

Experts versus the public

Hamza, Neveen; Borg, Ruben Paul ; Camillieri, Liberato; Baniotopoulos, Charalampos

DOI:

[10.3390/en15207743](https://doi.org/10.3390/en15207743)

License:

Creative Commons: Attribution (CC BY)

Document Version

Publisher's PDF, also known as Version of record

Citation for published version (Harvard):

Hamza, N, Borg, RP, Camillieri, L & Baniotopoulos, C 2022, 'Experts versus the public: perceptions of siting wind turbines and performance concerns', *Energies*, vol. 15, no. 20, 7743. <https://doi.org/10.3390/en15207743>

[Link to publication on Research at Birmingham portal](#)

General rights

Unless a licence is specified above, all rights (including copyright and moral rights) in this document are retained by the authors and/or the copyright holders. The express permission of the copyright holder must be obtained for any use of this material other than for purposes permitted by law.

- Users may freely distribute the URL that is used to identify this publication.
- Users may download and/or print one copy of the publication from the University of Birmingham research portal for the purpose of private study or non-commercial research.
- User may use extracts from the document in line with the concept of 'fair dealing' under the Copyright, Designs and Patents Act 1988 (?)
- Users may not further distribute the material nor use it for the purposes of commercial gain.

Where a licence is displayed above, please note the terms and conditions of the licence govern your use of this document.

When citing, please reference the published version.

Take down policy

While the University of Birmingham exercises care and attention in making items available there are rare occasions when an item has been uploaded in error or has been deemed to be commercially or otherwise sensitive.

If you believe that this is the case for this document, please contact UBIRA@lists.bham.ac.uk providing details and we will remove access to the work immediately and investigate.

Article

Experts versus the Public: Perceptions of Siting Wind Turbines and Performance Concerns

Neveen Hamza ^{1,*}, Ruben Paul Borg ^{2,*}, Liberato Camilleri ³ and Charalampos Baniotopoulos ⁴¹ School of Architecture, Planning and Landscape, Newcastle University, Newcastle upon Tyne NE1 7RU, UK² Faculty of the Built Environment Malta, University of Malta, MSD 2080 Msida, Malta³ Faculty of Science, University of Malta, MSD 2080 Msida, Malta⁴ School of Engineering, Birmingham University, Birmingham B15 2TT, UK

* Correspondence: neveen.hamza@newcastle.ac.uk (N.H.); ruben.p.borg@um.edu.mt (R.P.B.)

Abstract: Experiences of wind turbines (WT) shape public perception and acceptance of the technology, influencing government policy, deployment, and land-use policies of wind turbines. This paper attempts to find changes in public perceptions over the last three decades and differences between experts and the public over different land-use options. A semi-structured questionnaire that integrates a visual survey of 10 images of WT technology in different urban, landscape and seascape settings was presented to both groups. The perceptions of siting, proximity, landscape type, and maturity of urban wind turbines' technology in renewable energy generation were contrasted. The results revealed that both the public and experts alike significantly preferred images of WT inclusion in seascape and landscape settings and responded negatively to images of WT as an addition to buildings in urban contexts. Images of wind turbines around transport settings were ranked in the second set of acceptances, after landscape settings, indicating that closer proximity to WT is acceptable, but for a short duration. The analysis also highlighted a preference by the public for aesthetically engaging WT, even if they resulted in lower energy yields, but were less accepted by the experts who based their judgment on technical performance.

Keywords: wind turbines; siting; expert-public perceptions

Citation: Hamza, N.; Borg, R.P.; Camilleri, L.; Baniotopoulos, C. Experts versus the Public: Perceptions of Siting Wind Turbines and Performance Concerns. *Energies* **2022**, *15*, 7743. <https://doi.org/10.3390/en15207743>

Academic Editor: Davide Astolfi

Received: 12 July 2022

Accepted: 12 October 2022

Published: 19 October 2022

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2022 by the author. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

In a global economy, energy consumption is correlated to technological development and economic progress. There are concerted worldwide government-backed strategies to curb climate change and air pollution from fossil fuel energy generation and use. The use of fossil fuels is also related to insecurity of supply, depleting resources, and global monopolies. To reduce the environmental and socio-economic impacts of using fossil fuels, governments attempt to implement different energy saving strategies, trial energy saving technologies, and introduce a mix of alternative sources of energy from renewable energy generation. Governmental level attempts to curb rising carbon emissions will lead to wind energy technology development and deployment, playing a significant role in meeting future energy demand.

Public perceptions of wind energy as a green power technology will be supportive of the technology if positive environmental impacts outweigh its negatives, which is repeatedly communicated to the public through televised documentaries and news articles. The negative impacts of wind turbines are attributed to concerns over flicker from blades, noise pollution, visual interference, and negative impacts on land-use policies, wildlife, and decrease in neighbouring property value [1,2]. However, the short term economic return on investment in WT, from the energy produced, from the WT must be noted [3]. Wind turbines can be sited close to locally power communities and industries, reducing network energy losses, carbon dioxide footprints and high-water consumption used in

fossil energy generation [4]. Based on a comparative study of literature, the Parliamentary Office of Science and Technology's UK research indicates that the carbon footprint of wind farms was low compared to other power generating technologies. The manufacturing processes for onshore and offshore WT are similar. The carbon footprint of renewable energy technologies could be substantially reduced if the production phase uses an alternative renewable energy supply. As with other renewable technologies, 98% of the total life cycle CO₂ emissions are attributed to the use of fossil fuels in the production of the steel mast, concrete foundations and the epoxy used for blade manufacturing and other lubricants [5]. Operational emissions arise due to maintenance trips, using vehicles for onshore wind turbines and helicopters for offshore wind turbines. Negative impacts on marine species due to exposure to the electromagnetic fields from cables and lubricant spills are also recorded [5]. The life-cycle GHG emission intensity is 0.082 kg CO₂-equivalent (eq)/megajoule (MJ) for an onshore wind turbine compared to 0.130 kg CO₂-eq/MJ for an offshore wind turbine. An offshore wind turbine has greater life-cycle GHG emissions than an onshore wind turbine, owing to the floating platform installation in a marine environment [6].

The public's exposure to wind turbine dates back to the invention of the technology credited to the Hero of Alexandria, Egypt, who was the first to use wind to power a machine in 1AD [7]. Although the history of using wind turbines in their current form, three blades or less, dates back to the 1960s; almost fifty years later, the benefit of the technology is acknowledged and promoted by governments, although it remains controversial in its public acceptance. Since then, the technology has been developed to use more aerodynamic blade design and lighter materials to improve its energy generating performance. According to the Global Wind Energy Council [8], 2020 was the best year in history for the global wind industry, with a 93 GW increase in capacity, a 53 percent year-on-year increase, but this growth is not sufficient to ensure the world achieves the net zero goal by 2050. The world needs to install wind power three times faster over the next decade to stay on a net zero pathway and avoid the worst impacts of climate change. The global wind power market has nearly quadrupled in size over the past decade and established itself as one of the most cost-competitive and resilient power sources across the world. There is now 743 GW of wind power capacity worldwide, helping to avoid over 1.1 billion tonnes of CO₂ globally, which is equivalent to the annual carbon emissions of South America. The International Energy Agency Report [9] reported that in the EU, seven countries, including the UK, now meet more than 20% of their electricity demand with wind power, and eleven countries meet more than 10%. In the EU, 15% of its electricity demand is met by wind energy, with 14 of the 27 Member States having wind shares above 10%. The highest share was in Denmark, where 47% of the electricity demand in 2020 was met by wind energy, followed by Ireland at 36%, Portugal at 25% and Germany at 24%.

Deployment of WT depends on experts successfully communicating to communities, aspects of WT performance, land-use, and lessons learnt from previous projects. The feedback from social engagement and social acceptance reforms energy policy and community-supported planning mechanisms, in addition to financial incentivization mechanisms to communities [10]. In the UK, the political support for WT deployment was announced by Boris Johnson, the Prime Minister of the UK, on the 18th of November 2020, announcing the government's vision on reviving the UK economy and pledging to quadruple offshore wind power by 2030, to 40 GW, which would be enough to power every UK home. Although support for land-based solar farms is the highest in Europe and the UK, the 50% of the land required to achieve generation goals [11] is substantial if compared to seascapes or land requirements for wind farms where arable land can still be used for farming.

Surveys in Europe and non-EU countries indicate that more than three-quarters of respondents in every EU country think wind energy will have a positive effect, with proportions ranging from 99% of respondents in Portugal, 98% in Malta and 97% in Ireland, to 76% in France and Romania, and 84% in Poland. In 19 countries, at least half of all respondents think new technologies in wind energy will have a 'very positive' effect. The

majority of non-EU country respondents think wind energy will have a positive effect, with the largest proportion in Iceland and the UK (96%) and the smallest in Albania (58%) [12]. The need for a wider deployment of WT to meet energy demand and provide better diversification of energy sources, may bring about radical changes in society's technology perceptions. A negative societal response may be caused by the fact that, while many technologies deliver benefits to society, they may also introduce new risks. Consequently, such developments are often shaped by public controversies and concerns [13]. Understanding societal changes in the perception of WT helps in forecasting societal and political technology support. The earliest behavioural studies on perceptions of WT were influenced by the 'Not In My Back Yard' theory (NIMBY), showing that communities, in general, supported renewable energy but WT deployment still faced local opposition when these projects were in real planning or implementation phases [14,15]. Various research followed to contest the theory, arguing that communities were becoming more familiar with the benefits and drawbacks of WT technology, adding layers of understanding to the behavioural dimensions and empowerment of communities in decision-making and developing a new theory on 'Please in my Back Yard' 'PIMBY' [16]. Elk and Pearson [17] concluded that the public evaluation differs significantly on preferences regarding the minimum distance from turbines; 'old opponents' would prefer to move turbines further away, while 'young advocates' have no preferences on distances.

Studies show that the interlinked effect of renewable energy policies and incentivisation schemes on perception and public acceptance of the technology are more complex than the NIMBY label [18–20]. Wustenhagen et al. [21] categorized the influential determinants on the acceptance of renewable energy into three types of social acceptance, which were broken down into issues of socio-political acceptance, market acceptance, and community acceptance. This research falls in the latter category, taking on the notion that both experts and lay people are an integral part of a community-based research.

Although the integration of WT in various geographies tends to be driven by governmental policies and local authorities [22–25], public perceptions play a major role in the deployment of the technology. The technological, distributional, and economic issues are not usually visible to the public; however, externalities of exposure to wind turbines, such as shadow flicker, noise, loss of visual amenity to nature and avian mortality, influence the public experience and opinion, creating a cohort of opponents or advocates. Recent research [26] that analysed the health effects of exposure to wind turbine noise compared to road traffic noise concluded that the effect of wind turbine noise is downgraded to an 'annoyance' rather than a health hazard. Other public perceptions, studied in the literature, advocate that it is essential to address and minimise the conflict between wind power generation and nature protection and to address the perception that WT deteriorate the visual amenity of natural scenery [26,27]. Pasqualetti and Stremke [28] presented a literature review of a large number of studies conducted over the last 30 years on the impact of renewable energy technology, indicating a possible shift in accepting the change from 'natural landscapes' to 'energy landscapes'. However, concerns around large terrestrial wind turbines changing birds flight paths, collisions, and change in bird habitats, leading to environmental imbalance, remains a concern for the public and in research [29].

Other factors that affect public perceptions are the lack of clear technical guidance, policies, and financial benefits to the public, which defers influencing public acceptance of WT to the discourse presented by mass and social media. Inaccurate mass and social media, can act as a virtual space that may increase exposure to opposition to WT, with a profound impact on the public discourse and slowing down the deployment of WT in urban and offshore deployment [30]. However, the general lack of experience of both the public and regulators regarding appropriate location of WT in urban contexts and the impact of the urban environment's height and roof-scape on wind flow can lead to lowering the technology efficacy and affect the public perception of the technology's performance [31]. Public and policy makers' acceptance tends to be interchangeable, as the public tend to be affected by policy decision-making processes and how politicians frame this technology

[32,33]. Rountree [34] highlighted that politicians, although ideally influenced by expert opinion, may also be influenced by a utility company's interests, or powerful interest groups, which can succeed in swaying politicians' attitudes towards renewable energy. This research seeks to find if public perception preferences depart from previous research findings in comparing current acceptance of WT in urban, transport and natural settings.

A growing number of publications examine social and behavioural public acceptance of wind turbines under the lens of public conditional acceptance of ownership structures, public participation approaches in decision-making, spatial proximity to the technology, and perceived loss of cultural and ecosystem value of landscapes where wind turbines are constructed [35,36].

This research departs from previous publications in its aim to compare the perception of experts and the public by ranking siting preferences for wind turbines in urban and landscape/seascape settings, and the salient issues of WT deployment in each setting. Both groups are influential in shaping and changing societal attitudes towards wind energy deployment and reflect on governments' policy to reduce/eliminate dependency on fossil fuel grid-generated energy.

In this research, we further investigate the influence of education on the perception of wind turbines, hypothesizing that experts studying or researching renewable energy will express pronounced awareness and positive attitudes towards promoting WT in different locations.

The technology acceptance model (TAM) [37] highlights 'perceptions' as the crucial factor that affects the potential growth of technology adoption based on its perceived usefulness, and perceived ease of use. Relevant to the acceptance of wind turbines is the expansion of the model TAM 3 that resulted in the inclusion of the effects of trust in and perceived risk of system use [38]. Growing up with renewable energy sources also has an impact on perceptions of renewable energy. Karasmanaki et al. [39], Karatepe and et al. [40], Zyadin et al. [41] and Ozil et al. [42] looked at groups of undergraduate university students studying courses focused on renewable energy resources (in Greece, Canada, Romania, and Turkey) and on school students as young experts and concluded that 'seeing' the technology leads to higher familiarity and preferences for wind and solar energy around the world.

To achieve social acceptance of wind energy generation, users must accept that the nature of energy production is intermittent, with visual and land resource implications [10,24]. Although public awareness of the technology is related to familiarity with utilitarian landscapes, including windmills, and electricity masts, more research is still needed to understand how, after decades of exposure, wind turbines are valued from a societal perspective.

This research departs from previous research in adopting a methodology to contrast experts' versus the public's perceptions and siting preferences of wind turbines in urban and natural settings that vary in proximity and length of exposure to the viewer.

2. Materials and Methods

A major corpus of research utilises questionnaire methods to test public perceptions of wind turbines [43–47]. More recently, studies that focus on testing the sensitivity of the viewers' perceptions and acceptance use imagery, showing how landscapes change before and after the installations of WT in suburban settings. Wind turbine imagery was projected in labs to elicit self-reported psychological responses and it was reported that wind turbines set in natural settings were rated as equally pleasant as churches and more pleasantly perceived than other technological installations, such as pylons or nuclear reactors, but WT were preferred visually in small numbers [48,49].

In urban settings, wind turbine integration in buildings has been implemented in well publicized architectural iconic buildings (i.e., the Strada in London, World Trade Centre in Bahrain), However, studies that link public perceptions to wind turbines in

urban built up areas are still emerging, indicating that the public are more averse and skeptical of WT deployment and performance [24,50].

However, the focus of previous research reflects the emphasis on capturing the perceptions of members of the community, with less focus on the role of the experts in promoting or demoting the propagation of the technology or on their influence on land use for renewables in various settings [51]. Experts are members of the society, but their views influence policy makers and both directly and indirectly impact public opinion.

The research methodology is built on capturing perceptions using a three-stage methodology.

The first stage was a series of hybrid textual questions and imagery semi-structured questionnaire to illicit responses to WT siting and ranking of potential concerns related to the WT performance.

2.1. First Stage: The Expert as a Focus Group

Experts are defined here as follows: “as individuals who are highly educated and are trusted by the public in making informed decisions concerning siting wind turbines. These experts are individuals who typically know the knowledge stock that is “characteristic” or “relevant” for a certain field. S/he has, an overview of a specialist knowledge field and can offer fundamental problem solutions or can apply these to individual problems within this area”. This research was carried out under the framework of COST Action TU1304 WINERCOST (WIND Energy technology Reconsideration to enhance the CONcept of Smart ciTies) and addressed the objective of wind energy integration into built environments (urban and suburban) and natural landscapes. The scientists from 28 countries researched methods regarding the acceleration of uptake of wind turbines in European communities to overcome technological, structural and societal barriers [52].

The expert perceptions strengthen their judgment of siting wind turbines using technical information and experiential knowledge.

Characteristics of the experts’ opinions included in the survey sample of this research are as follows:

- 1- Members of academia and active researchers across Europe (including social scientists and engineers);
- 2- Experts from various cultural and regulatory backgrounds, to capture an array of different perceptions and backgrounds of regulatory frameworks;
- 3- Experts who have a professional opinion on the technical performance of energy generation from wind turbines;
- 4- Experts who interact with technology diffusion networks through interpersonal communication at various levels, from regulatory authorities, politicians and the media to education.

This first stage focused on gathering responses from a focus group of experts, using convenience sampling, to elicit the salient issues around WT deployment [2,53]. An open-ended questionnaire was sent electronically to 28 experts (23 European and 5 near EU zone countries) from the WINERCOST project and 41 external experts from their wider network; 69 valid expert responses in total were received. The electronic textual questionnaire was used to allow the experts to respond in their own time and to allow for an open data gathering technique that would feed into generating a more detailed second questionnaire intended for a wider audience. Content analysis was used to extract the salient issues that affect the deployment of the WT technology.

The first stage asked the experts to provide the following information:

- Country where they work;
- Number of years that they have worked as an expert in WT technologies;
- Areas where they thought WT had a positive contribution to the urban environment;
- Policies in their respective country that support WT installation;
- Factors that would adversely affect supporting WT installations.

The survey results indicated 6 main areas identified by the experts that were to be extended for exploration in the second stage of the questionnaire (Table 1). The analysis mainly highlighted issues that affect the proliferation of wind turbines, relating, in particular, to the interpretation of regulations that affect the location of the technology, and uncertainties of the effectiveness of the technology in urban locations. The experts also highlight the importance of social acceptance, and major environmental considerations of exposure to flicker, noise and safety of proximity to moving blades. Experts' opinion suggests that onshore and offshore wind farms were a more established technology, but the perceptions of the visual amenity of sea and landscapes may be a concern to the public, which needed further exploration.

Interestingly, there were indicators to suggest positive social acceptance based on wider encounters with the technology and with incentivization schemes that support the phenomena of PIMBYS (Please in My Back Garden).

Table 1. Analysis of the Stage 1: Experts Open-Ended Survey Based on [2] and [52].

Collective Positive Opinion	Collective Areas of Concern
Reducing bills and contributing to a low carbon society	Perceptions of negative impacts on property value due to visibility and proximity to a WT.
Expert feedback integrated into land-use policies	Uncertainty by experts on how to meet local city and in-country legislation
-Visually interesting models are available and a good symbol of commitment to clean energy production	-Visual impact due to size of WT
- Visually more acceptable if perceived as an integrated design to buildings, or in a regeneration of derelict industrial sites	-Negative perceptions if WT is seen as an add on to an existing structure
	-Moving parts increases risk of falling elements and risk of fire when integrated in buildings
	For all WT installations, the scale of installation may generate noise that is disturbing for nearby neighbours
-Comparing the same energy production, a smaller land area is needed for large scale WT installations compared to PV farms.	
-Other activities of farming and breeding animals can be maintained alongside WT farms.	

2.2. Stage Two: The Expert Survey

The visual survey was then constructed, combining the salient issues raised in Stage 1, and open-source images that were found in Google searches for various urban and landscape contexts that included wind turbines. The inclusion of images in the questionnaire was to reduce long descriptive and textual questions and provide a visual stimulus. Visual stimulations clarify meaning and motivate or entrain the respondents to take part without influencing the responses and increase participation and reduce break-offs [54]. As the contexts differ, so does the background and illumination of the image; we were concerned this might affect responses, but it seems that this was not the case, as the responses were not related to the brightness of the image as much as it related to proximity, or perceived length of exposure to the WT.

The principal focus of research on climate change and energy-related issues has been largely cognitive and rationalistic, depending on mathematical calculations and analytical graphs. The importance of public perception on government policies leads to mass media images being harnessed and woven into texts in a variety of ways to develop narratives

to test public perceptions on complex and abstract issues about climate change, use of renewables and the environment. Leiserowitz [55] explains that imagery aids the cognitive processing system, which is rational, analytic, logical and deliberative, encoding reality in abstract terms and triggering a response and engagement from the experiential processing system in encoding reality through imagery and metaphors. Experiential processing is holistic, effective, fast, and intuitive and plays a role in shaping the emotions we feel about climate change. Epstein (1994) reported the following two types of systems: “two parallel, interacting modes of information processing: a rational system and an emotionally driven experiential system”. The rational processing system is analytic, logical, and deliberative and encodes reality in abstract symbols, words, and numbers. In contrast, the experiential system is intuitive and encodes reality in images, metaphors and narratives linked in associative networks [56]; it is the latter that is pertinent to the analytical framework of the images provided to the respondents.

More recently, research has offered accounts of how affect and imagery influence the processes associated with the conceptualisation of ideas, judgement, and choice [49,57,58]. An image can communicate a complex issue more readily than standard alternative communications, specifically when presenting issues related to climate change and technologies that have an impact on energy use [59]. Communications through visual aids, such as imagery, improve decision making and communication in collaborative teams that may include experts and non-experts [60,61].

Spielhofer et al. [49] more recently used electrodermal activity to determine participants’ physiological and behavioural responses to landscapes with different numbers of renewable technologies and their preferences to natural and urban landscapes. The visual stimuli were composed of either a low or high number of wind turbines and photovoltaic systems in seven different landscape types. Participants were asked to choose their preferred landscape image from pairs of sequentially presented images, with and without the technologies, while their electrodermal activity was recorded. The study showed natural settings with and without wind turbines in Alpine landscapes, recording preferences and lower levels of arousal when a low and an even lower distribution of wind turbines or photovoltaics in the landscape was shown. This paper embarks on using affective imagery that is collated from a Google search on open-source images of renewable energy and from the authors’ collections of the following three main contexts: (1) wind turbines on buildings, (2) turbines close to transportation routes and (3) turbines in land and seascape areas.

The same set of images was distributed to the expert and non-expert groups. However, the two questionnaire groups were conducted in diverse settings. The proposition to introduce imagery was to support the view that the concepts of mental imagery and affect can provide a powerful framework for predicting both intended and actual behaviour from relatively simple image elicitation techniques and a two-step methodology used to uncover emotional influences in the process of attitude formation was implemented.

In the first step, the experts formed a focus group to identify the salient issues related to wind turbines and the respondents were asked to list spontaneous associations and concerns that came to mind related to wind turbines and rank them in order of importance to the respondents.

In the second stage, both the public and experts used the questionnaire and the imagery to rate these associations on an affective 5-point scale, indicating whether these images elicited positive or negative feelings [62,63].

The expert group was interviewed in person during the International WINERCOST conference in Cantanzaro, Italy, on the 21st to 23rd of March 2018 [64], where the images (Figure 1) were projected on the wall and a physical hard copy, including the same images and a 5-point Likert scale questionnaire, was handed out. Each photo had an additional table where respondents could tick the aspects that were of concern to them, and more than one aspect could be chosen.

The total number of attendees in the session was 96 and 71 valid responses were received (response rate of 73.9%). In total, 23 respondents were experts from WINERCOST,

and 48 respondents were expert scientists, and postgraduates who were researching methods to enhance the mechanical, electrical performance and positioning of wind turbines in offshore and onshore applications. As the experts themselves are members of the community and would have a role to play in promoting/demoting the technology according to their scientific knowledge, capturing the experts' perceptions of the technology's performance, aesthetic appeal, and siting preferences would also indicate a social acceptance measure.



Photo 1



Photo 2



Photo 3



Photo 4



Photo 5



Photo 6



Photo 7



Photo 8

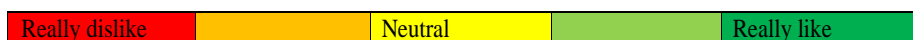


Figure 1. Wind turbines displayed in eight different contexts.

The room dimensions were 10 m × 25 m in depth and the furthest respondent was about 20 m away from the projection screen. Lighting in the room was set to allow a clear view of both the images projected and the room surfaces remained constant for the duration of the experiment. The questionnaire started by the generic question on gender and years of experience spent researching wind turbines. There were three sets of photos, all presented with the same size, so each A4 sheet had only two photos sized 110 × 160 mm. The first set (Photos 1–2) presented wind turbines over buildings, the second set looked at driving experiences (Photos 3–6) and the third set presented a landscape and a seascape (Photos 7–8).

2.3. Stage Three: The Public Survey

Snowball sampling was used to reach out to the public, where the experts, as part of the network formed in the previous stages, were used as gatekeepers to distribute the Survey Monkey digital questionnaire to their wider network of university students, colleagues, friends and family members. A virtual online tool was used for the public (Survey Monkey). The first part of the questionnaire was based on textual questions to gather generic data on respondents, such as gender, age, education level. The electronic survey platform allows for the presentation of one image (scalable on the screen by viewers), followed by a five-point Likert scale, and the four main concerns of moving parts on a building, creation of sound, creation of light reflection and safety of installation were included after each image.

3. Analysis

The sample comprised 404 participants (71 experts and 333 individuals from the public), which guaranteed a maximum margin of error of 4.88%, assuming a 95% confidence level.

The following two statements and responses to siting imagery were rated on a 5-point Likert scale, where 0 corresponds to strongly disagree and 4 to strongly agree:

Statement (1): I think urban wind turbines are a well-developed technology for use in urban areas.

Statement (2): I would install a wind turbine in my garden.

Since the rating scale has a narrow range, it was deemed more appropriate to display the mean rating score as a measure of central location, rather than the median. The advantage of using a mean rating score is that it takes into account all the observations; it is affected the least by sampling fluctuations, and can be expressed correct to several decimal places. The Mann–Whitney test was used to compare mean rating scores when the participants were clustered by expertise (public, experts) and gender (female, male), while the Kruskal–Wallis test was used to compare mean rating scores when the participants were grouped by age (20–29 years, 30–39 years, 40–49 years, 50 years or more), education level (undergraduate, masters, PhD) and research duration on wind turbines (less than 1 year, 1–5 years, 6–10 years, more than 10 years). In both tests, the mean rating scores ranged from 0 to 4, where a larger mean rating score indicated higher agreement. The two tests yield a *p*-value to identify statistical significance, where a *p*-value smaller than the 0.05 level of significance indicates that the mean rating scores differ significantly between the groups.

3.1. Perceptions of Wind Turbines as a Developed Technology

The first question was concerned with contrasting the experts versus the public on their perception of the degree of WT technology development.

All the mean rating scores, as displayed in Table 2, exceed 2, which indicates that both the public and experts tend to agree more than disagree that the technology is well-

developed for use in urban areas. However, these mean rating scores vary marginally between the two groups, since the p -values exceed the 0.05 level of significance. Moreover, the standard deviation (Std. Dev.) is a measure of dispersion between the rating scores. This implies that there was more spread in the rating scores provided by the experts compared to the public.

Table 2. Differences in perceptions on wind turbine technology between experts and public.

	Group	Sample Size	Mean	Std. Dev.	p -Value
I think urban wind turbines are a well-developed technology for use in urban areas	Public	333	2.23	1.087	0.497
	Experts	71	2.13	1.206	

All the mean rating scores, as displayed in Table 3, exceed 2, which indicate that both male and female participants tend to agree more than disagree that the technology is well-developed for use in urban areas, with expert males scoring higher than all other categories, and experts scoring higher than the public.

Table 3. Differences in perceptions on wind turbines as a developed technology, grouped by gender.

Group	Gender	Sample Size	Mean	Std. Dev.	p -Value
Public	Female	154	2.20	1.069	0.841
	Male	175	2.25	1.075	
Experts	Female	8	2.63	1.188	0.465
	Male	10	3.00	0.943	

For the public, Table 4 shows that younger participants of the public aged 20–29 years old agree significantly more than their older counterparts that wind turbines are a well-developed technology, and this is comparable to experts who are more than 50 years old. This is a promising indicator and concurs with the technology acceptance theories. This can be attributed to young people being less conservative to change and are more perceptive to diversifying energy resources towards more environmentally friendly options. The younger generation has grown to be more accepting to the technology due to higher levels of visual exposure and media coverage. For the expert group, researchers aged between 30 and 50 years seem to be marginally less convinced with the technology than their elder professoriate level respondents.

Table 4. Perceptions of the development of wind turbines technology, grouped by age.

Group	Age	Sample Size	Mean	Std. Dev.	p -Value
General public	20–29 years	149	2.52	0.984	0.000
	30–39 years	67	2.24	1.016	
	40–49 years	67	2.01	1.135	
	50 years or more	50	1.62	1.123	
Experts	20–29 years	31	2.19	1.223	0.433
	30–39 years	14	1.93	1.269	
	40–49 years	10	1.70	1.252	
	50 years or more	16	2.44	1.094	

For the public, Table 5 shows that the participants with a bachelor's degree agree significantly more than their more qualified counterparts with a master's or PhD that wind

turbines are a well-developed technology for use in urban areas. This can be attributed to the culture of ‘research leads to more questions’ that underlies the perception that more research should be carried out to improve the resilience and performance of the technology.

Table 5. Differences in perceptions on wind turbines technology, grouped by level of education.

Group	Education Level	Sample Size	Mean	Std. Dev.	<i>p</i> -Value
Public	Undergraduate	135	2.53	0.984	0.000
	Master’s degree	67	2.09	1.125	
	PhD	131	1.98	1.102	
Experts	Undergraduate	3	3.00	1.000	0.422
	Master’s degree	27	2.15	1.262	
	PhD	41	2.05	1.182	

Table 6 analyses responses to perceptions of the technology maturity related to the length of research (experts) or exposure to the technology by reading or working on projects (public), surprisingly showing that the more mature researchers and public (over 10 years of research) perceived the technology to be less developed than their younger respondents. This might be due to higher expectations of performance. However, differences in the mean rating scores are not significant, since the *p*-values exceed the 0.05 level of significance.

Table 6. Differences in perceptions on wind turbines technology, grouped by duration of research work.

Group	Research/Work Related to Wind Turbines	Sample Size	Mean	Std. Dev.	<i>p</i> -Value
Public	Less than 1 year	5	2.80	1.095	0.266
	1–5 years	22	1.73	1.202	
	6–10 years	15	1.80	0.941	
	More than 10 years	8	2.00	1.069	
Experts	Less than 1 year	13	2.62	1.121	0.311
	1–5 years	41	2.00	1.225	
	6–10 years	10	2.30	1.059	
	More than 10 years	7	1.71	1.380	

3.2. Willingness to Site the Wind-Turbines in Own Garden

To test the NIMBY theory, Table 7 shows that the experts display a marginally higher acceptance than the public in installing wind turbines in their garden. This may be attributed to the experts’ expertise and confidence in positioning and managing the perceived drawbacks of noise, and flicker from wind turbines to maximise their performance. The public are more influenced by mass and social media, where wind turbines in urban settings have generally received negative publicity. However, the difference in mean rating scores is not significant, since the *p*-value exceeds the 0.05 level of significance. Therefore, there was a need to further disaggregate data by age and level of education.

Table 7. Willingness to install a wind turbine in one’s own garden by experts and general public.

	Group	Sample Size	Mean	Std. Dev.	<i>p</i> -Value
I would install a wind turbine in my garden	Public	333	2.05	1.228	0.057
	Experts	71	2.35	1.255	

Table 8 looks at the willingness to site the wind turbines in one's own garden grouped by age. It is evident that younger respondents from both groups are more likely to locate the technology in close proximity if enough space is available for the wind resources and blade movement and if would not annoy their neighbours, indicating that more exposure to the technology and awareness of the climate crises changes the attitudes of the younger generation.

Table 8. Willingness to install a wind turbine in one's own garden, grouped by age.

Group	Age	Sample Size	Mean	Std. Dev.	<i>p</i> -Value
Public	20–29 years	149	2.12	1.241	0.192
	30–39 years	67	2.19	1.062	
	40–49 years	67	1.94	1.336	
	50 years or more	50	1.76	1.222	
Experts	20–29 years	31	2.65	1.226	0.170
	30–39 years	14	1.79	1.188	
	40–49 years	10	2.10	1.101	
	50 years or more	16	2.44	1.365	

Table 9 shows that individuals with higher educational levels (PhD) are less willing to install a wind turbine in close proximity. This can also be related to a higher level of understanding of the shortcomings of the technology's performance and higher expectations.

Table 9. Willingness to install a wind turbine in one's own garden, grouped by level of education.

Group	Education Level	Sample Size	Mean	Std. Dev.	<i>p</i> -Value
Public	Undergraduate	135	2.10	1.217	0.608
	Master's degree	67	2.09	1.228	
	PhD	131	1.96	1.243	
Experts	Undergraduate	3	2.33	0.577	0.250
	Master's degree	27	2.67	1.271	
	PhD	41	2.15	1.256	

Table 10 shows that male and female participants show similar willingness to install a wind turbine in their garden, since the mean rating scores are similar and differences are not significant.

Table 10. Willingness to install a wind turbine in one's own garden, grouped by gender.

Group	Gender	Sample Size	Mean	Std. Dev.	<i>p</i> -Value
Public	Female	154	2.08	1.182	0.864
	Male	175	2.01	1.246	
Experts	Female	8	2.75	1.389	0.928
	Male	10	2.80	0.919	

Table 11 shows that the more mature researchers and public (over 10 years of research) are less willing to site the wind turbines in close proximity, which can imply that this group are less convinced of the capabilities of the technology. However, differences in the mean rating scores are not significant.

Table 11. Willingness to install a wind turbine in one's own garden, grouped by duration of re-search.

Group	Researching WT	Sample Size	Mean	Std. Dev.	p-Value
Public	Less than 1 year	5	2.40	1.517	0.597
	1–5 years	22	2.23	1.232	
	6–10 years	15	1.87	1.356	
	More than 10 years	8	1.63	1.302	
Experts	Less than 1 year	13	2.62	1.121	0.614
	1–5 years	41	2.39	1.339	
	6–10 years	10	2.20	0.919	
	More than 10 years	7	1.86	1.464	

3.3. Statistical Methods for Rating Responses to Images

The following photos were rated on a 5-point Likert scale, where 0 corresponds to 'dislike a lot', 2 corresponds to 'neither like nor dislike' and 4 corresponds to 'like a lot'. Since the rating scale has a narrow range, it was deemed more appropriate to display the mean rating score as a measure of central location, rather than the median. The Mann–Whitney test was used to compare the mean rating scores of each feature in individual contextual images between two groups of participants (general public and experts). A 0.05 level of significance was used for all tests. This section tests the four salient assessment variables that emerged from the expert focus group.

3.3.1. Moving Blades in Different Contexts

Table 12 shows that both the public and experts rated the acceptance of wind turbines in urban contexts placed on buildings as the least favourable in terms of acceptance to moving blades and a wind turbine as an add-on (Photo 2) was rated the least acceptable, with those placed on a modern building that is purpose-built being more favourable. Interestingly, when comparing the acceptance of a traditional three-blade on the side of the road to a small turbine that is presented as a more visually intriguing wind turbine (Photo 4) in a parking lot (Photo 5) and central reservation (Photo 6), the acceptance of the more aesthetically presented designs was higher. This was the reverse with the expert group, who were less influenced by the aesthetic of the WT, knowing that the energy generation performance of the larger wind turbine on the side of the road with less surface roughness and resistance to wind flow is higher, when compared to the locations of the aesthetically presented turbines. Interestingly, both groups favoured WT integrated near to motorways or as installations on the central reservation more than all other contexts, which might point to the acceptance of looking at the moving blades as being linked to the length of the visual exposure. The general public provided significantly larger mean rating scores for Photos 5, 6 and 7, compared to the experts.

Table 12. Evaluation of wind turbine blade movement by experts and the public.

Photo	Group	Mean	Std. Deviation	p-Value
1	General public	2.58	1.59	0.704
	Experts	2.64	1.38	
2	General public	1.98	1.70	0.373
	Experts	2.16	1.42	
3	General public	2.54	1.67	0.429
	Experts	2.70	1.07	
4	General public	2.92	1.53	0.076
	Experts	2.58	1.23	
5	General public	2.96	1.45	0.014

	Experts	2.50	1.16	
6	General public	3.18	1.29	0.000
	Experts	2.54	1.07	
7	General public	2.92	1.48	0.048
	Experts	2.56	1.18	
8	General public	2.92	1.43	0.512
	Experts	2.78	1.87	

Table 13 shows that the experts express larger mean rating scores for the creation of sound than the general public. This suggests less concern with sound generation from WT by the experts. However, the differences in the mean rating scores are significant for Photos 1 and 2 only. The presented analysis shows that the sound generation was a real concern and negatively affected the perception of the WT in both groups, tending very closely towards the neutral to dislike levels, with the WT on buildings being the least favoured on buildings. Interestingly, the acceptance of sounds seemed to be lower on a hilly landscape than on transport routes and in car parks, suggesting an emotional attachment and protective behaviour to the visual aspects of nature on land, but not so for seascapes.

Table 13. Evaluation of creation of sound by experts and the public.

Photo	Group	Mean	Std. Deviation	<i>p</i> -Value
1	General public	0.80	1.30	0.000
	Experts	1.52	1.37	
2	General public	0.84	1.29	0.007
	Experts	1.30	1.22	
3	General public	1.96	1.44	0.102
	Experts	2.26	1.01	
4	General public	2.20	1.40	0.242
	Experts	2.40	1.06	
5	General public	1.94	1.45	0.609
	Experts	2.02	1.19	
6	General public	2.18	1.39	0.173
	Experts	2.42	0.95	
7	General public	2.00	1.52	0.685
	Experts	2.08	1.24	
8	General public	2.36	1.38	0.381
	Experts	2.50	1.05	

Table 14 indicates that experts' responses seem to suggest a slightly higher level of acceptance than the public's acceptance to 'flicker' phenomena, created by light reflections on the blade when moving. Negative perceptions were again associated with WT on buildings and in contexts where it might interfere with clarity of vision when driving on a motorway for both groups (Photos 1–4). However, the mean rating scores for the creation of light reflections differed significantly between the two groups solely in Photo 3.

Table 14. Evaluation of creation of light reflections by experts and the public.

Photo	Group	Mean	Std. Deviation	<i>p</i> -Value
1	General public	1.84	1.58	0.699
	Experts	1.92	1.33	
2	General public	1.80	1.45	0.979
	Experts	1.80	1.27	

3	General public	1.78	1.49	0.006
	Experts	2.30	1.15	
4	General public	1.88	1.54	0.074
	Experts	2.22	1.33	
5	General public	2.30	1.45	0.696
	Experts	2.36	1.19	
6	General public	2.86	1.53	0.452
	Experts	2.70	1.40	
7	General public	2.44	1.37	0.481
	Experts	2.30	1.10	
8	General public	2.64	1.40	0.726
	Experts	2.70	1.02	

Table 15 points out that the perceived safety of WT on buildings still scored considerably lower than other contexts. Moreover, the general public provided significantly lower mean rating scores for the first four photos and marginally lower for the remaining photos, compared to the experts. This suggests that the experts had more confidence in the WT fixation and structural stability than the public. The public may link the moving blades to a higher possibility of failing fixations and structural stability. The only context where this was observed to be a smaller threat in both groups was the seascape.

Table 15. Evaluation of safety in close proximity to WT by experts and the public.

Photo	Group	Mean	Std. Deviation	p-Value
1	General public	1.88	1.54	0.002
	Experts	2.48	1.41	
2	General public	1.66	1.58	0.017
	Experts	2.14	1.49	
3	General public	1.68	1.62	0.000
	Experts	2.70	1.36	
4	General public	1.90	1.71	0.003
	Experts	2.60	1.41	
5	General public	2.28	1.64	0.233
	Experts	2.54	1.26	
6	General public	2.64	1.51	0.596
	Experts	2.74	1.23	
7	General public	2.94	1.35	0.678
	Experts	3.02	1.11	
8	General public	2.72	1.56	0.532
	Experts	2.84	1.29	

3.3.2. Comparative Results of All Acceptances to WT Contextual Concerns

The major limitation of the Mann–Whitney and Kruskal–Wallis tests is that they solely investigate the relationship between a rating response variable and a categorical predictor. However, the goal of many research studies is to estimate the collective impact of all the predictors upon the dependent variable. It is well known that a lone predictor could be rendered a very important contributor in explaining variations in the responses, but would be rendered unimportant in the presence of other predictors. In other words, the suitability of a predictor in a model fit often depends on what other predictors are included with it.

To address this issue, an ordinal logistic model is fitted to relate the rating responses (ranging from 0 to 4) to three categorical predictors, including group (public, experts),

feature (moving parts on a building, creation of sound, creation of light reflections and safety) and photograph (Photos 1 to 8). Table 16 shows that the parsimonious ordinal logistic regression model identifies all the main effects and two pairwise interaction effects as significant.

Table 16. Tests of model effects.

	Wald Chi-Square	Df	p-Value
Photo	334.114	7	<0.001
Group	7.062	1	0.008
Feature	265.866	3	<0.001
Photo × group	52.686	7	<0.001
Feature × group	68.157	3	<0.001

Table 17 shows the parameter estimates and standard errors of the ordinal logistic model. Moreover, the odds ratios and their corresponding 95% confidence intervals are also displayed. An odds ratio gives the change in odds when comparing a category of interest of a predictor with a reference category. An odds ratio larger than 1 indicates a greater likelihood of a higher rating score for the category of interest, compared to the reference category, while an odds ratio smaller than 1 indicates a lesser likelihood of achieving this outcome.

Table 17. Parameter estimates, standard errors, odds ratios and 95% confidence intervals.

	B	S.E.	O.R	95% C.I of O.R	p-Value
Photo = 1	−0.576	0.150	0.562	(0.419–0.754)	<0.001
Photo = 2	−0.909	0.149	0.403	(0.301–0.540)	<0.001
Photo = 3	−0.195	0.147	0.823	(0.617–1.098)	0.187
Photo = 4	−0.231	0.149	0.794	(0.593–1.063)	0.121
Photo = 5	−0.350	0.147	0.705	(0.528–0.940)	0.018
Photo = 6	−0.075	0.148	0.928	(0.694–1.240)	0.614
Photo = 7	−0.196	0.148	0.822	(0.615–1.099)	0.185
Photo = 8	0	.	.	.	.
Group = public	−0.232	0.140	0.793	(0.603–1.043)	0.097
Group = experts	0	.	.	.	.
Feature = moving parts on building	0.159	0.107	1.172	(0.951–1.446)	0.139
Feature = creation of sound	−0.692	0.106	0.501	(0.407–0.616)	<0.001
Feature = creation of light reflections	−0.427	0.107	0.652	(0.529–0.805)	<0.001
Feature = safety	0	.	.	.	.
Photo = 1 × group = public	−0.586	0.167	0.557	(0.401–0.772)	<0.001
Photo = 1 × group = experts	0	.	.	.	.
Photo = 2 × group = public	−0.508	0.167	0.602	(0.434–0.835)	0.002
Photo = 2 × group = experts	0	.	.	.	.
Photo = 3 × group = public	−0.651	0.165	0.522	(0.377–0.721)	<0.001
Photo = 3 × group = experts	0	.	.	.	.
Photo = 4 × group = public	−0.317	0.167	0.728	(0.525–1.010)	0.057
Photo = 4 × group = experts	0	.	.	.	.
Photo = 5 × group = public	−0.025	0.165	0.975	(0.706–1.348)	0.879
Photo = 5 × group = experts	0	.	.	.	.
Photo = 6 × group = public	0.160	0.167	1.174	(0.846–1.628)	0.336
Photo = 6 × group = experts	0	.	.	.	.
Photo = 7 × group = public	0.077	0.166	1.080	(0.780–1.495)	0.640

Photo = 7 × group = experts	0	.	.	.	.
Photo = 8 × group = public	0	.	.	.	.
Photo = 8 × group = experts	0	.	.	.	.
Feature = moving parts on building × group = public	0.906	0.120	2.474	(1.956–3.131)	<0.001
Feature = moving parts on building × group = experts	0	.	.	.	.
Feature = creation of sound × group = public	0.121	0.118	1.129	(0.896–1.422)	0.306
Feature = creation of sound × group = experts	0	.	.	.	.
Feature = creation of light reflections × group = public	0.384	0.119	1.468	(1.163–1.854)	0.001
Feature = creation of light reflections × group = experts	0	.	.	.	.
Feature = safety × group = public	0	.	.	.	.
Feature = safety × group = experts	0	.	.	.	.

Using these odds ratios, one can deduce that on average, the experts and general public combined rated contexts 1 and 2 significantly lower than the remaining six contexts. On average, the experts and general public combined rated the moving parts on static buildings and safety concerns significantly higher than sound creation and light reflection concerns. On average, the general public rated the contexts and features combined lower than the experts.

Figures 2–5 display the mean rating scores provided by experts and the general public for each context and feature combination. Using these graphs and the results of the ordinal logistic model, one can deduce several interesting contrasts in the evaluations given by experts and the general public. Regarding the moving parts on static buildings, the experts rated contexts 1, 2 and 3 higher than the general public, while the general public rated contexts 4, 5, 6, 7 and 8 higher than the experts. Regarding creation of sound, the experts rated all eight contexts higher than the general public. Regarding creation of light reflections, the experts rated contexts 1, 3, 4, 5 and 8 higher than the general public, while the general public rated contexts 6 and 7 higher than the experts. Regarding safety, the experts rated all eight contexts higher than the general public.

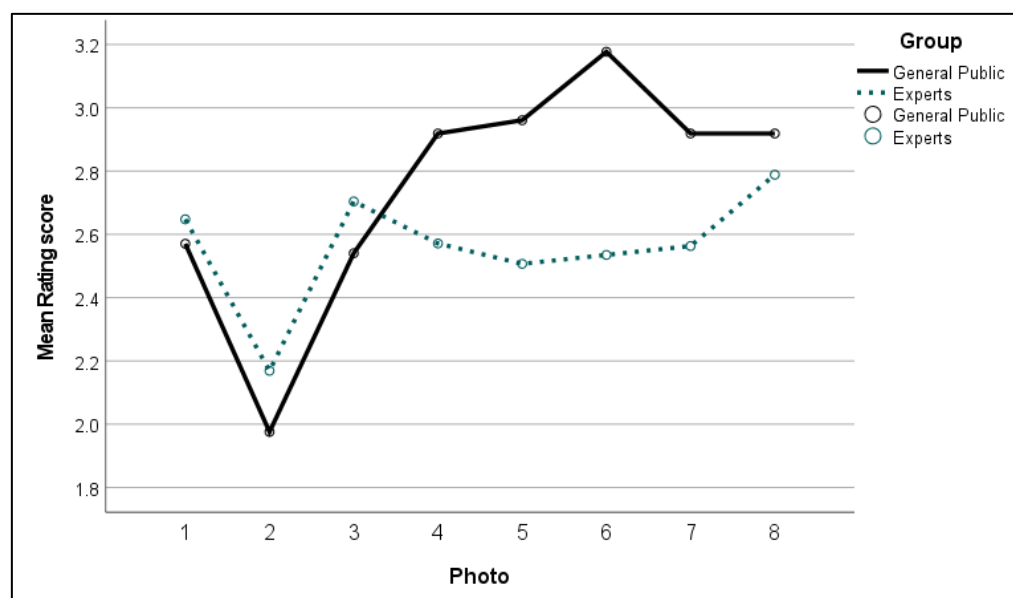


Figure 2. Mean rating scores of each context on the acceptance of visual aspects of WT moving parts.

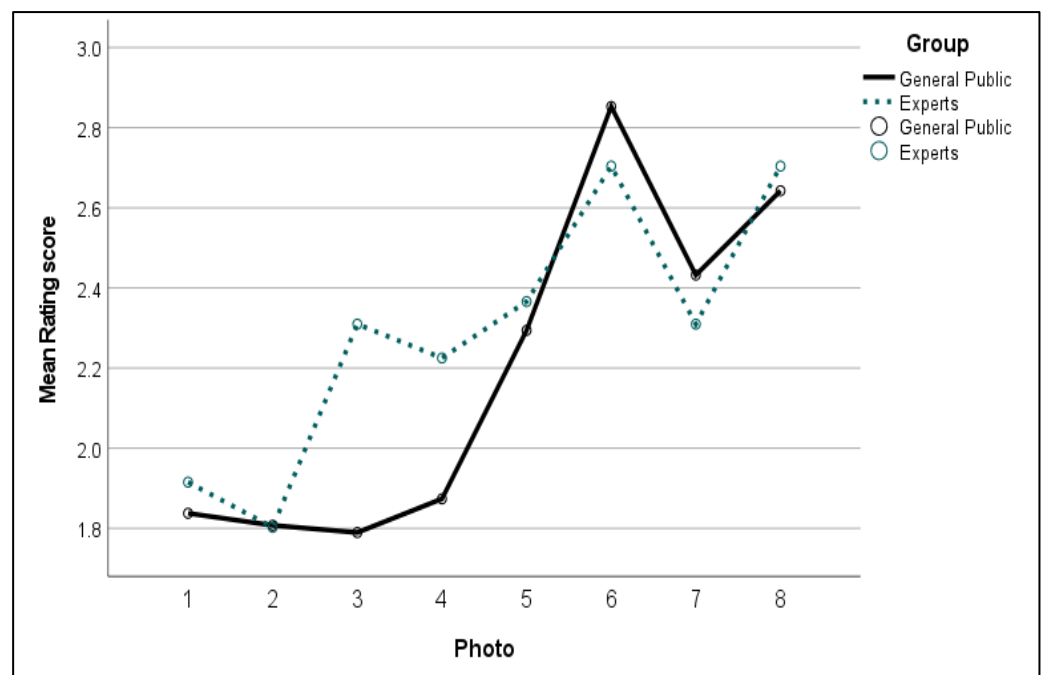


Figure 3. Mean rating scores of each context on the creation of sound.

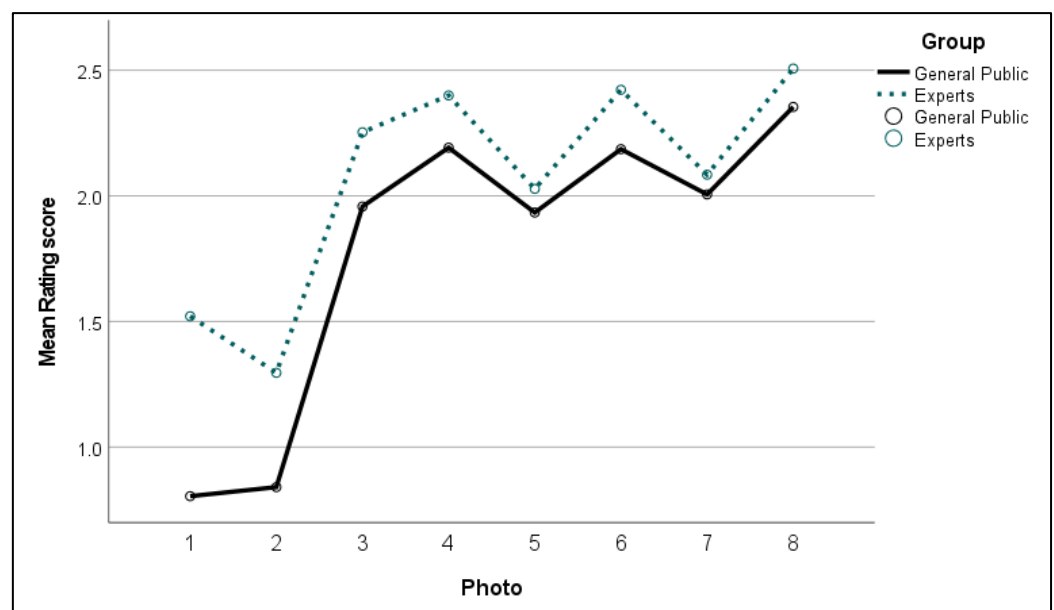


Figure 4. Mean rating scores of each context on light reflection.

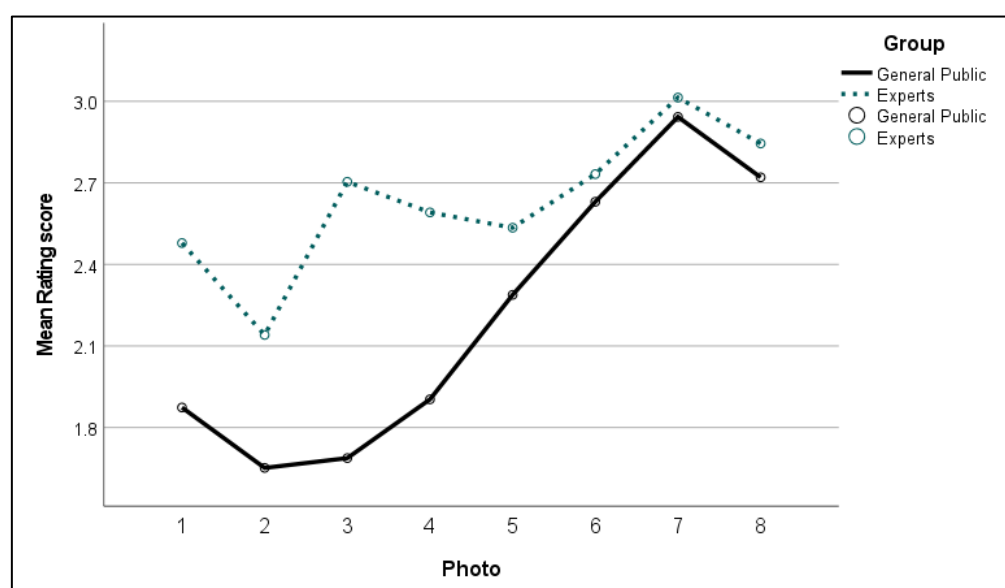


Figure 5. Mean rating scores of each context on safety.

3.3.3. Commutative Analysis of the Eight Contexts by Combining a Cumulative Effect of the Four Concerns

To rank the eight contexts by highest preference, the mean rating scores provided for each context were averaged across the four concerns [Figure 6]. The ranking order of the most preferred context is as follows:

- 1- Seascape (Photo 8);
- 2- Central reservation with an aesthetically engaging feature (Photo 6);
- 3- Landscape (Photo 7);
- 4- On the side of the motorway (Photo 5);
- 5- Metal structure over motorway (Photo 4);
- 6- Parking area (Photo 3);
- 7- Integrated in building design (Photo 1);
- 8- An add-on to an existing building (Photo 2).

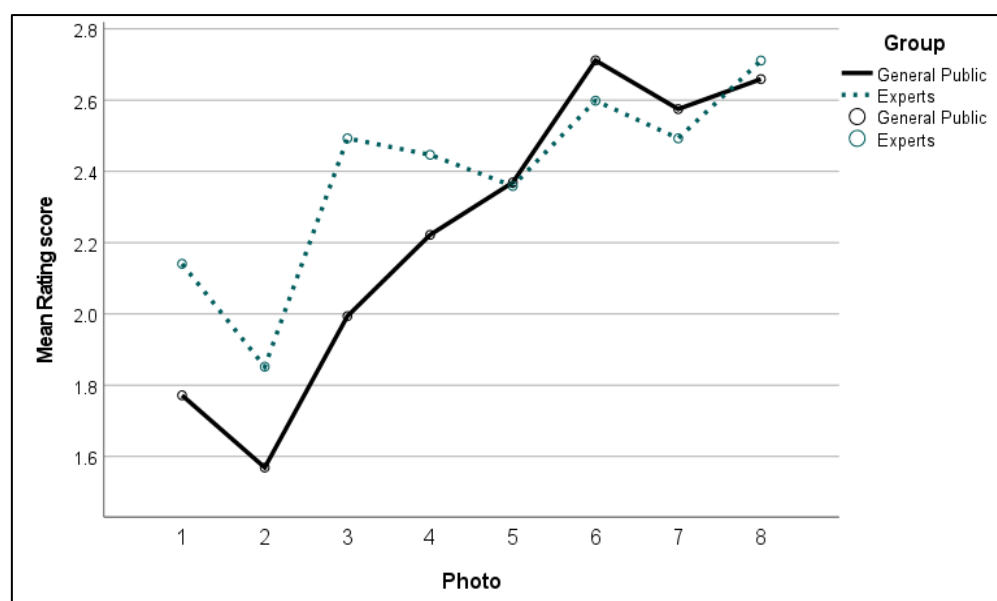


Figure 6. Overall mean rating scores provided by experts and the public for each context.

Table 18 and Figure 6 compare these overall mean rating scores between experts and the general public for each context (photograph). The experts provided significantly higher mean rating scores for the first four contexts (Photos 1–4), than the subsequent four contexts (Photos 5–8).

Table 18. Evaluation of each context by experts and the public.

Photo	Group	Mean	Std. Deviation	<i>p</i> -Value
1	General public	1.78	1.63	0.000
	Experts	2.14	1.44	
2	General public	1.56	1.57	0.005
	Experts	1.86	1.39	
3	General public	2.00	1.59	0.000
	Experts	2.50	1.17	
4	General public	2.22	1.60	0.027
	Experts	2.44	1.27	
5	General public	2.36	1.54	0.917
	Experts	2.36	1.21	
6	General public	2.72	1.48	0.226
	Experts	2.60	1.17	
7	General public	2.58	1.48	0.382
	Experts	2.50	1.21	
8	General public	2.66	1.46	0.580
	Experts	2.72	1.35	

4. Discussion

In testing the impact of the level of expertise and education on perceptions of the maturity of wind turbines as a deployable technology between experts and the public, the analysis indicates no difference between the responses based on gender. Interestingly, the public survey reveals that those with a lower stage of education and a younger age (the ‘young advocates’) were more supportive of WT as a technology, compared to experts between 30 and 50 years old. This may be attributed to the longer length of time growing up with WT encounters, and more acceptance of its technical performance issues, which reinforces the TAM theory that the more exposure and perception of the usefulness of renewable technologies for energy generation, the higher the level of technology acceptance, regardless of level of education. The experts express higher expectations of the technology and the need for further research to improve its performance.

However, confidence in the maturity and performance of the technology is linked to education level and the length of researching WTs. The questionnaire analysis reveals that older experts with a higher level of education had a higher level of confidence in the maturity of WT technology, compared to all categories of the public by age and education. Experts with 5–10 years of research experience with a PhD had more confidence than their younger expert counterparts regarding technology maturity.

By comparing the public and experts’ perceptions of the locations of WT and their responses to the perceived aesthetic, sound, flicker, and safety concerns, the following conclusions were drawn.

The existence of young advocates does not translate to actual WT installations. Although the analysis shows that those younger in age in both groups were amenable to installing WT in their gardens, this acceptance of WT proximity did not translate to acceptance of WT on new or existing buildings. Concerns of light flicker, safety and noise scored lower in the mean rating, tending more towards dislike of these aspects in buildings with integrated WT by both groups alike. Contrary to our initial expectations, the mean rating scores provided for the aesthetics of the moving element of the blades were

highest in most of the photos, leaning towards a liking of this aspect, and lower concern of the public than the experts. The public scored higher than the experts in their liking of moving blades on land and seascapes and indicated more acceptance of this aspect on transportation routes than experts. Expert knowledge of the technical issues resulted in a higher amenable response to wind turbines integrated in buildings, on structures over a motorway and close to a motorway (Photos 1–4), indicating that people's knowledge and expertise reduces their fears of technical and safety concerns regarding proximity to WT.

However, although building WT integration received the lowest scores of all contexts, experts indicate more support for it than the public, which may be attributed to their knowledge and expertise in optimizing positioning on buildings, and in contexts of higher terrain roughness, i.e., urban areas, which affects the energy yield. This indicates that further research is required to improve the performance, design, and integration of urban wind turbines. There is a need to publicize positive outcomes to increase public confidence in the technology, as well as the need to undertake appropriate wind availability mapping of urban contexts for more siting options for installation.

The contexts of WT on buildings, land and seascapes suggest a preference for a distant encounter. The transportation contexts suggest proximity but a shorter duration of encounter, and a personal control over the length of encounter due to vehicular movement. Experts and the public differ in their support of smaller wind turbines that are aesthetically interesting (Photo 6), but may have less energy generation output. Although both group responses show that they are 'liked' more than all the other contexts of building and transport locations, the marginally lower level of acceptance by experts may be attributed to their technical knowledge of the smaller energy yield from each unit. However, the results indicate that intriguing aesthetics of technology may result in higher acceptance of installations from the public.

This research indicates a consistency in the highest levels of acceptance by both the public and the experts for positioning WT in offshore wind farms. This concurs with other research findings in Italy [64], Sweden [65], Chile [66], and in Germany [67]. The analysis also indicates lower preferences for singular WT than wind farms in grouped installations in sea/landscapes. The physical and visual distance from WT of these contexts indicates reduced concern in both groups regarding issues of flicker, blade movement, noise, and safety. However, perceptions and expectations, of both the public and experts, of the visual and spatial amenity of these installations may change when governments start to intensify windfarms onshore and offshore, and with the expected increase in wind turbines' size and scale.

However, the surprising ranking of a transportation context (Photo 6 in Figure 1), as the second preference for location, which closely followed the seascape WT positioning, departs from previous findings. Molnarova et al. [68] stated that wind turbines are more tolerated if the structures are kept away from observation points of transportation infrastructure and viewpoints. This research points towards a shift in acceptance of both public and expert acceptance if wind turbines can be developed to be smaller in size, and are a more aesthetically intriguing technology with an improved energy generation capacity, life span and material consumption. Acceptance of singular WT in infrastructure settings is promising in terms of acceptance of their positioning in contexts where the duration of exposure is limited, but acceptance seems to decrease in transportation contexts where WT are in close proximity and exposure may be for longer durations, such as parking a car next to a WT.

Building-integrated wind turbines are the least accepted by both the public and the experts, and have tended to receive poor publicity that undermines confidence in their performance and in capital investment. However, experts tend to more readily accept this form of WT than the public and are markedly less concerned about their safety. Research on improving the performance and visual amenity of building-integrated WT is emerging. Studies continue to develop methods to harness the best wind velocities, direction, and availability in urban environments.

5. Conclusions

It is important to note the European and UK governments' efforts to combat climate change and curb carbon emissions from fossil fuels. The recent war on Ukraine and various political events since 1970, which have led to oil supply shocks, necessitate strategic provisions regarding diversified energy supply to reduce dependence on politically unstable economies. It is expected that the coming decades will experience an exponential growth in green sources of energy and the need for more wind farms and individual wind turbine installations.

This research contrasted the perceptions of experts versus non-experts in the positioning of wind energy generation installations in various urban and natural settings. A composite survey was undertaken, consisting of semi-structured questions and a visual survey, to collect responses regarding the degree of knowledge, acceptance of proximity, length of exposure and distance to wind turbines. These perceptions are crucial for planners and manufacturers in understanding where efforts need to be directed to address public concerns and improve acceptance of the deployment of wind turbine projects.

An upwards shift in positive perceptions towards WT as a mature technology and in acceptance of proximity to the technology is demonstrated in the responses of the younger advocates from the public, as well as from experts who have spent a considerable number of years researching and improving the technology. Acceptance of wind turbines in sea-scapes remains the highest, followed closely by contexts of transportation routes. This also indicates that acceptance of the technology is governed by the choice of exposure time, where an aesthetic appearance is also appreciated.

Experts and non-experts differ in their perceptions of the dominance of environmental effects on perceptions of WT, such as noise, safety and flicker.

The least acceptable positioning remains to be in built environments, although the experts are more amenable to positioning the technology in this context than the public. Experts prefer to position the WT in locations that prioritize maximum energy yield, and are less prone than the public to be influenced by the negative publicity that this positioning has received in the media.

Author Contributions: Conceptualization, N.H. and R.P.B.; methodology N.H. and R.P.B.; software, formal analysis, L.C.; investigation, all authors; resources, WinerCOST TU1304, Malta University and Newcastle University; data curation N.H. and R.P.B.; writing—original draft preparation, N.H.; writing—review and editing, all authors.; project administration, N.H. and R.P.B.; funding acquisition, C.B. All authors have read and agreed to the published version of the manuscript.

Funding: WINERCOST TU1304, Malta University, University of Malta and Newcastle University, UK.

Data Availability Statement: Newcastle University UK and University of Malta, Malta.

Acknowledgments: We would like to acknowledge the EU funded project WINERCOST TU1304 for funding the undertaking of the first stage of this questionnaire. We would also like to thank University of Malta and Newcastle University for funding the SurveyMonkey costs and the academic time spent on the study.

Conflicts of Interest: There are no conflicts of interest.

References

1. Kondili, E.; Kaldellis, J.K. Environmental–social benefits/impacts of wind power. In *Comprehensive Renewable Energy Encyclopedia*, Kaldellis, ed.; Chapter in the Wind Energy; Sayigh, A., Eds; Elsevier: Amsterdam, The Netherlands, 2012.
2. Borg, R.P.; Hamza, N.; Norton, C.; Efstathiades, C.; Marciukaitis, M. Urban Wind Energy: Social, Environmental and Planning Considerations. In Proceedings of the Harvesting Wind Energy Conference, Cantanzaro, Italy, 21–23 March 2018. Available online: www.researchgate.net (accessed on 1 September 2020).
3. World Energy Council. *Comparison of Energy Systems Using Life Cycle Assessment*; World Energy Council: London, UK, 2004.
4. Saidur, R.; Rahim, N.; Islam, M.; Solangi, K. Environmental impact of wind energy. *Renew. Sustain. Energy Rev.* **2001**, *15*, 2423–2430.
5. Hammar, L.; Wikström, A.; Molander, S. Assessing ecological risks of offshore wind power on Kattegat cod. *Renew. Energy* **2014**, *66*, 414–424.

6. Wang, S.; Wang, S.; Liu, J. Life-cycle green-house gas emissions of onshore and offshore wind turbines. *J. Clean. Prod.* **2019**, *210*, 804–810.
7. *Herons von Alexandria Druckwerke und Automatentheater*; Hero “Pneumatika, Book II, Chapter XI”; Schmidt, W., Translator; B.G. Teubner: Leipzig, Germany, 1899; pp. 228–232. (In Greek and German)
8. Global Wind Report 2017. GWEC: Wind Power Industry to Install 71.3 GW in 2020, Showing Resilience during COVID-19 Crisis | Global Wind Energy Council. Available online: <https://gwec.net/publications/global-wind-report-2/> (accessed on 30 July 2018).
9. International Energy Agency. IEA Wind, TCP Annual Report. 2020. Available online: www.iea.org/reports/world-energy-outlook-2020 (accessed on 10 January 2022).
10. Suskevics, M.; Eiter, M.; Martinat, S.; Stober, D.; Voller, E.; Boer, C.; Buschecker, M. Regional variation in public acceptance of wind energy development in Europe: What are the roles of planning procedures and participation? *Land Use Policy* **2019**, *81*, 311–323.
11. Capellán-Pérez, I.; de Castro, C.; Arto, I. Assessing vulnerabilities and limits in the transition to renewable energies: Land requirements under 100% solar energy scenarios. *Renew. Sustain. Energy Rev.* **2017**, *77*, 760–782.
12. *Eurobarometer: European Citizens’ Knowledge and Attitudes Towards Science and Technology, European Citizens’ Knowledge and Attitudes Towards Science and Technology*; Eurobarometer Survey: European Union, 2021; p.98. Available online: eurobarometer@ec.europa.eu (accessed on 11 July 2022).
13. Gupta, N.; Fischer, A.; Frewer, L. Socio-psychological determinants of public acceptance of technologies: A review. *Public Underst. Sci.* **2012**, *21*, 782–795.
14. Walker, G.; Devine-Wright, P. Community renewable energy: What should it mean? *Energy Policy* **2008**, *36*, 497–500.
15. O’Driscoll, A.; Claudy, M.; Peterson, M. Understanding the attitude-behavior gap for renewable energy systems using behavioral reasoning theory. *J. Macromark.* **2013**, *33*, 273–287.
16. Brinkman, J.; Hirsh, R. Welcoming Wind Turbines and the PIMBY “Please in My Backyard” Phenomenon: The Culture of the Machine in the Rural American Midwest. *Technol. Cult.* **2017**, *58*, 335–367.
17. Ek, K.; Persson, L. Wind farms where and how to place them? A choice experiment approach to measure consumer preferences for characteristics of wind farm establishments in Sweden. *Ecol. Econ.* **2014**, *105*, 193–203.
18. Boyle, K.; Boatwright, J.; Brahma, S.; Xu, W. NIMBY, not, in siting community wind farms. *Resour. Energy Econ.* **2019**, *57*, 85–100.
19. Sposato, R.; Hampl, N. Worldviews as predictors of wind and solar energy support in Austria: Bridging social acceptance and risk perception research. *Energy Res. Soc. Sci.* **2018**, *42*, 237–246.
20. Baxter, J.; Walker, C.; Ellis, G.; Devine-Wright, P.; Adams, M.; Fullerton, R. Scale, history and justice in community wind energy: An empirical review. *Energy Res. Soc. Sci.* **2020**, *68*, 101532.
21. Wüstenhagen, R.; Wolsink, M.; Bürer, M.J. Social acceptance of renewable energy innovation: An introduction to the concept. *Energy Policy* **2007**, *35*, 2683–2691.
22. Efstathiades, C. The role of local authorities in the engagement of small wind turbines in urban areas. In Proceedings of the WINERCOST Action TU1304, International Conference, Coimbra, Portugal, 30–31 March 2015.
23. Borg, R.P.; Huber, S. Social, Environmental and Planning Considerations of Wind Energy Technology in the Built Environment. In Proceedings of the Work Group 3: Introduction, WINERCOST Action TU1304, International Conference, Coimbra, Portugal, 30–31 March 2015.
24. Teschner, N.A.; Alterman, R. Preparing the ground: Regulatory challenges in siting small-scale wind turbines in urban areas. *Renew. Sustain. Energy Rev.* **2017**, *81*, 1660–1668.
25. Norton, C. Planning and environmental considerations for the development of wind energy in the urban environment. In Proceedings of the WINERCOST Action TU1304, International Conference, Coimbra, Portugal, 30–31 March 2015.
26. Radun, J.; Maula, H.; Saarinen, P.; Keränen, J.; Alakoivu, R.; Hongisto, V. Health effects of wind turbine noise and road traffic noise on people living near wind turbines. *Renew. Sustain. Energy Rev.* **2022**, *157*, 1–13.
27. Mariel, P.; Meyerhoff, J.; Hess, S. Heterogeneous preferences toward landscape externalities of wind turbines—combining choices and attitudes in a hybrid model. *Renew. Sustain. Energy Rev.* **2015**, *41*, 647–657.
28. Pasqualetti, M.; Stremke, S. Energy landscapes in a crowded world: A first typology of origins and expressions. *Energy Res. Soc. Sci.* **2018**, *36*, 94–105.
29. Therkildsen, O.R.; Balsby, T.J.; Kjeldsen, J.P.; Nielsen, R.D.; Bladt, J.; Fox, A.D. Changes in flight paths of large-bodied birds after construction of large terrestrial wind turbines. *J. Environ. Manag.* **2021**, *290*, 112647.
30. Reusswig, F.; Braun, F.; Heger, I.; Ludewig, T.; Eichenauer, E.; Lass, W. Against the wind: Local opposition to the German Energiewende. *Util. Policy* **2016**, *41*, 214–227.
31. Abohela, I.; Hamza, N.; Dudek, S. Effect of roof shape, wind direction, building height and urban configuration on the energy yield and positioning of roof mounted wind turbines. *Renew. Energy* **2013**, *50*, 1106–1118.
32. Baygulen, O.; Benegal, S. Green Priorities: How economic frames affect perceptions of renewable energy in the United States. *Energy Res. Soc. Sci.* **2019**, *47*, 28–36.
33. Griesera, B.; Sunak, Y.; Madlener, R. Economics of small wind turbines in urban settings: An empirical investigation for Germany. *Energy Policy* **2015**, *78*, 33435.
34. Rountree, V. Nevada’s experience with the Renewable Portfolio Standard. *Energy Policy* **2019**, *129*, 279–291.

35. Cordoves-Sanchez, M.; Vallejois-Romero, A. Social Construction of Risk in nonconventional renewable energy: Risk perception as a function of ecosystem services in La Araucania, Chile. *Ecol. Econ.* **2019**, *159*, 261–270.
36. Chappell, E.N.; Parkins, J.R.; Sherren, K. Climax thinking, place attachment, and utilitarian landscapes: Implications for wind energy development. *Landsc. Urban Plan.* **2020**, *199*, 103802. <https://doi.org/10.1016/j.landurbplan.2020.103802>.
37. Davis, F.D. Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Q.* **1989**, *13*, 319–340.
38. Venkatesh, V.; Bala, H. Technology Acceptance Model 3 and a Research Agenda on Interventions. *Decis. Sci.* **2008**, *39*, 273–315.
39. Karasmanaki, E.; Tsantopoulos, G. Exploring future scientists' awareness about and attitudes towards renewable energy sources. *Energy Policy* **2019**, *131*, 111–119.
40. Karatepe, Y.; Neş, S.V.; Keçebaş, A.; Yumurtacı, M. The levels of awareness about the renewable energy sources of university students in Turkey. *Renew. Energy* **2012**, *44*, 174–179.
41. Zyadin, A.; Puhakka, A.; Ahponen, P.; Cronberg, T.; Pelkonen, P. School students knowledge, perceptions, and attitudes toward renewable energy in Jordan. *Renew. Energy* **2012**, *45*, 78–85.
42. Ozil, E.; Ugursal, V.I.; Akbulut, U.; Ozpınar, A. Renewable energy and environmental awareness and opinions: A survey of university students in Canada, Romania, and Turkey. *Int. J. Green Energy* **2008**, *5*, 174–188.
43. Peri, E.; Becker, N.; Tal, A. What really undermines public acceptance of wind turbines? A choice experiment analysis in Israel. *Land Use Policy* **2020**, *99*, 105113.
44. Bronfman, N.C.; Jiménez, R.B.; Arévalo, P.C.; Cifuentes, L.A. Understanding social acceptance of electricity generation sources. *Energy Policy* **2012**, *46*, 246–252.
45. Jobert, A.; Pia, L.; Solveig, M. Local acceptance of wind energy: Factors of success identified in French and German case studies. *Energy Policy* **2007**, *35*, 2751–2760.
46. Willis, K.; Scarpa, R.; Gilroy, R.; Hamza, N. Renewable energy adoption in an ageing population: Heterogeneity in preferences for micro-generation technology adoption. *Energy Policy* **2011**, *39*, 6021–6029.
47. Firestone, J.; Bates, A.; Knapp, L. See me, Feel me, Touch me, Heal me: Wind turbines, culture, landscapes, and sound impressions. *Land Use Policy* **2015**, *46*, 241–249.
48. Maehr, A.M.; Watts, G.R.; Hanratty, J.; Talmi, D. Emotional response to images of wind turbines: A psychophysiological study of their visual impact on the landscape. *Landsc. Urban Plan.* **2015**, *142*, 71–79.
49. Spielhofer, R.; Thrash, T.; Hayek, U.; Grêt-Regamey, A.; Salak, B.; Gröbel, J.; Schinazi, V.R. Physiological and behavioral reactions to renewable energy systems in various landscape types. *Renew. Sustain. Energy Rev.* **2021**, *135*, 110410.
50. Hamza, N. The sustainable high rise building: Renewables and public perceptions. In *The Sustainable High Rise Buildings in Urban Zones*; Springer: Berlin/Heidelberg, Germany, 2016.
51. Long, Y.; Tang, M.; Liao, H. Renewable energy source technology selection considering the empathetic preferences of experts in a cognitive fuzzy social participatory allocation network. *Technol. Forecast. Soc. Change* **2021**, *175*, 121317. Available online: www.sciencedirect.com.
52. WINERCOST. TU1304. In Proceedings of the Memorandum of Understanding, COST Association, Brussels, Belgium, 22 November 2013.
53. Hamza, N.; Borg, R.; Baniotopoulos, C. Urban wind turbines for smart cities: Capturing the perceptions of EU experts. In Proceedings of the SBE Malta, University of Malta, Msida, Malta, 21–22 November 2019. Available online: researchgate.com (accessed 5 July 2020).
54. Couper, M.P.; Conrad, F.G.; Tourangeau, R. Visual Context Effects in Web Surveys. *Public Opin. Q.* **2007**, *71*, 623–634. <https://doi.org/10.1093/poq/nfm044>.
55. Leiserowitz, A. Climate change risk perception and policy preferences: The role of affect, imagery, and values. *Clim. Change* **2006**, *77*, 45–72.
56. Epstein, S. Integration of the cognitive and the psychodynamic unconscious, American. *Psychology* **1994**, *49*, 709–724.
57. Slovic, P.; MacGregor, D.G.; Peters, E. *Imagery, Affect, and Decision Making*; Decision Research: Eugene, OR, USA, 1998. Available online: scholarsbank.uoregon.edu (accessed on 14 December 2020).
58. O'Neill, S.; Boykoff, M.; Niemeyer, S.; Day, S. On the use of imagery for climate change engagement. *Glob. Environ. Chang.* **2013**, *23*, 413–421.
59. Boomsma, C.; Goodhew, J.; Goodhew, S.; Pahl, S. Improving the visibility of energy use in home heating in England: Thermal images and the role of visual tailoring. *Energy Res. Soc. Sci.* **2016**, *14*, 111–121.
60. Sheppard, S.; Salter, J. Landscape and Planning | The Role of Visualization in Forest Planning. In *Encyclopedia of Forest Sciences*; Burley, J., Ed; Elsevier: Amsterdam, The Netherlands, 2004; pp. 486–498.
61. Hamza, N.; DeWilde, P. Building simulation visualization for the boardroom: An exploratory study. *J. Build. Perform. Simul.* **2014**, *7*, 52–67.
62. Cousse, J.; Wüstenhagen, R.; Schneider, N. Mixed feelings on wind energy: Affective imagery and local concern driving social acceptance in Switzerland. *Energy Res. Soc. Sci.* **2020**, *70*, 101676.
63. Cranmer, A.; Ericson, J.; Broughel, A.; Bernard, B.; Robicheaux, E.; Podolski, M. Worth a thousand words: Presenting wind turbines in virtual reality reveals new opportunities for social acceptance and visualization research. *Energy Res. Soc. Sci.* **2020**, *67*, 101507.

-
64. WINERCOST. COST Action. In Proceedings of the TU13040 Wind Energy Harvasting, Cantnazaro-Lido, Italy, 21–23 March 2018.
 65. Vecchiato, D. How do you like wind farms? Understanding people's preferences about new energy landscapes with choice experiments. *Aestimum* **2014**, 15–37. Available online: [researchgate.com](https://www.researchgate.com) (accessed on 1 January 2021).
 66. Aravena, C.; Martinsson, P.; Scarpa, R. The effect of a monetary attribute on the marginal rate of substitution in a choice experiment. In Proceedings of the Environmental and Resource Economists 3rd World Congress, Kyoto, Japan, 3 July 2006.
 67. Salomon, H.; Martin Drechsler, M.; Reutter, F. Minimum distances for wind turbines: A robustness analysis of policies for a sustainable wind power deployment. *Energy Policy* **2020**, *140*, 111431.
 68. Molnarova, K.; Sklenicka, P.; Stiborek, J.; Svobodova, K.; Salek, M.; Brabec, E. Visual preferences for wind turbines: Location, numbers and respondent characteristics. *Appl. Energy* **2012**, *92*, 269–278.