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Chapter 5

Where to put wind farms? Challenges related to planning, EIA and social acceptance

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Wind energy is today the workhorse in the green transformation of our energy sector. To reach the 2°C target by 2050, we need to triple today's level of effort in reducing GHG emissions and speed up the pace at which we install new wind capacity. At the same time, we are experiencing long development times for wind farms due to planning and permissions processes. In Figure 1, some of the factors that influence both the strategic planning and the approval of single projects are shown. The legislation sets the scene in that it prescribes the approach for carrying out environmental or social impact assessments, as well as setting specific limits or thresholds in some cases.

This chapter will address the challenge of balancing social interests, of increasing the pace at which we allocate space and install wind farms, and of how we incorporate the interests of other stakeholders, local communities and biodiversity.

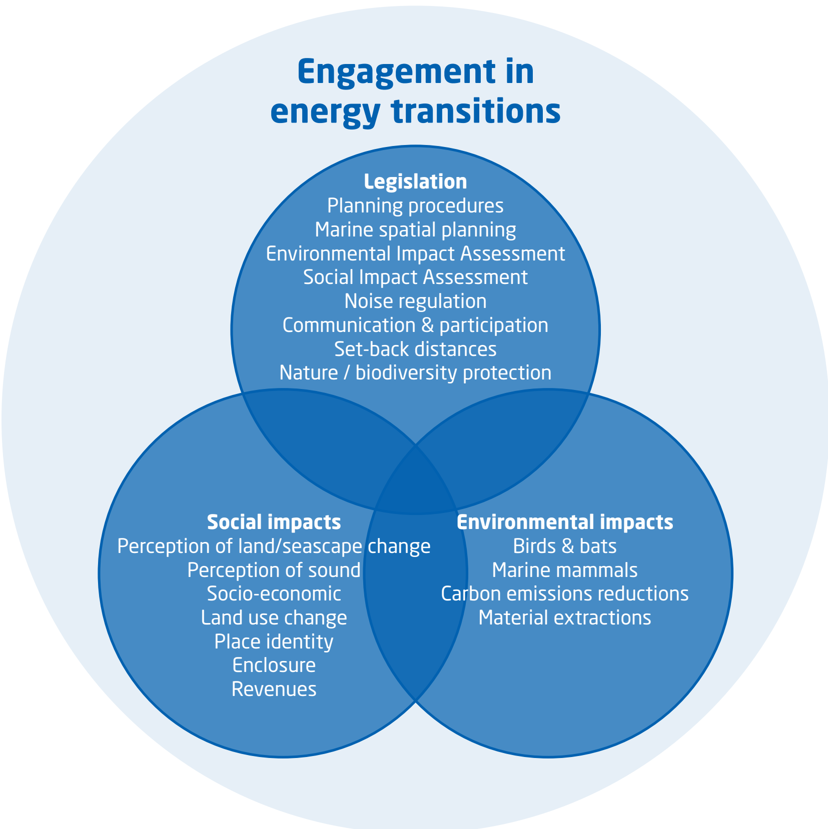

Figure 1. The success of the energy transition depends on the interplay between many factors that can be grouped into legislation and the social and environmental impact.

Can't we just put it all in the sea? On the need for onshore wind and repowering

From onshore to offshore ....

Offshore wind energy is widely considered to have three main advantages over onshore wind: the availability of more physical space, better and more stable wind conditions, and less public resistance to the deployment of large wind farms are all considered as having contributed to a shift towards the extensive exploitation of offshore wind.

In particular, the latter issue, manifested in local opposition, multifaceted conflicts and scarcer land resources, has not only been increasingly identified as a key obstacle to the growth of onshore wind capacities, but has also partially slowed down the realisation of new wind farm projects, especially in countries with more advanced wind-energy landscapes, like Denmark and Germany. Conflicts over the establishment and deployment of renewable energy facilities, in particular wind farms, have resulted in a wide-ranging and prolific research area which has been described as 'the social acceptance of renewable energy technologies and associated infrastructures' [for overviews, see 1, 2]. Both qualitative and quantitative studies focusing on wind energy have played a formative role in this research area. Research into social acceptance has broadly evolved along two pathways, both aimed at advancing the understanding of social contestations over wind farms. The first strand focuses on the procedural aspects of wind farm planning and development. This strand deals with the roles of the governance and planning processes in shaping responses to wind farms [3] and considers issues of public engagement and participation [4], trust and fairness [5,6]. The second strand of research highlights the significance of distributive justice in the deployment of wind farms, mainly in terms of the distribution of their perceived impacts and benefits. Research within this strand has made use of various approaches to look at the ownership of wind farms [7], the delivery of community benefits [8] and socio-psychological factors related to the perception of the visual [9], noise [10] and economic [11] impacts or perceived changes to landscapes, place identity and place attachment [12].

In light of the intensifying tribulations of onshore wind development in many areas, general expectations or assumptions share the common understanding that offshore wind farms are less controversial and enjoy higher levels of acceptance than those onshore. This presumption seems to be inferred from the NIMBY (not-in-my-backyard) phenomenon, assuming that a location offshore is more tolerable due to the larger spatial distance from where most people live. However, in contrast to this hopeful assumption, offshore wind farms also encounter fresh opposition with specific characteristics. In one of the first overviews to focus on non-technical issues related to offshore wind-farm development, Haggett [13] already suggested that moving wind farms offshore is unlikely to avoid all the challenges that wind farms have encountered on land and that in fact novel issues are also likely to arise. Indeed, numerous studies have described various conflicts between offshore wind farms and other marine or coastal uses and environmental interests [14-16]. Thus, the emergence of offshore wind farms has likewise highlighted the need to create new approaches to the co-existence of new and established uses of marine environments and have urged enhanced marine governance and the implementation of strategic planning of such uses. This becomes particularly relevant as more and more offshore wind farms commence operation. Despite their advantages, there are also challenges that need to be taken into account in the future. A so far less recognised consequence is the potential risk of the affective alienation of the general public from the urgency of the energy transition, if electricity production is largely moved away from people's everyday lives. Given their scale, technological complexity, required expertise, and the costs and risks involved, it is mainly multinational energy companies and utilities that have driven the development of offshore wind farms. As a consequence, a current feature of offshore wind farms is a less diverse ownership structure and the material participation of the public compared to their counterparts onshore.

Considering the manifold possibilities and challenges of both offshore and onshore wind, the question is neither one of putting all wind turbines offshore, nor of emphasising the expansion of one over the other. Both developments should be pursued in their own right and need to be advanced in parallel while considering their particular advantages and disadvantages. Although the climate emergency demands a certain pace for the large-scale expansion of renewable energy, the wider social context must be taken into account as well [17]. The energy transition is not just about ramping up renewable energy capacities in the most (cost-)efficient way, it also provides an opportunity and lever for social transformation. This latter aspect is where the utilization of onshore wind energy has proved advantageous, although its full potential has not yet been realised yet.

.... and back again?

On the one hand, the expansion of offshore wind energy is much needed to increase the renewable energy capacities that are vital if the deep decarbonisation of the energy and transport sectors is going to reach a position where they can disrupt and replace fossil fuels, rather than adding to and compensating for ever-increasing energy consumption. This is where offshore wind will need to be ramped up to meet Europe's targets of installing 250-400 GW by 2050 in comparison to 20 GW in 2019 [18].
On the other hand, the use of onshore wind has shown that ownership of wind turbines and access to land to harvest wind can enable meaningful and impactful asset-based economic development in the areas in which wind farms are deployed. In that regard, the production of renewable energy comes secondary, whereas the primary purpose of wind energy is conceived as way to initiate local sustainable development, in particular in peripheral and disadvantaged communities. During the early stages in the evolution of wind energy development, this has mainly been achieved through the cooperative local ownership of wind turbines [19, 20]. In light of technological advances and the increasing commercialisation of wind energy driven by the larger developers, an economic re-anchoring of wind turbines in the localities in which they are deployed has been pursued either through a proactive re-distribution of revenues to create positive local impacts [21] or a diversification of ownership structures by making possible the community (co-)ownership of wind turbines [22, 23]. However, new possibilities for local benefits have emerged more recently that bring production and demand closer together by directly linking onshore wind to other sectors, like green fuels, transport and agriculture (P2X), or linking electricity from wind turbines to a network of decentralised energy solutions (e.g. virtual power plants, power purchase agreements).

The need for repowering

One of the biggest challenges for onshore wind in the pioneer countries, such as Denmark and Germany, is the advanced age of the existing turbines [24]. In Denmark, 30% of all onshore wind turbines are more than twenty years old, while in Germany more than 30% of the wind turbines will reach the end of their FiT support in the next four years [25]. The approaching end of the operational lifetime and phasing out of subsidies requires further large rounds of repowering wind turbines if existing capacities are not going to dwindle. While previous cycles of repowering old turbines between 2001 and 2003 in Denmark replaced 1480 turbines (122 MW in total) with 272 more efficient turbines (324 MW in total) [26], the required extent of future cycles would need to be substantially larger. In particular, the latest Danish legislation requires the removal of old turbines before new wind turbines can be built, which puts more pressure on developers to incorporate decommissioning as part of their development process. However, this poses a number of regulatory, spatial and socio-economic challenges that need to be carefully re-considered [27] in order to steer an efficient process that enables the fruitful re-attachment of local communities to onshore wind farms and facilitates a just transition. These issues include expiring and changing subsidy schemes which tend to affect the ownership structures of wind farms, changing regulations, such as set-back distances or environmental assessments, that may constrain previous locations, or modifying planning procedures. Furthermore, there is a blatant lack of knowledge on how community responses to wind farms may change over time once they are operational. Although adaptation to and familiarisation with change is assumed to lead to contentment, it cannot simply be taken for granted that communities will develop highly positive attitudes when living with wind farms [2]. Thus, there is also an urgent need for research examining how people's lived experiences with existing wind farms may be manifested in new iterations of development, end-of-life decision-making and repowering with taller wind turbines [28]. Considering these issues becomes particularly vital because the approach to planning and developing wind farms has proceeded with reference to greenfield sites, while a holistic framework for repowering is still largely absent, resulting in ad-hoc practices and a slow pace of repowering.

Trends in impact assessments for land-based wind

As stated earlier, an important trend in research and practice regarding land-based wind power especially is opposition from local residents. The conflicts over land-based wind projects are a major concern, as they are seen as presenting obstacles or delays in the green transformation of energy systems [see e.g. 2]. In order to minimize or avoid conflict, it is important to know what the conflicts consist of. In this context, impact assessments often become an arena for disputes, as they are the main decision-support tool, where information on the impacts of a project is gathered, shared and discussed in a fixed process that includes transparency and public participation [29].

In Europe, impact assessments of land-based wind mainly take the form of Environmental Impact Assessments (EIA) enacted through the EU Directive. The EIA is a formalised process of assessing a project's impact on the environment, providing information that can enter into the decision-making process before a project is approved or rejected. Besides aiding decision-making, the goal is to contribute to designing more sustainable projects and to ensure transparency for the general public. It is characteristic that impacts on the environment are broad in their scope, including, for example, population and human health [30].

A high level of conflict in the process in general can result in legal complaints over the decisions and the process itself. In Denmark, complaints related to EIA are mainly addressed to the Board of Appeals on Environment and Food. The content of these complaints can be seen as an expression of the concerns of local residents and are at the core of opposition and conflict. A search on the portal of the board of appeals in April 2021 yielded thirteen rulings from the board concerning land-based wind projects in 2020 and 2021. An overview of the parts of the assessments that were subject to complaints is provided in Table 1 below. To provide an idea of the proportions of these complaints, during 2020, 157.3 MW of land-based wind power was put into operation [31], while the complaints for which a ruling was made in 2020 cover approximately 172 MW.

Most of the complaints are against assessments of the visual and noise impacts, and generally many of them concern the social and health impacts, such as human health and socio-economic aspects. The concerns about shadow flicker, visual impacts and noise are related to human health and well-being (the example of noise is treated a further length in the next section). Studies have shown that one of issues causing conflicts is the mismatch between the EIA reports and community concerns; the former tend to focus on the biophysical environment, while local residents also care about the social and socio-economic impacts, as supported in hearing comments and in interviews [29]. Assessing the impacts on local bat populations is the only biophysical issue which surfaces as part of only four complaints.

Local residents are concerned about the assessment of social and human health and the well-being impacts of planning wind projects. They are also concerned about the process: nine of the complaints are about the process and the lack of perceived local authority responses to citizen concerns and comments voiced in statements and during hearings. This emphasizes the importance of the design and transparency of the planning process, as it can also be the locus of opposition and conflicts [see, e.g. 29,2].

Challenges related to social acceptability and noise

One of the obligatory aspects, one that, as shown above, is of great concern to the general public, that an EIA needs to address is the sound made by wind turbines and the "amount" of sound (technically defined) that is predicted to be present at dwellings in the vicinity of a wind farm. However, the neutrality of such approaches is seldom evident, as, in most cases, the impact assessment and the regulations they are based upon classify the sound as "noise" (i.e. an unwanted sound). In Denmark, the statutory order on the noise impact of wind turbines[1] outside a dwelling states that it must not exceed 44 dB(A) at a wind speed of 8 m/s and 42 dB(A) at 6 m/s. In areas of noise-sensitive land-use (clusters of dwellings) the levels are lower: respectively 39 and 37 dB(A). For low frequency noise (10 - 160 Hz) the limit is 20 dB(A) measured inside the house. The impact applies to all the wind turbines in the area and is calculated using a method set out in the statutory order. The results of these calculations are often displayed in EIA reports as contour plots of constant dB(A). Most other countries have similar specific legislation regarding noise and require these to be addressed in EIA reports.

Despite noise being such a well-regulated area, the sound – often framed as unwanted 'noise' – emanating from wind turbines is one of the most contested issues in wind-farm planning and development. As can be seen in Table 1, noise is the aspect that has received the most complaints in the EIA reports (10). This is supported by Borch et al. [32] who show

1 Danish Environmental Protection Act, cf. Consolidation Act No 753 of 25 August 2001 and following amendments

Table 1.
Number of complaints concerning the impacts mentioned in the EIAs. A complaint can concern more than one impact. Extract from thirteen rulings of the Danish Board of Appeals in 2020 and 2021.

Theme	Human health	Bats	Shadow flicker	Socio-economy	Visual impacts	Noise
Number of complaints	3	4	5	5	8	10

that noise, especially low-frequency noise, is among the phenomena that are most commonly complained about and the most highly contested areas in planning a proposed wind farm on land.

One of the techno-scientific challenges involved is that the traditional dB(A) weighted sound assessment regime was designed for assessing sounds that were more or less constant and for taking into account with just one figure of how the human ear responds to many various frequencies. All standards, rules and regulations for wind turbine noise use this regime. However, wind turbine noise is not constant, but has characteristics that vary, are intermittent, and can be masked or be more evident, as well as being dependent on atmospheric conditions, particularly the wind itself.

Fieldwork conducted by DTU Wind in the Wind2050 project [33] has focused on how developers and planners in the planning and development phases default to using scientific descriptions and technical communications. That is, by deferring to regulations, and given their definitive noise-level specifications in units of dB(A), the socio-technical interface between wind farm planning and development is turned into a purely technical domain. This, for most lay people, is a difficult area to understand with the proliferation of graphs, logarithmic units and comparisons to scales of 'everyday' noises such as lawnmowers and airplanes. Further, it often leads to wind farm developers and promoters using a 'present and defend' approach to noise, where they attempt to counter people's feelings about noise with technical facts and a demonstration of the fulfilment of regulations, thus causing a contested boundary between the 'legitimate' 'expert' and 'illegitimate' lay knowledge [34]. This can help explain why noise is the complaint most frequently raised at public hearings and why it is a central issue in many written complaints as well.

Several studies in the planning literature have looked into the issue of wind turbine noise, thus moving beyond the technical perspective. One major part of the literature is based on quantitative psychometric studies measuring the health impacts of annoyance and the perceived risks of noise [35, 36 (Danish Cancer Society's Health Report)]. Here, the sound emanating from a wind turbine is treated as a stressor that can lead to annoyance, and repeated sounds can have a detrimental effect on people's well-being. Survey-based 'dose-response' studies have detected to what extent the distance from and quantity of noise exposure translates into a certain intensity of annoyance and health impacts [10,35,37,38]. In contrast, the more qualitative part of the literature has looked at how the sound emanating from wind turbines produces a social and spatial reaction (annoyance), with the noise from wind turbines impacting on the landscape, people's sense of place and their identity [e.g. 39]. Others have stressed how uncertainty and immeasurability regarding noise impacts can trigger public resistance to the 'scientific facts' [40].

Drawing upon recent developments in public engagement with science [41] and citizen science [42,43], several studies have inquired into how innovative science communication and co-creation [44] between diverse experts and publics can ameliorate controversies in wind energy development. Building on this latter research stream, an ongoing project (Co-Green, 2021-2024) led by DTU Wind Energy [45] inquires into the many modes of understanding of what noise and sound are.

Current and critical topics in offshore EIA

Marine spatial planning

As touched upon previously in relation to off-shore wind farms, marine spatial planning (MSP) is a process that is used to balance the needs of the multitude of marine users and uses by applying principles derived from spatial planning on land. In the EU, the directive on 'establishing a framework for maritime spatial planning' directs the new planning with a point of departure in 'The high and rapidly increasing demand for maritime space for different purposes, such as installations for the production of energy from renewable sources, oil and gas exploration and exploitation, maritime shipping and fishing activities, ecosystem and biodiversity conservation, the extraction of raw materials, tourism, aquaculture installations and underwater cultural heritage, as well as the multiple pressures on coastal resources…' [46 p.1]. Based on this statement, marine spatial planning aims to prioritize and allocate offshore space to various activities, including offshore wind turbines, in a holistic and transparent process. This represents a shift in the planning paradigm for, e.g., offshore wind evolving from planning on an individual project-to-project basis to having a strategic plan as a larger framework.

The potential of the shift to having a strategic planning level includes:

- Improved assessment of cumulative impacts between the different activities preventing over-exposure or exploitation of the natural environment

- A smoother process at project level because the assessment and balancing of impacts have already been started at the strategic level
- Ultimately securing sustainable development at sea, e.g., by using an ecosystem-based approach

In the EU, six of the 22 EU coastal member states had handed in their marine spatial plans by the mandated deadline of 31st March 2021, including Belgium, Denmark, the Netherlands, Finland, Latvia and Portugal [47]. The marine spatial plans are pivotal to the continued development of offshore wind energy, and it will be crucial to evaluate the outcomes of the new planning instrument. The plans are at different stages of development, with some having been reviewed by stakeholders and others undergoing review currently. The review of the Danish Maritime Spatial Plan and the associated Environmental Impact Assessment report runs from 31 March until 30 September 2021.

Challenges for offshore wind

The Danish Maritime Spatial Plan identifies expansion areas for renewable energy installations to comply with the political target of a 70% reduction in CO2 emissions by 2030. The total area reserved for renewable energy is 11,000 km2, of which 4000 km2 is projected to be occupied by 12.4 GW offshore wind by 2030. Table 2 contains an overview over the main environmental and social impacts to be considered in planning large amounts of offshore wind energy.

For example, consider noise from offshore wind farms. Two types of noise are relevant: noise emitted into the air, and noise emitted underwater. As regulations for airborne noise refer to humans, this is normally not an issue for offshore wind farms. However, the noise emitted under water can be significant and will travel far: in particular, noise emitted in the construction phase can travel 10-20 km if not mitigated. Underwater noise originates from the following three sources, the first being the main one:

- Monopile pile-driving
- Underwater dredging for cable-laying
- Increased vessel traffic during construction

Although the amount of vessel traffic during the construction phase can be quite significant, the noise from pile-driving is by far the dominant source. During construction with pile-driving the noise level is so high that it may harm the hearing of marine mammals such as harbour porpoises or seals. By 2011 the German authority BSH2 had set a limit to the sound exposure level of 160 dB, measured at 750 m from the construction site [49]. In order to comply with this noise level, developers

2 Bundesamt für Seeschifffahrt und Hydrographie (German regulatory Federal Maritime and Hydrographic Agency of Germany)

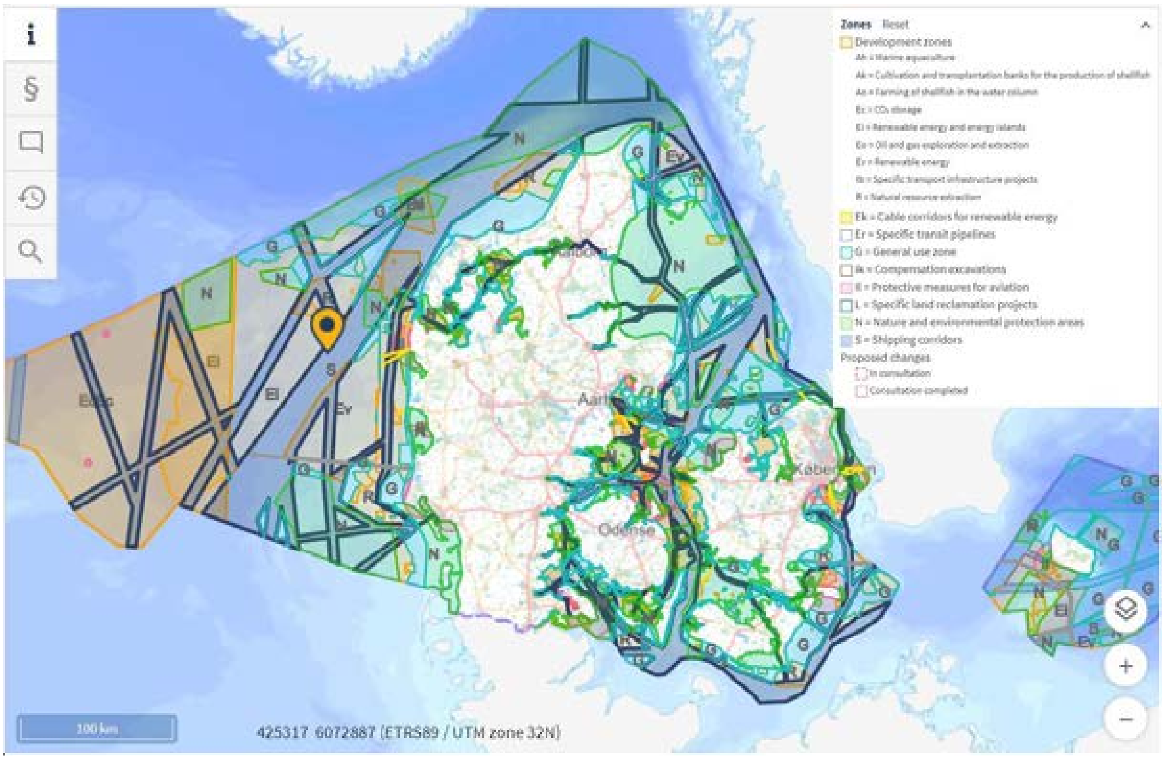

Figure 2.
Screen shot of the Global Wind Atlas web page, showing the user interface, approximately 2 TB of data available for display in the atlas.

Offshore impact category	Specific impact
Birds	Displacement and loss of habitat Risk of collision Barrier effect from multiple wind farms
Marine mammals	Piling noise
Fish	Loss of spawning grounds Artificial reef and creation of new habitats
Visual and landscape	Visual impact from inshore wind farms
Nature protection and biodiversity	Potential conflict with Natura2000 areas
Commercial fishery	Loss of income

Table 2.
Main impacts in the North Sea from offshore wind. Based on (Danish Maritime Authority 2021)

needed to deploy mitigation measures like air-bubble curtains and double-walled piping.

During the operational phase of the wind farm, the underwater noise is significantly lower, and marine mammals will return to the wind farm site and use it as before. In this phase, the wind farm and the mammals can co-exist.

In the future, with larger and larger turbines and wind farms entering deeper water, we also expect larger mono-piles. Accordingly new foundation principles or floating platforms for wind turbines are being developed for depths of water greater than 60 m.

Discussion and Outlook

One way to acquire access to more space for renewable energy, in particular wind farms on land as well as offshore, is to look for areas of co-existence, that is, areas where wind farms can exist together with one or several other users of the same area. Areas of co-existence can be divided into three types [50]:

- Negative co-existence, where there is a mutual disadvantage
- Passive co-existence, where there are no disadvantages or synergies
- Active co-existence, where there are mutual planned benefits or synergies

An example of applications with passive co-existence is an offshore wind farm with tourism activities such as whale-watching in the same area, while a wind farm on land with farming in between the turbines might be an example of active co-existence leading to additional income for the landowner. Other examples of active co-existence are wind farms where a part of the annual revenue is earmarked and used for the benefit of the local community, for example, to upgrade the local infrastructure and invest in new sports facilities or similar. On the other hand, areas of negative co-existence will often lead to conflicts.

Finally, it is important to note that although conflict can clearly have negative consequences for the speed of the transition to renewable energy, it also serves purposes such as quality assurance and is part of a living local democracy concerning significant infrastructural developments.

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