Rammaáætlun
Vernd og orkunýting landsvæða

# Tourism and onshore wind turbines: Literature review

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September 2023



Publisher: Institute of Life and Environmental Sciences, University of Iceland

ISBN: 978-9935-9742-3-5

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# 1 Introduction

Wind energy harnessing keeps increasing globally due to its positive contribution to the mitigation of global warming. Wind turbines do not require any fuel for operating, consequently they emit no greenhouse gases (Jaber, 2013). The carbon footprint of wind turbines is mostly related to manufacturing, transportation, construction, and later disposal of wind turbines (Clarke et al., 2022). Energy payback of wind power technology is estimated to be less than one year (Bonou et al., 2016; Fonseca & Carvalho, 2022).

However, wind energy development comes with various environmental impacts, such as visual and noise pollution, bird and bat fatalities due to collisions with wind turbines and habitat loss caused by avoidance, deforestation and land erosion (Marques et al., 2020; Nazir et al., 2020; Reusch et al., 2022). Thus, wind energy projects often pose a green-green dilemma by presenting a conflict between combatting climate change through renewable energy harnessing and negative impacts on the local environment and biodiversity (Straka et al., 2020).

The impacts of wind energy infrastructure on the surrounding landscape often lead to public opposition and conflicts related to most suitable locations for wind energy development (Pasqualetti & Smardon, 2017; Rand & Hoen, 2017; Wolsink, 2007b). This is especially relevant for onshore wind turbines, since they are often located in the vicinity of areas used for tourism and recreation, as well as residential, agricultural, or other land use areas (Felber & Stoeglehner, 2014; Frantál et al., 2023). Furthermore, the size of wind turbines keeps increasing due to rapidly evolving technology. Over the last 20 years their height has more than doubled (Enevoldsen & Xydis, 2019; Rohrig et al., 2019), with the highest turbines reaching over 260 m to the tip of the blade (Alphan, 2021). Such technological advances significantly contribute to reducing the cost of wind power (Beiter et al., 2021; Rohrig et al., 2019). In an increasing number of markets electricity generated from wind harnessing onshore costs less than electricity produced from fossil fuels (Clarke et al., 2022). Nonetheless, as wind turbines grow in size they cause greater landscape impacts.

Despite issues related to the public opposition to onshore wind energy projects, onshore wind power constitutes most of the global wind power market. While offshore wind is stronger and more constant (Bosch et al., 2018), construction and maintenance of offshore wind energy projects as well as electricity transmission are more costly compared to onshore, resulting in more development onshore (Clarke et al., 2022; Hevia-Koch & Klinge Jacobsen, 2019). In 2022, onshore wind energy projects were present in 115 countries, and onshore wind constituted 93% of the world´s total installed wind capacity, which reached 900 GW. Meanwhile, only 7% of the total installed capacity came from offshore wind energy projects, which were present in just 20 countries (IEA, 2023). However, the importance of offshore wind power in the global market is increasing (REN21, 2023). Among the countries with the highest installed onshore wind capacity in 2022 were China (335,504 MW), United States (140,820 MW), Germany (58,186 MW), India (41,930 MW) and Spain (29,303 MW) (IRENA, 2023).

Onshore wind energy projects have been used for renewable energy generation in some countries for a significant amount of time. However, in other countries, this type of energy infrastructure is relatively new and not yet widely adopted. This might lead to differing attitudes and perceptions of wind turbines. Existing research has shown that previous experience with wind energy infrastructure affects people's attitudes and can potentially lead to lower acceptance of future wind energy development (Ladenburg & Krause, 2011).

Moreover, countries where onshore wind energy development is in the early stages could largely benefit by learning from international experience.

The present literature review is an updated version of the literature review "Interrelationships of onshore wind farms with tourism and recreation: Lessons from international experience for countries with an emerging wind energy sector" by Tverijonaite and Sæþórsdóttir (2020). Both the previous and the current version of the literature review aim to provide an overview of existing academic knowledge on the issues related to wind energy development and tourism and recreation, as well as to identify potential knowledge gaps. The review focuses on the interrelationships between onshore wind energy infrastructure and tourism and recreation, the ways wind turbines can impact tourism and recreation, and the factors affecting the scale, character, and spatial extent of these impacts. It furthermore provides insight into the effects of wind turbines on tourists' decision-making to visit an area and investigates potential of wind energy projects to become tourist attractions. The impacts of wind energy infrastructure on tourism and recreation are closely related to issues concerning social acceptance and landscape changes due to wind power production. Therefore, to facilitate the interpretation of the results related to the impacts of wind energy infrastructure on tourism and recreation, the state of knowledge on both social acceptance and landscape impacts of wind energy infrastructure is presented in this literature review.

The search for relevant articles for the updated version of the literature review was conducted in July 2023 in three online databases of scientific research literature: Scopus, Web of Science, and Science Direct. The terms used for the search were 'wind energy/turbine*/farm*/ infrastructure AND touris*/recreation*'. Articles containing these terms in the title, abstract, keywords or topic heading were considered for this review. No time limit was used for the publishing date of the articles during the search. After scanning the abstracts, articles related to the topic were identified. Full texts of these articles were read, and relevant articles were included in the review. The bibliographies of these articles were examined to identify additional papers related to the topic of this review.

# 2 State of knowledge

## 2.1 Social acceptance of wind energy projects

Public attitudes towards wind energy in general tend to be positive (Rand & Hoen, 2017) and play an important role in determining the level of support for local wind energy development (Johansson & Laike, 2007; Molnarova et al., 2012; Walter, 2014). Nonetheless, specific wind farm proposals often face opposition. This discrepancy is often explained by using the NIMBY (not-in-my-back-yard) term, which describes individuals' support for developments like wind energy harnessing, but not in their own area (Dear, 1992; Wüstenhagen et al., 2007). However, numerous researchers (e.g., Petrova, 2013; van der Horst, 2007; Wolsink, 2006) have criticized this approach and stated that it does not identify the actual causes of opposition. According to Wolsink (2007b), visual impacts on landscape value are among main factors explaining public opposition, while NIMBY inclination often relates to fairness and equity in decision-making. Devlin (2005) emphasized that the benefits of wind energy development are experienced globally, while the negative impacts are mostly local and related to the degradation of the surrounding environment. To increase the acceptance of wind energy development, it would be beneficial to offer opportunities for those who are affected by the environmental degradation caused by wind energy infrastructure to also reap its benefits. In line with that, various studies showed that involving the public, promoting community ownership and local economic benefits, and ensuring fair distribution of benefits

can increase public support for wind energy development (Bauwens & Devine-Wright, 2018; Devine-Wright, 2005; Devlin, 2005; Toke, 2007; Warren & McFadyen, 2010).

Research on the effects of proximity of residence to wind energy infrastructure on public opposition has revealed mixed results. In a study by Swofford and Slattery (2010), support for wind energy increased with increasing distance between people's residence and wind energy infrastructure. Warren et al. (2005), on the other hand, have observed an 'inverse NIMBY syndrome'. In their study residents living closest to the wind farms (0-5 km) were the most supportive of them. Some elements of NIMBY-ism, such as preference to site wind energy projects in uninhabited areas or offshore, were observed also in the study by Warren et al. (2005). However, such preferences were stronger in the study areas with proposed wind energy projects compared to the areas already containing wind turbines, suggesting that people's attitudes change to more positive after the construction of a wind farm. In line with the results of Warren et al. (2005), a study conducted by Hoen et al. (2019) showed that residents living within 1.6 km from wind turbines were significantly more positive towards wind energy projects compared to those living further away. On the other hand, in several studies (Johansson & Laike, 2007; Wolsink, 2007b) no relation between proximity of the residence of the respondent and the intention to oppose a wind energy project was found. Notably, a study by Molnarova et al. (2012) revealed that residents living within 3 km from a wind farm are less influenced by landscape type and quality when evaluating the suitability of a wind farm in a certain landscape. Instead, overall attitudes towards wind power hold greater significance. Jones and Eiser (2010) aimed to assess 'how big is the backyard' with regard to NIMBY syndrome and compared attitudes of local residents towards building wind turbines in nearby sites and in various locations on land and offshore in United Kingdom. The study showed that the increase of support for wind energy development with distance from residence was not linear, suggesting that other factors, especially site visibility and impacts on landscape, play an important role in shaping the support for wind energy projects (Jones & Eiser, 2010).

As revealed by Wolsink (2007b), public attitudes towards wind energy projects are not static but rather develop in a U-shape pattern. Initially, people are usually very positive towards wind power. However, when specific wind energy projects are announced in their neighborhood, they become more critical. Yet, if the environmental impacts of the infrastructure are properly addressed, their attitudes shift back to being more positive within a year from construction (Wolsink, 2007b). The findings of Wolsink (2007b), are supported by a study conducted by Warren et al. (2005), investigating the views of local residents in Scotland and Ireland, which showed that visual and noise impacts of wind turbines often turned out lesser than anticipated. Moreover, the existing wind farms were often perceived as attractive, which resulted in higher support for wind energy development in the areas where wind farms are already present. Such findings partly align with the results of Eltham et al. (2008). Their study did not identify a significant increase of residents´ approval of the established wind farm. This could be attributed to the fact that the support rate was already high both before and after the construction. However, a higher proportion of residents perceived the wind turbines as visually attractive after the construction (Eltham et al., 2008). In a study by Ladenburg et al. (2013), on the other hand, viewing wind turbines from their residence in combination with seeing more than five wind turbines daily had a negative effect on participants' attitudes towards wind energy infrastructure. This suggests that increasing number of wind turbines can lead to lower level of support for wind energy development. Jones et al. (2011) conducted a study in Humberhead Levels in northern England, characterized by a flat and low-lying landscape, aiming to estimate the perceived maximum number of wind turbines the region can accommodate. The majority, or 89% of respondents

thought the region had the potential for further wind energy development. However, opinions varied greatly regarding the number of wind turbines. The biggest proportion, 21% stated that the region could accommodate 1-25 more wind turbines. Around 15% of respondents thought it could support 26-50 additional wind turbines, while the same proportion thought it could support 76-100 turbines. Almost 14% of the participants expressed that the region has the capacity for 151 or more wind turbines. The study revealed that perceived regional suitability, fairness and equity, and visual attractiveness of wind turbines were among the main factors affecting estimated capacity of the region to host wind turbines. Furthermore, higher perceived knowledge of existing and proposed wind energy projects in the region led to more wind turbines perceived as acceptable. Environmental values and acceptance of wind turbines were also positively related. On the other hand, a negative relationship was observed between community attachment and acceptable number of wind turbines. Respondents who reported higher levels of community attachment were found to accept fewer wind turbines (Jones et al., 2011). As a result, determining the appropriate number of wind turbines is a subjective matter that depends on various factors.

According to Warren et al. (2005), public opposition could partly be explained by NIABY, or 'not-in-anybody's-backyard'. The term suggests that disapproval of wind energy development can also stem from the perceived importance of preserving wilderness and naturalness of rural areas because of their value for recreation and relaxation, or due to other environmental reasons (Meyerhoff et al., 2010; Petrova, 2013).

A study by Mueller and Tickamyer (2020) conducted in 14 counties in Pennsylvania, USA, looked into rural residents' support for various natural resource development options in their community. Results revealed that general support was the highest for outdoor recreation development, followed by wind energy, tourism, natural gas, and real estate development. However, participants on average did not express support for mining and commercial logging development. Trust in the industry, perceived impacts on quality of life, environment, employment, and local economy, as well as industry power were found to be strong predictors of support for development. Additionally, there was a positive relationship between support and personal or family history with the industry, particularly on their own or family's property (Mueller & Tickamyer, 2020).

In addition to the visual impacts on the landscape, environmental and socioeconomic concerns, attitudes towards wind energy projects are also influenced by various other factors. These include the perceived need for wind energy (Devlin, 2005), procedural concerns and divergent perspectives on the preferred project outcome (Aitken, 2010; Mills et al., 2019). Noise pollution (Hoen et al., 2019; Peri et al., 2020; Rand & Hoen, 2017), including infrasound (Langer et al., 2018), and concerns about potential health impacts are also important considerations (Baxter et al., 2013).

Leiren et al. (2020) conducted a study focusing on stakeholder perceptions in study areas located in Germany, Spain, Italy, Latvia, Poland, and Norway and identified six categories of factors that play a role in shaping the social acceptance of wind energy projects:

1. Technical characteristics of each wind energy project, including turbine height and size, visibility, distance from residential areas and need for necessary infrastructure improvements, such as grid connections.
2. Environmental impacts, such as impacts on the physical environment, wildlife, biodiversity and GHG emissions).
3. Societal impacts, such as impacts on human health, quality of life and overall wellbeing.

4. Economic impacts, including those on tourism, agriculture, and local and individual income generation.
5. Contextual factors such as the energy market characteristics, planning and permitting process, trust in key actors, and regulatory frameworks.
6. Individual characteristics such as socio-cultural values, self-identity, place attachment, sense of place, discourses and political climate surrounding wind energy.

As noted by the authors, policy and corporate measures aiming to enhance perceived procedural justice through transparency and inclusiveness, and distributional justice through benefit-sharing schemes can affect social acceptance. The study by Leiren et al. (2020) furthermore showed that among the most critical barriers to social acceptance of wind turbines are their impacts on the physical environment, on biodiversity and wildlife, distance of a wind farm from residential areas, its size and visibility. The most critical drivers of acceptance are, on the other hand, impacts on GHG emissions, as well as economic impacts, such as local income generation and degree of local ownership. Impacts of wind energy projects on tourism were perceived as barriers to social acceptance in four out of six regions, while in the remaining two regions they were perceived neutrally (Leiren et al., 2020).

Notably, the relationships between attitudes towards wind energy development and the factors affecting them can be bidirectional. For instance, negative attitudes towards wind power and higher perceived visual impacts can result in higher levels of noise annoyance (Klæboe & Sundfør, 2016; Pedersen & Waye, 2004). This, in turn, can lead to lower mental health and reduced quality of life for people living in the vicinity of wind energy projects (Jalali et al., 2016).

## 2.2 Impacts of wind energy infrastructure on landscape

As stressed by numerous researchers (Pasqualetti & Smardon, 2017; Suškevičs et al., 2019; Warren et al., 2005; Wolsink, 2007b), the visual impacts of wind turbines influence both the public´s opposition to and support for wind energy development. High wind turbines with moving blades often lack aesthetic integration in the surrounding landscapes (Torres Sibille et al., 2009). Obstruction of Sun's rays by periodic movement of wind turbine blades results in shadow flicker, which has a significant visual impact and can potentially cause health issues (Alphan, 2021; Tabassum et al., 2014).

The visual impacts of wind energy infrastructure on the landscape can differ strongly depending on various factors and are closely linked to the perceived suitability of the wind energy infrastructure in the landscape (Johansson & Laike, 2007). Therefore, the type of landscape where a wind energy project is located is crucial in shaping how wind turbines are perceived and accepted. In a study by Wolsink (2007a) conducted by the Wadden Sea, industrial and military areas were viewed as the most suitable for siting wind turbines, while nature reserves, scenic and recreational areas were considered less suitable. Molnarova et al. (2012) investigated respondents' visual preferences for wind farms in three types of landscapes in the central region of the Czech Republic. The participants were shown photographs of these landscapes without wind turbines and were asked to rate their aesthetic appeal. The top-ranked area boasted a distinctive terrain with mountains in the background, containing mostly natural elements and minimal human impact. The second area consisted of a blend of agricultural and forest landscapes. In contrast, the least attractive location was a lowland landscape heavily used for agriculture, with factory infrastructure visible in the background. Participants were then shown pairs of photographs, one without and one with wind turbines. They were then asked to rate them using a 5-point Likers Scale with 1 indicating a significant deterioration of the landscape and 5 indicating a significant

enhancement. Wind turbines in the least attractive landscape were perceived as the least negative addition to the landscape. Around 8% of the participants perceived wind turbines as a significant enhancement to the landscape, while 5% viewed it as a significant deterioration. Wind turbines in the most attractive landscape were perceived as a significant deterioration of the landscape by 35% of the respondents, while only 1% viewed them as a significant improvement. In line with that, in a study by Lothian (2008), wind farms were perceived to have a higher negative impact on the scenic quality in coastal areas, particularly in the most beautiful spots. However, in inland areas with lower scenic quality, wind farms were viewed as positive additions to the landscape (Lothian, 2008).

The distance between the observer and the wind turbines is another factor that affects the perceived visual impacts of wind turbines on the landscape. In a study by Molnarova et al. (2012), photographs presenting wind turbines located 1.5 km away received significantly lower rating than those with wind turbines located at a distance of 4.5 km and 8.0 km. Betakova et al. (2015), further researched the same landscape types and discovered that with increasing distance the negative impact of wind turbines decreased most effectively in more attractive landscapes, with most reduction occurring at the distances between 7.5 and 10 km. In the least attractive landscape, however, increasing distance reduced the negative impact of the wind turbines much less, with more evident reduction happening at the distance between 3 and 5 km. In a study by Betakova et al. (2015), the rating of all landscapes with one wind turbine (105 m high, 90 m blade diameter) at a distance of 10 km and further was similar to landscapes without wind turbines. Therefore, the authors established that the visual threshold distance for one wind turbine in landscapes of higher aesthetic quality should be 10 km, while in those of lower quality it should be around 5 km. Notably, a wind turbine located at the distance of 750 m, resulted in a similar rating for all three types of landscape. This is because the wind turbine eliminated the scenic qualities of the landscape by dominating it. The strongest impacts were felt within a radius of 1.5 km from the wind turbine. Bishop (2002) estimated the threshold of visual impacts of a wind turbine (50 m high tower, 26 m long blades) by considering the contrast with the surrounding landscape and atmospheric scattering and the movement of the blades. He concluded that in transparent weather conditions the visual impact of a wind turbine might reach up to 30 km, while poorer viewing conditions may shorten this distance. Sullivan et al. (2012) estimated the maximum limit of visibility of approximately 90-120 m high wind turbines. Under optimal viewing conditions, they can be seen up to 58 km away. The authors set the limit of casual visibility, meaning that visual impacts of wind turbines are moderate in normal viewing conditions, at 32 km, and limit of visual preeminence, when wind turbines are a major focus of attention and have a large visual impact, at 16 km. In the western U.S. landscapes, which are characterized by wide open views, Sullivan et al. (2012) suggested using a 48 km limit when conducting viewshed analyses of wind turbines which are 90-120 m high. Similarly, Scottish Natural Heritage (2017) recommended using the distance of 40 km for wind turbines reaching the height between 131-150 m and a distance of 45 km for wind turbines higher than 150 m while estimating the zone of theoretical visibility.

Various design-related characteristics of wind energy infrastructure can also affect its impacts on the landscape (Lothian, 2008; Molnarova et al., 2012; Tsoutsos et al., 2009). The number of wind turbines is one of them. In a study by Molnarova et al. (2012), respondents preferred a landscape that had only one wind turbine rather than four. Similarly, a study by Ek (2006) revealed that smaller wind farms with less than 10 wind turbines were preferred over larger wind farms, ranging between 10 and 50 turbines, as well as individual wind turbines scattered throughout the landscape. Bergmann et al. (2008) showed that respondents preferred smaller onshore wind farms consisting of 30 wind turbines, as opposed to larger onshore farms with

80 turbines. However, large offshore wind farms containing 100 turbines were perceived as the most acceptable option. On the other hand, a study by Lothian (2008), found no significant differences in perceived landscape quality despite the number of wind turbines varying between six and thirteen. Lothian (2008) assumed that this might be due to a relatively small range of wind turbines used in the study. Meyerhoff et al. (2010) showed divergent preferences regarding the height of the wind turbines. In a study by Lothian (2008), wind turbines painted in white, grey, or blue, depending on the landscape, were found to be more preferred over tan and rainbow colors. When planning new wind energy development, Ladenburg et al. (2013) suggested considering the function of the number, height and distance of wind turbines from residential areas to determine the most socially acceptable options. On the other hand, Wolsink (2007a) emphasized, that the type of landscape is more significant in determining the acceptance of wind energy infrastructure than the number and height of the turbines.

Baynard et al. (2017) calculated the total landscape disturbance footprint of wind turbines in Colorado's Pawnee National Grasslands. They included factors such as roads, transmission lines, easement lines, turbine pads and substations. The results showed a direct disturbance footprint of 0.01 $km^2$ or 1 ha per wind turbine. As noted by the authors, such results are in line with the World Bank estimates that the landscape footprint for wind energy development, which includes cleared vegetation for wind turbine pads and road construction, reaches 1-2 ha/MW (Ledec et al., 2011). Baynard et al. (2017) emphasized that despite relatively small direct impacts of wind turbines on land surface, their visual impacts often are far reaching.

Public opposition to wind energy development and, furthermore, lack of local support, might hinder the implementation of wind energy projects. Public opinion is crucial, as general public holds political power through voting, for instance, when it comes to giving permits for a wind energy projects (Toke, 2005; Toke et al., 2008). To make informed decisions when planning wind energy development, it is important to have the knowledge of the factors affecting public support for wind energy development and to take them into consideration. In countries and regions relying on tourism and recreation it is furthermore highly important to have an in-depth understanding of the impacts of wind energy infrastructure on tourism and recreation and the factors shaping them. This report aims to contribute to it.

# 3 Tourism and onshore wind energy infrastructure

## 3.1 Perceived impacts of wind energy infrastructure on tourism and recreation and their spatial extent

Acceptance of wind energy among tourists seems to be somewhat lower compared to other renewable energy sources (Sæþórsdóttir et al., 2018). However, as shown by various studies (Brudermann et al., 2019; de Sousa & Kastenholz, 2015; Silva & Delicado, 2017), tourists and tourism service providers view wind energy mostly positively, in line with attitudes of general public. Wind is generally perceived as a green, clean, renewable, and sustainable source of energy (de Sousa & Kastenholz, 2015; Silva & Delicado, 2017). However, the levels of acceptance among tourism stakeholders tend to be lower with regard to specific wind energy projects, similar to the views of general public.

Among the main negative impacts of wind energy projects on tourism identified by visitors and local tourism stakeholders are the visual impacts on the landscape and its character (Frantál & Kunc, 2011; Lenz, 2004; Ólafsdóttir & Sæþórsdóttir, 2019). This might be related to high reliance of tourism and outdoor recreation on landscape quality. In a study by

Sæþórsdóttir et al. (2021), tourism service providers expressed concerns about the potential impact of five proposed wind farms in Iceland. They stated that wind farms are likely to negatively impact visitor experience by degrading the quality of surrounding landscapes, which ultimately can result in visitors avoiding areas containing wind farms and economic losses in surrounding regions. However, in order to maximize their efficiency, wind turbines are often constructed areas that are highly exposed, such as open fields or mountain ridges (Salak et al., 2022). Notably, such areas are often considered valuable for tourism and outdoor recreation. Consequently, while sometimes proposed to enhance opportunities for tourism, wind farms in some cases are rejected or reduced in size due to high landscape impacts and consequent impacts on tourism and recreation (Kohsaka & Kohyama, 2022). Furthermore, as revealed by a study by Sirr et al. (2023) conducted in Ireland, people who think that wind farm developments can negatively impact tourism are less willing to invest in local wind energy projects than the ones who do not think so. As a result, increasing number of studies are proposing tools and methods for wind energy planning that take into account their visual impacts on various tourism aspects, such as tourism destinations, protected areas, viewpoints, and routes used by tourists and recreationists (e.g., Alphan, 2021; Cunden et al., 2020; Dehshiri & Dehshiri, 2022).

Noise disturbance and related potential health issues are also brought up by the visitors and residents as impacts negatively affecting visitor experience (de Sousa & Kastenholz, 2015). In a study by Goudriaan et al. (2023), concerns over potential impacts of wind turbine noise on hunting activities were expressed. This is because hunters might not hear their dogs barking due to the noise. Tourism service providers discussing a proposed Búrfell wind farm in the Southern Highlands of Iceland also stressed that light pollution from wind turbines can negatively impact experience of visitors participating in northern light tours during the winter months (Ólafsdóttir & Sæþórsdóttir, 2019).

Main positive impacts of wind energy projects pointed out by visitors include contribution to sustainable energy production. Locals on the other hand, also mention economic benefits wind farms bring to their communities (de Sousa & Kastenholz, 2015). According to a study by Brudermann et al. (2019), visitors tend to have a higher level of acceptance of wind farms if they have a positive perception of the benefits and reliability of wind energy, favorable attitudes towards renewable energy, and lower levels of skepticism and annoyance towards the wind energy infrastructure.

The spatial extent of the impacts of wind energy infrastructure on tourism was investigated in a study by Tverijonaite et al. (2022). They estimated the impact area of proposed and existing renewable energy infrastructure on tourism in Iceland, including the proposed Búrfell wind farm, as perceived by tourism service providers. The study revealed differences in the character of perceived impacts. While most participants estimated negative impact areas of the proposed wind farm, one perceived potential impacts on tourism as positive and two as mixed (Figure 1). Participants' reasoning regarding the spatial extent of the impacts can be categorized into three groups. Some of the participants who estimated negative impact areas thought that the visibility of the wind energy infrastructure would mark the end of the proposed wind farm's negative impacts on tourism. Others focused on tourist mobility and included routes and destinations where visitor experience would likely be affected due to previous encounter with the wind farm when they defined the impact area. One participant who estimated a negative impact area based their reasoning on changes in tourist movement and their travel pattern e.g., due to avoidance of the area containing the wind farm by some tourists and improved roads and consequent higher visitation by others. The two participants who estimated mixed impact areas argued that the impacts of the proposed wind farm on

tourism would end with visibility. They furthermore stated that the character of these impacts would highly depend on various factors, such as information provided by the guide to visitors or previous experience of wind turbines. The only participant who estimated a positive impact area of the proposed Búrfell wind farm on tourism claimed that the wind farm would be an interesting sight in an already developed area containing several hydropower plants.

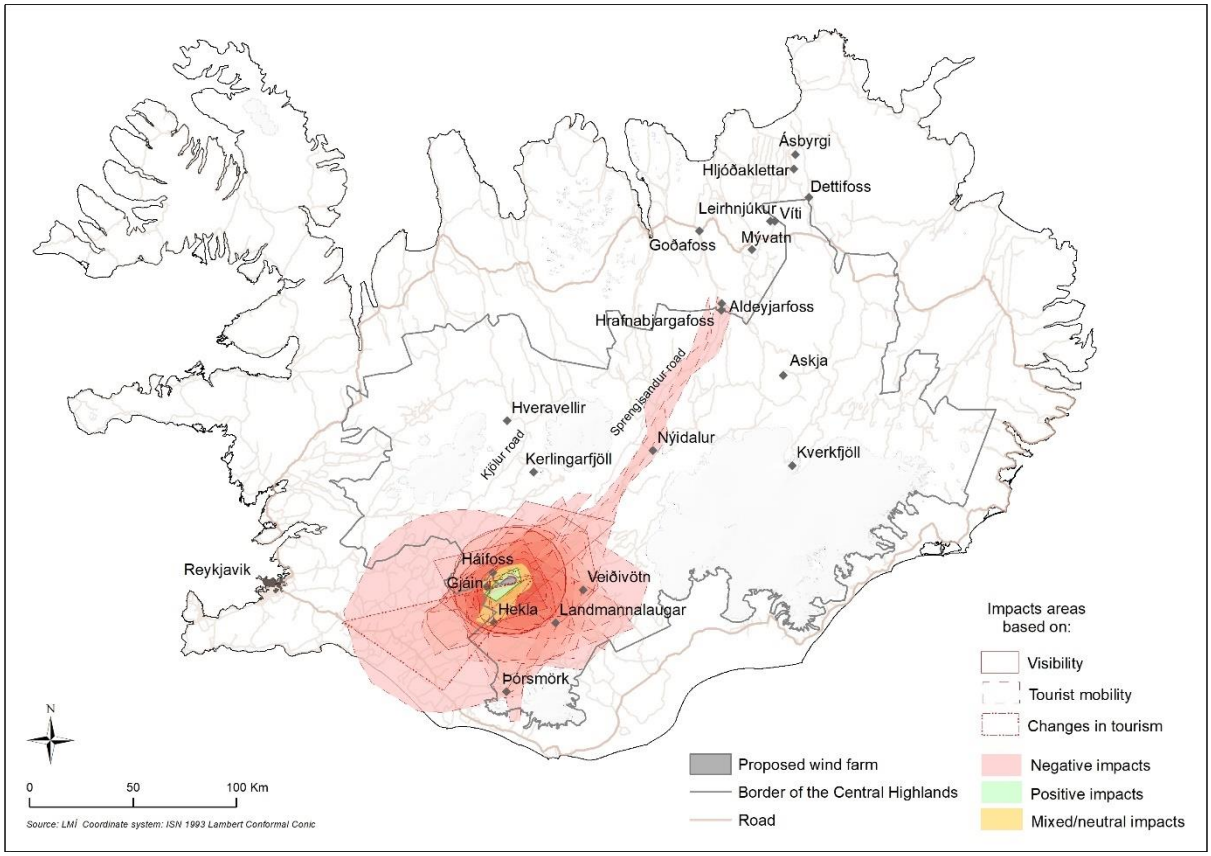


*Figure 1. Perceived impact areas of the proposed Búrfell wind farm on tourism (Tverijonaite et al., 2022).*

## 3.2 Factors affecting the character and severity of impacts of wind energy infrastructure on tourism and recreation

*Factors related to the location of wind energy projects*

Locational factors are highly important in shaping wind energy infrastructure's impacts on tourism and outdoor recreation and stakeholder support, stressing the importance of spatial planning in wind energy development (Alphan, 2021). Existing research increasingly emphasizes the role of meanings assigned to places and landscapes as well as to energy infrastructure and their compatibility, also referred to as "place-technology fit" and "landscape-technology fit", in shaping public support (Devine-Wright & Wiersma, 2020; Salak et al., 2022). This is in line with the findings of studies focusing on wind turbines and tourism. Frantál et al. (2017) investigated the attitudes of 'expert tourists' interested in renewable energy towards the Búrfell wind farm proposed in the Icelandic Highlands. In the study 48% of respondents approved of the proposed farm, while around 36% rejected it. The attitudes towards the proposed wind farm were highly correlated with the perceived compatibility of the proposed power plant with the current landscape of the area. Few respondents perceived the proposed wind farm as not compatible with the landscape but still approved it. This was related to their support for renewable energy in general. The few

participants that perceived the wind farm as compatible but still rejected it, did so because they thought the project to be redundant in the Icelandic context (Frantál et al., 2017). In a study by Tverijonaite et al. (2022), meanings assigned to the place surrounding the proposed Búrfell wind farm and to the infrastructure itself were shown to affect perceived impacts of this infrastructure on tourism and their spatial extent.

Depending on the ascribed place meanings and other characteristics, some locations are perceived by tourism stakeholders as more suitable for wind energy development than others. As revealed by various research (de Sousa & Kastenholz, 2015; Ólafsdóttir & Sæþórsdóttir, 2019; Sæþórsdóttir & Ólafsdóttir, 2020), wind farms are perceived as especially unsuitable in natural areas where pristine nature is the main element of visitor experience. However, while the acceptance of wind turbines in scenic natural areas tends to be lower, the views of visitors are divergent. A study conducted by Lenz (2004) in the recreational region of Eifel, Germany, revealed that 45% of the visitors stated that the movement of wind turbine blades and noise produced by them negatively affected the recreational value of the landscape of the area. Additionally, around half of the respondents thought that the wind turbines were too prominent to harmonically suit the landscape of Eifel. On the other hand, 63% of the respondents thought that wind turbines should be built in recreational areas such as Eifel if the wind conditions for that are suitable. The research by Frantál and Kunc (2011) conducted in two mountainous areas in the Czech Republic showed that only 27% of the respondents thought that the wind turbines significantly affected the landscape character of the areas. This might be related to the fact that the study areas were affected by dams, reservoirs, and activities of coalmining, and only 8% of the visitors identified wild nature without traces of human activity as the most important factor for the choice of this destination. In a study by Salak et al. (2022) based on an online panel of Swiss citizens, various scenarios which consisted of wind and/or photovoltaic (PV) and/or power lines were perceived more positively in settlement- and agriculture-dominated areas and tended to be rejected in near-natural landscapes. The rejection rate increased with the increasing number of wind turbines. In mountainous tourist areas, people preferred to limit energy developments to areas that already contain considerable tourism infrastructure. In such areas participants prioritized PV or a mix of PV with a small or medium number of wind turbines, with the latter having a low level of acceptance. Thus, energy developments in pristine landscapes were shown by this study to likely result in ‘place protective behavior’ (Salak et al., 2022).

Other areas perceived as rather unsuitable for wind energy development are historic heritage sites. Silva and Delicado (2017) conducted a study in a Portuguese historic village called Sortelha, located near two wind farms. One contains 17 wind turbines reaching the height of 85 meters and is located about two kilometers away from the citadel of Sortelha. The other wind farm is around 800 meters away from the citadel and contains eight wind turbines of the same height. As the results show, 42 out of 68 visitors interviewed in the study were concerned about the visual impacts of modern wind farms, especially on the medieval architecture of the village. On the other hand, 43 out of 68 visitors participating in the study accepted the wind turbines in the village since they perceived wind energy as environmentally friendly and clean. Furthermore, the vast majority stated that the wind farms did not affect their choice of destination. Interviews with the residents revealed that 14 out of 21 interviewed residents were against the existing wind energy facilities in Sortelha. Like the visitors of Sortelha, the interviewed residents perceived that the wind farms as modern constructions do not fit the historic village, and that this anachronism caused by the visual intrusion of the wind turbines might negatively affect tourism. According to the residents opposing the wind farms, such constructions have negative impacts on medieval characteristics of the village and thereby might spoil the unique attractions that differentiate

the village from other places and reduce its international competitiveness as a tourism destination. The residents admitted that the existing wind farms did not have negative effects on tourism demand. However, they believed that the wind farms have strong negative impacts on visitor experience due to the contrast of modern wind turbines and medieval architecture of the village. Other reasons for opposition among residents were related to the issues of fairness of process and justice in allocation of economic benefits of the wind farms, and they felt excluded from the decision-making process.

Agricultural lands, on the other hand, are often perceived as more suitable for wind energy development by tourism stakeholders. In a study by Frantál and Kunc (2011), construction of wind turbines in agricultural areas was preferred by 70% of visitors, while 5% preferred wind turbines in pristine natural areas. Similar results were revealed by a study by Sæþórsdóttir et al. (2018), where 65% of visitors preferred seeing wind turbines in agricultural land rather than wilderness areas, and 12.5% preferred wilderness areas for such development. In line with that a study conducted among tourism operators in Iceland (Sæþórsdóttir & Hall, 2019) showed that wind farms were perceived as more positive in the lowlands compared to the highlands, which is the unpopulated interior of Iceland. In the study by Frantál and Kunc (2011), on the other hand, wind turbine construction in the highland areas in the Czech Republic was preferred by 58% of the respondents, while 12% preferred to see such infrastructure being built in the lowlands and plain fields. According to Frantál and Kunc (2011), such results contradict the preference to build wind turbines in agricultural landscapes which are located in the lowlands. A study by Ek and Persson (2014) conducted among general public in Sweden showed that in general mountainous areas were perceived as less suitable for wind turbines compared to offshore. Moreover, people were much more against the presence of wind farms in the environments which they visit for recreation than in the environment in which they live. Thus, people owning summerhouses or regularly visiting mountainous areas for recreational purposes were less willing to accept wind turbines in mountainous areas. The same applied for open and coastal landscapes. This is in line with the findings of Johansson and Laike (2007), which showed that the impacts of wind turbines on recreational opportunities were a more important factor when predicting the opposition to a wind farm than its impacts on quality of daily life. In a study by Sims and Dent (2007) conducted in the county of Cornwall, UK, 95% of people objecting a wind farm application lived outside of Cornwall. According to Westlund and Wilhelmsson (2021) such findings could be explained by differences in local embeddedness between holiday-home owners and permanent residents. For holiday-home owners, which often live in urban settings, the area represents opportunities for ‘unspoiled’ nature experiences and outdoor activities. Permanent residents besides the above-mentioned factors also place importance on the local economy since their community’s well-being depends on it. Consequently, residents tend to be more tolerant towards landscape changes if they bring economic benefits than holiday-home owners (Frantál et al., 2023). Furthermore, a study by Sæþórsdóttir and Ólafsdóttir (2020) showed differences in the perceptions of wind farms by tourists and residents of Iceland. Landscapes without wind turbines were perceived as more beautiful by tourists compared to residents, while residents perceived the landscapes with wind turbines as more beautiful than tourists. Thus, the perceived loss of beauty of the landscape was bigger for the tourists than for the residents. Similar trends were observed with power lines in various landscapes. Moreover, while tourists preferred to see wind turbines in agricultural landscapes, residents perceived wilderness areas as more suitable for wind energy development in Iceland (Sæþórsdóttir & Ólafsdóttir, 2020). This points to the need for including various stakeholders in the decision-making when planning wind energy development.

Visual landscape characteristics also play an important role: over 63% of visitors in the study by Sæþórsdóttir et al. (2018) agreed with the statement that wind turbines should be prohibited in beautiful landscapes, with 55% stating that wind turbines spoil the landscape irrespective of their location. Furthermore, wind turbines were perceived as rather negative features in the Icelandic Central Highlands. They were also perceived more negatively in picturesque landscapes, such as landscapes containing volcanos, compared to more homogenous and desert-like landscapes (Sæþórsdóttir et al., 2018). Wind turbines interfering with scenic landscapes were viewed negatively also in a study by Beer et al. (2023). They conducted an online survey among Slovakian hikers and assessed their attitudes towards fictional wind turbines or photovoltaic parks in eight locations by using photomontages. The findings of the study revealed that fictitious wind turbines affecting the panorama of the High Tatras received the lowest level of acceptance, followed by locations containing historical heritage. Power plants in agricultural or industrial landscapes received higher participant support (Beer et al., 2023). Furthermore, statistical tests revealed that fictional wind or photovoltaic power plants were perceived significantly more negatively in locations containing historical element(s) compared to locations not containing them, in more natural landscapes compared to landscapes containing other built infrastructure, and in locations where power plants obstructed the view of the High Tatras compared to locations where power plants did not affect the view (Beer et al., 2023).

Regarding wind energy development within or nearby protected areas, in a study by Sæþórsdóttir et al. (2018), over 80% of the participants stated that wind turbines should be prohibited in national parks and other protected natural areas. This is supported by the study by Arnberger et al. (2018) conducted in the Bavarian Forest National Park, where both local recreationists and tourists disliked the hypothetical wind turbines within or close to the borders of national parks.

Various studies (Arnberger et al., 2018; Brudermann et al., 2019) show that distance is an important factor for the social acceptance of wind energy projects among visitors. Increasing distance between areas used for tourism and recreation and wind turbines tends to result in higher wind turbine acceptance among visitors. Distance was shown to play an important role for the acceptability of a proposed wind farm also among tourism service providers in a study by Ólafsdóttir and Sæþórsdóttir (2019). However, further research with more specific data is needed regarding the effects of distance on the wind farms' impacts on tourism and recreation.

Distance from recreational areas is also an important factor affecting the severity of noise pollution produced by wind turbines. Watts and Pheasant (2015) created a model aiming to estimate the impacts on tranquility by various constructions, which considers noise and visual impacts, and applied it to a wind farm in Ovenden Moor, in West Yorkshire, UK. According to the model, in tranquil countryside areas not containing any major roads within 2 km, a distance of 950 m – 2250 m from a wind farm with 11 wind turbines built in one line might be required to restore the previous tranquility of the area, depending on the noisiness of the wind turbines. The authors emphasized that natural areas with low levels of infrastructure tend to have high levels of tranquility and provide calming and pleasant experiences, pointing to the need for protecting such areas (Watts & Pheasant, 2015). In line with that, in a study conducted by Gale et al. (2021) among visitors to the Coyhaique National Reserve, Chile, natural sounds were perceived as more acceptable and appealing compared to anthropogenic sounds. The importance of protecting tranquil areas because of their recreational and amenity value has been stressed in the UK National Planning Policy Framework (Ministry of Housing Communities and Local Government, 2019). Thus, besides affecting visitor experience in

natural areas, wind energy projects can also negatively impact their restorative functions due to visual and aural disturbance.

A study conducted in Iceland by Sæþórsdóttir et al. (2021) focusing on the perceptions of the tourism industry identified five locational factors affecting the severity of negative impacts of wind farms on nature-based tourism. According to the participants of the study, in order to minimize negative impacts of wind energy projects on tourism, they should not be built in the areas where: (1) wind turbines would be highly visible, (2) high number of tourists visit or travel through; (3) (many) tourist attractions are present; (4) pristine nature is present; (5) there is low/no perceived need for more electricity production (Sæþórsdóttir et al., 2021).

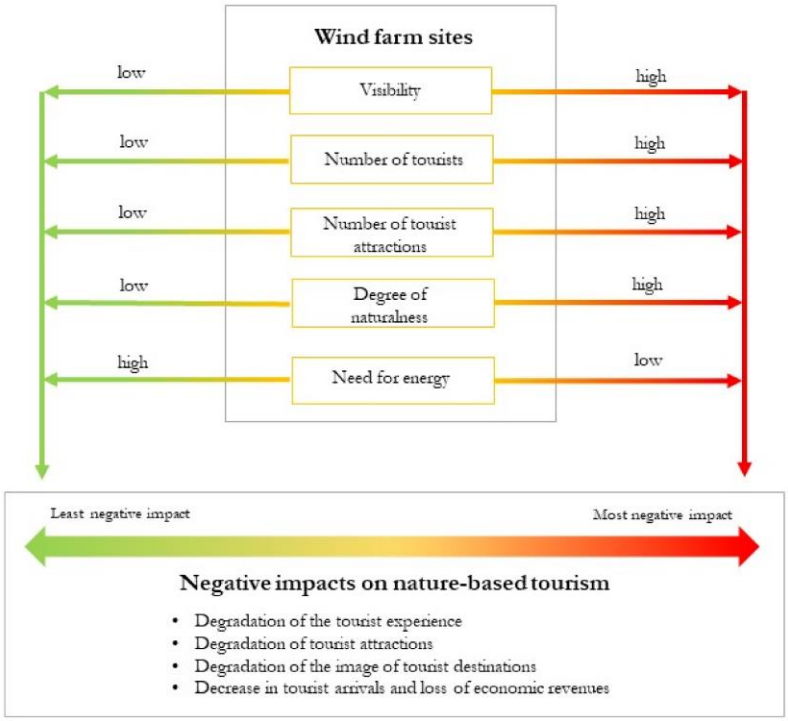


*Figure 2. Factors affecting the severity of negative impacts of wind farms on nature-based tourism as perceived by the tourism industry (Sæþórsdóttir et al., 2021).*

### *Factors related to the design of wind energy infrastructure*

Design of the wind energy projects also plays an important in shaping the attitudes of tourism stakeholders towards such projects and the impacts of wind farms on tourism and outdoor recreation. However, the knowledge on the design which would improve compatibility of wind farms with tourism and outdoor recreation is currently relatively limited and in some cases contradictory. In a study by Frantál and Kunc (2011), around 60% of surveyed visitors preferred several smaller wind farms consisting of 3 to 5 wind turbines over large wind parks containing 80-100 wind turbines, which were preferred by 10% of the respondents. These findings are contradicted by a study by Riddington et al. (2010) conducted in Scotland, which showed that participants preferred to see fewer but larger wind farms. In the study by Sæþórsdóttir et al. (2018) over 29% of participants agreed with the statement that 10 wind farms with 10 wind turbines are preferable to one wind farm with 100 wind turbines, while almost 39% disagreed with this statement.

The height of the wind turbines affects tourists' perceptions of and attitudes towards them. In the study by Sæþórsdóttir et al. (2018), 80 m high wind turbines at the distances of 1.5 km and 4 km were perceived more negatively compared to wind turbines reaching the height of

64 m. However, at the distance of 4 km 87 smaller turbines were perceived more negatively than 66 larger turbines. Thus, although smaller wind turbines are perceived more positively than the larger ones, larger but fewer wind turbines in a wind farm are perceived more positively than the higher number of smaller wind turbines (Sæþórsdóttir et al., 2018).

Wind turbines have a lifespan of approximately 20-25 years. While wind energy projects are typically seen as reversible (Jaber, 2013), the trend is towards repowering by replacing outdated turbines with new, more powerful and often higher models (Wind Energy Technologies Office, 2021). Szumilas-Kowalczyk et al. (2020) stressed that ongoing repowering of wind energy projects can lead to greater landscape impacts. This is not only due to the installation of higher wind turbines, but also because new turbines may not be compatible with the design of older wind turbines that are still in use in the same area. Thus, when planning wind energy development it is important to consider the potential impacts on tourism and recreation that may arise from future wind turbine repowering. Szumilas-Kowalczyk et al. (2020), however, provide an example of San Gorgonio Pass Wind Farm, USA, with various wind farm projects and over 3200 wind turbines of different ages and designs. The site has become a popular tourist destination, where visitors can learn about the history of energy transition. Based on this, Szumilas-Kowalczyk et al. (2020, p. 557) concluded "that perception of a place by potential observers depends a lot on the purpose of their stay in the area". This highlights the significance of visitor motivation and their characteristics in shaping the impacts of wind energy infrastructure on tourism.

*Factors related to visitor characteristics and their travel behavior*

Various visitor characteristics affect their perceptions of wind farms and their attitudes towards wind energy projects. Existing studies (Brudermann et al., 2019; Frantál & Kunc, 2011; Lenz, 2004) show that gender and education do not affect visitor attitudes towards wind energy projects. Regarding age, in a study by Frantál and Kunc (2011), younger visitors between 18 and 39 years old tended to be more positive than older visitor groups up to 60 years old, while people over 60 expressed higher support for wind energy development. In a study by Beer et al. (2023), hikers older than 55 years exhibited more negative attitudes towards fictional wind or photovoltaic power plants in various locations compared to younger participants involved in the study. A study by Sæþórsdóttir et al. (2015) revealed significant differences between age groups regarding attitudes towards wind turbines in Icelandic nature and in the Central Highlands, as opposition tended to increase with age. However, no significant differences were observed between age groups regarding attitudes towards the proposed Búrfell wind farm. A study conducted by Lenz (2004) also revealed no effects of age on the support for wind energy infrastructure. Hence, similar to public attitudes towards wind energy projects (Rand & Hoen, 2017), demographics do not seem to have a strong effect on the attitudes of tourists towards wind turbines, and further research investigating these relationships is needed.

In a study by Frantál & Kunc (2011), repeat visitors tended to have more polarized attitudes towards wind farms in the areas they visited compared to first time visitors. However, a study by Beer et al. (2023) found no significant differences in the attitudes of hikers who had visited locations of fictional wind turbines and those who had not. Visitors with positive attitudes towards renewable energy are more likely to support wind energy infrastructure in recreational areas compared to those with rather negative attitudes (Frantál & Kunc, 2011). On the other hand, concerns about potential negative impacts of wind turbines on animals and people are likely to lead to lower support for wind turbines (Lenz, 2004). In a study by Frantál & Kunc (2011), visitors coming from the same region were more opposed to wind energy infrastructure in a recreational area compared to visitors from other regions.

Furthermore, visitors living in environmentally degraded areas where coalmining, heavy industry, or chemical industry are present had more positive attitudes towards wind turbines and viewed them as a clean source of energy (Frantál & Kunc, 2011). A study by Frantál et al. (2017) conducted in Iceland showed that visitors from countries having more wind energy infrastructure (Germany, Netherlands, United Kingdom) were more supportive of the proposed Búrfell wind farm than participants from other countries. However, the sample of this study was relatively small (30 participants) and consisted of visitors interested in renewable energy development. Sæþórsdóttir et al. (2015) conducted an on-site survey of 1351 visitors in the same study area, which revealed opposite results. Visitors from Germany, Benelux countries, United Kingdom and Ireland were the most negative towards wind turbines in Icelandic nature, in the Central Highlands of Iceland, and towards the proposed Búrfell wind farm. These findings suggest that visitors from countries with higher number of wind turbines prefer not to see them in Icelandic natural areas during their visit.

Residents directly or indirectly involved in the management or ownership of wind energy projects tend to be more positive towards them, also in tourism context (de Sousa & Kastenholz, 2015; Silva & Delicado, 2017). They state that wind turbines have rather neutral impacts on the surrounding landscapes and consequently on tourism, and bring economic benefits from electricity production (Silva & Delicado, 2017).

*Existing versus proposed wind farms*

Various research has revealed differences in the attitudes of tourism stakeholders towards existing and towards proposed wind energy projects. A study conducted by Brudermann et al. (2019) in the Austrian Alps compared visitors' acceptance level for wind energy as generation technology at four locations. Significant differences regarding the support for the four locations were observed, with the highest being support for wind energy in general (mean acceptance level 4.57 on the 5-point scale), followed by wind farms in the lowlands (4.26). The acceptance of wind farms constructed in a locality was lower, but the acceptance of the wind farms in the Alps was even lower (4.04) compared to the locality (3.82). Brudermann et al. (2019) proposed following explanation for such findings: it might be that participants compared existing wind farms in the locality with potential wind farms in natural landscapes of the Alps. The authors further noted that this could be explained by the phenomenon of "status quo bias" (Samuelson & Zeckhauser, 1988). It means that people tend to prefer the current situation over changes and are more likely to accept the status quo because they cannot change it. This is supported by other studies. In the study conducted by Sæþórsdóttir et al. (2018) in the Southern Highlands of Iceland almost half of the visitors who noticed the two already existing wind turbines were positive towards them, while 16% were negative. However, when asked about a proposed wind farm in the area, around 40% were negative, 25% were neutral and 36% of visitors had positive attitudes towards it. Similarly, tourism service providers operating in Iceland interviewed by Tverijonaite et al. (2022) perceived potential impacts of proposed power plants on tourism as more negative compared to existing ones.

## 3.3 Effects of wind farms on tourist decision-making and resulting economic impacts

Negative impacts of wind farms on the landscape and nature can lead to avoidance of areas containing wind energy infrastructure and to visitor displacement. Most studies show rather low effects of wind farms on tourists' decision-making to visit the area. In a study based on a visitor survey conducted by Frantál and Kunc (2011) in the Czech Republic, around 90% of the visitors to an area where a wind farm has been proposed stated that its construction would

not impact their future visits to the area. In another study area containing a wind farm, 95% of visitors stated that the wind farm did not affect their decision to visit the area (Frantál & Kunc, 2011). In line with these findings, in a study by Silva and Delicado (2017), almost all interviewed visitors stated that wind farms do not affect their choice of destination. Similarly, a study by Warren and McFadyen (2010) showed that the decision of around 90% of visitors to come back to the coastal area of Scotland containing several onshore wind farms would not be affected by the wind farms, 5% would avoid areas with wind turbines, while other 5% would be interested in visiting them. The proportions differed somewhat in a study by Sæþórsdóttir et al. (2018) conducted in Iceland. Here more than 60% of visitors stated that they would still visit the area if a proposed wind farm were to be constructed. About 31% would either not visit or be less interested in visiting the area, while 8% would be more likely to visit it due to the presence of the wind farm. Furthermore, almost 51% of participants stated that they tend to avoid travelling in an area containing wind turbines and over 66% were of the opinion that wind turbines negatively affect the attractiveness of an area for tourists (Sæþórsdóttir et al., 2018).

Notably, even low levels of avoidance can significantly impact local economies as revealed by a study conducted in Scotland by Riddington et al. (2010). They used a GIS model to estimate the number of tourists that would be exposed to the wind farms while on the roads and in their accommodation. In their study the authors included wind farms that already exist, have been permitted, or are in the application process. They also calculated the economic impact of wind farms on tourism considering a potential reduction in visitor numbers and reduction in accommodation prices. They conducted an intercept survey which investigated the likelihood of returning to the areas with wind farms and willingness to pay for the scenery. Around 93% of participants stated that they would not change their plans. Based on that and on the GIS results it was estimated that the reduction in visitor numbers and related expenditure in each area would reach around 1.5%. Then participants were presented pictures of a hotel room with a view of natural scenery and of wind energy infrastructure and were asked to indicate how much they would be willing to pay for the upgrade to this view. To calculate the total economic impact based on the change in expenditure, the change in direct expenditure, total change in output, and the associated changes in income and employment were calculated. At the area level a maximum total loss reached from 1.89% up to 5.77%, but since most tourists would likely relocate to other areas of Scotland less impacted by wind farms, the maximum estimated economic impact at the national level was estimated to be less than 0.1% of the estimated employment in tourism (Riddington et al., 2010). Hence, economic impacts on tourism are higher on a local scale and should be taken into consideration when planning wind energy development.

This is supported by a study conducted by Broekel and Alfken (2015) which showed that the presence of wind turbines around German inland municipalities within a 10 km radius from municipalities' center had negative impacts on tourism demand in those municipalities. Moreover, the study revealed that with a 1% increase in wind turbine capacity in 10 km vicinity of the municipality the occupancy rate in the accommodation provided in the municipality decreases by 0.01% in the same and in the following years. Furthermore, the study by Broekel and Alfken (2015) showed that wind farm capacity is a more important dimension affecting the tourism demand than the number of wind turbines. This suggests that when tourists select a destination to visit, the size of the turbines is also a factor to consider, not just the number. In line with that a study conducted by Gardt et al. (2018) in the state of Hessen, Germany, showed a weak negative effect of the presence of wind turbines on number of overnights in the surrounding areas, and this effect weakens with years passing. Therefore, Gardt et al. (2018) pointed to the need of further research looking into the effects of

becoming accustomed to wind energy infrastructure and the thresholds at which a high concentration of wind turbines would result in a significant decrease in overnight stays in the area.

Avoidance of areas in the vicinity of wind energy projects might also lead to reduction of recreational property value. A study conducted by Fast et al. (2015) on the Wolfe Island in Lake Ontario, Canada, containing 86 wind turbines, showed that higher proportion of recreational properties and properties located at the distance of 2 km to 5 km from the wind turbines exhibited price reductions compared to properties located more than 10 km away from the wind turbines. The interviews conducted for the study by Fast et al. (2015) revealed that recreational users of the properties prefer to invest in other areas, landscapes of which are not impacted by wind turbines.

Mordue et al. (2020) conducted a survey among tourism-related businesses in Northumberland County, UK, focusing on the impacts of wind farms on rural tourism. Around 37% of participants of the study stated that onshore wind farms negatively impacted their business. Among the main impacts were reduced tourist satisfaction, leading to lower visitation, and lower income due to degradation of scenic landscapes. Furthermore, 33% of the businesses believed that wind farms were likely to affect their future investment decisions, since business owners were not willing to invest in areas with natural landscapes degraded by wind turbines. Mordue et al. (2020), however, noted that such findings were supported neither by the responses about business turnover and visitor numbers, showing rather neutral impacts of wind farms on tourism in the county, nor by statistical data showing that tourism in the county has been growing in the last years. Therefore, Mordue et al. (2020, p. 1892) suggested that "claimed impacts of windfarms on tourism are often social constructions of risk rather than objective facts". The authors stressed that individuals' perceptions of wind turbines are shaped by the surrounding context, people's interests, perspectives, and activities undertaken in landscapes where wind energy development takes place.

## 3.4 The potential of wind energy projects to attract tourists

Various studies have indicated that wind farms have the potential to become tourist attractions. In a study by Frantál and Kunc (2011) conducted in the Czech Republic, 65% of respondents showed interest in visiting the wind farms in the discussed study areas if they would contain information centers. Beer et al. (2018) also noted that visitor and educational centers can help effectively combine renewable energy projects, such as wind farms, with tourism and thereby increase visitation in the area. A study by Liu, Upchurch, Curtis, et al. (2016) analyzed the comments and photos shared by domestic Chinese tourists visiting wind farms. Their results showed that the key factors that attract tourists to wind farms are: (1) aesthetic appeal, (2) educational value, (3) opportunities for socializing, especially on special occasions and public holidays, (4) sustainable energy practices, (5) ecological impacts, and (6) policy and planning concerns. In line with previous results, Liu, Upchurch and Curtis (2016) identified four types of domestic Chinese tourists visiting wind energy projects, based on the content analysis of wind farm pictures posted online. The first type, 'educational tourists', according to their interests were further divided into 'technology tourists' and 'sustainable tourists'. The second group comprised 'holiday tourists', divided into 'leisure tourists' visiting the area for landscape appreciation, and 'family tourists' combining family engagement with landscape experience. The third type was named 'romantic tourists' and included, among others, visitors coming on their wedding day. The fourth type were 'nature tourists' coming to the area exclusively for its fauna and flora, as well as for the natural landscapes of the area. The authors noted that philosophical ideas of Chinese culture shape

local tourists' experience of wind farms and can facilitate understanding of their perceptions. For example, in Taoist philosophy land is perceived as living and "filled with energy" (Liu, Upchurch, & Curtis, 2016, p. 2). This might lead to higher perceived compatibility between wind turbines and natural landscapes. Liu et al. (2019, p. 50) applied the theory of reasoned action to further research the intent of Chinese residents to visit a wind farm and concluded that "enculturation of beliefs, the need for personal affiliation, and intellectual intrigue strongly influence a person's pursuit of wind farm experiences". In a study by Liu and Upchurch (2020), undergraduate Chinese students were surveyed using eye-tracking technology and post-experimental questionnaires to determine their preferences for wind farm locations in tourism destinations. The results revealed that wind farms located in prairies and mountainous landscapes were the most attractive, while those in coastal areas and deserts were less appealing. Overall, a rather strong interest among Chinese students in visiting wind farms was revealed by the study. The authors furthermore pointed out that, according to Chinese fengshui, locals believe that spinning turbines bring wealth and good fortune. This belief may contribute to increased visits to wind farms (Liu & Upchurch, 2020).

Liu, Upchurch, Curtis, et al. (2016) emphasized the need for energy and tourism policies which support each other to ensure the highest benefits to all stakeholders. This is supported by Frantál and Urbánková (2017), who stressed the importance of cooperation between energy companies and regional/local governments. Such cooperation, according to the authors, might not only result in higher acceptance of wind energy but also help branding a region and thereby support local tourism. As shown by their study conducted in the Czech Republic among visitors attending a Dragon Kite Festival taking place under wind turbines, main motivational factors to visit the event included interest in wind power technology (63%), interest in energy in general (37%) and spending time out of usual places (29%). Furthermore, around 27% of respondents of the study developed a more favorable attitude towards wind power. The attitudes of 76% of participants remained unchanged, and only 2% of participants became more negative (Frantál & Urbánková, 2017). Thus, visits to wind energy projects might have positive effects on people's attitudes towards wind power, and energy tourism activities can effectively contribute to wind energy marketing.

The reviewed studies mainly focus on domestic tourists, which supports the conclusion of de Sousa and Kastenholz (2015) that since the standardized appearance of wind turbines is very similar in most countries, wind energy projects are likely to be visited only once and in a home country. According to de Sousa and Kastenholz (2015), tourists tend to seek unique settings and experiences when visiting foreign destinations. Silva and Delicado (2017) further noted that the potential of wind energy projects to become tourist attractions highly depends on the characteristics of each specific area. Wind energy projects have a higher potential to become tourist attractions in industrialized landscapes with little or no cultural or natural heritage.

# 4 Summary of the findings

This literature review has revealed that onshore wind energy projects can impact tourism and recreation in complex ways. It furthermore identified various factors shaping these impacts, which should be taken into consideration when planning wind energy development. The key findings of this review are outlined below:

- While wind energy generally receives high acceptance among tourists and other tourism stakeholders, specific energy projects tend to be viewed more negatively, similar to the attitudes of general public (Brudermann et al., 2019).

- The potential negative impacts of wind energy projects on tourism tend to become barriers to public´s acceptance of wind energy development (Leiren et al., 2020).
- Tourists and tourism stakeholders are most concerned about the visual impacts of wind turbines on the surrounding landscape and its character, as these are seen as having the greatest impact on tourism (de Sousa & Kastenholz, 2015; Lenz, 2004; Ólafsdóttir & Sæþórsdóttir, 2019; Sæþórsdóttir et al., 2021).
- However, the impact area of wind turbines on tourism tends to extend beyond their visibility. According to some tourism service providers, it includes the routes used by tourists, destinations where visitor experience may be affected by previous encounters with wind turbines, as well as areas where tourist travel patterns and demand for tourism services are affected by the construction of wind energy infrastructure (Tverijonaite et al., 2022).
- The location of a wind energy project plays an important role in shaping its impacts on tourism and recreation. Among locations perceived by visitors and other tourism stakeholders as least suitable for wind energy development are natural areas of high wilderness value, cultural heritage areas, protected natural areas, recreational areas, areas containing tourist attractions, areas with high visitation, and areas where wind turbines would be highly visible. Among areas considered as more suitable for wind energy harnessing are agricultural and industrial areas, as well as areas where more electricity is needed (Beer et al., 2023; Ek & Persson, 2014; Frantál & Kunc, 2011; Sæþórsdóttir et al., 2018; Sæþórsdóttir et al., 2021, Silva & Delicado, 2017). Visitors perceive picturesque landscapes to be less suitable for wind energy development compared to more homogenous landscapes, based on their visual characteristics (Beer et al., 2023; Sæþórsdóttir et al., 2018).
- Factors related to the design of wind energy projects also affect their impacts on tourism and recreation (Frantál & Kunc, 2011; Riddington et al., 2010). Visitor preferences regarding the number and height of wind turbines vary, but increasing the distance between turbines and tourist destinations can reduce negative impacts on visitor experience (Sæþórsdóttir et al., 2018). Therefore, when planning wind energy projects, it is important to identify the most suitable combination of height, number, color, layout and distance from main tourist destinations, attractions and viewpoints for each specific project.
- When it comes to visitor characteristics, socio-demographic factors like gender, education, and age do not seem to strongly affect attitudes towards wind energy projects. However, there have been some differences noted in attitudes among different age groups (Beer et al., 2023; Frantál & Kunc, 2011; Sæþórsdóttir et al., 2015). Attitudes of tourists towards wind turbines in nature destinations seem to be affected by their previous experience with wind energy infrastructure (Frantál & Kunc, 2011). Visitors from countries with a higher density of wind turbines, like Germany, Netherlands, United Kingdom and Ireland tend to prefer not to have wind turbines visible during their nature travels (Sæþórsdóttir et al., 2015).
- Tourism stakeholders are generally more negative towards proposed wind energy projects compared to already constructed ones (Brudermann et al., 2019; Sæþórsdóttir et al., 2018; Tverijonaite et al., 2022). This tendency may be linked to the concept of status quo bias (Samuelson & Zeckhauser, 1988), which refers to people's preference for the current situation over change (Brudermann et al., 2019).
- Wind farms can be appealing to tourists and have the potential to become tourist attractions. Furthermore, visits to wind farms can positively affect people's attitudes towards wind power (Frantál & Urbánková, 2017). However, wind farms are more likely to become tourist attractions in rather industrial landscapes containing low or

no cultural or natural value (Silva & Delicado, 2017). Moreover, most people are likely to visit a wind farm only once and typically in their home country, as wind turbines generally have standardized appearance across different countries (de Sousa & Kastenholz, 2015).

- Wind energy projects tend to have rather low effects on tourists' choice of destination (Frantál & Kunc, 2011; Warren & McFadyen, 2010). However, even low levels of avoidance can result in significant economic losses at a local level (Broekel & Alfken, 2015; Riddington et al., 2010).

In line with previous research (Frantál et al., 2017), this literature review has highlighted that people´s perceptions and experiences of landscapes and places are subjective. Consequently, the attitudes of tourism stakeholders towards wind energy projects can be diverse and dependent on numerous factors. Thus, specific wind energy projects are likely to encounter a certain degree of opposition which needs to be addressed by considering the subjective perceptions and concerns of stakeholders when planning wind energy developments. This literature review has shed light on various contextual factors that affect impacts of wind energy projects on tourism and recreation. It was found that the location of wind energy infrastructure is a crucial factor. This stresses the need to involve stakeholders in the planning process from the beginning, already when selecting locations for wind energy projects (Wolsink, 2007a). As emphasized by various researchers (Frantál & Kunc, 2011; Sæþórsdóttir et al., 2021), while wind energy development is likely to require tradeoffs, it is possible to identify locations where the impacts on other land uses such as tourism would be minimized and where wind energy projects would receive higher stakeholder support. It is also important to select the design of wind energy projects which would reduce their visibility and improve their suitability in the surrounding landscape. Visitor characteristics, like their place of residence, previous experience with wind turbines and travel behavior also play a role. Thus, in line with previous research focusing on renewable energy infrastructure and tourism (Navratil et al., 2019; Smythe et al., 2020; Tverijonaite et al., 2022), this review stresses the importance of taking the context of each energy project into account when planning wind energy and tourism development. By working with tourism and recreational stakeholders, the most suitable locations and design of each wind energy project can be identified to minimize its impacts on tourism and ensure stakeholder support for the project.

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