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UPWARDS

Deliverable 7.1

Literature review on social and environmental issues and acceptance of wind turbines

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Deliverable abstract

This report presents findings of literature review on social and environmental issues and acceptance of wind turbines in Europe as part of the UPWARDS project. Opposition to wind energy developments is often framed as the main challenge and a major issue for governance. This study shows that acceptance or the lack thereof are just two possible manifestations of attitudes towards wind energy. In line with the recent works that propose a critical perspective on acceptance, this study has outlined a more holistic approach focusing on engagement with wind turbines. This approach requires interdisciplinary research on wind energy systems. Furthermore, understanding how society engages with wind energy in the context of different landscapes can help to reveal the potential and constraints for participation that goes beyond organized public engagement.

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1. Introduction

This report presents findings of literature review on social and environmental issues and acceptance of wind turbines in Europe as part of the H2020 UPWARDS project. UPWARDS is an interdisciplinary research and innovation project on wind turbine technology, aiming to contribute to promotion of socially, environmentally and technically robust wind energy in Europe.

This report presents the results of the first step in research and innovation on wind turbines of WP7 within the UPWARDS project. By reviewing literature on the social and environmental aspects and acceptance of wind energy in the European context, this report lays the foundation for the next research steps in the project. First, the findings from this literature review will be used to develop an innovative and interdisciplinary approach to wind energy modelling. The purpose of such an approach is aligning technological innovation with societal needs, values and practices which is needed to develop socially robust wind turbines. Secondly, this literature review provides a conceptual basis for designing research methodology for the next step of this research project: an empirical study on social and environmental aspects of wind energy in Europe. Finally, some notes are included on how the results from this deliverable may contribute to the modelling efforts within the UPWARDS project.

This literature study contributes to the PhD research of Helena Solman, under supervision of dr. Mattijs Smits at Wageningen University and Research in the Netherlands.

Scope of the report: societal challenges of wind energy sector in Europe

The scope of societal concerns with respect to wind energy is very broad and the goal of this report is to summarize and to evaluate what the state of art knowledge about these concerns as reported by academic literature focusing on the European context. Positioned in the context of energy transitions that European countries are undergoing, this study looks particular into the social and environmental challenges of wind energy systems. These challenges can be considered problems of governance, largely due to the public nature of wind energy landscapes. In order to shed a light on these challenges in the context of Europe, this study examined literature on the acceptance and opposition to wind energy and developed a novel approach to studying social, environmental and technical issues around wind energy. Within this literature study, particular attention was paid to the diversity of

concerns that society expressed with respect to wind energy developments. Based on the findings, this study makes a careful distinction between concerns that relate to wind turbines design and technology, and issues that relate to chosen locations, landscape impacts and land use change. On top of that this review identified another category of concerns that pertain to the process of wind energy developments, and so they do not link to scepticism for wind energy. Summarising concerns with respect to wind energy in the European context, this study identified concerns that communities might experience even long before and after wind turbines/parks are implemented. Next to the extensive temporal perspective, this literature study looked into a variety of locations for wind energy projects, including both offshore and onshore wind energy.

2. Social and environmental science research on wind energy

Globally, there is an ongoing transition of conventional energy systems toward alternative energy sources. Renewable energy is the key solution at the moment and the major options include hydropower, solar energy, biomass, wind energy and geothermal energy. Wind energy is the fastest growing source of renewable energy in the world, with a significant expansion planned for the future (Saidur, Islam, Rahim, & Solangi, 2010). European countries set ambitious goals in respect to renewable energy, with a most recent target of 35% for 2030. For wind energy in Europe, these goals translate into rapid and substantial growth of wind development (European Wind Energy Association, 2012). Most of the big wind energy parks are, and increasingly will be concentrated on the sea or along the coastline (offshore), but a vast amount of developments will also need to take place inland (onshore). In spite of this potential and envisioned levels of developments, wind energy developments often face various forms of societal resistance (van der Horst, 2007). As a result of opposition, wind energy developments are often delayed, stopped or even removed after being already implemented (Rand & Hoen, 2017). This contradiction between planned levels of development and lack of public acceptance is problematic as failed projects and unimplemented plans may contribute to a delay in climate change mitigation plans and economic losses (Pasqualetti, 2011). In the future, the problem of carrying out wind energy developments can only be expected to amplify, as wind energy will increasingly be located in proximity of populated areas, with bigger wind parks and taller turbines (MacLeay & den Hollander, 2018). It is however not only proximity that explains attitudes toward wind energy, as the social aspect of wind energy systems are complex and difficult to use for explaining acceptance or opposition.

Objective of this literature review

Considering the societal challenges of wind energy system in Europe that manifests in opposition to wind energy developments, the objective of this literature review is to investigate the state-of-the-art knowledge about acceptance of wind energy in Europe and identify what aspects of wind energy cause societal concern. To enable such a holistic reporting of wind energy literature, this review performs a critical interdisciplinary investigation of the debate of acceptance. Doing so this study will reflect on the extent to which the concepts of acceptance and opposition justly explain why society resists wind energy developments.

Research questions

This literature review answers the following research question: **What societal concerns with respect to wind energy are currently evident in Europe?**

In order to answer the main research question, four sub-research questions are asked. These questions build on each other to cumulatively build knowledge needed to answer the main research question.

1. What is the state of art of the debate on acceptance?
2. What are the societal concerns with respect to wind turbine technology and landscape in wind energy developments in Europe?
3. Are there societal concerns with respect to wind energy developments that do not relate to wind energy directly but affect the outcomes of wind energy developments in Europe?
4. What types of engagement with technology and landscape can be identified at different stages of wind energy governance?

3. Methodology and Research Methods

This literature review takes a broad scope for the investigation of acceptance and concerns pertaining to wind energy in European context. First, this study investigates literature on acceptance of wind energy, and when relevant of renewable energy. Secondly, this review investigated empirical studies on wind energy to create an inventory of concerns reported in Europe. The analysis of the literature on acceptance was focused on identifying definitions of acceptance. The analysis of the empirical literature was focused on identifying concerns that people might have with respect to wind energy. In addition to the literature on wind energy, this study draws on theoretical literature on engagement in order to better understand the relationship of society with technology and the way in which society can be involved in co-production of sustainability technologies.

This review is an interdisciplinary and critical investigation of the debate of acceptance of wind energy, that bridges different academic disciplines such as: spatial planning, landscape architecture, geography, sociology, psychology, political sciences and sociological studies of technology to contribute to the understanding of wide range of concerns with respect to wind energy.

Considering the interdisciplinary focus, the assumption that underlies this review is that that bits and pieces of knowledge regarding acceptance of renewable energy already exist, but they are strongly departmentalized in the bodies of literature that belong to the different academic disciplines.

Credibility

In order to increase the credibility of the findings of this literature review, we followed a transparent way of reviewing the literature in terms of using clear inclusion and exclusion criteria, outlined below. The transparency of procedures also applies to the process of conducting analysis and reporting. By taking these steps in an organized and predefined way, the researcher bias can be limited. Consequently, this review follows the instructions of (Popay et al., 2006) with respect to reporting the choices that need to be made with the reader, explaining the trajectory of the study and identifying potential limitations.

Sampling

Scientific publications were found using the following search engines: Scopus, Google Scholar, WUR library and Web of Science. Additional publications were identified for review through backward and forward reference checking. The most important keywords (combinations of keywords) included: acceptance + wind energy, opposition + wind energy, environmental impacts + wind energy, concerns + wind energy, wind energy developments, community energy, energy landscapes, energy transition, governance + sustainability transitions, renewable energy, participation + wind energy.

These search terms had to appear in the title (TITLE), abstract (ABS) or key words (KEY), with possible synonyms for key words. For example, 'engagement' included synonyms such as 'participation', 'involvement'.

Data gathered from the review of academic publications is organised in a table (Excel sheet, see attachment 1) that summaries and categorises information into following topic of interest:

1. Author(s)
2. Year
3. Title
4. Type of document
5. Journal/ publisher
6. Territorial focus
7. Renewable/Onshore/ offshore/
8. Theoretical perspective
9. Research objective
10. Definition and contra- definitions of acceptance
11. Societal concerns
12. Stage in the timeline and corresponding form of engagement
13. Example of a form of engagement
14. Recommendations
15. Extra information

4. Findings

Reviewed academic publications on wind energy in Europe: summary of data

This literature review analysed in depth 51 academic works on acceptance and societal concerns with respect to wind energy in Europe, published between 1993 and 2018. The distribution of publications per year is visualized in Figure 1.

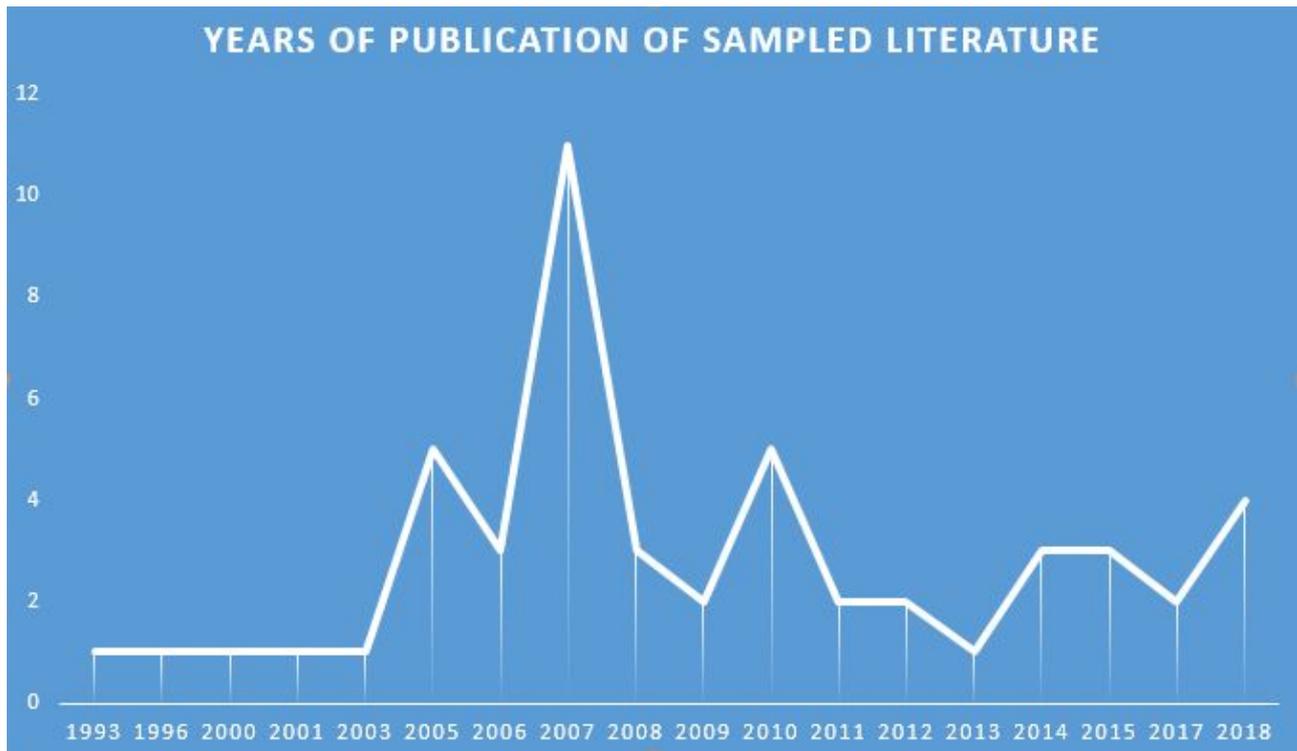


Figure 1. Sampled publications about wind energy: distribution of publication year

Given the interdisciplinary focus of this study, the selected publications were published in variety of academic journals. Figure 2 lists and visualizes the distribution.

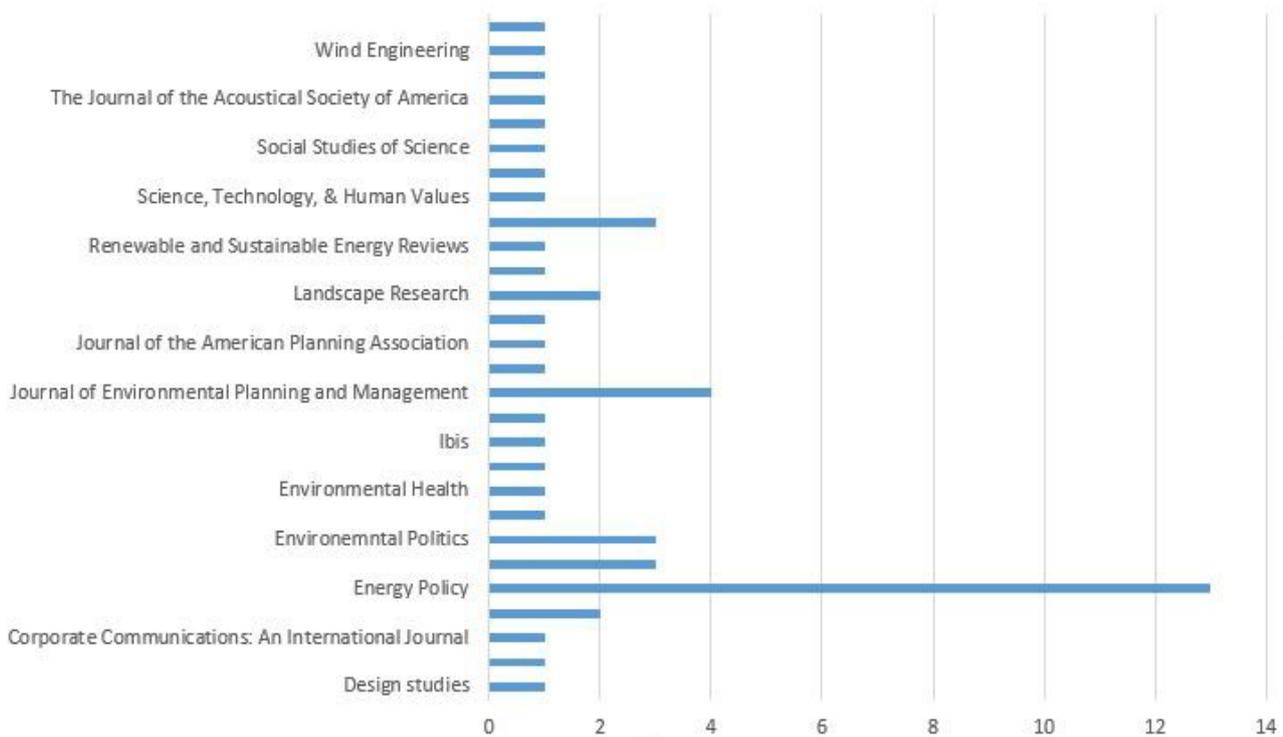


Figure 2. Sampled publications: Amount of sampled publications about wind energy per journal

Because this study focuses on European context, this literature study excluded from sample publications that pertained to non-European context, which mostly referred to publications about North American wind energy sector. Within Europe, most of the sampled papers covered the wind energy sector in Western Europe, including the UK, the Netherlands, Denmark, Germany, Belgium and France (Figure 3). This lack of publications from East and Southern Europe may be an indication that the wind energy sector in those countries is still in maturing phase and much research still needs to be done considering the social and environmental factors of wind energy in those countries. Furthermore, it provides some limitations in terms of generalizability of the findings outside of Western Europe.

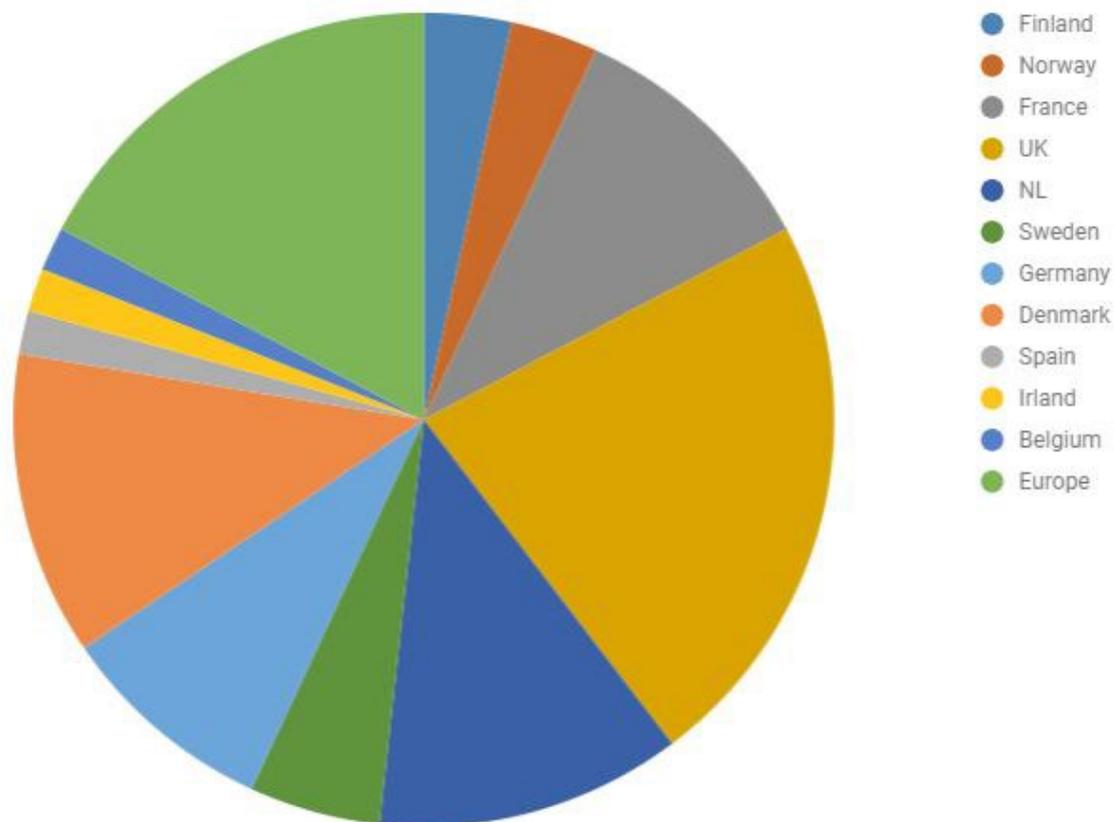


Figure 3. Territorial focus of sampled publications

Definition of acceptance

This literature study revealed that acceptance is a highly debated concept and various definitions of acceptance are used in the literature on renewable energy, including wind energy.

Traditional approach to acceptance

One of the most commonly used definitions of acceptance is the one presented by Wüstenhagen, Wolsink, and Bürer (2007) with 1551 times being referenced as of November 2018. According to the authors there are three categories of 'social acceptance of renewable energy innovation', these are: socio-political acceptance, market and community acceptance. At the most general level there is the 'socio-political acceptance' that refers to public support for renewable technology and policy in general. 'Market acceptance' refers to the extent to which renewable technologies are successfully adopted by the market. Here, the diffusion of renewable technologies is interpreted in terms of market mechanisms, such as competitiveness compared to other energy technologies (Wüstenhagen et al., 2007).

These two types of acceptance are important for the broader context of wind energy sector, but they do not determine the acceptance on their own (Wüstenhagen et al., 2007). Eventually, whether renewable energy project are accepted or not at the local level depends on 'community acceptance' that is shaped through interactions between stakeholders which lead to subjective evaluations of the level of justice and the fairness of the distributions of costs and benefits of renewable technology developments (Wüstenhagen et al., 2007). This definition has been critical in bringing nuance to the concept of acceptance as varied between the general level at which sustainability technologies gain public support (socio-political /market acceptance) and the local level. As it turns out, the general public support for wind energy should not be mistaken with acceptance for actual wind energy projects at the local level (Bell, Gray, & Haggett, 2005).

Critiquing the concept of acceptance

While it can be argued that acceptance is helpful in moving away from interpreting general public support for renewable energy as a sign of acceptance for renewable energy developments, there are several limitations to this approach. First of all, this literature review shows an increasing scepticism of academics towards the concept of acceptance. The reason for this scepticism is that acceptance is a static concept which carries a largely top-down perspective that is not unique for wind energy but relate to the general approach to governance of technologies that 'need to be accepted' (Chilvers, 2012). For example, in the conceptualisation of Wüstenhagen et al. (2007), acceptance becomes almost a quality of communities who either accept renewable energy developments or oppose it. This binary and static view of acceptance does not improve the understanding of how acceptance emerges and what the real-life spectrum and contingencies of acceptance are. A more nuanced line of reasoning, helps to discover that the extent to which people accept renewable energy is not hundred percent positive or negative, but it can include a wide array of possibilities in between (Chilvers & Longhurst, 2016).

In response to the criticism for the concept of acceptance, improvements to the concept as well as new ones were proposed. One of the propositions is to use concept of acceptability instead of acceptance or next to it (Cowell, Bristow, & Munday, 2011; Szarka, 2006). One way to use both concepts is by applying acceptance to represent public perceptions *ex post* of wind energy project implementation and acceptability *ex ante* wind energy developments take place (Cowell et al., 2011). This study has found that this distinction was helpful for studies that aim to show difference in perceptions of local communities towards projects

before and after projects were implemented. Indeed, based on a study on UK-based wind farm development (Eltham, Harrison, & Allen, 2008) there are reasons to believe that attitudes can change towards more positive over time as people get used to living in the proximity of wind turbines and start perceiving wind turbines in more positive light after their initial fears and concerns do not come true. A study on perceptions of risks related to renewable energy (Parkhill, Pidgeon, Henwood, Simmons, & Venables, 2010) also shows that this might be because people tend to accept thinking that happen in their lives even if somehow unpleasant.

The concept of acceptability is also used to replace the static concept of acceptance to emphasise the situatedness and conditions under which people approve of wind energy developments and to show the dynamic process of decision-making (Szarka, 2006). Whereas it is useful to think conceptually about the temporal dimension of wind energy developments and the ways in which attitudes change, this review study has found that both concepts of acceptability and acceptance are criticised by scholars who advocate more active and grassroots forms of getting involved with renewable energy technologies than being invited to appropriate technologies (Chilvers, 2008; Ryghaug, Skjølsvold, & Heidenreich, 2018; Wynne, 2007).

The relevance of the concept of acceptance for understanding the challenges of the wind energy sector

Acceptance and acceptability of renewable energy, including wind energy, remains ambiguous and there are various misconceptions about how the public relates to wind energy (Aitken, 2010). These fallacies include a belief that “the majority of the public supports wind power, opposition to wind power is therefore deviant, opponents are ignorant or misinformed, the reason for understanding opposition is to overcome it and that trust is key” (Aitken, 2010, p.1834). Understanding attitudes of the broader public as well as involved residents in line with these misconceptions leads to that their concerns in respect to wind energy are often questioned as illegitimate and against common good (Wolsink, 2000). Mitigating opposition is therefore counterproductive because it only stigmatises those expressing their concern with labels such as NIMBY (Not in My Backyard), which not only proved to be inadequate (Bell et al., 2005; Burningham, Barnett, & Walker, 2015) but also do not offer constructive solutions to the problem of opposition. Instead of trying to mitigate the opposition, planners and developers of wind energy developments should first

understand the concerns that each community might have and then address these concerns already at the early stages of the planning process (Bauwens & Devine-Wright, 2018). This is why, to understand the challenges of wind energy sector in Europe, manifesting as resistance or opposition, this review further investigates the concerns that society might have with respect to wind energy without attempting to associate them with acceptance and opposition. Instead, this review will identify and categorise these concerns and it will look into existing knowledge about governance approaches that are helpful in anticipating and preventing those concerns.

Societal concerns with respect to wind energy

As discussed in the previous section, acceptance is a contested term that often fails to capture the complexity of public perceptions on wind energy. This review found that acceptance is a generic and static concept and as such it cannot explain a large variety of concerns that society has with respect to wind energy and wind energy developments in general. This review of literature aimed to provide such knowledge by focusing on reviewing societal concerns with respect to wind energy. Analysing the sampled literature on societal concerns, three themes emerged in relation to concerns related to wind energy. These thematic concerns include: landscape, wind turbines technology and design, process of wind energy developments. These themes emerged inductively- the researcher coded the data which was then grouped into categories and finally overarching themes. These themes also appeared in similar way of phrasing in the studied literature, for example landscape and process was discussed by Nadai & van der Horst (2010) and wind turbine technology and design by Joviet & Heiskanen (2010).

First, **concerns about landscape** play a major role in shaping peoples' attitudes towards wind energy (Devine-Wright, 2005). Landscape, as a broad category of concerns that people might have with respect to wind energy can relate to a vast amount of place-based issues that come up when locations for wind turbines are being proposed. Landscape-related concerns with respect to wind energy developments are very likely to continue increase in the future, as at the moment only 2% of landscape is used for energy facilities but an estimated 20 % of landscape is needed for a complete transition to alternative energy (Stremke, Van Den Dobbelsteen, & Koh, 2011).

Secondly, studies show that opposition to wind developments may also be linked to **concerns related to the wind turbine design and technology**, for example as a fear for negative effects of wind turbine noise and shadow flicker (Knopper & Ollson, 2011)

Thirdly, this review has found that the causes for resistance to wind energy developments may not only relate to wind energy in any way, but to **the way in which wind energy projects are planned and implemented**. The main reason for concerns related to process tends to be a lack of participation (Wolsink, 2000) and perceived lack of fairness of the planning process which may take a form of an unequal distribution of benefits (Cowell et al., 2011) or a lack of community ownership of the projects (Nadaï & van der Horst, 2010).

This review presents a holistic overview of concerns for each of these three themes. These concerns may not be representative of all the possible concerns that exist, but they indicate the scope and nature of concerns that are likely to be held by societal actors. Importantly, these concerns should not be seen solely as causal variables but as aspects of wind turbine technology and design that interact with each other as well as with the broad range of concern linked to landscape and process. This means that on their own, they hardly can explain perceptions of wind energy, but they are often used to frame opposition and motivate resistance, which makes them important point for consideration.

Concerns with respect to wind turbine technology

Wind power is a highly-contested source of energy and wind turbine technology and design has may harness the problem as experienced by European society. The controversies of wind power technology and design were more sparsely discussed in the studied literature compared to concerns related to process or landscape. As a result of this partial gap in literature, little is known about what society thinks of wind turbine design and if the current designs correspond with needs and practices of society or not. The studied literature indicates that there is a reason to believe that the standardisation of wind turbine technology and design leaves little flexibility for societal actors for adaptations. Such adaptations in management and operation of wind turbines could be beneficial for addressing a broad range of societal concerns. For example, a common concern with respect to wind turbines is that they pose danger to birds and bats (Dai, Bergot, Liang, Xiang, & Huang, 2015). This danger could be mitigated by turning the turbines off in important movements of for example bird migrations. This adaptive approach can be seen as a compromise between social and environmental values and needs that needs to be accounted for (Nadaï & Labussière, 2010). However, to enable this kind of evaluations and to identify where flexibility and adaptations in design are desired, a better understanding is needed over how does society perceive the functionality and design of wind energy technologies in the context of different

landscapes. In this way, societal concerns with respect to wind turbines can be assessed comprehensively. Based on that, propositions about more socially robust design of wind turbines can be made. This study has found that there is a need for making a distinction between two aspects of social desirability of wind turbines design: the technology itself and the type of development that is envisioned (e.g. in terms of scale). Based on the studied literature, this report presents an overview of the societal concerns with respect to wind turbine technology that were identified so far by publications selected for this literature review in Table 1.

Table 1. Overview societal concerns

Concern	Main findings	Key Publications
noise	Noises tends to cause annoyance, but it is not always rational (can be related to lack of benefits form the project but limited to enduring the externalities in form of noise)	(Wolsink, 2000), (Ek, 2005), (Pedersen, van den Berg, Bakker, & Bouma, 2009)
	Noise is not proven to cause negative impacts on health other than stress, but stress that project may cause	(Knopper & Ollson, 2011)
Poor aesthetics of wind turbines	Wind turbines can be perceived as ugly/ industrial objects, availability of visualization	(Wolsink, 2000), (Breukers & Wolsink, 2007)
	Moral and social values with respect to technology design	(Künneke, Mehos, Hillerbrand, & Hemmes, 2015)
Inappropriate height of wind turbines	The height of wind turbines can be perceived as inappropriate for a selected site (large wind turbines are usually less preferred from the aesthetic point of view)	(Ek, 2005)
unreliability	Fear of unreliable energy supply can cause concerns about whether wind energy is the best options for energy supply	(Wolsink, 2000)

	Fear of that wind power is more expensive than conventional energy	(Wolsink, 2000)
Unsustainable wind turbine technology	Transparency in the origin of technologies and materials	(Edelstein, 2004)
Inflexibility of design	Lack of possibility for adaptations operation of wind turbines	(Hüppop, Dierschke, EXO, Fredrich, & Hill, 2006)

Concern with respect to wind energy landscape

Landscape is an important aspect of all wind energy developments which means that where wind turbines are placed matters to society. Europe set ambitious goals in respect to wind energy, mostly concentrating big wind energy parks on the sea or along the coastline, but a vast amount of developments will also need to take place inland. This means that wind energy installations will increasingly be complicated by the landscape-related concern that societal actors might have when it comes to choosing suitable locations and designing wind energy parks. Whereas the common assumption is that locating wind parks out of the sight would solve the problem of landscape related concerns, this review has found that it is misleading to believe so. The reason is that absence of residents living in the area does not mean that there are no values attached to these spaces (Wolsink, 2010). By contrast, sea landscape might be very valuable from the perspective of other uses and functions such as nature or recreation. The list of concerns with respect to wind energy developments below (Table 2) is meant to exemplify the variety of concerns that societal actors might have with respect to wind energy landscapes and to point that some of the values and preferences might be contradicting. It is however important to be aware of the variety of claims made by societal actors when legitimizing various views on wind energy and when augmenting their visions.

Table 2. Wind energy concerns related to landscape

Concern	Main findings	Key Publications
Concerns about landscape design	The design of wind parks/ the incorporation of wind turbines into the landscape is limited	(Mok & Hyysalo, 2018)
	The design does not match the landscape	(Ek, 2005), (Jobert, Laborgne, & Mimler, 2007)
	former use and perceptions of the territory does not match the envisioned new use/sound integration of landscape functions is missing	(Nadaï & van der Horst, 2010)
Concerns about chosen location	Location does matter for acceptance as wind energy are often envisioned as suitable only for certain areas. Whereas there is an ongoing debate about the suitability of seascapes for wind parks, increasingly it is argued that seascapes can be as valuable to people as landscape (good and bad locations as defined by social preferences)	(Wolsink, 2010), (Ek,2005)
	Proximity to residential areas tends to induce concerns about the impacts of wind energy but proximity does not explain acceptance adequately	(Edelstein, 2004)
	Fear of property loss value	(Cohen, Reichl, & Schmidthaler, 2014)
	Value conflicts can arise when preservation of natural landscape competes with wind parks	(Warren, Lumsden, O'Dowd, & Birnie, 2005), (Devine-Wright, 2005) (Cohen et al., 2014) (2014), (Woods, 2003)

Impacts on tourism and recreation	Wind parks tend to occupy areas which could otherwise be used for recreation and tourism, and in some cases these two functions need to be reconciled	(Warren & Birnie, 2009) (Langbroek & Vanclay, 2012)
Concerns about birds and bats	Wind turbines tend to cause collision with birds and bat which is often a reason for societal concerns, especially from the side of environmental NGO's	(Dai et al., 2015) (Nadaï & Labussière, 2010)
Concerns about marine species	Construction of wind parks offshore might bring concerns about the potential impact on marine species, especially that the environmental impact of offshore wind turbines is often uncertain	(Dai et al., 2015)
Fear of deforestation	When construction of wind turbines requires removal of trees	(Dai et al., 2015)
Fear of soil erosion	In vulnerable areas, people might be concerned that construction of wind turbines will cause soil erosion	(Dai et al., 2015)

Process-related concerns in wind energy

Apart from the concerns related to wind turbine technology and landscape, the extent to which projects can be viewed as successful and are welcomed by local communities is also depending on the process of planning and implementation of wind energy. When it comes to the process of wind energy developments, multi-stakeholder participation on the topic of wind parks siting and their management is strongly advocated in the literature (Jobert et al., 2007) (Jolivet & Heiskanen, 2010). Especially in most of the Western countries, participation in wind projects development is already institutionalized and legal mechanisms are established to protect the rights of stakeholders for participation. Even though organising process of participation tends to be complicated by issues of power, costs, benefits distribution, representativeness and many other nuances (Stirling, 2007). There is an increasing consensus in literature that lack of participation lead to negative responses from affected stakeholders (Wolsink, 2010). Transition of wind energy planning towards a more participatory and community-based process is already in progress in many of European countries, however, much of the reviewed publications argued that the extent to which participation is used needs to increase as so does the quality of the process (Janhunen, Hujala, & Pätäri, 2018), (Jolivet & Heiskanen, 2010); (Lienhoop, 2018). A potential pitfall of participation is that participatory planning may be misused and staged processes of inviting stakeholders only with a purpose to use the label of participation and without any further intention to account for their needs, concerns and opinions (Wolsink, 2010). Concerns with respect to the process, including participation are summarized in Table 3.

Table 3. Wind energy concerns related to process and participation

Concern	Main findings	Key Publications
Lack of meaningful participation	Extent to which stakeholders are involved in the process of decision making (empowerment and diversity)	(Jolivet & Heiskanen, 2010) (Eltham et al., 2008)
	The stage at which stakeholders are involved matters (the earlier, the better as positive attitudes tends to improve over time)	(Bell et al., 2005; Loring, 2007)

	Top-down approach is ineffective	(Wolsink, 2010)
	The possibility to close strategic alliances between different users of space/sea is important	(van der Horst, 2007)
	Participation can also lead to opposition when conflicts arise and issues cannot be solved	(Fournis & Fortin, 2017)
The overall quality of the planning process	Small range of arguments presented indicates limited collaboration	(McClymont & O'hare, 2008)
	Closing or opening up to opposition can influence opposition	(Langbroek & Vanclay, 2012)
	Open-ended process (no pressure to mitigate opposition and change attitudes) is beneficial	(Ellis, Barry, & Robinson, 2007)
	Avoiding stigmatisation/NIMBY is crucial	(Devine-Wright, 2005; McClymont & O'hare, 2008; Wolsink, 2000, 2006)
	Planners performance (planners recognise needs and fears of communities) influences people's attitudes towards proposed projects	(Lake, 1993; Wolsink, 2006)
	Performance of developers influences people's attitudes towards proposed projects	(Corvellec, 2007)

Lack of Institutional capacities/capabilities	The extent to which planners facilitate collaboration influences people's attitudes towards proposed projects	(Wolsink, 2000)
	Institutionalisation of collaborative planning approaches is important for countries overall performance in the energy sector	(Jacobsson & Karltorp, 2013)
	Support for niche developments facilitates wind energy transition	(Verbong & Geels, 2007)
Lack of financial benefits/ ownerships/ economic incentives	The extent to which local communities/residents benefit from projects influences positive attitudes towards the projects	(Breukers & Wolsink, 2007)
	Local taxation of wind farms for community benefits influences positive attitudes towards the projects	(Jobert et al., 2007)
	Community initiatives (residents maintain control over project) are often successful	(Szarka, 2006) (Hinshelwood, 2001)
	Presence of financial benefits is not enough on its own, people can't be simply bought, and the perceived fairness of benefits sharing is important factor. When perceived as unfair, opposition can emerge	(Fournis & Fortin, 2017)
Lack of certification of wind energy	The extent to which the source of wind energy is certified with traceable and	(Bergek & Jacobsson, 2010)

	transparent schemes matters to public	
Lack of capacities of communities	Lack of resources such as networks, knowledge, trust and financial support for developing own wind energy projects can prevent communities from investing in wind power	(G. Walker, Devine-Wright, Hunter, High, & Evans, 2010; Wolsink, 2007)

Moving beyond acceptance: Societal engagement with wind energy

Considering all the different concerns that people might have with respect to wind energy and the process through which they become involved with wind energy developments, this review study has found that it is useful to turn to look from governance perspective for what forms of engagement with wind energy help to address these concerns and how. Considering the multiplicity of concerns that people might have with respect to wind energy, including lack of content about the traditional, top-down approach to wind energy implementation, it becomes increasingly clear that governance of wind energy developments without societal actors is largely ineffective (O'Brien & Hope, 2010; Wolsink, 2010) and that mitigation of opposition is largely pointless (Burningham et al., 2015; Cohen et al., 2014). For wind energy systems to successfully make a transition towards socially robust energy infrastructure, there is a need for innovating governance of wind energy developments towards anticipatory and adaptive approaches (David H Guston, 2010). Such approaches allow for internalising societal concerns with respect to wind energy into the design of wind turbines and well as into the overall governance approach that adapts to changing needs and practices of society. Different forms of engagement offer an entry point for investigating how people relate to wind energy, chose with what aspects of wind energy system do they engage, when they become involved and through which means. Accordingly, the different concerns with respect to wind energy landscape and technology might require different forms of engagement. In this line of reasoning, resistance can also be seen as a problem of governance.

As the review showed the process of planning and implementation of wind energy development tends to be one of the reasons one projects fail, especially when projects are

imposed and when issues of landscape and technology are not addressed. Whereas the review showed that participation is important, the review also revealed that understanding engagement only in terms of stakeholder participation during the planning phase has multiple shortcomings. Firstly, the planning phase tends to limit engagement to issues related to landscape such as choosing a suitable location and tends to omit the issues of wind turbine design and technology. Secondly, participation is often understood in terms of involvement of local communities, however communities can be established at different spatial levels and have different stakeholder constellations (Chilvers & Longhurst, 2016). For example, communities around wind energy can be virtual and cosmopolitan as in the case of online shareholding in wind energy projects or consisting of users and interest groups that are not residents as it often happens for offshore wind projects (Jay, 2010). In these instances, organised stakeholder participation might not be suitable and feasible, which is why there is a need to think more flexibly and innovatively about how and where engagement with wind energy takes place.

Moving towards new a perspective on engagement opens up to a diversity of ways in which societal actors engage with wind energy (Ryghaug et al., 2018). This review has found that outside of organised stakeholder participation, there is a wide variety of ways in which societal actors are involved with wind energy at different stages of developments and even after the projects are already implemented.

Engagement with technology

Wind energy is one of the most visible and dispersed over the public landscape type of renewable energy. This inherent characteristic of wind energy causes many concerns that pertain to wind turbine technology and design. While some adaptations in design are possible and desirable when it comes to addressing societal concerns, improving design is not enough to transform wind turbine technology towards more sustainable energy infrastructure. This literature study has found that engagement of societal actors with technology not only can alleviate some of the concerns (Ek, 2005) but it also can be people more enthusiastic about wind energy in first place and eager to contribute to improvements of wind energy infrastructure (Karnøe & Garud, 2012). In contrary, lack of engagement leads to passive attitude towards envision expansion of wind energy developments. The opposite is when people develop very positive attitude toward technology, for example of old windmills in the Netherlands which are not only appreciated but also considered part of

Dutch culture and heritage that is actively being preserved, beautified, visited by tourists and photographed (Borgmann, 1987). In this line of reasoning, the meaningfulness and appreciation of technology for people is related to engagement with renewable technologies. The example of old wind mills shows how important interaction between people and technology is for what is essentially the same artefact as modern wind turbines. The point with engagement is not to romanticise people's interaction with wind turbines but to think of all the possible way in which people engage with wind energy.

Society can engage with wind turbines in multiple ways. Looking into engagement with technology requires to some extent taking a device-centered view on societal engagement (Marres, 2016; Schot, 2001) in which wind turbines are at the focal point of attention. In such perspective, socio-technical innovation is a prerequisite for socially robust technologies (Leach et al., 2005). Studies show that it is most desirable to engage users of technology already at the early stages of design and prototyping (Schot, 2001). Engagement with technology should also involve a multi-actor process of developing technology that can be characterized by anticipation, reflexivity and social learning (Schot, 2001). In this way, engagement with technology can be understood also as a form of active citizenship and rightful participation in technology in the context of democratisation of science and technology (Leach et al, 2005).

Apart from the organised type of engagement with technology, this review points out that people engage with wind energy also in their everyday life. This literature study has found that everyday engagement can be considered conscious, and often political choices that people make in their everyday life to act upon issues of energy (Thronsen & Ryghaug, 2015). For example, Marres (2011) shows by the example of carbon accounting technologies that people can apply at home that these technologies are in fact mediating participation in increasing the sustainability of energy system from the realm of home. According to Marres (2011) environment management is then a sign of political beliefs that translate into everyday routines that involve sustainability technologies (Marres, 2016). Nowadays, such routines are not only possible by interaction with physical artefacts of wind turbines but also by virtual engagement. With the developments of digital platforms, websites and apps that offer mediation with wind energy system, society can easily become consumer or producer of renewable energy (Kloppenburger & Boeleko, 2019).

The system of wind energy provision is rapidly changing which has significant implications for the ways in which engagement with wind energy is possible. These changes also can result in new roles of and relationships between producers and users (Van Vliet, Naus, Smale, & Spaargaren, 2016). In renewable energy system in particular, the roles of consumers are gradually moving from passive to active one of prosumers. In this active role, prosumers are “proactive consumers with distributed energy resources, actively managing their consumption, production and storage of energy”, for example by adapting energy practices to own energy supply. This relatively new way of thinking about ways of engagement in energy systems links to academic work on energy citizenship studied on cases where “politics and technology have become part of everyday life through material objects” (Ryghaug et al., 2018) (p.298). Whereas studies on the everyday type of engagement with technology (especially though material participation) becomes increasingly popular in social science on renewable technology (Ryghaug et al., 2018) this literature review reveals that wind energy has been omitted so far from this kind of analysis, which leads to that little to nothing is known about material participation with wind energy.

Engagement with landscape

For wind energy infrastructure to become more socially robust, an active engagement of stakeholders in the process of design and decision-making is advocated (Oosterlaken, 2015). Nevertheless, the difficulties of inclusive decision-making process are in the demarcations of what issues should be discussed with stakeholders and which can be decided upon by experts such as policy-makers or engineers. Increasingly, it is argued that stakeholder participation should be extended to all the aspects of planning projects (Breukers & Wolsink, 2007; Wolsink, 2010). Innovative approaches that foster deep level of participation include for example participatory design: “practices [that] rely on open-ended processes of design and on value-based strategies of engagement which will allow meaning- and decision-making to emerge in often contentious private and public contexts” (Smith, Bossen, & Kanstrup, 2017)(p. 66). To organise co-design of landscape various planning approaches can be used, for example by using a Value Sensitive Design approach (VSD) which focuses on incorporating stakeholders values, needs and practices into wind parks design (Oosterlaken, 2015).

Table 4 summarises them according to the type of engagement and stage to which it pertains.

Table 4. Overview literature related to engagement

Alternative forms of engagement	Stage	Guiding principles	Key publications
Collaborative planning and Landscape co-design	implementation stage	Communities could be involved in design of landscape that integrates their values, needs and practices into an open-ended process of design. Possible approach: Value Sensitive Design	(Künneke et al., 2015; Oosterlaken, 2015)
		Participation in agenda setting and decision-making should be facilitated	(Wolsink, 2007, 2010)
Everyday use and management	After implementation	The need for participation continues after the planning process for a wind farm ended with implementation of wind turbines. Planners and project developers should be prepared to continue communication and co-operation with residents/stakeholders after the planning phase.	(Toke, 2005)
		Engagement of users is needed to adopt management of wind turbines to changing needs and practices that concern energy use and production	(Stern, 2014)
Participation in technology design	At the stage of design	Social, economic and moral values should be guiding principles for design of wind turbines	(Künneke et al., 2015)
		Needs of users as guidelines for design / bricolage	(Karnøe & Garud, 2012)
		Technology assessment as learning (meaning of technological artefact)	(Grin & Van de Graaf, 1996)
		'responsible research and innovation' (RRI)	(Owens, Rayner, & Bina, 2004; Von Schomberg, 2013)

		'citizen advisory boards'	(Santos & Chess, 2003)
		'multicriteria mapping'	(Stirling & Mayer, 2001)
		'participatory technology assessment'	(Burgess & Chilvers, 2006; Joss & Bellucci, 2002; Stirling & Mayer, 2001)
		'constructive technology assessment'	(Schot & Rip, 1997)
		'Real-time technology assessment'	(David H. Guston & Sarewitz, 2002)
Local community initiatives	All stages	Communities initiate and design project, are active in engaging with wind energy in everyday life	(Hinshelwood, 2001; Toke, 2005; C. Walker & Baxter, 2017; G. Walker & Devine-Wright, 2008)
Virtual engagement	Possible at any stage	community is a network/ community of interest, constituted by social relationships which are not necessarily place-based	(Bauwens & Devine-Wright, 2018; Kloppenburg & Boekelo, 2019)

5. Conclusions and recommendations

This study shows that wind energy sector in Europe faces multiple social, environmental and technological challenges. Opposition to wind energy developments is often named as the main challenge and a major issue for governance. However, this study has showed that acceptance or the lack thereof are just two possible manifestations of attitudes towards wind energy. Based on the literature review on wind energy in Europe, this study showed that the debate on acceptance is a largely unconstructive way of framing the challenges of wind energy sector. In line with the recent works that propose a critical perspective on acceptance, this study has outlined the debate around opposition to wind turbines.

As this review showed, proximity only cannot explain why society does not welcome wind energy developments. Whereas issues of location and landscape in general do play an important role, this study showed that looking through the prism of concerns rather than opposition offers a fruitful way to understand what bothers people about wind energy landscape, technology and the process of wind energy developments. Based on these findings, this study used academic literature on governance of wind energy that discusses the need of societal engagement in energy system to transition towards more sustainable energy infrastructure. This literature review used these findings to reflect on the desirable, appropriate and promising ways in which people are or could be involved with wind energy. Looking at different stages of wind energy governance: from the stage of wind turbine design, through wind energy planning and implementation and continuing with use and management, this study has identified different ways of organizing, facilitating and recognising engagement with wind energy. These different forms of engagement were categorised into engagement with technology, engagement with landscape.

Based on the findings, this study identifies several avenues for future research:

1. There is a need for research on wind energy sector in upcoming European markets that at the moment are marginalized or absent from academic research, especially including countries of Eastern Europe.
2. Research on wind energy in Europe, but also globally should move away from the debate on acceptance and focus on addressing the range of concerns that people might have with respect to wind energy, already at the early stage of wind energy design and to continue after wind energy projects have been completed. At this stage, particular attention needs to be paid to increasing flexibility in operation of wind turbines and innovating in e-mediated monitoring and adaptation of energy production and consumption.
3. Participatory research and innovation should be stimulated as it is a promising way for developing socially robust designs and responsible technologies of wind energy
4. Future research should focus on the merging forms of engagement with wind energy that go beyond state-led planning. In particular attention is needed for:

- community-led initiatives which are a promising way of engaging people with wind energy, however collective engagement remains a largely unexplored phenomena in social science from the perspective of engagement with wind turbines in the context of different landscapes
- participation through online means (e-participation) and virtual engagement with wind energy (through shareholding, purchase of wind energy etc.) is an upcoming and promising way of engaging people with wind energy however little is known about the consequences of this type of engagement for wind energy sector and about changing needs of consumers with respect to engagement with wind energy system (and energy system in general)

Based on this research agenda, it becomes clear that there is a need for more interdisciplinary approaches to research on wind energy systems. Within interdisciplinary studies, there is a need for critical accounts of engagement that wind energy system currently enables. Wind energy systems remain largely centralized, even though different forms of engagement gradually emerge and transform the energy system. Still, often an assumption remains that people can much easier engage with technologies that they install in their homes, such as smart meters, solar panels etc., but less in case of large scale and centralized technologies such as wind turbines. To go beyond this traditional view on wind energy systems, there is a need to explore new theoretical perspectives that enable researchers and practitioners to look at engagement with wind technologies as diverse in terms of actors involved as well as spatial and temporal scales at which society can engage with wind turbines. This review study concludes that such engagement with wind turbines should always relate to physical landscape as an integral element of wind energy system. Understanding how society engages with wind energy in the context of different landscapes, can help to reveal the potential and constraints for participation that goes beyond organized public engagement (Irwin, 2015). In this way, engagement in wind energy systems can be organised and facilitated at different stages of design, implementation and management of wind energy.

6. Implications for modelling within UPWARDS

This final section describes how the results of this deliverable will be linked to the wider UPWARDS project and specifically on the integration of various technical models which is central to the project, e.g. through the development of a digital twin.

In general, this review makes clear that there are a large number of concerns related to public acceptance of wind turbines, and their nature varies considerably as well. They touch upon technical, social, environmental and economic factors, to name but a few. Furthermore, some of them can be traced to individual people, whereas other factors concerns groups of people, regions, or even whole countries. Finally, these concerns may change over time and vary across the different stage of wind turbine design, planning, implementation and operation.

As such, it is clear that not all these factors can easily be included into a model, not even the sophisticated integrated model that UPWARDS aims to deliver. This conclusion is important in itself as it makes clear what the possibilities and limitations of these models are and indeed, who decides on what is included and excluded in these models. For example, they may be very good at predicting power output, given certain geographical and atmospheric conditions, but they may be less good at 'predicting' human behaviour, such as whether a wind turbine park will generate protests or not.

That said, there are some social issues and aspects that can be taken into account, such as:

- Levels of annoyance caused by certain noise levels (e.g. Wolsink et al., 1993).
- Levels of annoyance caused by shadow flicker (e.g. Hübner et al., 2019).
- National or regional regulations on noise and visual disturbances (e.g. Nieuwenhuizen & Köhl, 2015).
- The influence of financial participation and revenue-sharing on acceptance.

There is existing literature and there are datasets on some of these issues which can provide input for the UPWARDS modelling (digital twin). In addition, WP7 will generate data on public engagement at various stages of wind turbine development to further contextualise and analyse the boundary conditions of what the model can and cannot do. This will further our understanding on social acceptance and engagement of different types of publics and open up to how publics can be engaged in coproduction (e.g. through digital twins).

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Attachment

Attachment 1: Sheet with all reviewed literature on wind energy and acceptance