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# Hydro, Wind, and Geothermal: Navigating the Compatibility of Renewable Energy Infrastructure with Tourism

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**Abstract:** Knowledge of the compatibility of various types of renewable energy infrastructure (REI) with tourism can help avoid conflicts between the energy and tourism sectors and facilitate the energy transition. This study aims to investigate the attitudes of tourism service providers operating in Iceland towards three types of REI—wind, hydro, and geothermal power plants—and identify the factors that shape their perceptions regarding the compatibility between REI and tourism. Mixed research methods were employed to achieve that, which included an online questionnaire survey and semi-structured interviews. The study revealed that tourism service providers were the most positive towards geothermal power plants, followed by hydropower plants, and the most negative towards wind farms. The identified factors that shape their perceptions regarding REI's compatibility with tourism included landscape and environmental impacts of REI, impacts on tourist attractions, potential of REI as a tourist attraction, perceived reversibility, and the image of REI. These factors help to identify locations where each type of REI is likely to be the most compatible with tourism. Thus, considering them in spatial energy planning is likely to reduce foreseeable conflicts between REI and tourism.

**Keywords:** renewable energy infrastructure; tourism; geothermal power; hydropower; wind power



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## 1. Introduction

Renewable energy plays a pivotal role in implementing climate action, addressing air pollution, meeting the ever-growing energy demand, and achieving the Sustainable Development Goals [1]. The share of renewable energy in the total final energy supply is growing, with the shift especially noticeable in the power sector, where it reached almost 30% in 2022, marking a 9% increase compared to 2012 [2]. However, energy-related greenhouse gas (GHG) emissions keep increasing, even if their annual growth rate is slowing down [3]. In 2022, global GHG emissions in the energy sector grew by 0.9% and exceeded 36.8 Gt, marking a new high [4]. Hence, for the reduction of GHG emissions and effective mitigation of climate change, the energy transition has to be accelerated and investments in clean energy need to triple [5].

Renewable energy developments face various challenges that need to be addressed, often including limited public support for renewable energy infrastructure (REI) [6,7]. Concerns surrounding REI developments encompass potential environmental, social, and economic impacts of such infrastructure [8]. In regions where tourism is an important economic sector, apprehensions related to the impacts of REI on tourism can lead to lower stakeholder support for REI developments. Tourism highly relies on landscape quality. Thus, landscape changes delivered by REI are feared to result in a degraded visitor experience, avoidance of the area, and economic losses [9–11]. Such stakeholder concerns can, in some cases, result in the authorities rejecting the REI proposal [12–15].

Furthermore, tourism stakeholder attitudes towards REI play a critical role in shaping its impacts on tourism. The subjective perceptions of tourism stakeholders are likely to

influence their behavior. If tourists perceive REI negatively, they are more likely to avoid areas containing such infrastructure [16,17]. Conversely, positive attitudes and interest in REI can turn it into a tourist attraction, while the travel behavior of some tourists might remain unaffected by the presence of REI [18,19]. Notably, tourism service providers also adapt their activities and business decisions in response to the presence of REI [9,10]. They can be less willing to invest in tourism businesses in the areas they perceive as being degraded by the presence of REI [11]. Thus, the inclusion of tourism stakeholders' perceptions in REI planning can facilitate the timely identification of potential conflicts between renewable energy harnessing and tourism.

Different types of REI have inherent characteristics that lead to varying impacts on the environment and landscape [20,21]. Wind turbines cause extensive visual impact due to their large size, visual contrast, and shadow flicker created by their rotating blades. For their support, they generally require reinforced concrete foundations, which are getting larger with the increasing height of wind turbines [22]. Furthermore, to address their relatively low energy density and downwind turbulence, a required spacing between wind turbines has to be maintained [23]. Thus, wind energy projects tend to need a lot of land and often lead to bird and bat fatalities, land erosion, and habitat loss [24,25]. Large-scale hydropower plants typically contain a power station, tunnels, canals, dams, and reservoirs. Their environmental impacts include, among others, flooding vast areas of land, far-reaching changes in river basins, and alterations to water flow in rivers and waterfalls [26]. Geothermal power plants contain a power plant with steam turbines, separation tanks, widely scattered boreholes, extensive pipeline systems, and ancillary infrastructure, such as storage facilities and, in some cases, treatment facilities for thermal water [27]. They produce plumes of steam which, in good weather conditions, are visible from long distances, as well as noise and odor pollution. In addition, most types of REI are accompanied by the construction of roads and transmission lines, further impacting the surrounding landscape and environment.

Consequently, people's perceptions of different types of REI vary strongly [28]. This results in different degrees of acceptance among tourists [16,29] and tourism service providers [30,31] regarding various types of REI. Therefore, an increased understanding of how tourism stakeholders perceive the compatibility of various types of REI with tourism and the factors driving such perceptions can aid renewable energy planning and preserve the values and resources that are important for the tourism sector. Furthermore, there is a need for deeper insights into the factors that shape the compatibility of different types of REI with tourism, extending beyond visibility. This is especially relevant for the energy transition in countries and regions where REI and tourism are increasingly required to coexist, such as Iceland. The country is a global leader in renewable energy harnessing per capita while highly reliant upon tourism as an economic sector. Iceland contains several examples of power plants and related infrastructure which have become popular tourist attractions [32]. This is in line with internationally observed trends of emerging energy tourism [33,34] and growing interest in REI as tourist attractions, driven by people's interest in sustainability and clean energy technologies, the novelty of such infrastructure, and its educational value [35,36]. However, nature is the main aspect attracting international visitors to Iceland [37]. Thus, nature-based tourism, which generally relies on high-quality natural landscapes, is of high importance to the Icelandic economy. This complicates the compatibility of REI with tourism in the country and stresses the need for research contributing to minimizing potential conflicts between REI and tourism. This study aims to examine the attitudes of tourism service providers in Iceland towards three types of REI that harness the country's most abundant energy resources: hydro, geothermal, and onshore wind. The study aims to answer the following research questions:

1. How do tourism service providers perceive the compatibility of three types of REI—wind, hydro, and geothermal—with tourism?
2. Which factors affect the perceptions of tourism service providers regarding the compatibility of the three types of REI with tourism?

## 2. Review of Existing Research

Knowledge of the compatibility of different types of REI with tourism is currently rather limited despite its importance for the sustainable use of natural resources and renewable energy planning. Most of the existing studies focus on tourist preferences and perceptions. Dalton et al. [38] investigated the attitudes of visitors to two city resorts and two eco-resorts towards several types of micro-generation REI in Australia. To compare tourist attitudes, they used visual cue questions and presented photographs of REI to the participants. The study revealed that around 90% of participants were positive towards photovoltaics, both on roofs and on the balconies of buildings. Wind energy conversion systems were viewed positively by 38–60% of participants, with wind energy conversion systems on rooftops being perceived more positively than stand-alone wind turbines [38].

Navratil, Picha, Buchecker, Martinat, Svec, Brezinova, and Knotek [29] investigated the preferences of visitors to two natural heritage sites and two cultural heritage sites in the Czech Republic regarding six types of environmentally friendly energy sources in hotels. In this study, solar panels on rooftops were the most preferred type of REI. Visitors were also positive towards wind turbines, heat pumps, "green" tariff energy, and anaerobic digestion plants. Solar panels on the ground were the least preferred energy source, with its average preference value being below neutral, suggesting rather negative attitudes from visitors [29]. Visitors were grouped into five clusters in the study based on their preferences for various types of renewable energy sources. The first cluster included visitors with a high preference for all researched types of REI, while the fifth cluster included those with a low preference for any type. The second cluster comprised visitors with a rather high preference for all types of REI except for solar panels on the ground. The third and fourth clusters included respondents with average interest in some types of REI. Cluster three had an above-average preference for "green" tariff energy and solar panels, while cluster four had an above-average preference for anaerobic digestion plants and wind turbines [29].

A study by Salak et al. [39] based on an online panel of Swiss citizens revealed that in mountainous tourist areas, respondents were more in favor of either photovoltaic infrastructure or photovoltaics combined with a low or medium presence of wind turbines. However, scenarios containing only wind energy infrastructure received the lowest levels of acceptance. Voke et al. [40] researched visitor attitudes towards REI developments offshore, specifically visible tidal or wave devices and sub-surface tidal devices not visible from the shore. Their study focusing on St. David's peninsula, United Kingdom, revealed that underwater devices invisible at the surface of the water, such as tidal stream turbines, were the least likely to have a negative effect on visitors' enjoyment. On the other hand, devices located on the surface of the water and devices reducing the height of the waves were shown to have a much higher negative effect [40].

In a study conducted in Iceland by Sæþórsdóttir, Ólafsdóttir, and Smith [16], visitors to an area where a wind farm had been proposed in the southern highlands were subjected to a survey seeking their opinions on the proposal and wind energy harnessing in Iceland. They were also asked about their views on the use of various energy sources in the country. The highest proportion, or almost 85% of the respondents, were positive towards geothermal energy, 79% were positive towards tidal energy, 72% towards hydropower, 65% towards wind energy, 63% towards bio energy, and only 7% were positive towards the use of oil in Iceland. In a study focused on visitor perceptions of the existing Blanda Hydropower Plant in the northern highlands of Iceland [41], visitors were asked how desirable 19 types of infrastructure were, including several types of REI, in the area of the power plant. Among the various types of power plants, geothermal power plants were viewed as appropriate in the area by the highest proportion of respondents, or almost 33%, 27% of respondents viewed hydropower plants as appropriate, while 16% stated that wind turbines were appropriate in the area.

Tourism service providers play an important role in shaping tourism trends and directing visitor flows. Thus, their perceptions of various types of REI in areas they use for their businesses and related business decisions affect tourism processes both in areas

surrounding REI and regions stretching far beyond them [10]. However, the perceptions of tourism service providers regarding the compatibility of various types of REI with tourism have so far received little attention. Sæþórsdóttir and Hall [30] investigated the views of tourism operators in Iceland on power production in the country. The survey also asked tourism operators about their attitudes towards further REI developments. Participants were significantly more negative towards REI developments in the uninhabited highlands compared to the lowlands. Further hydropower plant developments in the highlands were perceived as the most negative, with 74% of respondents viewing them negatively, followed by geothermal power plants in the highlands (70%), hydropower plants in the lowlands (65%), wind farms in the highlands (60%), and geothermal power plants in the lowlands (56%). Respondents were the least negative towards wind farm developments in the lowlands; 48% viewed them negatively [30].

Five years later, the same questions were again submitted to travel agencies and day tour providers operating in Iceland [31]. Tourism service providers' attitudes towards the development of different types of REI seemed to have changed over the five-year period between the two surveys. In the latter study by Tverijonaite, Sæþórsdóttir, Ólafsdóttir, and Hall [31], the respondents were most strongly negative towards wind farm constructions in the highlands, with 68% viewing them as negative. Similarly, 65% of the respondents had a negative view of hydropower developments in the highlands and 59% opposed geothermal power plants in the highlands. In contrast, respondents were significantly less negative towards REI developments in the lowlands of Iceland. Still, the highest proportion of respondents (45%) were negative towards wind farms, followed by hydropower plants (40%). On the other hand, 37% of respondents had positive attitudes towards the further development of geothermal power plants in the lowlands, while only 32% had negative attitudes. Furthermore, the environmental attitudes of respondents were shown to be negatively related to their attitudes towards most REI developments, with the exception of wind farm developments in the lowlands [31].

The present study builds on further analysis of the survey data collected by Tverijonaite, Sæþórsdóttir, Ólafsdóttir, and Hall [31] and incorporates additional data from semi-structured interviews with tourism service providers with the aim of deepening the understanding of their attitudes and perceptions. Most of the existing studies employed quantitative research methods and provided a good overview of the trends in tourists' and tourism service providers' attitudes towards various types of REI. However, knowledge about the drivers of the views of tourism service providers and the reasons underlying their perceptions should be increased to facilitate the understanding of what makes certain types of REI more compatible with tourism than others. Furthermore, a better understanding is needed of the compatibility of various types of REI with the place storytelling by the tourism sector and their impacts on the competitive advantage of tourism destinations.

## 3. Renewable Energy Harnessing in Iceland

Iceland is an island country located on the northern end of the Mid-Atlantic Ridge. Due to its geographic position and geological characteristics, it contains abundant renewable resources, such as freshwater, geothermal energy, and wind. Consequently, the country is a global leader in renewable energy harnessing per capita, and nearly all electricity produced in Iceland comes from renewable sources. In 2022, 70.55% of electricity originated from hydropower, 29.40% came from geothermal power, 0.03% came from wind, and 0.02% of electricity was produced using fuel [42].

Iceland has used its water resources for electricity production for over a century. The first hydropower plant was built in 1914 in the town of Hafnarfjörður, which now forms a part of the greater capital area, while the first hydroelectric power plant providing electricity for Reykjavík was constructed in 1921 [43]. The construction of large-scale hydroelectric energy projects started in the 1960s when the Búrfell Hydropower Plant within the Þjórsá and Tungnaá Catchment Area in the southern highlands of Iceland was built [44]. The electricity produced by this power plant was used to power the first aluminum smelter

constructed south of Reykjavík. Over time, more hydropower plants were constructed. As a result, there are now nine large-scale and several dozens of small-scale hydropower plants operating throughout Iceland [45]. Their total installed capacity reached over 2105 MW in 2023 [42]. In 2019, about 78% of Iceland's total electricity production was consumed by a few international heavy industry companies [46] that operate on the island due to the low cost of energy. Besides serving as a main electricity source for heavy industry, the harnessing of hydropower resources played a crucial role in ensuring access to electricity for all the inhabitants of the country, a milestone that was achieved in the 1970s [43].

According to historical records, geothermal water has been used in Iceland for bathing, washing, and other purposes since the 13th century [47]. This began gaining economic importance in the 1930s, when its harnessing for heating houses in Reykjavík commenced. However, the first geothermal power plant for electricity generation was built in 1969. It was the Bjarnarflag Geothermal Power Plant, with an installed capacity of 5 MW, constructed in the northeast of Iceland, close to Mývatn Lake [48]. Since then, eight other geothermal power plants have been built in Iceland [45]. In 2022, their total installed capacity reached almost 758 MW [42]. Geothermal power plants not only produce electricity but also provide hot water, which is used to heat buildings and streets, as well as for horticulture, among other uses. In 2020, geothermal energy accounted for over 70% of the total primary energy consumption in Iceland [42], underscoring its importance for Icelandic society.

Currently, several wind turbines are operating in Iceland. Two wind turbines with a total installed capacity of 1.8 MW have been operating since 2013, situated at the edge of the southern highlands of Iceland [49]. Two smaller wind turbines with a capacity of 36 kW [42] have been constructed on the island of Grímsey in 2022. Furthermore, two wind turbines reaching a total installed capacity of 1.8 MW were constructed in Þykkvibær, South Iceland, in September 2023. The interest in harnessing abundant wind energy resources in Iceland is currently very high, and various wind energy proposals are under consideration [50]. In 2022, the Icelandic Parliament approved two wind farm proposals [15]. The planned location of one of them, the proposed Búrfellslundur Wind Farm, at the gateway to the southern highlands, has raised concerns among stakeholders about its potential negative impacts on tourism and outdoor recreation [9]. In June 2023, despite Parliament's approval of the proposal, the municipality of Skeiða- and Gnúpverjahreppur, one of the municipalities adjacent to the construction area of the wind farm, requested that the National Planning Agency postpone the decision on land use for the wind farm. While Iceland faces various challenges that must be addressed for the development of this new source of energy infrastructure in the country, the number of wind energy projects is likely to increase over the coming years, creating further challenges for wind energy and tourism planning.

The rapid increase of Iceland's reliance on harnessing domestic renewable energy in the 20th century was mostly driven by fluctuations in oil prices, which the country was not able to sustain [51]. However, in light of the pressing need to mitigate climate change, Iceland together with Norway and the EU Member States participates in a joint commitment to reduce GHG emissions by 55% by 2030 compared to the levels of 1990 under the Paris Agreement [52,53]. Furthermore, in its Climate Action Plans released in 2018 and 2020, Iceland established a target to reduce its GHG emissions by at least 40% by 2030 compared to the levels of 2005 and to reach carbon neutrality by 2040 [53,54]. Later, in November 2021, a more ambitious independent national target of reducing GHG emissions by 55% by 2030 compared to 2005 levels was set in the agreement of the then newly formed Icelandic Government [55]. The updated version of the Climate Action Plan, published in 2020, comprises numerous measures aiming at reducing GHG emissions in all economic sectors, with special emphasis placed on energy transition in transport, as well as increasing the rates of carbon sequestration [56]. The implementation of these measures will raise the demand for electricity. As estimated by the Icelandic National Energy Authority [57], electricity demand between 2022 and 2030 is likely to increase by 144–290 MW depending on a scenario, while in 2040 it will increase by 288–667 MW compared to 2022. Thus, if heavy industry companies continue to use a high share of electricity produced in Iceland,

the country will need to increase renewable energy harnessing to achieve its climate targets. However, various saving measures can slow the growth in electricity demand [58]. Furthermore, as pointed out by the Icelandic Environment Association, Landvernd [59], reduced electricity consumption by heavy industry companies would facilitate energy transition without a drastic increase in electricity demand.

## 4. Methods

This study employed mixed research methods to investigate differences in the compatibility of three types of REI—hydro, geothermal, and wind energy infrastructure—with tourism, and the reasons for these differences. Triangulation of the findings increased construct validity [60], whereas the qualitative data provided explanations and better insights into the trends identified by the quantitative data.

Trends in the attitudes of tourism service providers towards the three types of REI were investigated in an online survey. The link to the survey was distributed via email to all travel agencies and day tour providers licensed by the Icelandic Tourist Board, 984 companies in total. The survey remained open for one month in November–December 2020. To address the potential issue of relatively low response rates, which online surveys tend to encounter [61,62], two reminder emails were sent to the recipients during the data collection period. The response rate of the survey reached 40.13%. A more detailed description of the data collection via the online survey is provided in Tverijonaite, Sæþórsdóttir, Ólafsdóttir, and Hall [31]. The online survey allowed for the collection of representative data and the identification of trends and patterns in the perceptions and attitudes of tourism service providers [60]. Quantitative data analysis was conducted by running Friedman tests in SPSS to identify potential differences between the attitudes of tourism service providers towards the three types of REI.

Furthermore, 32 semi-structured interviews were conducted with tourism service providers. During the interviews, the perceptions and attitudes of tourism service providers towards the three types of REI and their perceived compatibility with tourism in Iceland were discussed, as well as factors shaping this compatibility. Purposive sampling was used when selecting interviewees for this study. The sample included travel agencies and day tour providers offering tours in the vicinity of existing power plants or in areas where new renewable energy projects are under consideration, as well as nearby companies providing tourist accommodation and food services. Notably, over 90% of international visitors come to Iceland for its nature [37]. Consequently, most travel agencies and day tour providers focus on selling tours to the country's nature attractions. However, in some cases, their customers encounter power plants en route or visits to them are included on their tours.

Maximal variation sampling [63] was employed when selecting interviewees who differed in the type of tourism services they provided, areas used for their business, size and number of customers served, length of operation, and location of headquarters. The interviews were conducted in English or Icelandic, depending on the preferences of the interviewee, and mostly by two interviewers, but some participants were interviewed by one interviewer. Interviews were conducted face-to-face at a location convenient for the interviewee.

Before the interview, the research team was introduced to each participant as well as the main objectives of the research. Interviewees were asked for their consent to participate in the study and permission to audio record the interview. Furthermore, they were informed that the collected data would be treated confidentially and that their participation was entirely voluntary. During each interview, tourism service providers were asked to describe their company, the type of services provided, as well as characteristics of their customers and their preferences. The areas and tourist attractions visited by the customers of the interviewed tourism service providers were also discussed. Interviewees were furthermore asked how compatible, in their opinion, the three types of REI are with their business and with tourism in Iceland in general, and what factors shape this compatibility.

The interviews were transcribed verbatim. Qualitative data collected during the semi-structured interviews were analyzed inductively, based on grounded theory [64]. The analysis commenced with exploring and organizing the data through open coding, during which relevant interview segments were assigned descriptive codes. Later, axial coding was conducted to locate the links between the codes and identify emerging themes. Atlas.ti software was used for qualitative data analysis. The data from the interviews was then triangulated with the quantitative data from the online survey and the findings were compared in aggregate. The findings from the interviews were used to explain the results of the online survey and gain a deeper understanding of the factors influencing the varying attitudes of tourism service providers towards the three types of REI.

## 5. Results: The Compatibility of Hydro, Geothermal, and Wind Energy Infrastructure with Tourism

### *5.1. Tourism Service Providers' Attitudes towards Three Types of REI*

Tourism service providers participating in the online questionnaire survey were asked about their attitudes towards the future development of hydro, geothermal, and wind energy infrastructure in the highlands and lowlands of Iceland. The results revealed differences in locational preferences: participants were more negative towards the development of all three types of REI in the highlands of the country (Figure 1) compared to the lowlands (Figure 2). Furthermore, Friedman tests revealed significant differences in attitudes towards the three types of REI, both in the highlands ($\chi^2(2) = 7.35$, $p = 0.025$) and in the lowlands ($\chi^2(2) = 15.38$, $p < 0.001$). Participants were the most negative towards wind energy infrastructure developments, followed by hydropower plants. They were the most positive towards geothermal power plants. The differences in the attitudes towards the different types of REI were higher for developments in the lowlands of Iceland due to more negative attitudes overall towards REI developments in the highlands.

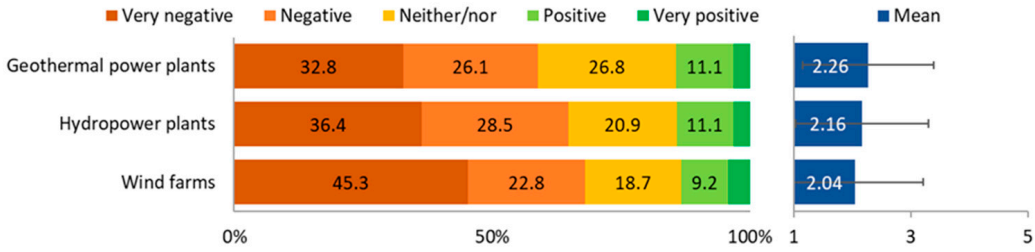


**Figure 1.** Attitudes of tourism service providers towards future developments of three types of REI in the highlands of Iceland.

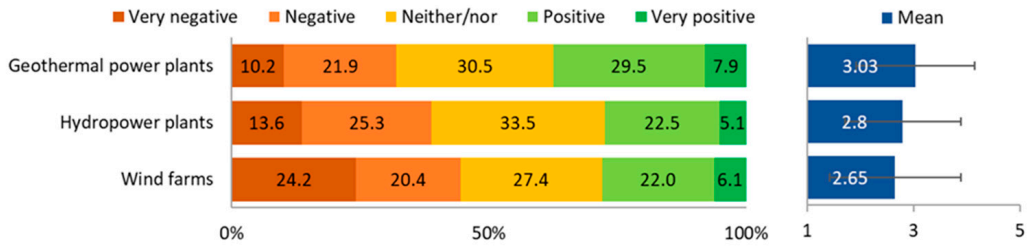


**Figure 2.** Attitudes of tourism service providers towards future developments of three types of REI in the lowlands of Iceland.

### *5.2. Factors Shaping the Perceived Compatibility of Hydro, Geothermal, and Wind Energy Infrastructure with Tourism*

#### 5.2.1. Landscape and Environmental Impacts

Interviewees perceived the landscape impacts of REI to be an important factor in shaping its compatibility with tourism. As noted by one participant when discussing the compatibility of hydro, geothermal, and wind energy infrastructure with tourism, "I think the difference of the three of them is what's on the surface". Most participants expressed

concern about the impacts of wind energy infrastructure on the surrounding landscape. Iceland currently does not contain any large-scale wind farms, but, while discussing proposed wind energy projects, interviewees often brought up potential landscape impacts: "I think just visibility of a large wind farm could have a negative effect [on tourism], they are very conspicuous in the landscape". Some interviewees shared their own experiences of wind energy landscapes abroad, which tended to be negative: "I didn't think it was beautiful. It wasn't the postcard you saw from Holland or Belgium, it just wasn't like that at all". In line with that, most participants did not see wind turbines as suitable in Icelandic landscapes. One participant said, "You are maybe taking a picture of a waterfall and you have to go on the other side to not have this [wind farm] in the photo. I just do not think this is what I would call Iceland". Participants furthermore stressed that wind turbines affect the experience of the landscape not only by visually impacting it but also through noise pollution.

Similarly, geothermal power plants were perceived by most as having high landscape impacts. One participant said, "Geothermal power plants are, with all the pipes going like a spider's web all over the place, not the nicest looking". As added by another participant, besides the impacts caused by the infrastructure itself, "there is smell, there is noise and the steam". Thus, tourists' experience and perceptions of the surrounding landscape are affected not only by the visual impacts of geothermal power plants but also by their noise and odor pollution. One participant talked about their horse-riding tours through a historically interesting area where previously they had many stories to tell, but now, a geothermal power plant has been built:

*Now they have built this power plant, and you are not telling any stories because it is so loud, nobody can hear you. So, we just ride down there, and we put the horses in the pasture, and we go away.*

Hydropower plants, on the other hand, were perceived by most participants as fitting rather well into the surrounding landscape. Participants mentioned that Icelandic hydropower plants tend to be well designed, often containing underground power stations, and, therefore, such infrastructure "does not affect the experience of the landscape". The most visible parts of the infrastructure are reservoirs, which look rather natural. One participant noted the following:

*When you drown something, that's pretty bad for those that knew what was there before, but at least the current tourists, if they don't know, then they might think there's a lake. It still doesn't make it always acceptable, because if there's a huge area that is drowned, then you might be losing big potential area for tours.*

Another participant added that despite looking like rather natural water bodies, reservoirs are characterized by fluctuating water levels that often degrade the view: "By itself the reservoir is not a problem but when you have changing water levels you will see the shorelines that are clearly different and that will look a bit more artificial". Furthermore, other environmental impacts caused by hydropower plants were mentioned by many. They were mostly related to flooding large areas for reservoirs. As pointed out by some participants, knowing that a huge natural area has been flooded for energy harnessing can affect the visitor experience:

*To know that the lake is a product of a choice is a different thing. Then you are unconsciously making this cost-benefit analysis. Like, what did we lose? What is under this? How is the topography? What if there were some archaeological things? Were there some waterfalls? Are there some pictures of this area? But yeah, it's all about each and everyone's sensibilities regarding the area.*

Concerns about the impacts of REI on tourist attractions were revealed also by interviews with other tourism service providers. They noted that hydropower plants can degrade tourist attractions, not only by flooding large areas but also by altering the water flow in rivers. Waterfalls are one of Iceland's landmarks and of high interest to tourists. They are either a stopover destination on a tour among various other nature attractions or a primary destination on some day tours such as the "Golden Circle" tour, with the Golden Waterfall (Gullfoss) being one of the highlights. Hydropower plants tend to decrease the water flow in rivers and waterfalls or totally dry them out so that waterfalls disappear

either permanently or temporarily. One participant shared their personal experiences around hydropower plants harnessing the Þjórsá River: "Have you seen Þjórsá when it is empty? It is really a sad thing, you know, you are almost sentimental to see this beautiful river being empty". The participant further expressed, "Here you have two beautiful waterfalls Þjófafoss and Tröllkonuhlaup, and when the river is empty you have this beautiful waterfall that is empty". By bringing such changes to rivers and waterfalls, hydropower plants degrade or even destroy scenic natural features that are of value for tourism, thereby negatively impacting tourism.

Similarly, as noted by the participants, the most active geothermal areas are often characterized by picturesque colorful hot springs, which are attractive to tourists. The construction of geothermal power plants often results in their destruction or degradation. Furthermore, even if geothermal springs are not damaged by the REI, the surrounding landscape becomes industrial instead of natural and therefore of lower value for tourism.

This was perceived as a lesser issue for wind energy infrastructure since the presence of wind does not have to coincide with the presence of scenic natural features, such as rivers, waterfalls, or hot spring areas. However, several participants pointed out that wind turbines generally have to be built in exposed areas where winds are strong; thus, it is hard to hide them from the eyes of tourists in order to preserve the quality of their experience. Overall, while having high landscape impacts, wind energy projects were perceived to impact less on the surrounding environment, especially compared to hydropower plants with reservoirs. However, bird mortality due to collisions with wind turbines was brought up by some, but it was not expected to significantly impact visitor experience.

Notably, some interviewees also mentioned cases where the construction of REI had resulted in new tourist attractions being created and thereby having positive impacts on tourism. Among the most famous cases is the Blue Lagoon, one of the most visited tourist attractions in Iceland. It was accidentally created when water discharged by the nearby geothermal power plant in Svartsengi did not infiltrate into the ground as predicted. Another example of a new tourist attraction mentioned by the participants is Stuðlagil Canyon with basalt rock formations, which became exposed when water levels in the river dropped after the Fljótsdalur Hydropower Plant was constructed. The Canyon was made famous by a photo in an advert for an Icelandic airline, went viral on Instagram, and has since then been one of the most popular tourist destinations in the east of Iceland. In another example raised by the participants, damning the Blanda River for a hydropower plant resulted in the water downstream becoming clearer, which created better conditions for recreational salmon fishing, attracting fishing enthusiasts to the area. The examples provided by the participants were related to hydro and geothermal energy infrastructure. This might indicate a lower likelihood for wind energy projects to create tourist attractions but might also be due to limited Icelandic experience with wind energy infrastructure, providing opportunities for further exploration.

#### 5.2.2. Potential of REI as a Tourist Attraction

An important factor shaping tourism service providers' perceptions of the compatibility of different types of REI with tourism was their potential as tourist attractions. Geothermal power plants were perceived by most participants as the most interesting to tourists; therefore, they were seen as having the greatest potential to become a marketable product. This study identified two factors shaping the potential of REI to become tourist attractions: (1) uniqueness and rarity and (2) the design of the power plant. They are discussed in more detail below.

##### Uniqueness and Rarity

Many interviewees pointed out that geothermal power plants are relatively rare in other countries and therefore more interesting to international visitors compared to, for example, wind turbines. Various participants mentioned that geothermal energy is "very special for Iceland" and tourists are interested in learning about geothermal energy and

how it is harnessed. One participant stated, "I think geothermal plants are more beneficial for tourism because it's a special type of power that Iceland produces in high quantity. So, geothermal power gives us more edge in tourism and energy tourism".

There were divergent opinions regarding the potential of hydropower plants as tourist attractions. Some participants mentioned that visits to this type of power plant leave a strong impression on their customers. Others, however, did not experience high interest from their customers for visiting a hydropower plant when traveling in the vicinity. One participant said the following:

*None of my guests have ever asked me to look into these hydropower stations at Búrfell, . . . to go in there and have a guided tour—you can get a guided tour there—to tell about how electricity is produced, that's not of interest.*

Various interviewees pointed out that wind turbines are ubiquitous in many European countries. Therefore, visitors might prefer not to see them when traveling in Iceland, a country which they visit for its unique nature. One participant shared their experience from undertaking tours: "Quite a lot of tourists have said, it is so nice here, there are no windmills". Another interviewee supported this:

*I think people are more happy to associate Iceland with geothermal and hydro energy rather than wind energy, something people are used to seeing at home. I mean Californians and Scandinavians have windmills all over the place and then it would just be as at home. So, I think people could react to it more negatively.*

One participant compared the three types of REI and their potential to become tourist attractions for international visitors in the following way:

*Hydropower plants they see at home. Probably not those that are dug into the ground, they are different. And windmills they definitely see at home, while a geothermal power plant is interesting for the technology. . . . They want to know about it, how it looks like, how it works, what we do with it and so on.*

Thus, the rarity of geothermal power plants makes them the most interesting type of REI to visit and learn about in Iceland, while wind turbines are rather common in most countries that visitors to Iceland are coming from and, therefore, they are not perceived as a product that can be strongly promoted to tourists.

### Interesting Design

According to participants interviewed in this study, geothermal power plants are also interesting to international visitors due to their design and exposed infrastructure. One interviewee offering airplane and helicopter tours spoke about geothermal power plants as follows:

*People are really impressed seeing the turbines turn from above. You can see the steam coming up, you can see all the little boreholes all over the place, you can see the pipelines with the hot steam coming into the power plant, and then you can see the power lines coming out. So, it is a very visual process. You can say look, they are making electricity. It is a good story to tell when you are flying above.*

Similarly, tour operators offering sightseeing tours on land mentioned that exposed infrastructure and steam make geothermal power plants interesting sites to visit and to learn about the use of geothermal energy. According to one participant, "the power there is more touchable somehow".

Hydropower plant infrastructure is somewhat hidden. As noted by some participants, viewing it is more complicated, and opening it to visitors can result in safety issues. However, some participants thought that visits to hydropower plants and learning about the machinery and the process of hydro energy harnessing could be of interest to a certain tourist market group. One participant said the following:

*Occasionally, when I have very important customers, I get permission from Landsvirkjun [the National Power Company] to go and actually see one of the plants and to go in and all the way down, underneath the turbines. . . . People are flabbergasted.*

Wind energy infrastructure, which generally looks similar in most countries, was perceived as a less interesting sight for tourists to explore. One participant noted, "You do not take a picture of a valley where there are lots of windmills. Right?".

Hence, geothermal power plants that are rather rare and characterized by exposed infrastructure, and thereby provide a unique opportunity to learn about the process of harnessing geothermal energy, were perceived to have the highest potential as tourist attractions among the three types of REI. Standardized wind energy infrastructure was viewed as having the lowest potential.

#### 5.2.3. Reversibility

Reversibility was mentioned as an aspect that might affect the compatibility of REI with tourism. In Iceland, so far, only one small-scale hydropower plant has been removed to restore nature. Consequently, interviewees perceived hydropower plants as difficult to reverse. Wind energy infrastructure, on the other hand, was more often viewed as reversible. One participant said the following:

*[A hydropower plant] you can't take it back. Because it's just forever, it's going to be destroyed. But with windmills you can actually take them down, and maybe there is a better technology in 20 years that we will replace them with].*

Due to the possibility of removing wind turbines, the participants saw their landscape impacts and consequential impacts on tourism as temporary, while the impacts of hydro and geothermal power plants were viewed as long-lasting.

However, not all interviewees believed that wind turbines would be removed once their life cycle is finished since old wind farms tend to be repowered. Regarding wind energy infrastructure, one participant stated, "It is much more visible and even if they say that we can always take it down again, I think that will never be done". Furthermore, interviewees stressed that even though wind turbines can be taken down, their construction requires concrete foundations built into the ground, roads, power lines, and other infrastructure. Thus, all the environmental damage is not easy to reverse.

#### 5.2.4. The Image of REI

The interviews revealed that the general image of the three types of REI plays an important role in their compatibility with tourism, making it possible to present them to visitors as clean and sustainable sources of energy. Thus, the presence of REI does not contradict Iceland´s image as an environmentally conscious country. When traveling through certain areas, it may be difficult to avoid seeing power plants on tours. For example, regarding the Þjórsá and Tungnaá Catchment Area, which contains several hydropower plants stretching along the road to some of the most visited destinations in the southern highlands, one participant said, "You can't just pass through that area and pretend these things aren't there. So, you have to incorporate that into the tour and just give the history a bit". Accordingly, while driving through the area, guides often tell their customers about the history of renewable energy development in Iceland. They often mention that the first hydropower plants were constructed in this area in the 1960s. Since then, these power plants have been providing clean and renewable energy to Icelandic society. As further noted by the participant, "If those were aluminum smelters it would not really fit into the narrative". Furthermore, as noted by some participants, the use of geothermal energy sources for electricity, hot water, and heating makes Iceland a positive example in the international context due to its innovative use of renewable natural resources. When discussing the Hellisheiði Geothermal Power Plant, which both produces electricity and provides hot water to the capital area, one participant noted, "I am quite sure all governments over Europe are dreaming about this situation for their citizens". Thus, tourism service providers incorporate REI into their tours by using narratives of sustainable and green energy harnessing, which tend to positively contribute to the visitor experience. However, most of the interviewees stressed the need to strike a balance between harnessing renewable energy and preserving nature. This is particularly important in

Iceland, which heavily depends on nature-based tourism and possesses both an attractive natural environment and abundant renewable energy resources. One participant said the following:

*You have to know when there is enough, because we are one of the last frontiers of Europe in terms of unspoiled land, and no tourists come here to look at power plants either geothermal or whatever they are. They come here for calmness and unspoiled nature.*

## 6. Discussion and Conclusions

In line with previous research [9,10], this study showed that tourism service providers in Iceland tend to be rather negative towards future power plant developments since they degrade the natural environment and the quality of natural attractions, which are the main products they market. However, this study revealed that tourism service providers in Iceland are less opposed to geothermal energy developments compared to hydropower and are the most negative towards onshore wind energy infrastructure developments. Moreover, attitudes towards REI are influenced by the locational settings. In this study, respondents were significantly more negative towards the development of all types of REI in the highlands compared to the more developed lowlands. In Iceland's highlands, which are characterized by natural and wilderness landscapes, 58.9% of respondents were negative towards the construction of geothermal power plants. On the other hand, the further construction of geothermal power plants in the lowlands was viewed negatively by 32.1% of respondents, while a higher proportion, or 37.4%, perceived such developments as positive. Such findings suggest that consideration of the type of REI together with other factors, such as locational aspects, is likely to help identify energy projects that would be the most compatible with tourism.

This study further revealed that positive attitudes towards geothermal power plants were mostly due to their potential to become tourist attractions. These findings align with previous research showing that geothermal power plants can successfully attract tourists [32,35]. The uniqueness and rarity of geothermal power plants in the international context were shown by this study to be among the main factors contributing to this potential. Worldwide, in 2022, geothermal energy was harnessed for electricity generation in 27 countries. In four of them, the total installed capacity of geothermal energy infrastructure did not exceed 10 MW [65]. Thus, geothermal power plants in Iceland constitute an interesting tourist attraction that makes the country stand out internationally. The interesting design of geothermal power plants was also shown to contribute to their potential as tourist attractions. The relatively exposed infrastructure of this type of REI allows visitors to observe various steps in the geothermal energy harnessing process, which many tourists find fascinating. Consequently, geothermal power plants built in easily accessible areas, where they can be included in tour itineraries, can in some instances benefit tourism. Furthermore, when planning the development of geothermal energy infrastructure, the value and level of use of the geothermal areas for the tourism industry should be taken into consideration because these are likely to be destroyed or degraded by the power plant. Notably, while of interest to international tourists, geothermal power plants can result in the degradation of natural areas used for outdoor recreation by locals and sometimes international visitors [66].

Various previous studies have shown that wind farms can become tourist attractions for visitors curious to take a closer look at them, interested in energy tourism, willing to learn more about the technology, or when events are organized in wind energy landscapes [32,33,67]. This study, however, revealed that Icelandic tourism service providers perceived the potential for wind energy projects to become tourist attractions to be relatively low since wind turbines tend to be similar in most countries. Furthermore, wind turbines have high landscape impacts, which caused concern among tourism service providers because they can degrade the visitor experience in vast areas. Such impacts are especially likely in landscapes of high natural quality where tourists seek experiences related to the wilderness and limited human interference [68]. Thus, the construction of wind energy

projects in areas with low value for tourism and visitor flow may minimize impacts on tourism [9]. Numerous participants in the study viewed wind energy projects as reversible, suggesting that the negative impacts of such projects on tourism are temporary and can be undone. This is a valuable finding, as Windemer and Cowell [69] have stressed that knowledge of stakeholder perceptions regarding the (ir)reversibility of REI and its long-lasting impacts is largely lacking. Notably, the increasing trend of repowering wind turbines [70] underscores the need for planning end-of-life strategies for the demolition or repowering of wind energy infrastructure in advance [67]. Furthermore, the findings of this study stress the importance of including stakeholders in the timely end-of-life planning of wind energy projects to avoid misconceptions and reduce the likelihood of potential land use conflicts.

The potential of hydropower plants as tourist attractions was debated by tourism service providers. While some thought visits to such power plants can be of interest to tourists, others did not see hydropower plants as fascinating tourist attractions. In the eyes of tourism service providers, their relatively low landscape impacts made them rather compatible with tourism since reservoirs tend to look like natural lakes, and other infrastructure, such as power stations, is often partly hidden or even located underground in Iceland. However, the environmental impacts of hydropower plants containing reservoirs were perceived as rather high due to submerging vast areas under water. Furthermore, hydropower plants often result in water flow reduction in rivers and waterfalls, and some of the latter are important tourist attractions. Thus, hydropower energy developments can lead to impacts on biodiversity, geological diversity, and, potentially, natural and cultural heritage, thereby impacting tourism. Therefore, the findings of this study suggest that when the construction of hydropower projects is planned, the presence of natural and cultural attributes that are valuable for tourism should be assessed and taken into consideration to mitigate negative impacts on tourism.

In Iceland, power plant proposals are evaluated by expert groups of the Icelandic Master Plan for Nature Protection and Energy Utilization that rank them based on their impacts and place them into utilization, on-hold, or protection categories. In June 2022, the Icelandic Parliament [15] approved a parliamentary resolution with an updated categorization of the proposed power plants in the Master Plan. According to the parliamentary resolution, four proposed hydropower plants, 10 geothermal power plants, and two wind farms were placed into the utilization category [15]. Geothermal power plants were revealed by this study to be the most compatible with tourism in the eyes of tourism service providers. However, international visitors to Iceland are likely to visit a geothermal power plant only once during their stay. Thus, it is unlikely that having more geothermal power plants will strengthen Iceland's competitive advantage as a tourism destination. Therefore, finding a balance between renewable energy harnessing and preserving nature, which is the primary attraction for international visitors to Iceland and a key selling point for the tourism industry, as well as ensuring that REI developments preserve the values essential for the tourism industry, is of crucial importance.

This study has several limitations that could be addressed by future research. It focused on the perceptions and preferences of tourism service providers, which constitute only a small although important part of all tourism stakeholders. Investigating the perceptions of tourists regarding the impacts of various types of REI on their experience would provide deeper insights into their compatibility with tourism. Furthermore, knowledge of the perceptions of other stakeholders, such as local communities and environmental groups, would further contribute to a holistic understanding of the issues related to this compatibility. Moreover, this study focused on renewable energy projects which are generally connected to the national grid of the country and not aimed at supplying specific tourism businesses. Consequently, some of the concerns that would be relevant to tourism accommodation and similar tourism businesses, such as the reliability of renewable energy sources, revealed by Dalton et al. [71], did not appear to be a concern among the interviewed tourism service providers. With a growing number of small-scale renewable energy projects to supply tourism businesses, further contributions to the existing knowledge on

the perceptions of tourism service providers regarding the suitability of each type of REI in various types of tourism accommodation and other tourism infrastructure could foster the improved coexistence of REI and tourism. Another limitation is the current absence of large-scale wind energy projects in Iceland. Currently, only a few wind turbines are operating in the country. Thus, this study investigated the attitudes of tourism service providers towards two types of REI that Iceland has extensive experience of using and one type, namely, wind energy projects, which is taking its first significant development steps in the country. This suggests the need for similar research after the construction of the first wind farms in Iceland investigating if and how the attitudes of tourism service providers have changed. International studies comparing the findings from several countries would provide further insights facilitating renewable energy planning.

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