0.593$, $p = .898$) nor image C ($H(3) = 1.529$, $p = .676$) nor image D ($H(3) = 0.878$, $p = .831$) (see Fig. 2 and Fig. 3).

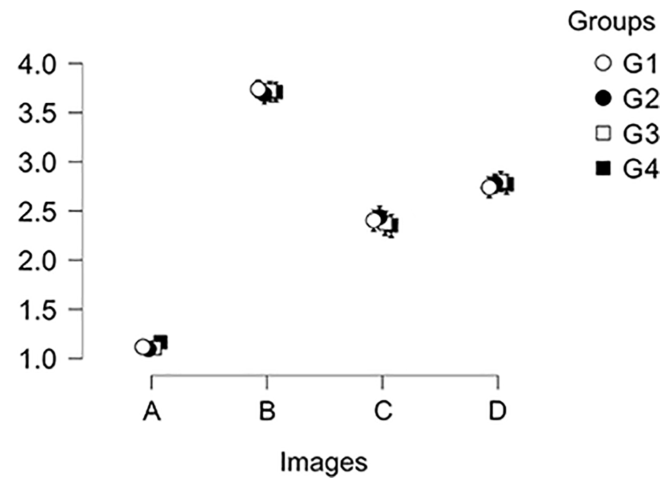

Fig. 2. Rankings (1 = rank 1 to 4 = rank 4) of the four images split by experimental groups. Image A: no mast-like structure; image B: incinerator chimney; image C: wind turbine; image D: communication tower. Group 1: description without any statement about the mast-like structures seen in the pictures; group2: type of structure was named; groups 3 and 4: additional information about the wind turbine’s operator, naming “large company” for group 3 and “local energy cooperative of citizens from surrounding villages” for group 4.

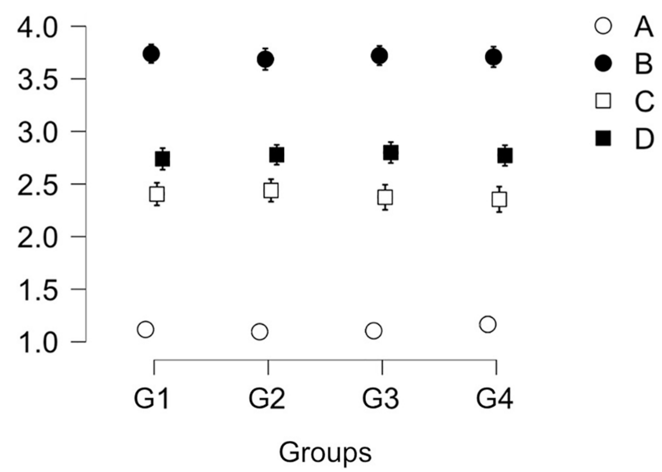

Fig. 3. Average rankings (1 = rank 1 to 4 = rank 4) across the four experimental groups G1 to G4 split by images A to D (cf. description of Fig. 2).

We found neither an effect for gender (image A: $H(1) = 1.498$, $p = .221$; image B: $H(1) = 2.642$, $p = .104$; image C: $H(1) = 0.868$, $p = .352$; image D: $H(1) = 0.004$, $p = .948$) nor of the childhood environments “countryside”, “outskirts” and “city” (image A: $H(2) = 0.453$, $p = .797$; image B: $H(2) = 4.812$, $p = .090$, image C: $H(2) = 2.258$, $p = .323$; image D: $H(2) = 1.775$, $p = .412$) on the ranking results.

3.2. Ratings

On average, the data in the rating section coincided with the results from the ranking section. Averagely, image A without any mast-like structure was rated by far the most positive ($M = 8.644$, $SD = 1.605$), followed by image C with a wind turbine ($M = 5.928$, $SD = 2.109$) and image D with a high-frequency communication tower ($M = 5.079$, $SD = 1.788$). Image B with an incinerator chimney was rated by far the most negative ($M = 3.505$, $SD = 1.605$). All images with mast-like structures were rated significantly less positive than image A ($p < .001$, image B: $t(815) = 59.17$, *Cohen’s d* = 2.071; image C: $t(897) = 34.85$, *Cohen’s d*

= 1.163; image D: $t(902) = 50.89$, *Cohen's d* = 1.693). Once more, this pattern looked identical across all four experimental groups (see Fig. 4).

Mauchly's test indicated that the assumption of sphericity had been violated (*Chi-Squared*(5) = 106.81, $p < .001$). Degrees of freedom were corrected using Huynh-Feldt estimates of sphericity (epsilon = 0.929) (Field, 2013).

The results of the repeated measurements ANOVA showed that the differences in the ratings of the four images were significant across all respondents ($F(2.79, 2235.9) = 1463.45$, $p < .001$; omega2 = 0.502) (see Table 2). In contrast, the experimental groups (G1 to G4) did not differ significantly in their ratings ($F(3, 710) = 0.852$, $p = .466$). The same applied to the childhood environments "countryside", "outskirts" or "city" ($F(2, 710) = 0.043$, $p = .958$. For gender, there was one significant difference in the ratings ($F(1, 710) = 7.231$, $p = .007$). Female participants rated image C with the wind turbine significantly more positively than male participants ($M = 0.456$, $SD = 0.142$, $p = .038$).

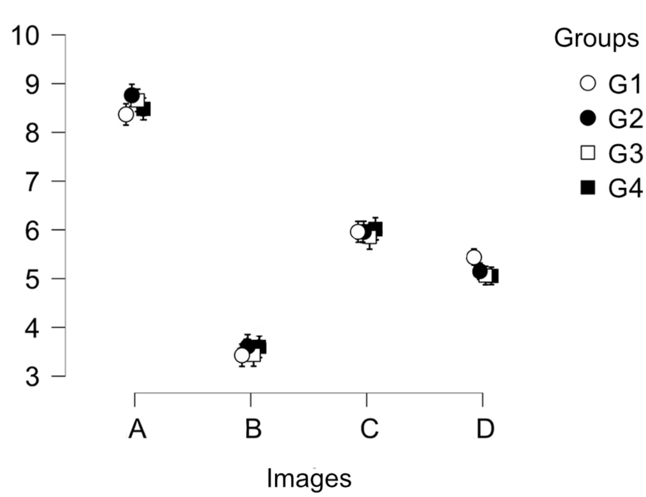

Fig. 4. Average ratings (1 = "ugly" to 10 = "beautiful") of the four images A to D split by experimental groups G1 to G4.

3.3. Attitude statements

Both the Kaiser-Meyer test (*KMO* = 0.85) and Bartlett's test (*Chi-Squared*(66) = 3891.708, $p < .001$) indicated that the attitude variables fulfil the requirements for a factor analysis. An exploratory factor analysis with promax rotation was conducted. According to the Kaiser criterion (eigenvalue > 1), a single factor could be extracted from the data set whereas the scree plot indicated a 2–factor solution which could explain 38.7% of the variance (versus 31.8% for the 1–factor solution). Based on the level of explained variance, it was decided to proceed with the two-factor solution. (See Fig. 5 and Table 3.).

It was noticeable that statement item B019 ("Wind turbines should be operated by the citizens.") did not load on either of the two factors. A look at the correlation matrix (see Fig. 6) shows indeed that item B019 was only very slightly related to all other statements.

In terms of content, there was a separation between negative statements (factor 1) and positive statements (factor 2) about wind turbines (see Table 4).

For the statement items, there were largely no statistically significant group differences in the response patterns (subject to gender, urban–rural difference, experimental group etc.), with the following exceptions showing marginal to small effect sizes (see **Appendix A** for the English translation of the online questionnaire, experimental group 4; see **Appendix B** for statistics).

Item B015 "Wind turbines lead to falling property prices.": Participants from city outskirts agreed significantly stronger that "wind turbines lead to falling property prices" than participants from the

Table 2
Bonferroni post-hoc comparisons of pairs of the four images. Note: P-value was adjusted for comparing a family of 6.

Image		Mean Difference	SE	t	p_{bonf}	
A	B	5.048	0.078	64.849	< 0.001	***
	C	2.619	0.078	33.645	< 0.001	***
	D	3.389	0.078	43.538	< 0.001	***
B	C	−2.429	0.078	−31.204	< 0.001	***
	D	−1.659	0.078	−21.311	< 0.001	***
C	D	0.770	0.078	9.893	< 0.001	***

*** $p < .001$.

countryside, $p = .022$, *Cohen's d* = -0.22. According to Cohen (1988) this is a small effect. There were no significant differences to the participants who grew up in city environments.

Item B013 "Only investors benefit from wind turbines.": Female participants ($M = 3.78$, $SD = 1.04$) agreed significantly less than their male counterparts to the statement that "only investors benefit from wind turbines" ($p = .008$). However, with *Cohen's d* = 0.18, this is a marginal effect (Cohen, 1988).

Item B019 "Wind turbines should be operated by the citizens.": Female participants ($M = 2.58$, $SD = 1.12$) agreed significantly less to the statement that "wind turbines should be operated by the citizens" than male participants ($p = .004$, *Cohen's d* = 0.20). Again, this is only a marginal effect (Cohen, 1988).

3.4. Statements and rankings/ratings

Notably, the ranking of image C with the wind turbine was the only one in the study reaching medium-sized correlations ($r > 0.3$) with some statement ratings.

Item B010 ("Wind turbines are important for the energy transition.") correlated positively with the ranking of image C by *Spearman's rho* = 0.35 ($p = .001$) showing that participants who gave higher rankings for image C also showed higher approval to the statement B010. Furthermore, the ranking of image C correlated negatively with item B018 ("Wind turbines destroy our homeland."), *Spearman's rho* = -0.387 ($p > .001$).

Looking at the rating data there were six statements that correlated with image C by *Pearson's* $r >$ (-) 0.30 meaning a medium effect size (Cohen,1988; see Fig. 7): Item B010 ("Wind turbines are important for the energy transition."), $r = -0.329$, $p < .001$; item B012 ("Wind turbines cause damage to health."), $r = 0.367$, $p < .001$; item B013 ("Wind turbines only benefit investors."), $r = 0.34$, $p < .001$; item B020 ("Wind turbines have a negative impact on birds."), $r = 0.364$, $p < .001$ and item B021 ("Wind turbines should not be erected against the will of the citizens."), $r = 0.322$, $p < .001$. The strongest correlation between rating and statement data was found for image C and item B018 ("Wind turbines destroy our homeland."), $r = 0.498$, $p < .001$ showing that participants who disagreed more strongly to the statement also had rated the landscape with the wind turbine as more beautiful.

3.5. Post-hoc attitude groups

Based on the results of the factor analyses (see section 3.3), post-hoc attitude groups were formed to examine possible differences between wind energy supporters and opponents. For this purpose, the values of the positive and negative items were added up for all participants and weighted according to the number of items in each set. These were 6 items for the negative statements (factor 1) and three items for the positive statements (factor 2) about wind energy (cf. Table 4). The two scores were then subtracted from each other to give an overall score indicating a trend in each respondent's attitude. A positive sign indicated a positive attitude towards wind energy (pro), a negative sign indicated a negative attitude (contra). Those participants who had a total score of 0 were placed in the neutral group. The overall score had a

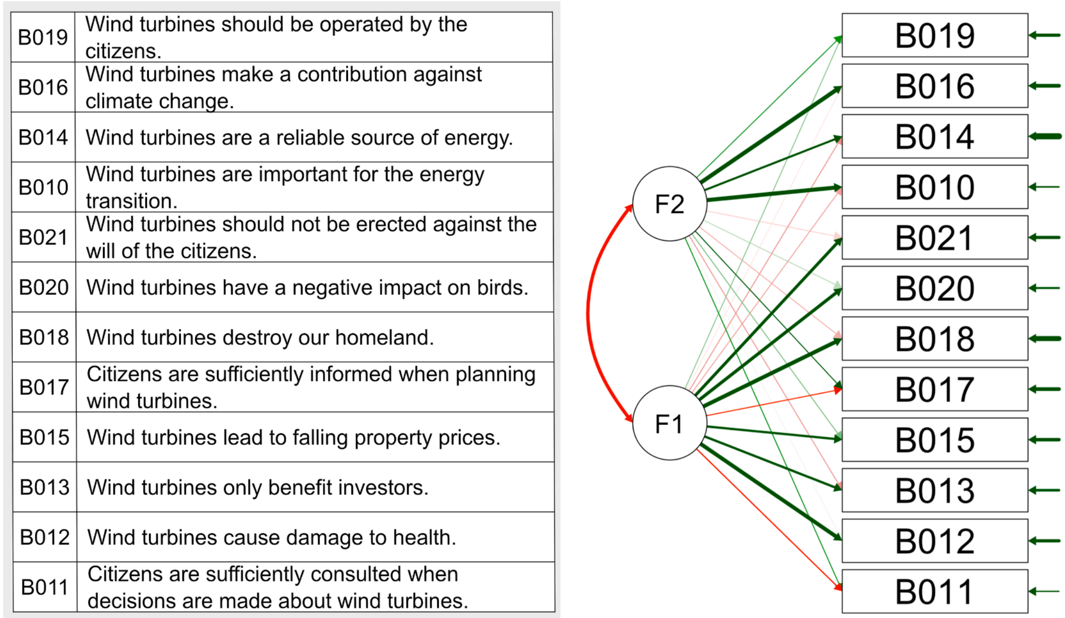

Fig. 5. Path diagram of the statements about wind energy. F1 = risks; F2 = opportunities. Bigger width of the arrows indicates higher factor loadings, positive loadings are shown in green, negative loadings in red. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table 3
Factor loadings >(-)0.35. Note: Applied rotation method was promax.

Statement	Factor 1	Factor 2	Uniqueness
B010		0.705	0.387
B011	−0.394		0.611
B012	0.685		0.540
B013	0.515		0.629
B014		0.481	0.667
B015	0.505		0.804
B016		0.713	0.470
B017	−0.370	0.354	0.606
B018	0.692		0.426
B019			0.931
B020	0.612		0.672
B021	0.588		0.614

positive sign, $M = 1.102$, $SD = 1.3$, showing that on average the participants rated wind energy positively in section 4. This tendency was also shown in the number of participants per attitude group: contra $n = 144$ (14%), neutral $n = 123$ (12%) and pro $n = 734$ (73%). Fig. 8 shows the average ratings for each post-hoc group.

A competing model using one standard deviation from zero for the grouping process (neutral $n = 493$, contra $n = 36$, pro $n = 472$) resulted in the same response pattern as in the first model. In the end, the first model was selected for the further analyses because it is more cautious and reduces the level of polarization. In addition, it provides shares that correspond to those of somewhat similar surveys, which report about 80% approval and 20% disapproval for wind energy (Fachagentur Windenergie an Land e.V., 2021), or 17% active non-acceptance (Langer et al., 2018).

3.5.1. *Landscape without mast-like structure (image A)*

Levene's test showed that the assumption of homogeneity of variance was not met for this data (F(2, 918) = 6.681, p =.001). Therefore, Welch's (1951) F was computed (F(2,102.736) = 6.293, p =.003, *omega2* = 0.007), showing that there were significant differences among the attitude groups regarding their ratings for image A. Games-Howell post-hoc comparison revealed that the contra group ($M = 9.007$, $SD = 1.259$) rated image A significantly higher than the pro group ($M = 8.578$, $SD = 1.637$, $t(245) = 2.938$, p =.009, *Cohen's d* = 0.27). Referring to Cohen (1988), this was a small effect. There were no significant differences for both comparisons with the neutral group ($M = 8.568$, $SD = 1.91$).

3.5.2. *Landscape with an incinerator chimney (image B)*

Levene's test showed that the assumption of homogeneity of variance was met (F(2, 813), p =.193). There were no significant group differences for the ratings in the ANOVA of image B across the three respondent groups (F(2, 813) = 2.335, p =.097).

3.5.3. *Landscape with a wind turbine (image C)*

Levene's test showed that the assumption of homogeneity of variance was met (F(2, 896), p =.567). The ANOVA (F(2, 896) = 71.567, p <.001, *omega2* = 0.136) showed that there were significant differences among the attitude groups. Games-Howell post-hoc comparison revealed that the participants in the contra group ($M = 4.008$, SD = 1.942) rated image C significantly lower than both the neutral group ($M = 5.905$, $SD = 2.272$, $t(62) = -4.856$, p <.001, *Cohen's d* = -0.94) and the pro group ($M = 6.263$, $SD = 1.945$, t(172) = –12.078, p <.001, *Cohen's d* = -1.16). Notably, this showed a large effect both times (Cohen, 1988). The difference between the neutral and pro group was not significant ($t(44) = -1.001$, p =.58) (see Fig. 9).

3.5.4. *Landscape with a high-frequency communication tower (image D)*

Levene's test showed that the assumption of homogeneity of variance was met (F(2, 900), p =.214). There were significant group differences with regard to the ratings of image D (F(2, 900) = 3.272, p =.038, *omega2* = 0.005). We found that the ratings in the contra group (Games-Howell post-hoc test; M = 4.719, SD = 1.642) were significantly lower than in the pro group ($M = 5.138$, $SD = 1.782$, $t(197) = -2.687$, p =.021). With *Cohen's d* = -0.24, this was a small effect according to Cohen (1988). There were no significant differences for the neutral group ($M = 5.214$, $SD = 2.203$, $t(44) = 0.221$, p =.973).

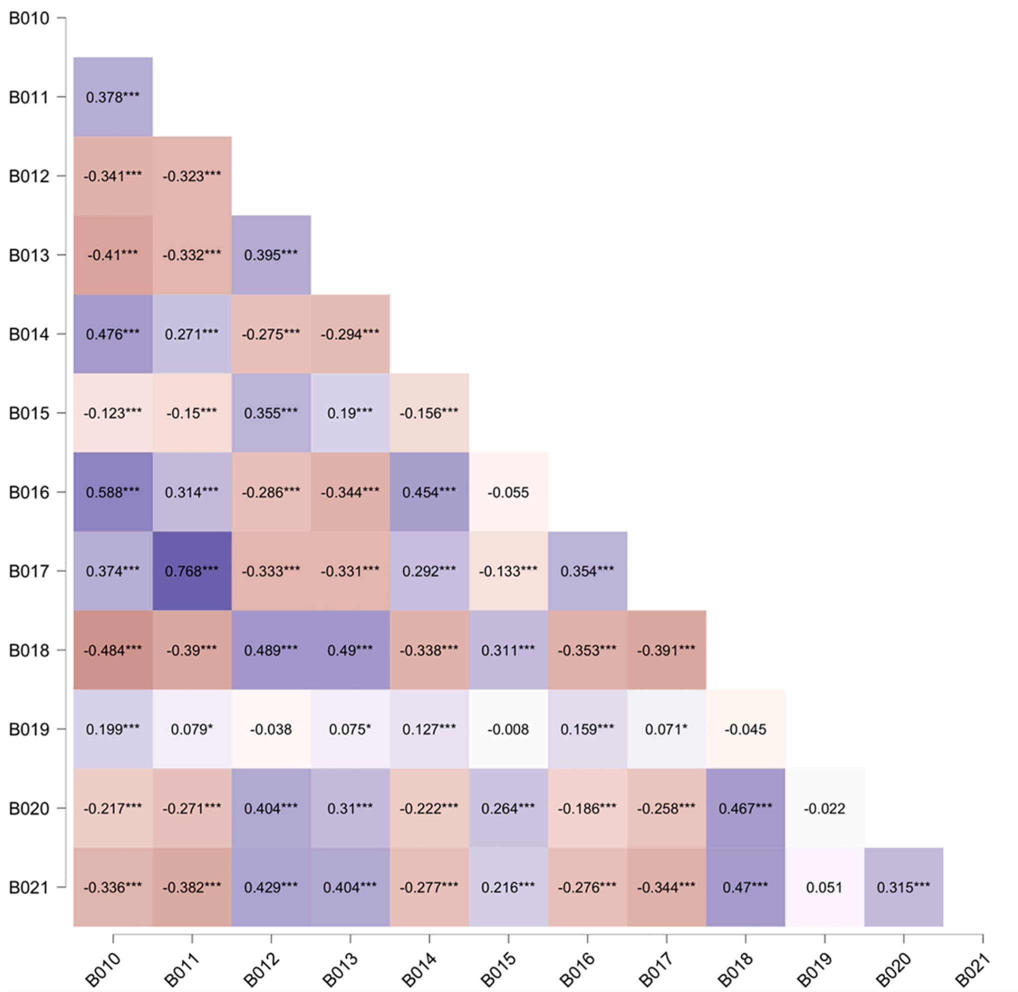

Fig. 6. Pearson's r correlation matrix of the statement items.

Table 4
List of negative and positive statements.

Negative Statements (Factor 1)	Positive Statements (Factor 2)
B018: "Wind turbines destroy our homeland." B012: "Wind turbines cause damage to health." B021: "Wind turbines should not be erected against the will of the citizens." B013: "Wind turbines only benefit investors." B020: "Wind turbines have a negative impact on birds." B015: "Wind turbines lead to falling property prices."	B010: "Wind turbines are important for the energy transition." B016: "Wind turbines make a contribution against climate change." B014: "Wind turbines are a reliable source of energy."

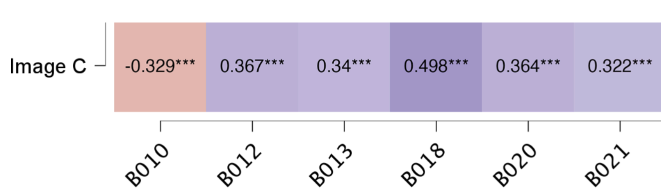

Fig. 7. Pearson's r correlation matrix for image C and selected statement items.

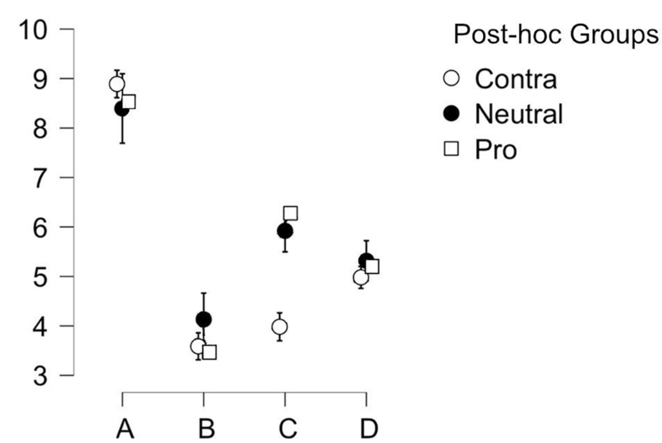

Fig. 8. Average ratings (1 = "ugly" to 10 = "beautiful") for all images split by the first model post-hoc attitude groups.

4. Discussion

4.1. Significantly different assessment of the four images

In accordance with our expectation, on average, the image without mast-like structure was ranked and rated by far the most positive, followed by the image with a wind turbine and the image with a high-frequency communication tower, while the image with an incinerator

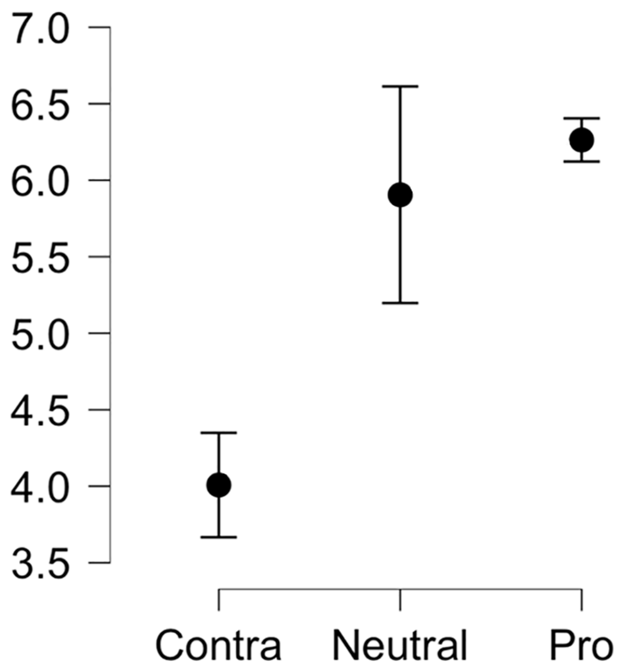

Fig. 9. Average ratings (1 = "ugly" to 10 = "beautiful") for image C with the wind turbine split by post-hoc attitude groups (Contra, Neutral, Pro). Bars indicate confidence interval 95 percent.

chimney was rated and ranked by far the most negative (see Fig. 2 and Fig. 4). This pattern was identical across all four experimental groups (see Fig. 2).

This result strongly supported our main hypothesis: the beauty evaluation of the four images of landscapes prompted in our survey was significantly influenced by (different implicit) moral judgments associated with the different mast-like structure.

The fact that incinerator chimneys were evaluated worst by far may be explainable by their by far most negative associations. First, incinerators are associated with emissions of harmful exhaust gases like dioxins. Second, waste incinerators might be symbols not of solved but of unsolved environmental problems (neither prevention nor recycling of waste). Third, waste incinerators might be associated with the household garbage one has individually produced and is responsible for. Accordingly, the public usually holds a negative view of municipal waste incinerators and tends to react very adversely to the construction of new incinerators (Subiza-Pérez et al., 2020).

On the contrary, wind turbines—notwithstanding some negative associations—involve strong positive moral associations. They are collective symbols of innovative environmental problem solving (reducing climate change, allowing for nuclear phase-out) by sustainable technology and indicate the individual possibility to consume energy without contributing to climate change. While wind turbines might initially have had the negative association to uncomfortably make visible that electricity, whose origin formerly had been mostly invisible, does not emanate magically from wall sockets (Hirsh & Sovacool, 2013), exactly this visibility might nowadays bear positive associations. In a way, wind turbines have become "cathedrals" of sustainable industrial culture (Peter Altmaier, German Federal Minister for the Environment, according to Schultz, 2012) and symbols of collectively taking responsibility. Accordingly, Maehr et al. (2015) found that most people rated wind turbines as less aversive and more calming compared with other industrial constructions—and equivalent to churches.

High-frequency communication towers might morally range between incinerator chimneys and wind turbines being linked to negative associations of harmful radiation as well as positive associations of possibility for communication. (For a general discussion of dilemmas between appreciation of technology and feelings of guilt about its consequences, see Thayer, 1994. See Spence & Townsend, 2008, for theories according to that images, which may be perceptual or symbolic representations, within the mind can be tagged to varying degrees with positive and negative affective feelings.).

4.2. Uniformity of assessment across socio-demographic differences

While the four images were rated significantly different, the individual ranking and rating of each of the four images was very uniform in itself (SD for ranking from 0.41 to 0.79; SD for rating from 0.706 to 2.109). Particularly, this uniformity held true irrespective of multiple significant socio-demographic differences in age (13–95 years), gender, education (from no formal education to university degrees), place of living (from all 16 German states, Austria and Switzerland; from city, suburb and countryside).

The consistency of the assessments across socio-demographic differences confirmed what had already been found in other studies: Although landscape perception differs significantly among genders, ages and social or cultural backgrounds (Buijs et al., 2009; BMUB & BfN, 2014; Kirchhoff, 2014; Kühne, 2019), there is—at least within modern societies of Western type—a high consensus in human preferences for and evaluations of specific landscapes (Palmer et al., 1990; Hägerhäll et al., 2018). This seems to hold true for the impacts of mast-like structures on landscapes as well (cf. Salak et al., 2021).

4.3. Uniformity of assessment despite different textual stimuli

Contrary to our expectations, there were no significant differences in assessment depending on the textual stimulus. The ratings of all four experimental groups G1-G4 in section 2 of the questionnaire were not only very similar in themselves, but also among each other (see Fig. 2, Fig. 3 and Fig. 4).

For groups 1 and 2, this uniformity is probably explained by the fact that the naming of the structures, which was given to the members of group 2 only, did not contain any additional information because the structures could already be correctly identified visually by the members of group 1 from the pictures. That is, the description given to group 2 was not a relevant stimulus.

For groups 3 and 4, there are two main explanations for this uniformity: (i) Given the "preeminence of the visual" (Marcum, 2002), given that we are in a way visual by nature as our brains process images 60,000 times faster than text, and 90% of information transmitted to our brains is visual (Vogel et al., 1986; Potter et al., 2014), the textual stimulus may have been insignificant compared to the visual stimulus regardless of its content. Possibly, the textual stimulus has not even been noticed as it was placed in a non-salient way below the images. (This is not to imply that textual stimuli are irrelevant or of minor importance in general; e.g., Ribe et al., 2018, have found significant effects of textual stimuli.) (ii) The textual descriptions have been noticed but did not differ significantly in moral respect.

How could the second be possible, given widespread critical attitudes against major energy corporations in Germany (i.e. the so-called "Big Four" E.ON, RWE, Vattenfall and EnBW) on the one hand, and of widespread favorable opinions on civic participation especially in the context of the energy transition (as expressed in calls for "energy democracy") in Germany on the other hand (Morris & Jungjohann, 2016; Burke & Stephens, 2018)? This apparent paradox may be dissolvable as follows: Our survey deals with wind turbines in a clearly fictional placeless context in which questions of participation, as against concrete local wind energy projects, are of minor relevance to those polled. This interpretation is in line with the fact that our national survey supports a two-factor-explanation (opportunities and risks), while our regional pre-study supports a three-factor-explanation (opportunities, risks, and participation). Another, more speculative explanation would be that the relevant difference is not the one we designated in our questionnaire (wind turbines owned by global corporations versus owned by local citizens), but rather consists in who benefits financially and who bears the costs: global corporations or wealthy local citizens versus all people in the municipality where the wind turbines have been built.

4.4. Comparison of the two statement sets

Although the twelve statements used in the study are based on the results of the survey in the Freising district and the items used were selected according to the highest factor loadings from the preliminary study, a different factor pattern emerges when comparing the two surveys. The 3-factor solution from the preliminary study with the dimensions a) risks, b) opportunities and c) participation could not be replicated. Instead, a 2-factor solution with a) positive expressions about wind turbines and b) negative expressions about wind turbines can be identified in the present data. A possible explanation is offered by the different context in which the statements were queried. While the survey in the Freising district took place in the context of concrete wind turbine projects in the region, the survey context for the nationwide survey was less specific and more related to general attitudes towards wind turbines. It is possible that the level of consideration (local versus global) influenced the response patterns or the measured attitudes towards wind turbines. This aspect holds potentially significant implications for the implementation of wind turbine projects, according to which attitudes may be influenced by the spatial level (local, regional, national, global) of consideration (cf. the so-called 'proximity hypothesis', see Swofford & Slattery, 2010). Further reasons for the different factor structure in the otherwise very similar statement batteries, however, could also be due to differences in the scales used (degree of agreement/disagreement 1 to 5 versus degree of agreement/disagreement −2 to + 2). Subsequent research should examine the possible explanations mentioned above in more detail, as a clear regional "shift in opinion" could emerge when wind energy projects become more concrete (cf. Enevoldsen & Sovacool, 2016; Rand & Hoen, 2017).

4.5. Correlations between evaluation of beauty and attitudes towards wind turbines

On average, there were no strong relations between the evaluations of beauty (sections 2 and 3 of the questionnaire) and the attitudes towards wind turbines (section 4). There were, however, two exceptions to this. Notably, the wind turbine image was the only image in the study that reached medium-sized effects in the correlations for both ranking and rating data ($r > 0.3$) for two statements. Namely, item B010 ("Wind turbines are important for the energy transition.") correlated positively with the ranking of the wind turbine image, showing that participants who gave higher rankings for this image also showed higher approval to the statement B010. The relationship was even stronger for image C with the wind turbine where high rankings correlated negatively with item B018 ("Wind turbines destroy our homeland.", *Spearman's rho* = –0.387, p >.001).

This picture changed significantly when the post-hoc attitude group comparison was included in the analyses (see section 3.5). Those participants who tended to have a negative attitude towards wind turbines rated image A without any mast-like structure better than the other two attitude groups (*Cohen's d* = 0.27). But most importantly the contra group rated image C with the wind turbine much worse than the neutral (*Cohen's d* = -0.94) and the pro group (*Cohen's d* = -1.16), with large effect sizes in both cases. This result contradicts the findings of Maehr et al. (2015) that supporters and non-supporters ($n = 60$) of wind energy did not differ significantly from each other in their rating of wind turbines as less aversive and more calming compared with other industrial constructions. It is in line with the findings of Molnarova et al. (2012) that respondents ($n = 337$) with a negative opinion of wind power considered landscapes with wind turbines significantly less attractive (mean = 1.69) than respondents who accept wind power conditionally (mean = 2.33), support wind power (mean = 2.8), or are indifferent to the issue (mean = 2.4). Corresponding results are provided by Salak et al. (2021): Respondents who viewed renewable energy as important for sustainability were more likely to report good fit between renewable energy infrastructure and presented landscapes, while respondents who viewed it as contributing to a mechanized world were less likely to do so. For the high-frequency communication tower image, the ratings of the contra group were lower than those of the pro group, however with a much smaller effect again (*Cohen's d* = -0.24). Thus, the participants in the contra group seem to have a general above-average dislike towards landscapes with any mast-like structure, but a particularly high above-average dislike if this structure is a wind turbine. Nevertheless, in absolute figures, the image with the wind turbine received significantly more favorable ratings in the contra group than the image with the high-frequency communication tower ($t = –4.921$, $p <.001$).

These results support our hypothesis that evaluations of the impact of mast-like structures on landscapes' scenic beauty strongly depend on how these structures are morally evaluated. Our results further show that not only general moral associations and judgments are decisive (cf. section 4.1), but also—at least in the case of wind turbines—group-specific different moral associations and judgments, namely a positive or a negative attitude towards wind energy in our "pro" or "contra" post-hoc groups (cf. section 3.5).

4.6. Even mast-like structures with positive moral associations degrade landscapes' scenic beauty

The fact that the image without any mast-like structure was ranked and rated by far the most positive, confirms the hypothesis that mast-like structures—even if they evoke positive moral associations, as wind turbines do in many people—are usually perceived as significant impairment of landscapes' scenic beauty, at least if the original landscape is regarded as beautiful.

This finding can be explained by the incompatibility of large-scale mast-like structures with almost all ideas of an ideal landscape that are influential in German culture, especially with romantic and conservative landscape ideals (cf. Nohl, 2001; Trepl, 2012; Kirchhoff, 2014; Kühne, 2019). It has turned out that many new visually dominat, large-scale technical elements have been introduced into landscapes in the last decades (like motorways, electrical powerlines, television masts), which are by no means aesthetically accepted by people due to their oversized dimension and 'urban' character (Nohl, 2001). In our study, only very few respondents ($n = 50$; 5%) deviated from this scheme by ranking or rating the landscape with wind turbine as more beautiful than the landscape without any mast-like structure. (For a similar finding see Molnarova et al., 2012.).

The widespread ambivalence towards wind turbines in the landscape might thus result from the fact that two widely held ideals—that both are important to people—come into conflict: The ideal of a natural-appearing landscape free of modern technology on one side, and the ideal of an energy transition through wind turbines in the landscape on the other (cf. Thayer, 1994; Salak et al., 2021).

5. Conclusions

Our survey shows that mast-like structures which—at least from a distance—differ rather little in visual terms are nevertheless judged to impair landscapes' visual quality and scenic beauty to very different degrees. This may be explained by the structures' significantly different moral associations which result in an incinerator chimney being judged as the by far largest, a wind turbine as the by far smallest, and a communication tower as a medium impairment. This correlation holds true for both supporters and opponents of wind energy. These groups, however, differ significantly in their judgment of wind turbines: Proponents attribute significantly lower negative impact than opponents do. Combined, these findings strongly suggest that scenic-beauty statements about mast-like structures in landscapes are significantly influenced by the structures' moral associations (cf. Gee, 2010; Salak et al., 2021). To a considerable extent, statements about their impact on landscapes' visual quality and scenic beauty reflect moral judgments of these mast-like structures.

This conclusion has substantial implications for the interpretation of visual landscape quality assessments, not only in terms of the impact of wind turbines on landscapes' scenic qualities. Namely, surveys on landscapes' visual quality and scenic beauty will have the less validity the more objects with strong moral associations are involved. In particular, surveys using explicit questions on whether wind turbines are—or are not—an impairment of landscapes' scenic beauty will more likely ascertain the spread of pro- and contra-wind energy positions, i.e. the degree of social acceptance of wind energy, than real judgments on landscapes' visual qualities.

As this influence of moral associations and judgments on statements about landscapes' scenic beauty can hardly be avoided, the central methodological consequence is to make such influences explicit and to reflect them in the interpretation of surveys. This is all the more true as landscapes themselves are almost always not only visual objects, but visual objects with symbolic meanings and moral associations (Cosgrove & Daniels, 1988; Gee, 2010; Gobster, Ribe, & Palmer, 2019; Salak, Lindberg, Kienast, & Hunziker, 2021; Trepl, 2012; Setten and Brown, 2009). Therefore, assessments of landscapes' visual qualities and scenic beauty that refer to formal properties only, or to alleged evolutionary preference only, or rely on context-independent indicators such as the number and distribution of universal landscape elements like hedges, waterbodies and groves (cf. Roth & Bruns, 2016; Kirchhoff, 2019a), all fundamentally fall short as they cannot capture a landscape's specific culturally shaped symbolic meanings and moral associations.

In view of this dilemma, a promising methodological approach for surveys might be: To ask not for "aesthetic judgments" on wind farms in a landscape but for judgments on their "acceptability", and then to ask for differentiated judgment in terms of (i) necessity of construction to achieve transition to renewable energy, (ii) impacts on human health, (iii) ecological impacts, and (iv) impact on the landscape's scenic beauty. Regarding energy transition strategies, beyond technical questions, the highly influential but often implicit moral judgments on wind farms—and solar fields or power lines as well—should be actively addressed in public relations and in planning processes, including the perception of fairness (cf. Gee, 2010; Molnarova et al., 2012; Maehr et al., 2015; Langer et al., 2018; Gölz & Wedderhoff, 2018; Ziegler, 2019; Salak et al., 2021).

Our study was performed in the German-speaking cultural area. Nevertheless, its results should be transferable to almost all so-called Western cultures. That is because in all of them the basically visual perceptions of landscape are interspersed with symbolic, ecological, political, and moral perceptions (cf. Cosgrove & Daniels, 1988; Trepl, 2012; Kirchhoff, 2019b; Kühne, 2019; Kühne and Antrop, 2015). This holds true even if these different perceptions are not subsumed under one single word—as with "landscape" in English, "paessagio" in Italian, "táj" in Hungarian, and "Landschaft" in German—but specific words for certain perceptions exist as "paysage" in French with its mainly visual connotations (cf. Drexler, 2013).

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

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Appendix A:. English translation of the online questionnaire (experimental group 4)

F·E·S·T HCE TUM

Hello!

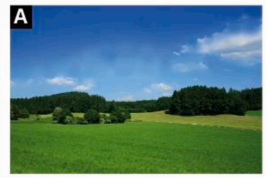
We are conducting a scientific, independently funded research project to investigate and compare different landscape images. We would be very pleased if you would fill in the following questionnaire in the next 5 minutes.

Thank you for your support!

1

Below you see four landscape images. In three images, a mast-like structure can be seen: a high-frequency communication tower (HF transmitter) *or* a wind turbine (WT) of a local energy cooperative of citizens of surrounding villages *or* a waste incinerator chimney (WIC).

Please rank the four landscape images according to your personal perception of beauty, by writing the corresponding letters behind the rankings 1, 2, 3 and 4. Rank 1 should be the best or most beautiful image, rank 2 the second most beautiful and so on.



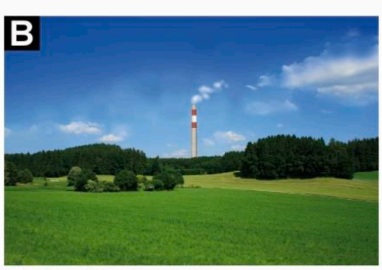
Ranking of the images:
1: ____
2: ____
3: ____
4: ____

2

Please rate the four images more precisely now.

How do you feel about image A?
Rate image A on a scale from 0 to 10.

○ 0= ugly ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10= beautiful



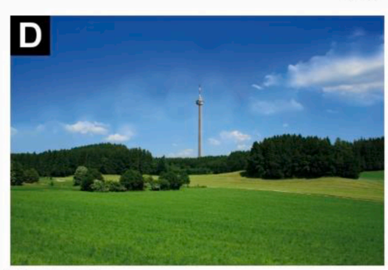
How do you feel about image B?
Rate image B on a scale from 0 to 10.

○ 0= ugly ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10= beautiful

3

How do you feel about image C?
Rate image C on a scale from 0 to 10.

○ 0= ugly ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10= beautiful



How do you feel about image D?
Rate image D on a scale from 0 to 10.

○ 0= ugly ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10= beautiful

4

Below you find statements made about wind turbines.

Please read the statements and tell us the extent to which you agree or disagree with them.

Thereby means:

- ++ completely agree
- \+ agree
- o neither agree nor disagree
- \- disagree
- -- completely disagree

Note: A "not applicable" or "don't know" option is deliberately not available as it's about your opinion, not about your knowledge.

Wind turbines are important for the energy transition.

○ ++ ○ + ○ 0 ○ - ○ --

Citizens are sufficiently consulted when decisions are made about wind turbines.

○ ++ ○ + ○ 0 ○ - ○ --

Wind turbines cause damage to health.

○ ++ ○ + ○ 0 ○ - ○ --

Wind turbines only benefit investors.

○ ++ ○ + ○ 0 ○ - ○ --

Wind turbines are a reliable source of energy.

○ ++ ○ + ○ 0 ○ - ○ --

5

Wind turbines lead to falling property prices.

○ ++ ○ + ○ 0 ○ - ○ --

Wind turbines make a contribution against climate change.

○ ++ ○ + ○ 0 ○ - ○ --

Citizens are sufficiently consulted when decisions are made about wind turbines.

○ ++ ○ + ○ 0 ○ - ○ --

Wind turbines destroy our homeland.

○ ++ ○ + ○ 0 ○ - ○ --

Wind turbines should be operated by the citizens.

○ ++ ○ + ○ 0 ○ - ○ --

Wind turbines have a negative impact on birds.

○ ++ ○ + ○ 0 ○ - ○ --

Wind turbines should not be erected against the will of the citizens.

○ ++ ○ + ○ 0 ○ - ○ --

6

In the following we ask you for some more information about yourself:

What is your gender?

- ○ female
- ○ male
- ○ diverse/other

What year were you born?

____

What is your highest educational qualification?

- ○ none or none yet
- ○ Hauptschule (lower secondary general; general secondary school)
- ○ Realschule (technical academic high school; secondary school)
- ○ Gymnasium (university preparatory high school; academic secondary high school)
- ○ Berufsausbildung (completed vocational training)
- ○ Meister (master craftsperson)
- ○ university of applied sciences
- ○ university
- ○ other

Where did you grow up first and foremost (childhood and youth)?

- ○ urban
- ○ peri-urban
- ○ rural

In which country or - if this is Germany - in which federal state did you primarily grow up?

____

Thank you for participating!

Appendix B:. Statistics for the three significant socio-demographical group differences in the statements section of the questionnaire

Item B015: "Wind turbines lead to falling property prices."

Levene's test showed that the assumption of homogeneity of variance was met, $F(2, 864)$, $p = .740$. Therefore, an ANOVA was calculated, $F(2, 864) = 3.732$, $p = .024$, omega2 = 0.006. Participants from the outskirts (ANOVA and Games-Howell; $M = 2.88$, $SD = 1.06$) agreed significantly more that wind turbines lead to falling property prices than participants from the countryside ($M = 3.107$, $SD = 1.04$, $t(488) = -2.631$, $p = .022$, *Cohen's d* = -0.22). According to Cohen (1988) this was a small effect. There were no significant differences between the countryside and outskirts group compared to the participants growing up in city environments ($M = 2.97$, $SD = 1.05$).

Item B013: "Only investors benefit from wind turbines."

Levene's test showed that the assumption of homogeneity of variance was not met for this data, $F(1, 848) = 23.02$, $p < .001$. Therefore, Welch's (1951) *F* was computed, $F(1, 847.73) = 7.018$, $p = .008$, *omega2* = 0.007, correcting for the violation of the assumption in order to control the Type 1 error rate. Games-Howell post-hoc comparisons revealed that female participants ($M = 3.78$, $SD = 1.04$) agree significantly less with the statement than male participants ($M = 3.58$, $SD = 1.21$), $t(848) = 2.623$, $p = .008$, *Cohen's d* = 0.18. Referring to Cohen (1988), this was a marginal effect.

Item B019: "Wind turbines should be operated by the citizens."

Levene's test showed that the assumption of homogeneity of variance was met, $F(1, 848)$, $p = .730$). There was a significant difference between men and women regarding Item B019, $F(1, 834.81) = 8.418$, $p = .004$, *omega2* = 0.009. Games-Howell post-hoc comparison revealed that female participants ($M = 2.58$, $SD = 1.12$) agreed with the statement significantly less than male participants ($M = 2.36$, $SD = 1.13$), $t(834) = 2.901$, $p = .004$, *Cohen's d* = 0.20. Referring to Cohen (1988), this was a marginal effect.

References

Betakova, V., Vojar, J., & Sklenicka, P. (2015). Wind turbines location: How many and how far? *Applied Energy, 151*, 23–31.

BfN. (2018). *Landschaftsbild & Energiewende. Band 1: Grundlagen. Ergebnisse des gleichnamigen Forschungsvorhabens FKZ 3515 82 3400 im Auftrag des Bundesamtes für Naturschutz.* Bonn-Bad Godesberg.

BfN, BBSR (eds). (2014). *Den Landschaftswandel gestalten! Potentiale der Landschafts- und Raumplanung zur modellhaften Entwicklung und Gestaltung von Kulturlandschaften vor dem Hintergrund aktueller Transformationsprozesse. Band 1: Bundesweite Übersichten.* 2. Auflage, https://www.bfn.de/sites/default/files/BfN/planung/landschaftsplanung/Dokumente/broschuere_lawa_band1.pdf.

Bidwell, D. (2013). The role of values in public beliefs and attitudes towards commercial wind energy. *Energy Policy, 58*, 189–199.

BMUB, BfN (2014). *Naturbewusstsein 2013. Bevölkerungsumfrage zu Natur und biologischer Vielfalt*, Berlin & Bonn.

Brady, E. (2003): *Aesthetics of the Natural Environment*, Cornwall.

Buijs, A. E., Elands, B. H. M., & Langers, F. (2009). No wilderness for immigrants: Cultural differences in images of nature and landscape preferences. *Landscape and Urban Planning, 91*(3), 113–123.

Burke, M. J., & Stephens, J. C. (2018). Political power and renewable energy futures: A critical review. *Energy Research & Social Science, 35*, 78–93.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences*, Abingdon.

Council of Europe (2000). *European Landscape Convention*, Florence.

Cosgrove, D. E., & Daniels, S. (1988). In *The Iconography of Landscape. Essays on the Symbolic Representation, Design and Use of Past Environments*. Cambridge: Cambridge University Press.

Dai, K., Bergot, A., Liang, C., Xiang, W.-N., & Huang, Z. (2015). Environmental issues associated with wind energy – a review. *Renewable Energy, 75*, 911–921.

de Vries, S., de Groot, M., & Boers, J. (2012). Eyesores in sight: Quantifying the impact of man-made elements on the scenic beauty of Dutch landscapes. *Landscape and Urban Planning, 105*(1), 118–127.

Devine-Wright, P. (2005). Beyond NIMBYism: Towards an integrated framework for understanding public perceptions of wind energy. *Wind Energy, 8*(2), 125–139.

Drexler, D. (2013). Landscape, paysage, Landschaft, táj: The cultural background of landscape perceptions in England, France, Germany, and Hungary. *Journal of Ecological Anthropology, 16*(1), 85–96. https://digitalcommons.usf.edu/jea/vol16/iss81/87.

Enevoldsen, P., & Sovacool, B. K. (2016). Examining the social acceptance of wind energy: Practical guidelines for onshore wind project development in France. *Renewable and Sustainable Energy Reviews, 53*, 178–184.

Fachagentur Windenergie an Land e.V. (2021). *Umfrage zur Akzeptanz der Windenergie an Land – Herbst 2021. Ergebnisse einer repräsentativen Umfrage zur Akzeptanz der Nutzung und des Ausbaus der Windenergie an Land in Deutschland.* Berlin: Fachagentur Windenergie an Land e.V.

Field, A. (2013). *Discovering Statistics Using IBM SPSS Statistics*, London.

Gee, K. (2010). Offshore wind power development as affected by seascape values on the German North Sea coast. *Land Use Policy, 27*(2), 185–194.

Gobster, P. H., Ribe, R. G., & Palmer, J. F. (2019). Themes and trends in visual assessment research: Introduction to the Landscape and Urban Planning special collection on the visual assessment of landscapes. *Landscape and Urban Planning, 191*, Article 103635.

Gölz, S., & Wedderhoff, O. (2018). Explaining regional acceptance of the German energy transition by including trust in stakeholders and perception of fairness as socio-institutional factors. *Energy Research & Social Science, 43*, 96–108.

Hägerhäll, C. M., Ode Sang, Å., Englund, J.-E., Ahlner, F., Rybka, K., Huber, J., Burenhult, N. (2018). Do humans really prefer semi-open natural landscapes? A cross-cultural reappraisal. *Frontiers in Psychology, 9*, article 822, https://doi.org/10.3389/fpsyg.2018.00822.

Hirsh, R. F., & Sovacool, B. K. (2013). Wind turbines and invisible technology: Unarticulated reasons for local opposition to wind energy. *Technology and Culture, 54*(4), 705–734.

Johansson, M., & Laike, T. (2007). Intention to respond to local wind turbines: The role of attitudes and visual perception. *Wind Energy, 10*(5), 435–451.

Kirchhoff, T. (2014). Energy turnaround and landscape aesthetics – objective evaluation of the aesthetics of energy plants referring to three intersubjective landscape ideals / Energiewende und Landschaftsästhetik. Versachlichung ästhetischer Bewertungen von Energieanlagen durch Bezugnahme auf drei intersubjektive Landschaftsideale. *Naturschutz und Landschaftsplanung, 46*(1), 10–16. https://www.nul-online.de/artikel.dll/NuL01-14-Inhalt-10-16-1_NDE2MDg3Mw.PDF?UID=7E817A5C6AD94EE51C242647E477953CD2FAE3EBF43B10.

Kirchhoff, T. (2019a). Abandoning the concept of cultural ecosystem services, or against natural–scientific imperialism. *BioScience, 69*(3), 220–227.

Kirchhoff, T. (2019b). Politische Weltanschauungen und Landschaft [Political worldviews and landscape], in: *Handbuch Landschaft [Handbook Landscape]* (O. Kühne, F. Weber, K. Berr, C. Jenal, eds), Wiesbaden, 383–396.

Kirchhoff, T., & Trepl, L. (2009). Landschaft, Wildnis, Ökosystem: Zur kulturbedingten Vieldeutigkeit ästhetischer, moralischer und theoretischer Naturauffassungen. Einleitender Überblick [Landscape, wilderness, ecosystem: on the culturally shaped ambiguity of aesthetic, moral and theoretical concepts of nature. Introductory overview]. *Vieldeutige Natur. Landschaft, Wildnis und Ökosystem als kulturgeschichtliche Phänomene* (pp. 13–66). Bielefeld: transcript.

Kirchhoff, T., Trepl, L., & Vicenzotti, V. (2013). What is landscape ecology? An analysis and evaluation of six different conceptions. *Landscape Research, 38*(1), 33–51. https://doi.org/10.1080/01426397.2011.640751

Knopper, L. D., & Ollson, C. A. (2011). Health effects and wind turbines: A review of the literature. *Environmental Health, 10*(1), 78.

Kühne, O. (2019). *Landscape Theories. A Brief Introduction*, Wiesbaden.

Kühne, O., Antrop, M. (2015). Concepts of landscape, in: *Landscape Culture – Culturing Landscapes* (D. Bruns, O. Kühne, A. Schönwald, S. Theile, eds), Wiesbaden, 41–66.

Langer, K., Decker, T., Roosen, J., & Menrad, K. (2018). Factors influencing citizens' acceptance and non-acceptance of wind energy in Germany. *Journal of Cleaner Production, 175*, 133–144.

Lothian, A. (2008). Scenic perceptions of the visual effects of wind farms on South Australian landscapes. *Geographical Research, 46*(2), 196–207.

Maehr, A. M., Watts, G. R., Hanratty, J., & Talmi, D. (2015). Emotional response to images of wind turbines: A psychophysiological study of their visual impact on the landscape. *Landscape and Urban Planning, 142*, 71–79.

Marcum, J. W. (2002). Beyond visual culture: The challenge of visual ecology. *Libraries and the Academy, 2*(2), 189–206.

Molnarova, K., Sklenicka, P., Stiborek, J., Svobodova, K., Salek, M., & Brabec, E. (2012). Visual preferences for wind turbines: Location, numbers and respondent characteristics. *Applied Energy, 92*, 269–278.

Morris, C., & Jungjohann, A. (2016). *Energy Democracy. Germany's Energiewende to Renewables*. Cham: Palgrave Macmillan.

Nassauer, J. I. (2012). Landscape as medium and method for synthesis in urban ecological design. *Landscape and Urban Planning, 106*, 221–229.
Nohl, W. (2001). Sustainable landscape use and aesthetic perception – preliminary reflections on future landscape aesthetics. *Landscape and Urban Planning, 54*(1–4), 223–237.
O'Shea, T. J., Cryan, P. M., Hayman, D. T. S., Plowright, R. K., & Streicker, D. G. (2016). Multiple mortality events in bats: A global review. *Mammal Review, 46*(3), 175–190.
Palmer, J. F., Alonso, S., Dong-Hee, K., Gury, J., Hermandez, Y., Ohno, R., … Smardon, R. (1990). A multi-national study assessing perceived visual impacts. *Impact Assessment, 8*(4), 31–48.
Palmer, J. F., & Sullivan, R. (2020). Visual prominence as perceived in photographs and in-situ. *Journal of Digital Landscape Architecture, 2020*(5), 286–294.
Potter, M. C., Wyble, B., Hagmann, C. E., & McCourt, E. S. (2014). Detecting meaning in RSVP at 13 ms per picture. *Attention, Perception, & Psychophysics, 76*(2), 270–279.
Rand, J., & Hoen, B. (2017). Thirty years of North American wind energy acceptance research: What have we learned? *Energy Research & Social Science, 29*, 135–148.
Ribe, R. G., Manyoky, M., Wissen Hayek, U., Pieren, R., Heutschi, K., & Grêt-Regamey, A. (2018). Dissecting perceptions of wind energy projects: A laboratory experiment using high-quality audio-visual simulations to analyze experiential versus acceptability ratings and information effects. *Landscape and Urban Planning, 169*, 131–147.
Roth, M., & Bruns, E. (2016). *Landschaftsbildbewertung in Deutschland – Stand von Wissenschaft und Praxis –*. Bonn: Bundesamt für Naturschutz (BfN).
Salak, B., Lindberg, K., Kienast, F., & Hunziker, M. (2021). How landscape-technology fit affects public evaluations of renewable energy infrastructure scenarios. A hybrid choice model. *Renewable and Sustainable Energy Reviews, 143*. https://doi.org/10.1016/j.rser.2021.110896
Schultz, S. (2012). So steht es um die Energiewende. Altmaiers Hundert-Tage-Bilanz. *Der Spiegel Wirtschaft,* 27.08.2012, https://www.spiegel.de/wirtschaft/energiewende-was-altmaier-bei-eeg-offshore-und-netzausbau-tun-muss-a-851934.html.
Setten, G., Brown, K. M. (2009). Moral landscapes, in: *International Encyclopedia of Human Geography* (R. Kitchin, N. Thrift, eds.), Amsterdam, volume 7, 191–195.
Shelley, J. (2022=: The concept of the aesthetic, in: *The Stanford Encyclopedia of Philosophy (Spring 2022 Edition)* (E.N. Zalta, ed.), https://plato.stanford.edu/archives/spr2022/entries/aesthetic-concept/.
Spence, A., & Townsend, E. (2008). Spontaneous evaluations: Similarities and differences between the affect heuristic and implicit attitudes. *Cognition and Emotion, 22*(1), 83–93.
Spielhofer, R., Hunziker, M., Kienast, F., Wissen Hayek, U., & Grêt-Regamey, A. (2021). Does rated visual landscape quality match visual features? An analysis for renewable energy landscapes. *Landscape and Urban Planning, 209*, Article 104000.
Subiza-Pérez, M., Marina, L. S., Irizar, A., Gallastegi, M., Anabitarte, A., Urbieta, N., … Ibarluzea, J. (2020). Explaining social acceptance of a municipal waste incineration plant through sociodemographic and psycho-environmental variables. *Environmental Pollution, 263*, Article 114504.
Suda, M. (2017). Attitudes of the local population towards wind turbines. Case study in three municipalities in the district of Freising (Bavaria) within the framework of "Policy Field Analysis of Landscape Development". *[unpublished]*.
Swofford, J., & Slattery, M. (2010). Public attitudes of wind energy in Texas: Local communities in close proximity to wind farms and their effect on decision-making. *Energy Policy, 38*(5), 2508–2519.
Thayer, R. L. (1994). *Gray World, Green Heart: Technology, Nature and the Sustainable Landscape*. New York: Wiley.
Thayer, R. L., & Freeman, C. M. (1987). Altamont: Public perceptions of a wind energy landscape. *Landscape and Urban Planning, 14*, 379–398.
Torres Sibille, A., & d. C., Cloquell-Ballester, V.-A., Cloquell-Ballester, V.-A., Darton, R.. (2009). Development and validation of a multicriteria indicator for the assessment of objective aesthetic impact of wind farms. *Renewable and Sustainable Energy Reviews, 13*(1), 40–66.
Trepl, L. (2012). *Die Idee der Landschaft. Eine Kulturgeschichte von der Aufklärung bis zur Ökologiebewegung*. Bielefeld: transcript.
Vogel, D. R., Dickson, G. W., Lehman, J. A. (1986). *Persuasion and the Role of Visual Presentation Support: The UM/3M Study*, Minneapolis, http://www.brendans-island.com/blogsource/20170523-Documents/20170603-8611.pdf.
Wang, S., & Wang, S. (2015). Impacts of wind energy on environment: A review. *Renewable and Sustainable Energy Reviews, 49*, 437–443.
Welch, B. L. (1951). On the comparison of several mean values: an alternative approach. *Biometrika, 38*(3/4), 330–336.
Wolsink, M. (2000). Wind power and the NIMBY-myth: Institutional capacity and the limited significance of public support. *Renewable Energy, 21*(1), 49–64.
Yu, T., Behm, H., Bill, R., & Kang, J. (2017). Audio-visual perception of new wind parks. *Landscape and Urban Planning, 165*, 1–10.
Ziegler, A. (2019). The relevance of attitudinal factors for the acceptance of energy policy measures: A micro-econometric analysis. *Ecological Economics, 157*, 129–140.