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8th April 2020

Response to Scottish Government's 'Draft Offshore Wind Policy Statement: Consultation'

Dear Sir or Madam,

We thank you for the opportunity to respond to this important consultation. Below we outline our combined response to Scottish Government's consultation on its Draft Offshore Wind Policy Statement.

We have not responded directly to all the questions raised in the consultation but have instead targeted a large selection of these. Some of the responses will have relevance to multiple questions and where this is the case, we have tried to make this clear. Wherever possible we have also cited underpinning research to provide an evidence-based response to the consultation's questions.

Should you have any queries, please feel free to contact us. We look forward to hearing from you in due course.

Yours sincerely,

Dr. Matthew Hannon, Dr. David McMillan (University of Strathclyde)

Eva Topham (DNV GL Renewables Advisory and University of Strathclyde)

Additional input from Sally Shenton of Generating Better.

University of Strathclyde Glasgow

Consultation Response

3. What actions do you believe should be taken by the Scottish Government, UK Government and agencies in order to realise the full potential of Scotland's offshore wind sector?

First some important context. The CfD has been incredibly effective at reducing the cost of offshore wind projects. Projects in the 2019 auction are approaching merchant prices (zero subsidy). However, this has come at the price of a very substantial supply chain squeeze. Margins on contracts in the wind industry are much lower than in the past (McKinsey 2018). This situation tends to favour countries with lower production cost bases than compared to Scotland (OffshoreWind.biz 2019). Consequently, this is one of the key reasons that driving up the local content should be seen as a UK/Scottish government responsibility, since increasing local content could have the unintended consequence of making UK-led projects less cost-competitive.

There are effectively two strategies open to the Scottish and UK government when it comes to increasing the local supply chain share.

1. **Large structural interventions** – Examples include co-funding a major manufacturing facility similar to the investment, which led to the Siemens blade factory in Hull (Green Port Hull 2016). These interventions require substantial public funds and probably a good deal of certainty regarding the project pipeline in Scottish & UK waters in the coming decades. Such an intervention would result in a large uplift in highly skilled jobs that the government is looking for, albeit partly at public expense.
2. **Smaller, more targeted interventions** – Examples include funding for supply chain technology competitions, such as via the Offshore Wind Accelerator (OWA) and ORE Catapults 'backing the game changers' scheme (ORE Catapult 2020).

Ultimately, both are important. The first option is certainly more challenging to deliver, as it would require a significant and concerted effort, involving a major turbine Original Equipment Manufacturers (OEMs), such as Siemens Gamesa, Mitsubishi/Vestas and General Electric. It would also require substantial and wide-ranging political support in order to drawdown the necessary funds. The location of such a facility is key to any political support and the expected gross value added (GVA) these interventions provide in different locations, not least tax receipts, employment benefits and wider supply chain benefits. When looking back in 2030 and beyond, with a huge amount of offshore wind deployed in Scottish waters, there could be a sense of missed opportunity without considering such major interventions.

The second option (smaller more targeted interventions run as competitions) has certainly resulted in some excellent work being done. The key to this has been the competitive nature of the OWA tenders, which evaluates projects based on a very high degree of technical and economic merit. This model has been highly successful to date.

4. What are the key regulatory and cost challenges facing the offshore wind sector?

Capital costs

The offshore wind sector has achieved some huge cost reductions in recent times. In this rush to achieve very competitive CfD bids, the supply chain has come under intense pressure to lower its costs. It remains to be seen how sustainable these cost reductions are for different parts of the supply chain.

Much of the recent existing cost reduction drive has come from rapid up-scaling of wind turbines and current designs in the 8-12 MW bracket are pushing at the limits of what can be achieved with current turbine technology. There is a risk that some of the capital cost reductions, which have been achieved on recent projects, could be counterbalanced by higher operational costs (Carroll et al. 2016).

Decommissioning & recycling costs

As the first tranche of operational projects approach their end of life, decommissioning costs are becoming a growing concern in terms of life-time project costs. Decommissioning costs have traditionally been underestimated and represent approximately 60-70% of the installation costs of offshore wind projects (Smith et al. 2015), standing at over £200,000 per MW (Topham and McMillan 2017).

Most jurisdictions require that the infrastructures are removed once projects cease operation and that the site is returned to its initial state. To prevent insolvency risks due to these high costs, most jurisdictions now require owners to provide strong financial guarantees i.e. paying into a secure decommissioning fund during the life of the facility, bonds or letters of credit. Furthermore, the growing capacity of offshore wind installations is seeing the volume of O&M and future decommissioning work grow too. Both these activities putting key supply chain resources, such as the vessels that are typically used in both the offshore wind and in oil and gas industries.

In addition, circular economy principles must be encouraged by means of targeting sustainable solutions once projects are decommissioned. It has been estimated that between 80-90% of the weight of a wind turbine could be recycled, as mainly corresponds to metals (Topham et al. 2019). This would not only reduce decommissioning costs by 20% but also lessen the amount of raw materials used, yielding obvious environmental benefits. Blades, however, are currently one of the biggest challenges faced regarding decommissioning offshore wind projects as are found to be very difficult to reuse/recycle due to its material composition while being the most voluminous part of the wind turbine which difficulties its handling, so are currently just being shredded and incinerated, or sent to landfill for disposal.

Further research is necessary to develop better sustainable solutions. Besides, wind turbine components in good condition should be encouraged for reusing purposes, and/or refurbished to be reutilised in other projects. This idea has led to second-hand markets emerging, were components and even turbines are given a second chance at a reduced cost. The tendency is that in the near future, the industry shifts to reusing more of the structures in order to minimise costs, as large projects will try to reuse part of its existing infrastructure to keep the project ongoing for as long as possible by means of refurbishing and repowering.

Local Content and the Cost Reduction Drive

There are some important interactions between the cost reduction drive and the desire to increase local content of Scottish projects.

The first of these concerns likely costs of seabed leases. Crown Estate Scotland have commendably set up ScotWind to make it financially attractive in terms of leasing costs (Pinsent Masons 2019). The cost of offshore acreage in ScotWind is likely to be substantially less than that of England and Wales coast (rUK) round four. This is intended to counter-balance the higher inherent costs of development in Scotland, such as deep water, TNUoS etc. (see Pinsent Masons 2019). Ultimately, this is one of the reasons there has been so much developer interest in ScotWind to date. However, it does have the unfortunate effect of further shrinking the GVA benefit in the DEVEX phase of projects, where historically projects would have been paying substantially more to the UK's Crown Estate in order to secure acreage. This does create a challenge as the local content in the project DEVEX has historically been very high in the UK, very often over 70% (BVG 2019).

Secondly, in the operational phase, future projects in Scottish waters are likely to be more reliant on larger service vessels (SOVs) which to date have been manufactured in Norway and Denmark (ESVAGT 2020). Earlier offshore wind rounds tended to be serviced by small workboats (CTVs), which were generally UK manufactured and crewed. As a result, the operational phase of an offshore wind project tends to be where local content calculations show the biggest benefit. However, the likely reduction in project spend on UK manufactured vessels means that any increased local content will likely have to come from other aspects of the supply chain.

5. What more can the sector and other key stakeholders do to tackle these?

As per Question 4, some associated actions could usefully be taken to tackle these project cost challenges:

- Heavy lifting vessel demand continues to rise due in line with the marine activities of the offshore wind and oil and gas sectors. Stakeholders could usefully coordinate with other offshore stakeholders and in advance, plan their activities alongside other offshore projects within the area. This could help save high mobilisation costs and reduce associated logistics time.

- Research consortiums and partnerships are being created to face common challenges encountered within the industry, such as best ways to deal with decommissioning or develop blade recycling solutions.
- Create market mechanisms that encourage component reuse in offshore wind projects, to reduce the lifetime environmental impact of these installations.

8. What steps can be taken to improve interactions between offshore wind and other marine sectors?

24. What can be done, on the part of government and / or others, to strengthen and benefit from the synergies with a) hydrogen and b) the oil and gas sector?

There is naturally a tremendous amount of overlap in the knowledge and skills accrued across the offshore wind sector and other synergistic offshore and marine renewable sectors, such as wave and tidal stream. Importantly, this relates to a two-way exchange of information, where advances in offshore wind (e.g. floating wind) could potentially support these marine technologies and vice versa. Examples include sub-sea cables, foundations, moorings and connectors.

Drawing upon Hannon et al.'s (2017) research into the effectiveness of the UK's wave energy innovation policy, we note that the UK's marine energy sector has not had a particularly strong track record in knowledge exchange in the past. It is important lessons are learned from this and applied to the offshore wind sector where applicable. Consequently, we presented a set of best-practice guidelines to engender knowledge exchange and collaboration between offshore renewable sectors:

1. **Avoid over-reliance on private sector for funding numerous discrete early stage innovation projects** - The 'state aid' linked requirement for recipients of public grants to secure a significant amount of private sector match-funding has placed an intense pressure on offshore renewables developers to 'fast track' their innovation timeline and avoid knowledge exchange in a bid to protect their intellectual property (IP). This led to 'best practice' not being shared across the marine energy sector and the same mistakes being made by numerous different companies. State aid compliant procurement frameworks, such as Wave Energy Scotland, can avoid the need for private sector match funding, and its associated pressures to avoid sharing sensitive information, by offering 100% public funding for earlier stage innovation projects. The same principles could be usefully applied to driving innovation in early-stage offshore wind technologies, such as novel foundations or turbines types.
2. **Mandate knowledge sharing from publicly funded projects –** Traditionally many publicly (part-)funded projects have not had to make their results publicly available or have not seen their IP licensed. To engender knowledge exchange and collaboration between offshore renewable and marine sectors, it is essential that there is a requirement for: a) all results to be made publicly available, with knowledge hosted on a 'free-to-access' online repository; and b) a requirement to licence any IP generated. If the latter is not achieved, then

government have the option to take ownership of the IP and licence it. Again, Wave Energy Scotland employed the latter approach and also retrospectively actioned the former by purchasing the IP of former wave power developers and making it publicly available via an online library. The same principles could usefully be applied to publicly funded early stage offshore wind projects.

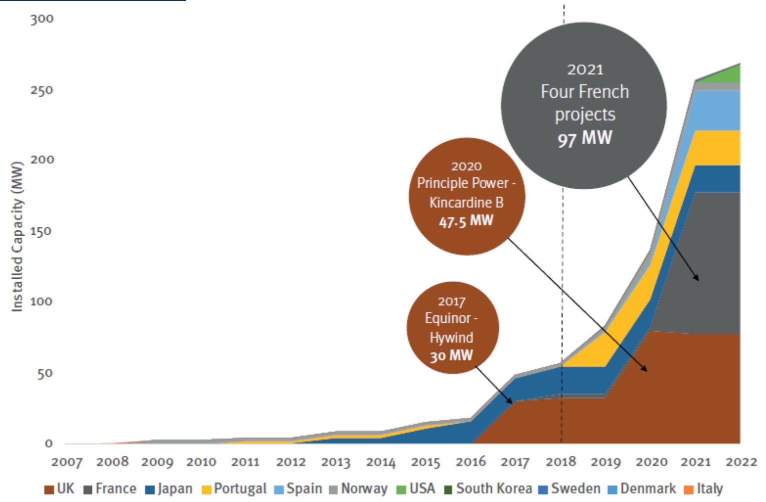
3. **Joint industry projects to promote collaboration –** Consortia based funding models, where a combination of public and private funding to tackled innovation challenges shared by the sector as a whole are critical. Joint-Industry Projects are a useful model to follow and we note Scottish Government has employed with the Floating wind Joint Industry Project, which offers an excellent foundation. We note however that there this initiative could usefully sit within a wider umbrella JIP that focuses on offshore renewables and brings together a wider set of actors to work towards shared offshore renewable challenges (e.g. connections, mooring, environmental impacts). This would promote a two-way flow of information:
    a. **Top-down** – where solutions applicable to wider offshore renewable challenges filter down to new offshore wind technologies (e.g. floating wind); and
    b. **Bottom-up** – where solutions specific to offshore wind challenges (e.g. floating wind) could be applied across other synergistic offshore renewable sectors (e.g. tidal stream).

Turning to oil and gas there is an opportunity to redefine the supply chain so this long-standing sector can be reutilised to support offshore wind and other marine sectors (i.e. tidal, wave). This would not only feed in through facilities, ports and factories, but also by means of sharing knowledge and experience. On the latter, floating wind draws heavily from oil and gas floating platform technologies, bottom-fixed turbine foundations have also borrowed from the sector too (i.e. monopiles, jackets) (Windpowermonthly 2014). In summary, mapping shared supply chain services to deliver offshore wind projects, in addition to the ongoing exchange of knowledge to support wind power innovations, is critical to bolstering deployment of UK offshore wind.

9. How could a competitive market framework that promotes the development of floating wind be developed whilst still retaining value for money for the consumer?

23. What actions should be taken to address the key challenges facing the uptake of commercial scale floating in Scotland?

With 32 MW and 56% of global capacity, the UK is the current world leader in floating wind deployment. It has undoubtedly led the world in terms of the scale and ambition of projects, and this trend is likely to continue. By 2022, this could rise to 78 MW if we consider projects that have at least applied for consent (), with a further 1.9 GW of projects in the pipeline that have yet to apply for consent ().



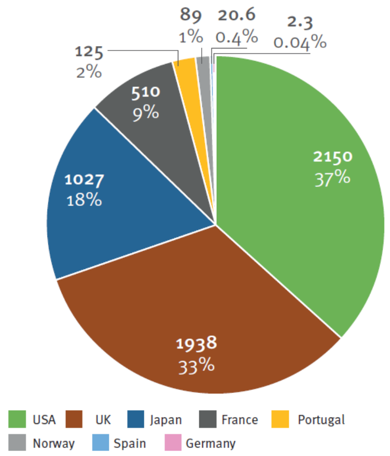


Figure 1: Cumulative installed capacity to 2022 by nationality (excluding projects in early planning) (Source: [Hannon et al. 2019](#))

NOTE: *Record-capacity installations shown by circle area and are sized proportionally*

Figure 2: Installed capacity (MW) by nationality of deployment (only early-planning projects) (Source: [Hannon et al. 2019](#)))

The majority of these planned projects are large, utility-scale arrays, the average installed capacity being 248 MW. At this scale, they will be competing directly against both bottom-fixed offshore wind and onshore wind for market share, assuming there are still sufficient suitable sites for both in the lead up to 2030. This raises questions about whether this is the most suitable path forward for growing the floating wind market in the UK.

In the absence of the Renewables Obligation (RO) (see Questions 20 and 21), a paying customer becomes more important than ever in terms of growing start-ups with new product-services and building a supply chain capable of delivering floating wind ‘at scale’ within the next 10 years. This first tranche of projects are critical to demonstrating the commercial potential of the technology and reinforcing its legitimacy, in turn helping attract further investment. Finally, these first projects are also essential to generating knowledge through ‘learning by doing, using and interacting’, which helps to optimise future projects and drive down cost.

Without subsidy, delivering this first tranche of projects will be extremely challenging when we consider that they carry a higher levelised cost than some other competing forms of renewable power, not least bottom-fixed offshore wind and onshore wind. We may encounter a situation whereby suitable onshore and bottom-fixed offshore sites begin to dwindle over the comings years and we reach a point where, in order to meet our net-zero ambitions, we must turn to floating wind only to find that the technology and supply chain are not sufficiently developed to provide wide-scale deployment.

One route forward may be to identify potential niche markets, where the unique advantages of floating wind means it makes commercial sense to deploy. Historically, we have seen new technologies typically gain traction in niche markets before enjoying wider scale deployment. Examples include solar PV on satellites and lighthouses, or electric vehicle battery technology in airport vehicles, golf buggies and fork-lift trucks. These all presented novel solutions to distinctive challenges, in a context where the user was willing and able to pay a relatively higher cost for this versus other offerings. These niche markets ultimately acted as a 'spring board' for these technologies to launch into much larger, mainstream markets.

Floating wind's primary advantage over other forms of wind power is that it avoids competition for space or restrictions on land-use as faced by onshore wind, and can be sited offshore in water more than 50-60m deep, unlike bottom-fixed offshore wind. In the case of Scotland, there are a number of potential niche markets, including deep-water aquaculture and off-grid islands that rely on oil-fired generators for power. Whilst additional research is required into their potential, there is little evidence to suggest that either present natural niche markets for floating wind, see for example Aquaterra's report on aquaculture and how commercial-scale (floating) offshore wind turbines are "unlikely to be suitable due to scale of technology and capital costs involved" (Aquaterra 2014).

In contrast, floating wind to power offshore oil and gas platforms is a potentially much more promising niche market. Around 16 TWh per annum of power is consumed by oil and gas platforms globally, comparable to the domestic electricity consumption of Croatia (~15 TWh/yr) (Wood MacKenzie 2019). In turn, this generates roughly 200 million tonnes of CO_2 a year, which is equivalent to Argentina's territorial emissions.

To power these platforms "around 5 percent of global offshore oil and gas wellhead production is used as fuel to power offshore production platforms" (Wood MacKenzie 2019). Floating wind power would therefore displace the need to burn these fossil fuels to power further extraction, saving a valuable market commodity for general sale. Utilising floating wind could also save vital space on the rigs, improve health and safety and to reduce the carbon footprint of their fossil fuel production (Wood MacKenzie 2019).

Whilst various options exist to replace oil or gas turbines with renewable power (e.g. connections to the mainland renewables), various major oil and gas companies are already moving to take advantage of floating wind to power their offshore platforms. The current global market leader for floating wind is Equinor, with 32 MW across two projects. Equinor is also developing a 88 MW Tampen array next to the five Snorre A and B and Gullfaks A, B and C platforms off Norway, which will provide 35% of their annual power demand and reduce emissions by 200,000 tCO_2/yr (Equinor 2020). Its deep-water location (260-300m) means bottom-fixed offshore wind was not viable, nor was providing a connection to the mainland due to its 140km distance from shore (Equinor 2020). The project will deploy 11 Siemens Gamesa 8 MW turbines, cost approximately £390m and be operational by 2022. Importantly, it will receive approximately £180m in funding from Norwegian government, evidencing the significant subsidy still needed to deliver floating wind (Offshorwind.biz 2020).

A large number of other oil and gas majors are also investing heavily in floating wind RD&D:

- Shell, the world's second most valuable oil and gas company, has invested in Stiesdal's TetraSpar demonstration project, due for commissioning in 2020, increasing its share in the project to 66% in 2019 (Wind Power Offshore 2019). It also invested in Makani, which recently deployed its airborne wind energy kite system offshore (Felker 2019). Since Alphabet (aka Google) pulled out of Makani, Shell are still considering further investment (Recharge 2020).
- Repsol, the major Spanish oil and gas company, became a 19% shareholder in the WindPlus subsidiary, set up to deliver the 25 MW WindFloat Atlantic project off the west coast of Portugal (EIB, 2018).
- In 2020 Total "signed an agreement with the developer Simply Blue Energy to acquire 80% stake in the pioneering floating wind project Erebus located in the Celtic Sea, in Wales. The project will have a 96 MW capacity and will be installed in an area with water depth of 70 meters" (Total 2020).

There is a broader ethical question about whether the oil and gas industry are employing floating wind as part of their transition away from fossil fuels and towards renewable power or they are using it to support 'business as usual', by enabling relatively minor emissions cuts across their oil and gas production regime. There is also the question of how long the floating wind powered rig model will remain commercially viable as the wider economy transitions away from fossil fuels and its business model becomes compromised. Either way, in the short-to-medium term, it presents Scotland with a compelling niche market to explore, especially considering that there are 184 offshore rigs in the North Sea alone (Rigzone 2018). Harnessing this niche market could then put Scotland in a stronger position to be able to deploy utility-scale floating wind projects in its deeper waters over the next decade.

13. What areas of the Scottish supply chain do we excel at, and what could we do better?

Again, we employ a focus on **floating wind** given our recent research into it (see Hannon et al. 2019). The UK currently has no major floating foundation developers and the UK's two flagship floating wind projects, Hywind Buchan Deep and Kincardine, have relied heavily on overseas firms to be delivered. Almost two thirds of the companies directly involved with these projects were non-UK headquartered and furthermore, both projects are majority owned by overseas firms:

a) Hywind by the Norwegian oil and gas company Equinor; and
b) Kincardine by the Spanish OEM, ACS Group.

This is representative of the broader situation across the UK's offshore wind sector, where the majority of supply chain content is controlled by foreign companies (see BVG Associates and Whitmarsh). Where we do find UK firms, they are mostly involved in project development and O&M, but are largely absent in the manufacture and supply of key components, especially turbines, foundations, etc. A full supply-chain breakdown is provided for both cases on p.64-5 in Appendix A of Hannon et al. 2019.

The overwhelming majority of these overseas firms are either from the EU or the European Economic Area (e.g. Norway) – and by extension the European single market. Brexit therefore raises serious questions about how leaving the single market and the customs union could impact negatively on the prospects of future UK floating wind projects. This is due to the potential introduction of tariffs, supply-chain disruption and a lack of access to skilled labour. It also raises concerns about the health of the UK firms involved in floating wind, which currently export products or services to EU countries. A weakening of these firms may erode the UK's capacity to deliver its current pipeline of floating wind projects.

Such an arrangement also cuts both-ways; simultaneously limiting UK floating wind projects' access to imported products and services from Europe *and* UK companies' access to exporting a European floating wind market, which has 870 MW of capacity in the development pipeline (Hannon et al. 2019). This could have a negative impact upon the health of the companies that currently or could potentially export products or services to EU markets. In turn, this could damage their capacity (e.g. capital, knowledge, skills, reputation etc.) to help deliver floating wind projects back in the UK.

It is therefore essential we assess how Brexit will impact upon cost and delivery timelines of floating wind projects, as well as the financial performance of UK offshore wind companies. Consideration should be given to what trading arrangements will support the future growth of floating wind in the UK and Europe more widely.

We acknowledge that another means of increasing the UK's domestic content of floating wind, and indeed offshore wind more broadly, could be to demand a minimum threshold of domestic content that projects must meet to unlock subsidies (e.g. via the CfD). Whilst we acknowledge the potentially powerful role this could have in encouraging the expansion of the domestic offshore wind supply chain, it also creates a new risk that projects with a lower domestic content going undelivered. This is in turn potentially threatens the UK's commitment to deliver 30 GW of offshore wind by 2030 and put its net-zero emissions target in jeopardy. Furthermore, any sanctions imposed on non-domestic firms providing essential products and services could be mirrored by countries elsewhere, thus limiting the UK's scope for exports.

Consequently, to avoid these unintended consequences and ensure that projects still get built, it could be that offshore wind projects above a certain level of domestic content (e.g. 60%) are not excluded from the CfD auction but receive a 'bonus payment'. This might for instance constitute a 'top up' on their strike price, at an additional £X/MWh. Furthermore, such an arrangement would usefully consider the local/regional economic benefits these projects could provide through an increased share of domestic content (e.g. tax receipts, jobs, supply chain benefits).

14. Where are the new areas that Scotland can develop and exploit a competitive supply chain advantage?

The offshore decommissioning sector can offer an important socio-economic opportunity and job creation for Scotland and the UK, while already having a well-established oil and gas supply chain. With numerous ports having been involved in oil and gas decommissioning (Aberdeen, Dundee, Nigg Energy Park - Moray Firth, Dales Voe – Shetland, etc.) and with the port of Blyth as UK's example for participating on both the oil and gas and offshore wind industry, Scotland could also seek to establish key ports for decommissioning and recycling components within the North Sea by means of redefining and investing in its current facilities.

The expected peaking decommissioning demand and the need of recycling services in the upcoming years in contrast to the current lack of available ports that can provide these solutions could make Scotland become a key player during the dismantling phase of these sectors. Moreover, it would also enhance the provision of more sustainable end of life solutions for these projects where the amount of materials reused and recycled is maximised in order to minimise the volume of waste sent to landfill, while creating a greener and more sustainable economy.

One further potentially valuable area is met-ocean sensing (i.e. direct measurement of wind, wave, current). Wind farms typically use a mix of wave buoys and wave radars and use this information to support operational decisions. However, increased/improved met-ocean measurement has the potential to be very valuable especially when sites cover very large geographic areas (Browell et al. 2016). Scotland has excellent knowledge base in sensor technology and a number of SMEs in this space. The export market for such technologies is likely to grow as global growth in offshore wind accelerates this decade.

15. What are the main challenges a company faces when tendering for a contract?

16. Subject to procurement law, what more should government and its agencies do to assist the supply chain secure contracts?

A major barrier to those Scottish companies who would like to enter the offshore wind supply chain is the contractual packaging of a typical offshore wind project. A developer will seek to manage risk in procurement and construction by separating the project into key packages (e.g. marine package, turbine package, OFTO package etc.). The party appointed to manage each package effectively takes procurement decisions on behalf of the developer. In order to manage this inherited risk, the package manager will fall back on existing trusted supply chain relationships. This creates an effective block on any new entrant who desires to enter the supply chain, no matter how good or well-priced their product might be.

Rigidity in contracting and procurement structures established to support the market can also constrain operators', and the wider supply chain's, ability to adapt to meet changing demands. Increasing the flexibility of the existing procurement strategies, whilst reducing the previous experience proof requirements would allow new participants to enter the market and potentially present innovative approaches.

17. What are the key skills issues and gaps facing the sector over the coming years, in the short and medium term?

Two key areas of focus for growing supply chain skills and capacity include:

- **Decommissioning** of projects in the North Sea will rapidly progress and vessels demand will peak, as are needed decommissioning of both oil and gas and installation and O&M of offshore wind.
- **Blade recycling solutions and expertise** – expertise on how to integrate circular economy principles, and in general, how to make projects more sustainable from a raw materials and life-cycle perspective (Strathclyde 2020).

18. What more should government and the sector do to build on the progress made in recent years?

One potentially useful route forward would be to establish a transparency platform, where as much as possible useful non-confidential information regarding offshore wind projects across all stages is uploaded and available for research or data analysis. This focus here is on promoting sectoral best-practice and ramping up cost-effectiveness for all parties.

20. What can the Scottish Government most usefully and feasibly do to build on the innovation support previously and currently available?

21. How can we support technologies and developments which reach a viable stage between leasing rounds and CfD auctions?

Drawing upon the **floating wind** report from Hannon et al. 2019 our research identified two major concerns surrounding the UK and Scotland's innovation support for floating wind are expected to undermine growth of floating wind in the UK:

1. A critical lack of **long-term revenue payments** for pre-commercial floating wind projects; and
2. An **over-reliance on EU innovation support**, access to which is under threat from Brexit.

Should the UK fail to put in place a long-term revenue payment programme for pre-commercial floating wind and/or retain access to EU innovation funds, UK floating wind projects are unlikely to be able to source the patient pre-commercial capital they require to both scale-up and drive down costs. We unpack these in more detail below and emphasise that the lessons are relevant to all early stage offshore wind innovations; not just floating wind.

Long-term revenue payments

Long-term revenue payments represent an important 'market-pull' mechanism that generate a market demand for new generation technologies. In essence, they subsidise the cost of energy of immature technologies, opening up market applications that would have otherwise not been financially viable.

Until recently, pre-commercial and commercial UK floating wind projects were able to access the Renewable Obligation (RO) (Figure 3). It provided eligible renewable generators with support per MWh of renewable electricity generated at a fixed rate for 20 years. In Scotland, special provision was made for floating wind, which received 3.5 ROCs per MWh (Ofgem, 2018).

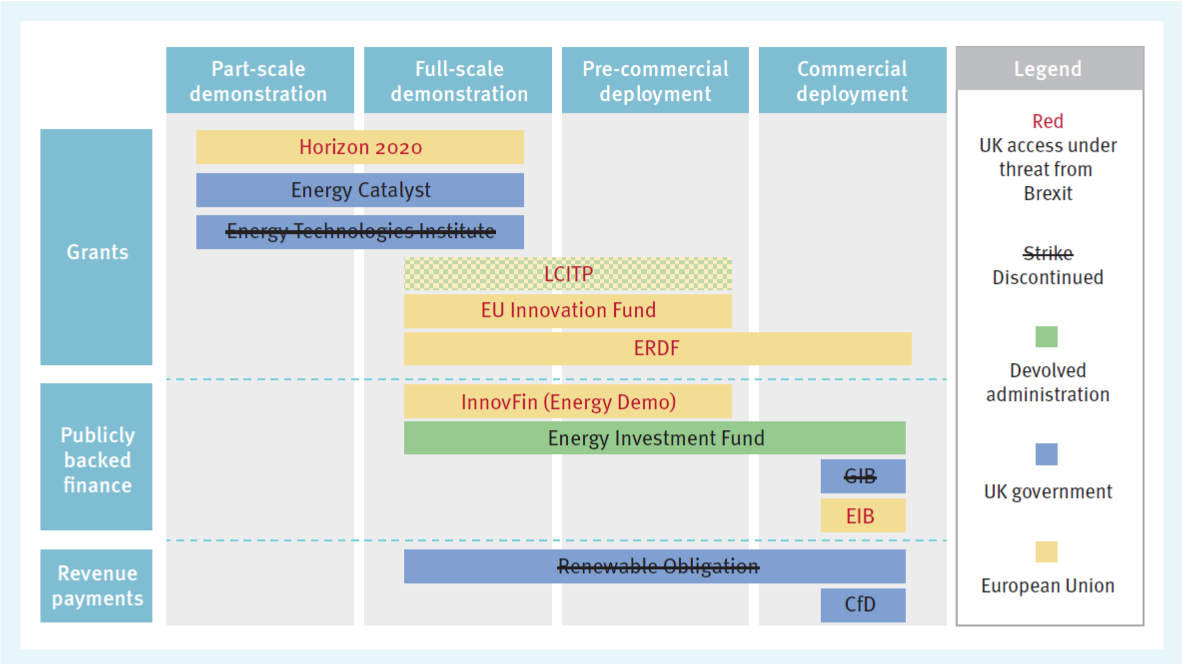


Figure 3: Major funding programmes offering innovation support to floating wind projects in the UK (Source: Hannon et al. 2019)

NOTE: *LCITP - Low Carbon Infrastructure Transition Programme; ERDF - European Regional Development Fund; GIB - Green Investment Bank; EIB - European Investment Bank; CfD - Contracts for Difference*

Both of the UK's floating wind projects that have been delivered to date have relied heavily upon the Renewables Obligation (RO). For example, taking the period from 1st Dec 2017 to 30th November 2018, we estimate that Equinor received £25m from the RO during this period[1].

[1] Data was taken from Ofgem's Renewables and CHP Register. The number of ROCs is calculated by the number of Renewable Energy Guarantees of Origin (REGOs), multiplied by the 3.5 ROCs per MWh for floating wind. Assumes a buy-out price of £45.58 for 2017/18 and £47.22 for 2018/19 (Ofgem, 2018) per ROC, each period running from 1 April to 31 March. A recycle value of £5.85 per ROC is taken for both the 2017/18 and 2018/19 period (Ofgem, 2018). Recycle value for 2018/19 not available at time of calculation so we have adopted the previous year's, which is likely to be marginally lower than the actual value, potentially under-estimating the total subsidy Equinor received. Our independent analysis, which accounts for a typical wind resource year and Equinor's own capacity factor for Hywind Buchan Deep, yields a very similar amount of subsidy, suggesting this level of subsidy is likely to be normal over forthcoming years. Equinor declined to confirm the exact sum they received via the RO for Buchan Deep.

In October 2018, the RO closed to any new floating wind generation, meaning this valuable source of pre-commercial support was no longer available. Prior to the announcement, the floating wind industry encouraged government to extend the deadline to April 2020 (Foxwell, 2018), claiming two further consented schemes, namely the 10 MW Dounreay Tri and 12 MW ForthWind, would be unlikely to go ahead without the subsidy (Ward, 2018). The extension was not granted and today the future of both these projects remains in doubt (4COffshore, 2018).

With the RO now discontinued, and no analogous scheme in line to replace it, there is a distinct lack of long-term support for relatively small-scale pre-commercial floating wind projects. The RO played an important role in providing long-term government support for projects that were too large for the Feed-in-Tariff (FiT) (capacity up to 5 MW) and/or too advanced to access earlier stage grant funding. It also offered funding for projects too small and immature to realistically secure funding via the Contracts for Difference (CfD), which is essentially designed to support utility scale projects.

Consequently, floating wind developers are now left with the CFD as the only significant route to long-term subsidy. However, relatively small-scale floating wind projects are expected to struggle to compete with much cheaper forms of power for subsidy (e.g. bottom-fixed offshore wind).

We note and support the proposals to amend the structure of the CfD in BEIS's latest consultation (BEIS 2020) so that traditional bottom-fixed offshore wind is separated from floating wind, and placed into its own pot (Pot 3). We would agree that this would avoid a situation whereby floating wind is no longer competing against the significantly cheaper and more technologically mature traditional offshore wind.

Importantly though, floating wind would still be in direct competition with other cheaper Pot 2 technologies, like remote island onshore wind. For example, remote island wind secured a strike price of between £40/MWh (2012 prices) for delivery in 2024/25 (BEIS 2019), which is still significantly cheaper than the Offshore Renewable Energy Catapult's estimated cost for floating wind of £135/MWh by 2025 (ORE Catapult 2018). Consequently, we do not expect floating wind to be competing on a 'level playing field' for CfDs, even if offshore wind migrates to another pot.

There is a need for objective and transparent modelling of the future LCOEs of the technologies currently in Pot 2 over the coming 5 years. This is to better understand whether any of the 10 'less established' technologies are already exhibiting signs of being significantly cheaper and should be located in a separate pot to create a more 'level playing field'. This may result in the creation of an innovation-oriented CfD pot that allows for more expensive but potentially important pre-commercial technologies (e.g. floating wind, tidal stream, wave) to compete against one another for a limited combined capacity of projects that are guaranteed a reasonable strike-price (see Scottish Renewables 2019).

Access EU innovation support

Whilst the UK has provided targeted grants to support earlier stage floating wind innovation (e.g. Scottish Government's £1m Floating Wind Joint Industry Project (JIP)), much of the support for such projects is available through the EU. The EU provides significant grant funding from part-scale demonstration (e.g. Horizon 2020), all the way through to full-scale deployment (e.g. EU Innovation Fund) (Figure 3).

Brexit threatens UK-based floating wind developers' access to this wealth of EU energy innovation funding, with no guarantee that they would be replaced like-with-like by funding from UK government or devolved administrations. To avoid any shortfall in available innovation support, it is therefore critical that there is a concerted move towards retaining access to EU demonstration funding post-Brexit. Should this not be achievable, then the UK must consider how it can use its own public funds to cover any shortfall, with a focus on both grants and government-backed finance for demonstration schemes.

Moving further along the innovation chain towards (pre-)commercial deployment the EU also offers government backed finance for companies involved in later stage demonstration schemes, such as through the European Investment Bank. It offers financial support specifically tailored to the needs for small-scale companies that are delivering innovative products and services through its Innovfin programme. It provides a wide range of loans, guarantees and equity-type funding to projects deemed too risky to access other sources of funding on affordable terms (EIB, 2014). It typically offers finance of between €7.5m and €75m to innovative energy demonstration projects (EIB, 2019). For example, it provided a €60m loan to the 25 MW Windfloat Atlantic project (European Commission, 2018).

Brexit raises serious questions over whether UK companies will still be able to access this finance. With the discontinuation of the UK's Green Investment Bank, this means that Scotland's innovative offshore renewable start-up companies are left with schemes that offer relatively small sums of funding, such as the UK's £20m Clean Growth Fund (BEIS, 2019) and the Scottish Government's £20m Energy Investment Fund. It remains to be seen whether Scotland's new £200m per annum National Investment Bank, due in 2020, will make significant sums of low-cost finance available to these renewable energy start-ups, especially floating wind companies.

The level and type of innovation support given over to innovative forms of offshore wind, like floating wind, is only part of the challenge. Ensuring this is coordinated in a coherent fashion between different government departments, and also between governments operating at different levels of governance (e.g. regional, national, supra-national) is critical. Without appropriate coordination, it is likely we will see either duplication of effort in some places and the funding of competing, rather than complementary agenda (see Hannon et al. 2017). The latter may see multiple public bodies funding a wide variety of small-scale innovation efforts that advance multiple competing floating wind designs, as opposed to consolidating these efforts in a single large-scale project focused on just one or two designs.

There are still significant opportunities to improve the degree of co-ordination of offshore renewable energy RD&D support, both within and across different levels of government. There is very little public information available about the operational structure and effectiveness of energy RD&D coordinating bodies like the UK's Energy Innovation Board. In theory this brings together the relevant parties to coordinate the vast majority of UK-level innovation funding, with representatives from BEIS, Innovate UK, Research Councils, Defra, DfID, DfT and Ofgem. Whilst devolved administration are able to attend meetings, they do so in an observer capacity (BEIS 2018). Whilst it remains to be seen whether the UK continues to access EU innovation funding programmes (e.g. Horizon 2020), we also note that there is no formal membership from relevant European/EU bodies (e.g. European Commission, European Investment Bank) active in UK energy innovation funding. Consequently, we find that efforts to coordinate energy innovation funding are focused at the UK-level and rather overlook the need to coordinate national programmes with other sub- and supra-national programmes to maximize their cost-effectiveness.

22. Where respondents believe that scope remains for innovation in fixed offshore wind, what areas should be prioritised?

There are two key areas where innovation should be utilised to further reduce the costs of fixed bottom offshore wind. Both leverage substantial knowledge bases in Scotland.

Turbine Design

Turbine design innovation since the late 1980's has been based on iterating the so-called Danish concept wind turbine. That is a single rotor on the horizontal axis. The main innovations since then have been on the generator and power electronics side. There are two promising avenues for turbine design innovation which could lead to substantially lower costs

- **Multi rotor systems -** In this design, the turbine has multiple horizontal axis rotors. This design innovation has the advantage of functional redundancy (very important for far-shore offshore wind). It also lends itself much better to mass production as the individual components are smaller and can me manufactured in a smaller factory (see Jamieson 2018).
- **X-rotor** - This is a University of Strathclyde led innovation, which represents the next big evolution of turbine design. The weight distribution of X-rotor is much better suited to floating wind than current conventional designs (see Leithead 2019).

Operational Improvement

Operational phase accounts for around 30% of offshore wind costs. Any successful innovation action directed at operations cans significantly reduce the cost of offshore wind, especially with many projects now assuming a 30+ year project life. Scotland has a particularly strong operations innovation knowledge base, with several Universities, SMEs and consultancies very active in this space. Many operational innovations will also have a safety improvement aspect. Take for instance Limpet's solutions that offer a means of both safer and faster access to tall structures such as wind turbines. It was supported through OREC's 'Backing the Game Changers' programme (Limpet Technology 2020).