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Abstract
Offshore renewable energy, including offshore wind, tidal and wave energy, have sometimes been represented as opposition-free alternatives to controversial technologies such as onshore wind turbines, and have received increasing attention from social scientists in recent years. A fragmented literature has emerged investigating public engagement with these technologies and the determinants of public acceptance, comprising 58 key studies - the majority investigating offshore wind energy (60%). This literature review argues that while the ways in which public actors engage with offshore renewable energy are to some extent similar to onshore energy infrastructure, there are also important differences. These include the generally lower levels of public knowledge about the technologies, a changing role for visual impacts, a fundamentally different, marine, spatial context, and different sets of stakeholders in different decision-making arenas. There is a need to explore as yet unasked and unanswered questions - going beyond 'established' variables identified in the onshore wind-based 'beyond NIMBY' literature - especially regarding the role of the marine location of these technologies, and the cross-technology and cross-disciplinary applicability of findings. In order to more fully understand 'NIMBY' responses to energy infrastructures, future research needs to move beyond case studies of onshore wind developments, adopting more diverse and ambitious research designs and methodologies.

1. INTRODUCTION

Developments to address concerns over climate change and energy security through the deployment of renewable energy (RE) have recently shifted towards a greater emphasis on developing offshore renewable energy (ORE), which is expected by some to be more publicly 'acceptable' than its onshore alternatives[1,2]. ORE in this review refers to renewable energy technologies that are wholly or partly located offshore – it includes technologies that have already been applied on a commercial scale (offshore wind and tidal range or tidal barrage technologies), as well as technologies at an early stage of technological development (wave and tidal current energy).

Unlike similar terms like marine energy and ocean energy, ORE also encompasses offshore wind. To date, opinion polls have reported 70-75% of UK residents to support offshore wind and 'wave/tidal' development, which compares favourably with support for onshore wind and fossil fuel-based alternatives[3,4]. However, despite these supportive responses local ORE developments across various countries have not been received solely positively and have encountered significant opposition[5,6,7]. This 'gap'[8,9] between nationally high and locally mixed levels of support has popularly been ascribed to the NIMBY (Not In My Back Yard) hypothesis, which implicitly labels local opposition as selfish, hypocritical and ignorant to the greater good. However, the NIMBY explanation has widely been rejected[10,11] and alternative explanations have been proposed across a growing body of work that has mostly used onshore wind developments as case studies for understanding acceptability of energy infrastructure in general[12,13].

It could be argued, however, that relying predominantly on one form of research design (the case study) and one particular technology (onshore wind) to make claims about the nature and causes of public responses to energy infrastructure in general is problematic given the substantial diversity of renewable energy technologies, their varying modes of implementation[14] and contexts of deployment. Also, this emphasis on onshore wind case studies does not sit well with governments in countries like the UK instead relying increasingly on ORE technologies, especially offshore wind, to achieve carbon targets[15]. More recently, questions around public responses to ORE developments and their acceptability have given rise to an emerging body of social science literature that can be characterised as fragmented and in need of integration. Therefore, the aim of this review is to bring together and critically examine this research field, providing an overview of its methods and findings, to extend debates about acceptability of energy infrastructure beyond onshore wind case studies, and to steer the ongoing development of this field by providing suggestions for future research. In doing so, this paper understands 'public engagement with ORE' to encompass not just issues around 'social acceptability'[16], but the wider process of expectations of and interactions between 'public actors'[17] (e.g. local residents) and 'developing actors' (e.g. developers, regulators, decision-makers), and how these shape public responses to ORE developments, acknowledging recent criticism on the common unreflective use of terms like acceptability[18].

2. METHODOLOGY

Studies on public engagement with ORE were identified using Google Scholar, using combinations of keywords referring to ORE (e.g. 'offshore wind', 'tidal energy'), and public engagement with these technologies (e.g. 'acceptability', 'public', 'attitudes'), and checking reference lists and citations for further relevant papers. This yielded 58 papers that broadly focused on public engagement with ORE. Table 1 describes this literature and illustrates it is a very recent field of research, with only a small number of papers predating 2009.

Year published	Pre 2009 (14), 2009-2013 (44).
Type of study	Studies investigating contextual factors (29), Studies investigating personal and socio-psychological factors (20), Case studies of project-specific public debates (5), Review papers (4).
Methodology	Quantitative (28), Qualitative (20), Mixed methods (4), Reviews (4).
Location	United Kingdom (22), United States (13), Other Europe (9), Denmark (6), Australia (2), Chile (1), Taiwan (1).
Technology focus	Wind (35), Wave (9), ORE (8), Tidal stream (4), Tidal range (2).

Table 1. Overview of the reviewed literature

Though some studies could be argued to fall into more than one category, a substantial number of studies have focused on contextual factors as well as on personal and socio-psychological determinants of public responses to ORE developments. Table 1 furthermore highlights how

quantitative methods have been most commonly used and few studies have applied mixed methods. The vast majority of research originates from Europe and the US, and by far most studies have investigated offshore wind energy, with only a handful focusing on tidal energy.

3. REVIEW OF STUDIES TO DATE

This section reviews the research designs, methods and findings from the 58 studies, and in doing so distinguishes between three broad strands of research. The first part reviews studies that have explored public debate surrounding particular ORE developments without focusing on a specific predetermined variable. The second part discusses studies that focus on personal and socio-psychological factors associated with public responses (e.g. age, gender, perceptions). The third part instead examines studies focusing on the role of contextual factors, such as physical characteristics of the ORE development (e.g. distance from the coast) and the process through which ORE is implemented. The distinction between personal and socio-psychological factors on the one hand and contextual factors on the other has been made before[19]. The existence of a number of more exploratory case studies that did not focus on any particular personal or contextual factor was accommodated by creating a further group, which will be discussed first.

3.1 Case studies of project-specific public debates

Studies in this section have investigated public debate or discourse, exploring the reasoning behind oppositional and supportive public responses to particular offshore wind and wave energy developments in Europe and the US[6,20,21,22,23,24]. These studies contrast with studies reviewed in sections 3.2 and 3.3 in that they do not focus on any particular determinant of public responses to ORE – instead they adopt an exploratory, sometimes descriptive case study approach of a particular localised debate, utilising qualitative and quantitative methods.

Across these studies, concerns that were found to be associated with oppositional public responses included visual impacts, ecological impacts, noise concerns, wider anti-wind sentiments, anti-developer sentiments and lack of procedural fairness. Aspects that were linked with supportive public responses included economic benefits, attracting tourists, enhanced energy security and climate change mitigation. Aside from these general conclusions, which mirror earlier conclusions about public responses to onshore RE[13], a number of specifically 'marine concerns' were highlighted to shape public responses. Most notably among these was a perception of the 'ocean as a special place' that should be kept natural and where human structures do not belong, and a subsequent questioning of why energy infrastructure is not located on land instead[6]. Also, questions about the maturity and profitability of the technology (especially wave energy) shaped public debate, alongside development-specific concerns such as noise impact from a particular wave energy technology[23]. Additionally, some of these studies have commented on the nature of public attitudes and responses to ORE developments, concluding that there is a high degree of consistency between affective and cognitive components of attitudes: a negative feeling about landscape impacts are accompanied by beliefs that wind power is inefficient and unprofitable[24]. Another study, using Q methodology[25], offers a different, discursive perspective, suggesting that across individuals and collectives, different combinations of concerns and arguments come together in diverse ways to shape public responses – in other words, shared concerns may not lead to shared overall positions towards ORE developments[21].

While some of these findings are perhaps not surprising, they do suggest that public engagement with offshore energy infrastructure may not only be similar[26], but also different from public engagement with its onshore equivalent, in public representations of its marine setting, and public questioning of the maturity of the technology. It has also become clear that public responses to ORE vary across different technologies, places and contexts. However, it should be noted that the

evidence for certain conclusions sometimes remains unclear due to a lack of participant quotations[23,24].

3.2 Studies of personal & socio-psychological factors

Studies in this section and section 3.3 are less exploratory, instead focusing on one or more variables influencing public responses to ORE. This section explores studies coming from a broadly social psychological perspective, which predominantly focuses on individual mental processes, exploring how personal and socio-psychological factors shape attitudes to ORE developments.

Demographics

Representative survey studies across Denmark[27], the UK[4] and the US[28] have suggested attitudes towards the various ORE technologies are not only generally positive, but also vary across different socio-demographic groups. Younger people, those with a higher income or higher levels of education, and females were reported as generally more positive towards ORE in general than their respective counterparts. Fishers[29,30,31], frequent beach users[27] and owners of coast tourism-related businesses and land[29] have been reported to be less supportive towards ORE development in general. These findings broadly replicate patterns found in the literature on public responses to onshore RE, though a general question mark should be placed around the levels of knowledge respondents may have about novel technologies like ORE, and their subsequent ability to confidently and knowledgably respond to these survey questions.

Perceived procedural justice

Two studies have investigated how public perceptions of the fairness of the planning and implementation process[32,33] are associated with public responses to ORE developments[34,35]. A quantitative study of attitudes towards two proposed offshore wind farms in the US[34] suggested not only that justice concerns are equally relevant for ORE as for onshore RE, but also used regression analyses to investigate causality, suggesting justice concerns may shape attitudes rather than vice versa. In contrast, a mixed method study of public acceptance of a single operational tidal energy generator in Northern Ireland[35] found residents to be generally supportive despite concerns about procedural justice, in particular regarding planning and consultation procedures. Although this development was on a much smaller scale and used a very different technology than the US wind farm proposals, these studies and the corresponding body of work on onshore RE suggest justice concerns may be a sufficient rather than a necessary cause of oppositional attitudes for onshore and offshore RE[7,33,35]. While these studies focused on procedural justice, similar studies on distributional justice – the fairness of the distribution of development costs and benefits – are absent in the ORE context.

Prior experience with renewable energy infrastructure

Following from research on onshore RE[36], three survey studies have examined the hypothesis that individuals or collectives with visual 'experience' of RE are more positive towards offshore wind developments – similar studies are absent for wave and tidal energy. Two Danish survey studies[37,38] both found mixed evidence on the effect of distance to existing offshore wind farms on public attitudes towards existing offshore wind farms and public appraisal of the visual impacts of offshore wind. However, both studies are limited by the lack of direct measurement of respondents' levels of 'experience', instead relying on proxies such as travel time to nearest wind farm. By contrast, in a study which did measure 'experience' directly[34] using the variable 'having seen a wind turbine before', it did not emerge as a significant predictor of attitude towards two offshore wind proposals. These studies suggest that, at least when conceptualising 'experience with RE' as solely rooted in visual encounters, there is no straightforward relationship between this 'experience' and public

response to offshore wind developments – a conclusion also drawn in a literature review that focused on onshore RE[37].

Public expectations of ORE development impacts

Studies of an exploratory nature have investigated public expectations of the positive and negative impacts of various ORE developments, including proposed offshore wind farms in the US[22,39], and wave energy test facilities in the UK[40] and across Europe[41]. Though it is not always clear to what extent these expected impacts were participant-generated or introduced by the researcher, the substantial variability of respondents' expectations across these studies suggests that public expectations are likely to be very different across ORE technology and context. Common concerns include visual impact and perceived threats to wildlife, tourism, employment, surfer wave quality and community harmony. Expected beneficial impacts include climate change mitigation, enhanced energy security and economic or employment benefits to the region. The similarity of these public expectations in the pre-implementation stage to the concerns apparent post-installation, as described by the studies reviewed in section 3.1, suggests these concerns manifest in a similar way across different stages of the development process. That is not to say they are unchangeable though, as a comparison of various surveys from 2005-2009[22] indicated that these public expectations were not only dynamic and changeable themselves, but also shaped changes in public attitudes towards two proposed offshore wind developments. Finally, considering specific public actors rather than 'the general public', other studies[30,31,42] have argued that for UK fishers loss of access is the single biggest concern regarding ORE development, while positive impacts were not widely expected. Overall, these studies have highlighted that expectations are likely to vary across public actors, type of ORE technology, development scale and region/country of deployment. These points could be further explored through adopting more analytical and less descriptive approaches investigating the formation of these expectations, and what explanatory value they have when more explicitly linked to attitudes towards ORE developments.

Knowledge of ORE technologies

Studies employing interviews[43] and mixed methods[44] in relation to the UK's long-discussed Severn tidal barrage have highlighted the potential difficulties faced by public actors in making sense of this unfamiliar technology. They report highly varying levels of public understanding and awareness of tidal barrage technology – disagreeing on what it may look like and confusing it with wave and wind power – problematizing the formation of public views on the proposal's appeal. The research also reports that instinctively supportive public views were only complemented by more negative evaluations in a second series of interviews. This suggests that the dynamism and complexity of public responses to ORE should be studied using approaches that are sensitive to this evolution and instability of public responses. It was furthermore illustrated that in a context of limited knowledge and no material experience with the technology (due to the absence of an operational tidal barrage) individuals drew more heavily on social and media sources in making sense of these technologies. They also relied on general notions of the tide's dependability, associations with naturalness, and comparisons with familiar objects like the Thames Barrier, dams and roads. Though these findings do not reveal how knowledge levels may be correlated with attitudes towards ORE development, they do reveal the difficulties faced by participants when asked about relatively unfamiliar technologies, problematising some of the findings from quantitative studies reviewed in this paper.

Symbolic interpretations of place and technology

Qualitative and mixed method studies of public responses to wave[45,46] and tidal energy[35,47] in the UK, and offshore wind in the UK[5] and Germany[48] have explored how public responses to these were shaped by subjective public interpretations of what the technology and the place it is embedded represent. Looking across these studies, many different positive and negative symbolic interpretations were ascribed to both technology (e.g. industrialising the area, risky, pioneering, at

one with Mother Nature) and place of development (e.g. unspoilt nature, economically vulnerable, sense of local ownership), and indeed these studies have argued that acceptance of these developments depends on a good 'fit' between these perceptions of what place and technology represent. This 'fit' has been explained as being the result of various 'logics of opposition and support'[45]; e.g. perceptions of 'technology as experimental' combined with perceptions of 'place as nature' would explain oppositional public responses.

Mixed method studies which reconceptualise 'backyards' as 'places', and therefore more implicitly recognise the social, cultural and physical context in which ORE developments are embedded[49] have furthermore found that strength of place attachment significantly predicts attitudes towards ORE developments. In one case study a tidal energy converter was even seen to be place-enhancing, and was evaluated relatively positively by the residents despite a widespread perception of process unfairness, lack of local economic benefits, and potential threat to local livelihoods and wildlife. Though this suggests that a 'fit' between what technology and place represents can 'override' other concerns, it should also be noted that in a survey study[48] a variety of values attached to the seascape only partially shaped attitudes towards offshore wind, alongside a host of other arguments about energy, shipping safety and economic feasibility.

3.3 Studies of contextual factors

The studies in this section contrast with the broadly socio-psychological perspective adopted by studies in the previous section, which positions the processes that shape public responses to ORE developments to reside within the individual mind. Instead, in this section public responses are conceptualised as being shaped by the wider context in which these mental processes are embedded, exploring physical, procedural and energy system contexts of ORE developments and their influence on public responses to ORE developments.

Physical ORE project characteristics

Studies examining physical project characteristics have mostly focused on two questions relating to their location: 'is offshore wind preferred over onshore wind?', and 'is offshore wind more acceptable when located further away from the coast?'[50]. These studies have commonly used quantitative methods including questionnaire surveys and contingent valuation methods such as choice experiments – economic techniques asking how much individuals would be willing to pay for certain alternatives – exploring individual preferences in a context of multiple hypothetical wind farm alternatives.

A first set of choice experiments[51,52,,53] and questionnaire studies[54,55] has found mixed results as to whether individuals prefer offshore wind over onshore wind. Out of five studies, three[51,52,54] reported that individuals prefer offshore wind, while two[53,55] report a preference for onshore wind, suggesting there may not be a universal preference for either. This point is further emphasised by a survey study[7] which explored preferences across 19 specified land- and seascape types. It found that some (dunes, 'nature areas' and the environmentally sensitive Wadden Sea) are widely objected to as sites for wind farm development, while others are supported more widely (e.g. industrial, harbour and military areas, the North Sea, along the Afsluitdijk causeway), regardless of whether they are onshore or offshore. Though intuitively appealing, it should be noted that this conclusion is based on studies from three separate continents, where hypothesised developments are described to participants in differing ways that are presumed to mean something to participants (e.g. 300 football pitches of turbines), and which needs to become more transparent by including the visualisations that have been used, alongside a description of how they were produced.

Secondly, a number of contingent valuation[56,57,58,59] and 'contingent behaviour' studies[60,61] , which investigate how behaviour might change if wind turbines were added to the seascape, uniformly agree that coastal residents and tourists generally prefer wind turbines to be located at greater distances from the coast[62]. This is based on a reported willingness to pay for siting turbines further out to sea, and self-predicted future use of beaches were a wind farm to be constructed there. This preference is reported to be strongest for near-shore wind farms, as marginal willingness to pay decreases with distance from the shore. A different contingent valuation study on future tidal and wave development in Wales concluded that only a very small proportion of visitors would not return as a consequence of this potential development, while also suggesting underwater technologies were perceived more positively than technologies that were visible or reduced wave height[63]. Some studies furthermore point out that some stakeholders, like coastal residents, were found to be willing to pay more for relocating development further offshore than others[56,58]. However, it should be kept in mind that these were responses to hypothetical, not existing developments, in contexts where due to the absence of existing ORE technologies participants may be relatively unfamiliar with the technology and it appearance.

The process of ORE implementation

A final set of studies has moved away from a conceptualisation of public actors as passively being at the end of a one-directional stream of developments and information, towards a more relational interpretation that has highlighted the role of social interaction between all involved actors in shaping public responses. This perspective contrasts with an individualistic approach and relates more closely to a social constructivist epistemology in highlighting the influence of social interaction, negotiation and contestation on public responses to ORE. This contestation in the context of ORE has been highlighted in a study of consultations of fishers in offshore wind developments[64], which described how stereotyping and stigmatising of stakeholders on both sides contributed to the acrimony among developers, regulators and fishers. These interactions for example questioned the legitimacy of some claims for compensation and saw some stakeholders labelled as greedy (as also reported elsewhere[6]). Some aspects specific to ORE lay at the heart of these controversies, as there was a lack of adequate data on which areas were used by which fishers, problematising decision-making as to who should receive compensation.

While this example focused on fishers – one very particular offshore stakeholder – studies drawing on interviews with developing actors[1,2] have argued that their perceptions of 'the public' are also relevant in shaping their wider public engagement strategies, which in turn affect public responses[14]. These studies revealed a commonly shared perception of an ability to increase local support through communicating the benefits of the development – an 'information deficit' view of the public[65] – an idea that is also common across stakeholders in onshore energy developments[66]. However, a major difference with onshore RE is that public responses to ORE are often talked about as unproblematic, strongly rooted in a perception of the overriding importance of visibility, which is expected to be reduced due to siting further offshore or subsurface[1,2]. Stakeholders furthermore indicated a belief that due to a lack of public recognition of tidal energy public opinion was virtually non-existent, while others perceived support to be generally high[1], which strongly contrasts with developers' expectations of public actors as latently hostile towards onshore RE[67,68].

Many studies discussed in this review **[7,26]**, as well as other policy and best practice-oriented studies[69,70] and industry publications[71] have also argued for the importance of early and meaningful public engagement in fostering acceptance. One arena through which this could be managed for onshore developments is the land use planning system – its offshore equivalent, marine spatial planning, is currently emerging, but the literature on this has already made similar pleas for the importance of stakeholder participation and empowerment[72,73] and 'marine stewardship powers' to local communities[74]. Though case studies of the intersection between marine spatial planning and

ORE development are lacking at present, this is an area that is likely to co-shape public responses in the future. Potential shortcoming of more participative planning also need to be kept in mind in the context of ORE; for example a lack of certainty on the prioritisation of environmental outcomes and the possible domination of proceedings by influential or educated individuals, reflecting existing inequalities[75].

While the above section has focused on the interaction between what could be seen as the two 'sides' in ORE development (developing versus public actors), two further studies have instead considered interactions between various affected public actors by using deliberative methods that bring together stakeholders that are normally studied in isolation from each other. One study[76] that brought together actors impacted by an offshore wind farm in Taiwan aimed to draw on actor knowledge to build a model on the local ecological and socio-economic impacts – however no attention was paid to the kinds of social interactions and contestations that emerged, limiting the usefulness of the study for this review. A second study[77] explored the use of interactive tools in marine spatial planning by bringing together diverse stakeholders (e.g. fishing, sailing, tourism) potentially impacted by future tidal energy developments in Scotland. These studies, though also limited by a lack of quotations and reflections on the workshop processes, revealed that stakeholders were able to decide on a consensually sited tidal energy project, as they generally valued the sea closest to shore the highest, often based on usage intensity. However it also emerged that not all fishers would be willing to share information on which parts of the local sea are most important to them due to competition reasons. The exercise furthermore revealed a paradox between the dynamic use of the sea by many stakeholders, which problematised the valuation of specific areas of the sea, and the static nature of ORE, which requires siting on a fixed location. These disagreements and interactions highlighted by a relational approach contrast with findings from section 3.2 – further research in this area should focus on other specifically marine stakeholders, such as the UK's Crown Estate, and their role in ORE decision-making processes.

Wider energy system context

A small number of studies have commented on how aspects of the wider energy system or energy policy developments influence public engagement with ORE. A longitudinal two-survey study[78] before (2008) and after (2010) the Deepwater Horizon oil spill in the Gulf of Mexico found that this event did not significantly change support for offshore wind energy. The data also suggested that over this time period opponents to offshore wind became stronger opponents, while supporters also 'hardened' their positions. Experiences with the offshore oil industry in terms of community participation have also been argued to potentially offer a blueprint that could be repeated with ORE in some places, specifically in terms of granting communities near ORE development areas more control and a share of the profits[79]. Furthermore, other studies have, tangentially, commented on the wider energy policy context in shaping public responses to ORE. One contingent valuation study concluded that offshore wind in France may be more acceptable when accompanied by a coherent environmental policy[59], while a survey study found that a proposed ORE development in the US was seen as more acceptable would it have been the first of many such proposals[39]. These important points suggest the wider energy system and policy context can influence public responses to ORE developments, as has recently been argued to be the case for CCS in Indonesia[80] (Setiawan & Cuppen, 2013), and hint that the relative isolation in which ORE developments have to date been studied may cause scholars to overlook the role of wider historical and energy context in shaping public responses.

4. DISCUSSION

Key findings

This review has highlighted that public responses to ORE developments, and the processes that influences these responses, are dynamic, complex and variable – echoing similar conclusions made about public responses to energy infrastructure in general[19]. However, it has also illuminated numerous ORE-specific aspects that shape the ways in which individuals and collectives evaluate ORE developments that have sometimes been overlooked to date. First of all, it has become clear that knowledge levels about ORE – a novel, emerging group of technologies - are highly variable but generally low for most individuals; a strong contrast with more familiar onshore wind technology, which is not only visually familiar but is also associated with existing discourses of controversy and stigma. Secondly, keeping in mind that by far most studies have focused on land-based energy developments, the studies reviewed here have highlighted important uniquely marine issues that contrast with a terrestrial context: usage of the sea (i.e. many spatially dynamic activities that could give rise to multiple 'conflicts of use'[41]), ownership of the sea(bed) (not often privately owned – for example in the UK the seabed is owned by the Crown), and relatively recent questions around marine decision making processes, as well as conflicting visions of what the sea represents and should be used for (as previously discussed in relation to the rural[81]). Though developments in marine spatial planning may provide some answers to these governance issues, the relative lack of current clarity in these aspects shapes public engagement with ORE developments in ways that are very different from terrestrial energy developments[26,82]. Thirdly, studies have indicated many of the impacts expected of ORE developments relate to specifically marine issues such as loss of access to marine areas and subsequent loss of livelihood, concerns about marine wildlife and the quality of waves for surfing, while also noting fundamental belief about the sea as a special place where human structures do not belong – a perspective on ORE's location that seems to leave little room for enhancing ORE's 'acceptability'. Fourthly, visual impact is still one of the main concerns when asked about the impacts expected from ORE development – however, the role of visual impacts has been highlighted to be more complex than this. While previous research has highlighted the importance of visual impact in shaping public responses to energy infrastructure[83], it is apparent that visibility plays a different role for ORE. Though offshore wind farms that are clearly visible from the shore often run into opposition[5,6], others that are even closer to shore do not[68], while some nearshore tidal technologies have been seen as fitting in well visually and as place-enhancing[34]. This adds nuance to earlier conclusions that offshore wind farms are evaluated more positively when located further offshore[61], and highlights the important but inconsistent role of visual impact. In general there is an expectation among developers and regulators that ORE technologies will be less visible[1,2], which leads to presumptions of broadly high public support for ORE developments. This contrasts strongly with onshore wind, towards which developing stakeholders perceive the existence of a latent public hostility[66].

In addition, this review has also confirmed that many of the concerns that shape public responses to onshore energy developments also influence public engagement with ORE developments[26,84], such as procedural justice concerns, developing actor perceptions and the need for a 'fit' between interpretations of technology and place[5,45,85,86]. Moreover, some of the logic and reasoning behind public responses to ORE are similar to onshore wind – for example climate change arguments and anti-wind sentiment seems to stretch across both onshore and offshore wind[24,26].

Limitations of the reviewed literature

While the studies reviewed above have made substantial progress in enhancing our understanding of public responses to ORE, a number of shortcomings have also become apparent. First of all, while the unique, marine context of ORE developments has been highlighted across studies, some quantitative studies have simplified or overlooked this context[3,4,50-62]. Studies which did acknowledge this offshore setting, like those investigating symbolic interpretations of the sea, have disagreed on

what exactly to measure: attachments to coastal towns[5], symbolism of the sea as a whole[48] or even at different scales covering both[45]. Further scrutiny of the kinds of people-place bonds that are most associated with ORE implementation is needed in this area. Secondly, while various studies reviewed here have concluded that individuals are typically unfamiliar and not very informed about offshore technologies[43,44], many studies have overlooked this and treated participants as sufficiently knowledgeable to make judgements about their desirability, for example using terms such as 'wave/tidal' without further explanation[3]. Some studies have tried to inform participants using visualisations, but these were often not included in the published paper and no explanation was given as to how they were produced. There is a need for the application of further, diverse methodological innovations to deal with varying levels of public knowledge of ORE. Thirdly, the exact object of study across the reviewed literature is often ill-defined and varies across studies: terms like public or social acceptance, public opposition, public perceptions, public engagement, beliefs or attitudes, and various other concepts have been used. Given the lack of a common language or at least a definition of these terms, it remains unclear whether papers have talked about the same thing and can be compared as such[18]. Finally, there are two aspects of diversity across the reviewed studies that need to be acknowledged and critically discussed in future research. Firstly, many different disciplinary (psychology, geography, economics, sociology) and epistemological (positivist, social constructivist) approaches have been adopted without critically commenting on how specific approaches compare, add to, or question previous findings, resulting in a fragmented body of research. From a perspective of critical pluralism[87] this would be a limitation, as fully understanding complex questions around public engagement with energy requires the combined and integrated efforts from different disciplines. The second aspect of diversity concerns the diversity of the developments studied – this review argues that the variety of different types of development (e.g. test sites, commercial developments), implementation stages (e.g pre-proposal, proposed, operational), and local context (e.g. media coverage, historical controversy) have not been emphasised sufficiently, which complicates cross-study comparison of findings.

Future research needs

This final section proposes directions for future research, based on the gaps left by the body of work reviewed in this paper. Looking across previous reviews of public engagement with RE, mostly based on onshore wind research[12,13], a number of factors influencing public responses to ORE developments can be identified that have been absent in this review: physical characteristics of ORE devices (colour, spatial arrangement, size, number, noise), community benefits, ownership models, environmental concerns regarding underwater wildlife, and the role of trust in marine regulatory and governing bodies. Many lines of research can be envisaged along these lines to probe how these issues play out offshore – would there be a greater or lesser interest in alternative ownership models offshore, could there be a form of mixed ownership which includes stakeholders such as fishers, is there a reduced or greater rationale for community benefits in an offshore context?

Besides these suggestions along 'mainstream' lines, this review also argues for a move away from re-studying the factors that have already been concluded to be relevant in case studies of onshore energy developments, towards those that are specifically relevant to offshore developments. Some of these have already been mentioned above, but another aspect that needs further scrutiny is public engagement with ORE technologies that are entirely underwater - something which is often presumed to eliminate opposition altogether[1]. Comparisons with other less visible energy technologies such as carbon capture and storage[88,89], geothermal energy and hydraulic fracturing could help in exploring public responses in a context of limited visual impacts. Another avenue of future research should investigate how public perceptions and understanding of the marine environment, attitudes towards it, or ideas of 'marine citizenship'[90,91], shape public responses to various offshore developments of which, it should be remembered, ORE is only one type.

In terms of theory, the common absence of theory in the reviewed literature leaves a need for the use of more theory, the development and testing of subsequent hypotheses, and using these theories to more frequently and more robustly attempt to generalise findings from specific case studies, something which has been almost completely absent from the reviewed literature. Suggestions for the use of risk and reward perception[40] and theory of planned behaviour[92] could be supplemented by insights from social representations theory[93], and social practice theory[94].

In terms of research design, looking across the studies reviewed in this paper, a very common research design is the use of single ORE developments (mostly proposed or hypothetical) as case studies to better understand public engagement with RE in general[5,6,21,23,24,35,40,45]. While this has successfully enhanced understanding of public responses to specific localised developments, there is a need to be more adventurous in moving beyond this research design towards designs and methods that have been untested in this field of research. This is especially important to achieve a broader and more robust understanding of the processes and factors that shape public engagement with energy infrastructures, beyond the spatial and temporal confines of individual RE developments. For example, the lack of comparative studies means the literature cannot provide many answers to questions around cross-technology applicability and generalisability of findings, or the comparative acceptability of different local, regional or international sites. This suggests the merit of a multiple and comparative case study design. Moreover, few studies besides review papers have focused on comparing public responses to different technologies in a methodical way[95], implying a belief that public engagement with energy technologies is to some degree universal, irrespective of the specific technology. A further approach that would contrast with the focus on 'downstream' case studies (where major decisions about technology, siting and consultation have already been made) is provided by more 'upstream' approaches; either in the technology research and design process or in the ORE implementation process[96,97,98]. Upstream engagement in technology research and development may be possible due to the current early stage and plurality of pre-commercial stage wave and tidal devices being tested, and could benefit from looking at similar efforts in other early stage developments such as geoengineering[99]. Public engagement that is upstream in energy infrastructure decision-making processes has the potential to broaden our understanding of the context in which public responses are being shaped, by emphasising energy policy alternatives including other supply and demand-side options, a context that is almost always missing from existing studies.

Other overlooked methodological approaches include experimental methods, which are well-suited for exploring the neglected issue of the causality of attitudes and their associated factors, and ethnographic methods which pay more attention to personal lived experience and contextual factors. One potential avenue in this direction could be envisaged to adopt a 'sea-based' perspective, using ethnographic methods to explore lived experience of the sea and what this means for public engagement with ORE developments. Furthermore, many studies have focused on the role of a single variable in shaping public engagement with ORE (for example procedural fairness[34]); the determinants of public responses to ORE developments are rarely considered as a whole. This could be addressed by a greater use of statistical analysis to more rigorously test conclusions from quantitative studies, and for example move beyond the study of individual factors towards integrative analyses which scrutinise the relative importance of multiple factors[90,100].

5. CONCLUSION

This review has aimed to bring together, review and critique work from varied disciplinary origins that forms an emerging, fragmented and increasingly important research field. It has, by grouping these diverse studies under the banner 'public engagement with ORE', identified how public responses to ORE may be shaped very differently than responses to onshore energy developments,

and suggested avenues for future research. Though grouping diverse studies of highly diverse technologies in a single category – ORE – may be arbitrary, it has helped in distinguishing from research on onshore wind that has dominated the 'beyond NIMBYism' literature to date, and which has to a large extent informed conclusions about how public responses are shaped and what can be done to influence them[13,30]. It has highlighted numerous questions that have remained largely unasked and unanswered across this area, most prominently regarding the role of its offshore location, the specific technology and its stage of development, and the cross-technology and cross-disciplinary applicability of findings. Moving beyond a research focus on onshore wind is increasingly important given shifts, at least in the UK, away from onshore wind towards energy technologies that are increasingly taking alternative material manifestations such as offshore, underwater, or indeed under the ground. More rigorous scrutiny of these novel settings is needed, asking how they are understood and in what ways they shape public responses to these technologies when proposed – especially going beyond an emphasis on visual aspects. This review has tried to illustrate these dynamics by focusing on one particular stream of novel, offshore, technologies, and has argued that if public responses to ORE are to be fully understood, future research needs to consider the unique characteristics and concerns associated with ORE in more critical and ambitious ways.

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Related articles

DOI	Article title
10.1002/wcc.250	NIMBYism revisited: public acceptance of wind energy in the United States.
10.1002/wcc.176	Perceptions of geoengineering: public attitudes, stakeholder perspectives, and the challenge of 'upstream' engagement
10.1002/wcc.89	Public engagement with large-scale renewable energy technologies: breaking the cycle of NIMBYism

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