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The role of small-scale and community-based projects in future development of the marine energy sector

Nikolaos Proimakis[a,b], Tara Hooper[a] and Poul Alberg Østergaard[b*]

[a] *Plymouth Marine Laboratory, Prospect Place, The Hoe, Plymouth, PL1 3DH, UK*
[b] *Aalborg University, Rendsburggade 14, 9000 Aalborg, Denmark*

ABSTRACT

Despite high expectations for the sector, most marine energy technologies remain in the research and development, or at best demonstration, phase. The industry is in a period of stagnation, and requires new approaches to overcome the challenges that inhibit widespread deployment. Small-scale initiatives have proven to be a successful means of developing other renewable technologies but their role in supporting marine energy is not well researched. This paper provides a review of the barriers and opportunities presented by different policy landscapes, financial support mechanisms, markets, key actors, and wider regulatory and governance issues. Semi-structured interviews with marine energy stakeholders from the UK, Canada and Denmark were used to explore the role of small-scale marine energy projects, and were supplemented by interviews with the general public in England. This showed that while marine energy is appropriately scalable for local projects, financing remains a major hurdle. Discretionary local authority finance, as well as other novel options such as crowdfunding, tends to be relatively modest, supporting the argument for small-scale projects. A market for smaller devices exists, particularly for remote communities currently dependent on expensive energy from oil-fired generators. There remains a significant role for small-scale projects in testing the technology, contributing to reductions in cost and environmental risk. Current processes for environmental impact assessment can present a significant hurdle for small projects, but proportionate, adaptive assessments are evolving. Finally, community ownership and public participation have the potential to increase advocacy for the industry, with multi-actor partnerships presenting a positive way forward.

Keywords

Tidal energy;
Policy;
Governance;
Financial mechanisms;
Europe;
Canada

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1. Introduction

In 2018, the principal renewable energy source globally was hydro-power with a capacity of 1,132 GW, followed by wind and solar, which accounted for capacities of 591 GW and 505 GW respectively [1]. Wave and tidal power technologies stand out with the lowest capacities (below bio-energy, geothermal and solar thermal), reaching only 532 MW [1]. The 2009 National Renewable Energy Action Plans by the EU member states, foresaw wave and tidal energy reaching 2.25 GW by 2020 and 100 GW by 2050 [2]. There has been significant downward revision of these estimates recently, with Ocean Energy Europe [3], predicting a more modest capacity of 0.85 GW by 2021. Nonetheless, ocean energy remains a main focus area of the European Commission's Blue Growth Strategy [4], and for the planning of a transition towards sustainable, renewable energy-based energy systems, offshore is also seen as pivotal also in research [5–7]. One study suggests 2750 GW of offshore wind power in the European Union including the United Kingdom [8].

Numerous factors inhibit the widespread deployment of marine energy, however. These include technical challenges [9] and good resource assessments[10], but non-technical constraints are also significant. These relate

*Corresponding author - e-mail: poul@plan.aau.dk

to rules, regulations, support mechanisms and decision-making processes, and include funding programmes, technology market establishment, infrastructure support, administrative and environmental issues, social engagement and acceptance, ownership and legal aspects [1,2,11–16]. The issue of governance is central to these non-technical challenges [17], and the need to examine and implement governance changes, which would result in a more advantageous strategy able to accelerate marine energy deployment, has also been identified as a key priority by the European Commission [4].

As with energy infrastructure elsewhere, based on analyses using Scotland as a case, Wright concludes among others that "certainty and stability are crucial for supporting investment" [18] when seeing the development in offshore energy from an industry perspective.

At present, the prevailing governance model for marine energy systems focuses on centralized large-scale developments and has had only limited success in delivering viable projects. The marine energy sector has thus reached a stagnation point [2]. The efficiency of government- or business-driven developments in initiating new diversified energy routes have been called into question [19], and there is growing interest in the role of alternative governance models in achieving a transition to low-carbon societies [20,21]. Local initiatives have proven to be an alternative means of developing renewable energy strategies and enacting sustainability transitions [19–21].

In the case of marine energy, limited academic research has been undertaken to investigate the bottom-up approach from the perspective of crucial institutional actors and their potential influence in the implementation of renewable energy systems [22]. Therefore, in this paper we seek to explore the key barriers and opportunities for small-scale locally-focussed marine energy initiatives. The research examines the ways in which different countries within Europe manage these issues, to compare and contrast the enabling and obstructing features within each political context.

2. Method

A qualitative approach was taken using interviews with stakeholders from the United Kingdom (UK), Canada and Denmark to identify the challenges and opportunities for small-scale and community-led initiatives in the development of the marine energy sector. The UK and Canada were selected due to their progress in technology development and their varying governance arrangements, while Denmark provides a unique perspective on community-based renewable energy initiatives more generally, particularly through the case of Samsø Island [23,24]. Individual participants were identified following determination of the appropriate agencies and stakeholders within each country and through the "snowball" effect of recommendations made by previous interviewees.

A total of 22 semi-structured interviews (face-to-face or by video conferencing or telephone) were conducted with technology and project developers, community energy groups, regulators and seabed leasing authorities, environmental agencies, statutory nature conservation bodies, local authorities, marine energy associations and academics. Predominantly, the interviewees had experience of multiple renewable energy sectors (including onshore), although four participants specialised particularly in tidal energy and one in wave.

In addition, face-to-face interviews were carried out with 963 members of the public resident on the North Devon/Somerset coast of the Bristol Channel in south west England to determine their perspectives on ownership of, and investment in, local tidal energy developments Interviews were part of a wider project that required respondents from very specific postcodes. For this reason, a market research company was hired to carry out the face-to-face interviews. Further details of the specific case study sites and questionnaire content are given in [25].

3. Results

In this section, the results from the conducted interviews are presented. The results are categorised in the subsections: technological development, national policy landscape, financial mechanisms and cost issues, wider regulatory and governance issues, key players and motives including role of local government, and public attitudes to ownership of, and investment in, local tidal schemes.

3.1. Technological development

Interviewees did not perceive specific technological impediments to the development of small-scale devices, noting that the technologies are scalable and, as one developer stated "*we see them as perfect for community scale*." The potential, and importance, of starting at the smaller scale was emphasised by technology developers and by an academic in Denmark who said; "*with wind* *they implemented hundred smaller devices, got all the learning and the development stage from that before going up to MW scale and multi-MW scale. That is what we've got to balance up in the tidal industry.*" However, wider technological obstacles were identified, particularly around grid capacity constraints and connection costs.

3.2. National policy landscape

The term 'national' is applied broadly, as in the UK aspects of energy regulation have been devolved to the administrations in Scotland and Wales, and Canada also has a decentralized approach. However, the national-level policy landscape continues to be important in Canada, and the shift to a Liberal government in 2015 was considered by interviewees to have favoured marine energy deployment. The national government has implemented clean energy initiatives to support technology development and demonstration, aiming to accelerate the commercialisation of marine technologies. An interviewee stated that "*the federal government had played an umbrella role providing the funding and helping to de-risk aspects of the sector*". However, concrete outcomes of this positive national policy arena have been limited: one interviewee commented "*we are at the point now where this is kind of hopeful…but hasn't made its way yet*". Elsewhere, national governments are perceived to be failing to support marine energy. An interviewee from Scotland noted that "*the support needs to be from the centre, rock solid and long-term", and in Denmark "the wider policy does not favour marine energy at all at the current stage*".

3.3. Financial mechanisms and cost issues

The national policy landscape is particularly relevant from the perspective of financial support for the sector. Interviewees made repeated reference to the way in which national energy subsidy schemes failed to differentiate between mature technologies already well-established in the market (such as offshore wind) and emerging technologies. In the specific context of small-scale community-based initiatives, one Canadian respondent commented: "*it really needs the provincial government to make a commitment and say that we want to fund small scale to develop and decentralize the systems*".

Feed-in-Tariff (FiT) schemes (in which the producers of electricity are awarded a fixed price per kWh of energy produced) were identified as crucial in assisting small-scale projects. However, these can be centralised and inflexible, as noted by a Welsh respondent: "*the FiT scheme is national policy and there is no option in each country to establish its own*". In the UK, a recent closure of the FiT scheme to new generating capacity created "*a barrier for the advancement of the sector which struggles to balance its absence*". Nova Scotia introduced a targeted Community Feed-In Tariff (COMFIT), which was perceived by Canadian interviewees to benefit community-owned developments. However, "*the COMFIT program lasted for a couple of years but then it has been recently cancelled, because it was oversubscribed and most of it was because of onshore wind. There isn't any more COMFIT available for tidal*".

Devolved governments in the UK have the power to provide alternative financial support for emerging energy sectors, and this is often focussed on smaller projects. Interviewees from community and marine energy associations referred to targeted financial aid from the Welsh European Funding Office, which has included investment in a Marine Energy Test Area. Conversely, interviewees in England noted that "*there is no specific fund aiming for community-based renewable energy projects*", and "*there is more and more evidence the projects will be successful in the UK only if they have access to the market which is probably one of the greatest challenges*".

There were some positive perspectives on cost issues related to small-scale projects, including one developer who commented "*I can certainly see the sense in putting in multiple smaller devices because the installation costs are so much lower it is much easier to take devices in and out of the water if anything goes wrong. The actual capital expenditure of the devices is significantly lower, so there is a lot of benefit in that approach as well.*" However, others expressed doubt: "*it's challenging to identify how we can decrease the levelised cost of energy, because of all the construction and the huge installation costs".* A Canadian interviewee commented that "*developers have pulled out of small-scale marine energy projects, as there is no return on investment for putting a device in the water.*"

3.4. Wider regulatory and governance issues

Environmental compliance was described as a barrier for technology developers, with the associated economic burden (as a proportion of the project costs) perceived to be particularly significant for small-scale community-based projects. All interviewees from environmental agencies in England confirmed that they charge fees for discretionary advice, as part of their institutional requirements to seek income streams. They are aware that this might exclude communities from early engagement with the environmental screening process. "*We charge for these types of projects and I think it will put some people off, and certainly these small projects where the money is tighter and they don't have the background in marine licensing or any other type of consenting*."

Respondents from the industry and academic sectors considered the Environmental Impact Assessment (EIA) process to be rigorous, detailed and complex, with a high information burden but lacking specific guidance. However, regulators disagreed with this perception stressing that "*smaller-scale projects may have smaller environmental impacts and the level of evidence required for this type of projects is less compared to large-scale projects*." One project developer confirmed this: "*if you have one device and it is in an area that it is not considered as environmentally sensitive, in theory, you would get a consenting process quite quickly.*"

The current approach in Scotland is perceived positively. One developer commented, *"[Marine Scotland] look at the size of the project and the environmental risks that are specific to that project. After acknowledging that, they can use that to guide you on how much info you must provide, thus supporting the application."* Like Scotland, in Canada *"The principle that has been used is adaptive management"*. The role of Strategic Environmental Assessment was also raised in both Canada and Scotland, again as offering an approach where the key risks were identified in advance, making it easier to deploy devices as developments progressed. A member of an environmental agency in England similarly noted, "*You can't put the burden to one developer to sort out all the uncertainties for the whole industry. We try to work with the developers especially at the small scale as much as possible.*"

In the UK, the owner of the majority of the seabed is the Crown Estate, which has both a stewardship and commercial role. One participant expressed the opinion that economic profit was a strong motivator for the Crown Estate in issuing leases, and that community enterprises and small-scale projects are riskier prepositions than commercial projects with more certain economic results. Interviewees further identified the challenge for community groups of competing against large developers of commercial projects, although *"The leasing rounds favoured legitimate (big) developers with large-scale proposals, but in 2015 the Crown Estate changed approach and initiated a new programme of leasing for smaller-scale marine energy projects".*

Other leasing models may also improve opportunities for community projects. Interviewees described the process in Canada, where the leasing authority has certain socio-economic criteria for providing the lease contract, including requirements for utilizing the local supply chain and engaging local communities as much as possible, while in parallel providing proof of public consultation and wide stakeholder engagement. Technology developers thus make partnerships with community organizations and local authorities to ensure social engagement and local benefits.

3.5. Key players and motives, including the role of local government

Interviewees commented more widely on how key actors are trying to engage and involve communities in decision-making processes. As one technology developer noted *"there are opportunities for local planning policy to be more favourable to [projects that are] community led or with community involvement"*. However, respondents also identified the challenges faced by community organisations in the progression of marine energy initiatives due to lack of expertise, knowledge, and access to funding, particularly in the initial stages of a project. A range of organisations were identified that have been established (often by local authorities but also by the renewables industry) with mandates to support community projects, marine energy specifically or renewable energy more generally. The role of these agencies includes establishing partnerships and providing facilitation, linking communities with funding streams, and serving as a 'one stop shop' for licensing support.

Specific examples of cooperation between community groups and other actors include the DanWec wave energy test centre in Denmark, which *"came into place after a co-operation with a university, the local authorities, the local community and local companies operating in the harbour"*. This strategy of promoting and developing partnerships exists elsewhere including Canada and in Wales, where "*win-win*" partnerships exist with technology developers assuming responsibility for consenting and licensing processes, while community groups assist with stakeholder engagement and local supply chain management.

Several interviewees reflected on the ways in which local authorities can be instrumental and even pivotal in establishing a favourable environment that makes marine energy projects more attractive and feasible. In Wales, the local government played a crucial role in getting community-based projects off the ground by providing financial support for early stage feasibility studies. Local authority motivation (as perceived by respondents in Scotland and Denmark) is often around economic development, and they further recognise the benefits of building infrastructure that could be utilized both by the marine energy sector and other industries such as fishing. Local development plans were explicitly highlighted as a key opportunity for addressing the challenge of balancing the needs and concerns of existing sea users with a marine energy agenda. However, local policies that could benefit marine energy often require support from national governments: *"It would be very hard for the local government to write a policy which is in opposition from what the national policy says"*; *"You have got to get everything lined up"*.

3.6. Public attitudes to ownership of, and investment in, local tidal schemes

Overall, 78% of respondents to the public survey stated that would be likely or very likely to support a local tidal energy development. Factors influencing this level of support (beyond those related to ownership and investment) are discussed in [25]. The likelihood that an individual would support a tidal development varied according to the ownership of the scheme. Levels of support were maintained for projects owned by the national government (81%) or local communities (79%), but declined for turbine manufacturers (72%), local councils (71%) and, particularly, for large energy companies (63%). Participants who initially stated that they would oppose a tidal scheme were asked if their decision would change depending on who owned the project, and 13% agreed that this could affect their objections to the proposal.

Nearly a quarter of respondents stated that they would probably or definitely consider investing in a tidal energy development in their local area. Of those respondents, only 28% had invested in community projects before. This increase may suggest particular motivation related to tidal energy, but is perhaps more likely to represent a bias due to the presence of the interviewer. Stated willingness to invest also varied depending on what type of organisation initiated the project. In keeping with their overall preferences for ownership of tidal schemes, 16% would consider investing in a tidal project initiated by the UK government or their local community; 13% in those managed by their local council or the turbine developer; and 11% by a large energy company.

When the motivations for members of the public to invest in community tidal energy projects were explored, 54% agreed or strongly agreed with the statement "*I would only invest in a community tidal energy project if I was sure I would get a good financial return.*" Sixty two percent agreed/strongly agreed that "*The financial return on my investment would be less important to me than knowing I am supporting a project that is trying to reduce the use of fossil fuels*", and 58% that "*The financial return on my investment would be less important to me than knowing I am supporting a community project.*"

4. Discussion

The stakeholder interviews highlighted the important role of national governments (also provincial and devolved administrations) in providing the overarching framework for the development of marine energy, including the availability subsidies and policies such as marine spatial planning, but also in signalling high-level support for the industry. The situation in Canada, Wales, and Scotland, where this support has been more apparent and greater progress is being made in the deployment of devices, contrasts with that of England and Denmark. The international policy context is important even to local projects, as developers stage the location and timing of their investments depending on favourable jurisdictional conditions [26]. Stability of policy support is also a factor, with the consistent support for larger developments in the Canadian province of Nova Scotia considered influential in their progress, and contrasted with the fluctuating nature of policies applied to small-scale devices [27].

4.1. Addressing the high levelized cost of energy in the marine sector

A key theme that emerged from the interviews with technology and project developers, members of marine energy associations and academics was that wave and tidal energy cannot compete with established technologies within the current structure of energy markets and so subsidies are needed. New mechanisms for financing marine energy at the national level in the UK have been proposed by the marine energy industry. These include an Innovation Contract for Difference for utility-scale projects to create a dedicated mechanism within which all new technologies (tidal, wave and floating wind amongst others) would compete with each other rather than with established technologies such as fixed offshore wind [28]. However, ensuring value for money and reducing consumer energy bills continues to be a stated aim of the UK government [29,30]. The high relative cost of tidal energy has also been cited as a reason why research and investment for renewable energy at the national level in Canada should focus on wind, solar and hydropower, as the cost of these known and tested technologies is steadily decreasing [31]. Therefore, it will be a significant challenge to demonstrate why new forms of electricity generation should be subsidised when issues such as energy security, climate change mitigation, and economic development can be addressed by mature technologies, which require minimal state support. Arguments for the wider benefits that could result from supporting the sector will need to be particularly convincing, especially in the UK where the industry has overpromised in the past [32].

Arguments were made by developers that utility-scale projects are needed to impact significantly on the levelised cost of energy (LCOE), which echoed those in the existing literature [33]. However, these arguments stem very much from the context of a large-scale, centralised energy system. The dominance of such systems (and hence energy infrastructure and market-dependent support mechanisms that tend to favour large-scale, established actors) are particular barriers to change [34]. The existence of a centralised system dominated by corporate actors is one reason why countries such as the UK lagged behind those including Germany (where levels of local ownership were high), during early deployment of onshore wind [35].The development path of the wind power sector shows the importance of a significant period (decades) of small-scale deployment in reaching the current stage of commercial deployment of large devices and arrays. Wind turbines of 8MW are now commercially available, but in 1991 the average size of turbines was 224kW, and in 2001 this had only increased to 1MW [3].

Furthermore, the device itself represents 33% of the project cost for tidal energy (just over 50% for wave) [36] so reducing the costs associated with installation, operation and maintenance, and decommissioning has the potential to impact substantially on LCOE. Marine energy costs also link to device design, with significantly lower operating costs for surface-piercing and, particularly, floating tidal devices due to the opportunities for in-situ maintenance and reduced vessel requirements [37]. Even modest changes in annual energy production can result in a significant decrease in LCOE, through improved reliability and availability of device components [37]. Thus, it remains that the key to reducing LCOE is to deploy more devices, providing the necessary volume, experience, and innovation needed to reduce capital and operating costs [36]. Small devices remain essential to this process, as learning-driven cost reduction is achieved quickly with smaller capacity per unit [33]. Continued experience will also improve access to finance, by increasing understanding of risks [3].

4.2. Financing mechanisms for small-scale and community initiatives

Community energy representatives made less reference to the need for national subsidies, reflecting the alternative financial mechanisms available to smaller-scale projects. Respondents did, however, note how regional authorities have played a significant role in providing both a supportive policy environment and discretionary finance. There is some evidence that the active support given to the industry by devolved administrations and local authorities has drawn significant investment into local economies, even at the small scale of current tidal energy development. Direct investment of £46.8 million has been made into the Welsh economy by tidal stream energy developers to date, an increase of £17.4 million since 2017 [38]. For Scotland, it was further noted that even though major investment in consenting, construction and installation was short term, there would still be longer term positive impacts on the wider economy particularly where the expenditure was made locally [39].

In Scotland and Wales, schemes such as Scotland's Community and Renewable Energy Scheme and the Welsh Government Energy Service provide access to public funding and expertise for communities, with a particular focus on the early stages of project development, and have both supported small-scale community tidal projects [40,41]. However, interviewees highlighted how the removal of dedicated public financing for community projects can have significant negative consequences. England has seen a steep decline in the formation of community energy groups since feed-in tariffs and tax incentives were removed in 2015 [42].

Innovation Power Purchase Agreements (iPPAs) have recently been suggested as a mechanism for supporting smaller projects up to 5MW in the UK [28]. iPPAs would allow marine energy developers to sell their energy at above market rate, with the buyers of the energy (for example energy suppliers or large corporations) receiving tax rebates or credits for the difference between the cost of the energy and the market price [28]. Marine projects could therefore be financed without the need to pass on costs to household consumers. PPAs for marine energy are not themselves new and have already been used in Canada to support development of the tidal industry in Nova Scotia [43,44].

Investment from private individuals and organisations also has a role to play. Communities can be seen as relatively high risk by mainstream lenders, making it difficult for them to secure affordable loan rates [42]. Support from the public sector (via local authorities) remains crucial, as access to finance by community groups becomes easier once initial local investment capital has been secured. In Denmark, for example, some community schemes like district heating are provided with low-interest loans backed by public guarantees [45]. After obtaining financing from sources including the Scottish Government, one tidal energy company recently secured a further £7 million through a crowdfunding initiative [46]. This model has the potential to be particularly applicable for community marine energy projects as it allows for small contributions from individuals and can draw on place-based motivations. Investors in Scotland, where the tidal turbine manufacturer is based, contributed on average 50% more than other supporters [46]. The outcome of the questionnaires with members of the public provides further evidence of the willingness of local people to consider investing in tidal projects.

Previous research shows that energy cooperatives have a different ownership model to conventional businesses, and the maximisation of return on capital may not be a key objective [45], which is supported by the findings of this study. This is potentially significant in situations where initial grant funding would be necessary for projects that would otherwise be unprofitable, as has been the case in some examples of small-scale hydro schemes [47]. Also, community groups are motivated to establish energy projects for a wide range of reasons including climate change mitigation, contributing to local economic regeneration, and ideas of local autonomy, community empowerment, or the democratisation of control over the energy system [48]. The increase in the number of 'ethical' finance companies and products has improved the opportunities for small-scale community energy projects [48]. It has also been suggested that, for Wales, local government pension funds should divest from fossil fuels and instead support local renewable energy projects [49]. Support mechanisms such as the development of new instruments and the reallocation of existing investments require substantial momentum within the financial services industry to effect significant change. There is some evidence of the latter, with the analysis of environmental, social and governance factors becoming more common in investment decisions [50]. Community initiatives will, however, still need to demonstrate financial feasibility [42].

Access to market was identified by developers as a further challenge for the industry. Markets may be different for small- and utility-scale devices, which affects the relative cost competitiveness. For example, in remote locations relying on oil-based generators electricity costs are high and so there is the potential for marine energy to be competitive and to provide a return on investment even with little subsidy [3]. In Canada, there is a large market for small-scale and off-grid community schemes, and a growing number of tidal developers are involved in these projects, including in Northern Canada despite the particular challenges presented by harsh climatic conditions [36]. The United States (particularly Alaska) and island states in Asia are two examples of the wider global demand for smaller technologies to supply remote, off-grid communities [36], and a recent prediction was made that the potential marine energy export market will be worth £7 billion by 2050 [38].

Again, there are parallels with the development of the onshore wind sector. Despite the availability of large devices, there remains a substantial market for small and medium-sized wind turbines (up to 500kW). In the UK, over 2,200 devices were installed locally in 2014 and a further 2,600 exported [51]. However, as has tended to be the case across the renewable energy sector, the industry contracted following changes to Feed-In-Tariffs. Globally, growth in the sector nonetheless continued as new international markets emerged, and demand for off-grid solutions in remote rural areas was sustained [52].

4.3. The wider regulatory landscape

Industry bodies have called for a straightforward, clear, consistent and affordable environmental consenting process that takes account of, and responds proportionately to, the size and context of individual projects and supports the timely deployment of devices, particularly those of a smaller scale [3,36]. Developers interviewed in this study similarly continued to assert that statutory requirements for environmental compliance may act as a barrier to even small-scale devices. However, this was disputed by other participants who noted that significant steps have been taken (particularly in Scotland and Canada) to develop frameworks for proportionate consenting and to increase focus on adaptive management and data gathering (with significant investment in environmental monitoring) in order to narrow down the crucial risk factors. A key factor in addressing risk is to reduce uncertainty around environmental impacts, but this remains high because too few devices have yet been deployed for sufficient continuous periods [29]. Increasing the number of installations is therefore fundamental to understanding the interactions between devices and marine wildlife [3], and will be supported by the deployment of small-scale devices.

Project developments take place within the wider framework of marine spatial planning and also of strategic environmental assessment, which can have a significant influence on how the governance of new industries evolves [53]. The sectoral marine plan for tidal energy in Scotland has been highlighted as offering best practice in its provision of a strategic siting process within a clear regulatory regime, which supported the implementation of tidal energy [54]. However, the effectiveness of strategic environmental assessment in Canada has been limited due to its often *ad hoc* nature, the lack of mandatory provision for public engagement, and disconnection from larger, formal systems of integrated policy, planning and decision making [55].

4.4. Additional benefits of community involvement

Interviewees across the UK, Canada and Denmark referred to the positives of working in partnership with local communities, which included benefits to the developers of a favourable planning environment, and improved stakeholder engagement and supply chain management. Partnership working also supports the community participants, as they may lack the in-house expertise to conduct feasibility studies, work through the planning process, and scope financing options [42]. This may be a particular problem for community groups without existing renewables schemes that are considering marine energy projects. New entrants face considerably greater barriers than those already engaged in the sector [42].

Community involvement also has the potential to address issues of equity and justice within the energy system, which have been the subject of recent attention in the UK. The Welsh Government is seeking to ensure that local areas benefit from the process of cutting carbon emissions [56] and has established a target of 1 GW of locally-owned renewable energy capacity in Wales by 2030 [57]. Others have gone further and proposed that by 2020 all new renewable energy projects in Wales with a capacity greater than 5 MW should have between 5% and 33% community and local ownership, suggesting that this could be funded by business rate [tax] relief on the proportion of the project owned by the community [49]. Local ownership has also gained some interest in Denmark as a motivating factor for wind power developments to ensure a better geographical balance between revenues and perceived environmental impacts [14,58], but also from the perspective of better integration into local smart energy systems [59]. Broadly, it is to be expected that the interests of community groups would be a better fit to small-, rather than utility-, scale projects, although this may not always be the case. In seeking to set up a marine energy hub to benefit the local economy, a social enterprise working in North Wales has obtained the lease agreement for the West of Anglesey Demonstration Zone which has the potential to deliver up to 100MW of tidal energy [60].

Ownership may also be a factor in public acceptability of tidal projects. Denmark's position as a leader in wind energy manufacturing and development has been attributed to the role of local and cooperative ownership of early wind farm projects, while the more recent shift to developer-led projects has seen a concurrent increase in public opposition [61]. Similarly, community ownership or co-ownership was associated with positive attitudes to wind farms in Scotland and Germany [62,63]. Respondents in this study showed a similar preference for community projects, although also for nationally-owned tidal developments – perhaps this engenders a feeling of ownership or reflects support for a wider renationalisation agenda. The particular distrust shown by respondents towards developer ownership may reflect similar attitudes to those expressed for other renewables, with developers perceived as being motivated by profit and lacking any real interest in local people [64].

The potential role of the wider public in the development of the marine energy sector is often overlooked. Decision-makers respond to their constituents, and, as has been observed for onshore wind in Germany, when large numbers of people become actively involved with a renewable energy technology this enlarges the lobby advocating that technology at both local and national level [35]. The level of public knowledge of marine energy is, however, limited; 5.9%, 6.5% and 14.8% of a UK-wide sample of 1000 respondents reported that they had never heard of, respectively, tidal current, wave, and tidal lagoon power, more than for any other renewable energy sector including biomass [65]. Similarly, three quarters of people sampled in North Devon and Somerset described themselves as either not at all, or not very well, informed about tidal energy [66]. The development of small-scale, community-based marine energy projects provides the opportunity for the public to have first-hand experience, which will raise awareness of the advantages of these technologies, and, potentially, the level of advocacy for them.

5. Conclusions

The lack of both policy support and financial subsidy from national governments continue to be cited across stakeholder groups and countries as key barriers to the development of the marine renewable energy industry. Opinions are mixed on the role of small projects in reducing the levelised cost of tidal energy, but they do provide options for novel financing mechanisms, and there is public interest in investment in local initiatives. A market for smaller turbines exists (beyond their role in the staged development of utility-scale devices) particularly for remote, off-grid communities. Investment by local authorities remains key to attracting wider financing, and the removal of dedicated support for local projects has had significant impacts on community energy groups.

Developers retain the view that current processes for environmental impact assessment can present a significant hurdle for small projects, but progress (particularly in Scotland) on proportionate assessment, and in leasing, has improved opportunities for community-scale schemes. However, marine spatial planning has not yet fulfilled its potential as a tool in the strategic development of the sector. Multi-actor partnerships present a positive way forward, and ownership models may also have a bearing on public acceptability of new developments. Finally, community ownership and public participation have the potential to increase advocacy for the wider industry.

Further research is required to understand in detail the potential ownership and financing models for small-scale marine energy projects, and how they integrate with wider green financing opportunities and the environmental, social and governance drivers for corporate investment, as well as the opportunities for local, spatial planning that identifies sites of low environmental risk.

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