RSE

The Royal Society of Edinburgh

KNOWLEDGE MADE USEFUL

ADVICE PAPER

March 2020 | NO: 20-04

DRAFT OFFSHORE WIND POLICY STATEMENT: A RESPONSE TO SCOTTISH GOVERNMENT

Summary

The RSE strongly suggests the proposed target for offshore wind energy generation as presented in the Draft Offshore Wind Policy Statement be reconsidered and made more ambitious. Doing so will accelerate Scotland's and indeed the UK's quest to reduce greenhouse gas emissions, enable Scotland to become a major player in the European market, and promote the economies of scale necessary to build a thriving offshore industry.

However, we also recognise that the need for greater ambition is heavily predicated on Scottish Government swiftly fostering the necessary market conditions to allow the offshore wind energy sector to flourish in the nearer term. Until this is achieved, a significant proportion of this added ambition could likely be delivered by focusing on floating wind energy installations, which are less affected by some of the constraints currently posed on fixed-bottom structures.

It will also be critically important to ensure that additional offshore wind deployment does not exacerbate the already significant global biodiversity crisis. Greater monitoring and research activity can assist with quantifying the nature and magnitude of any impacts on nature, helping to inform subsequent decision making.

In order to support increased levels of energy generation, attract investment, maintain the reliability of electricity exports to the UK, and establish Scotland as a key energy provider to Europe, the existing transmission infrastructure would need to be fortified and expanded. However, doing so would require addressing certain challenges.

It is recommended that the Draft Offshore Wind Policy Statement clarify how offshore wind energy is integrated within Scotland's national Energy Strategy as well as paying heed to the demands that decarbonising heat and transport will place on the sector.

We recommend that Scottish Government capitalises on proposed changes to Contracts for Difference (CfD) funding allocations as well as Scotland's extant leadership and intellectual property in the field of floating offshore wind technologies to rapidly grow the sector and enable Scotland to fulfil more ambitious offshore energy generation targets.

While the construction of offshore wind turbines and their associated infrastructure could generate jobs in the short term, the development of a local supply chain for operation and maintenance services will provide Scotland with a higher value and more sustainable source of economic benefit. Scotland could also potentially position itself as a global leader in the commercialisation of offshore wind energy data, given it already has a thriving digital sector which projections suggest is poised to become one of Scotland's fastest growing economic sectors.

Summary

Scotland already has in place extensive infrastructure to support skills development, including a strong tertiary education sector and the work of Skills Development Scotland (SDS), Scotland's national skills agency. However, this could be expanded by further involving the colleges sector and establishing bespoke industry-owned training organisations for the offshore wind industry.

While the offshore wind industry could be said to be maturing, the technologies themselves are comparatively immature due to constantly changing deployment conditions and market demands.

There is a significant amount of research already occurring in the field of offshore wind energy which neither goes to full scale proving nor is adopted by industry. To this end, it becomes important to ensure a mechanism for effective knowledge exchange between researchers and developers. It will also be important to encourage further research and development (R&D) as well as increase demonstration capacity. There are several models through which this innovation and R&D could be funded.

Offshore wind projects could facilitate the corresponding development of a hydrogen industry for Scotland, further diversifying Scotland's energy sector as well as contributing to energy resilience. The RSE recommends that, when embarking on any programme of coordinated marine planning, sites be assessed on the basis of their suitability to support both wind and hydrogen operations.

Introduction

1 Having recently published a substantial inquiry into *Scotland's Energy Future*[1], the Royal Society of Edinburgh (RSE), Scotland's National Academy, welcomes the opportunity to respond to the Scottish Government's consultation on its Draft Offshore Wind Policy Statement. Following Scotland's declaration of a climate emergency in 2019[2], the need to further develop our offshore wind sector to help decarbonise and grow our economy and meet rigorous emissions reductions targets became more pressing. However, constraints such as an aging and geographically limited transmission network and the need for further research and development must be overcome if this ambition is to be realised. A working group primarily drawn from the RSE Fellowship and Young Academy of Scotland comprising a diverse range of expertise and experience in offshore wind energy technologies, energy policy, engineering, economics, conservation, and other related disciplines prepared this response. Our comments are organised according to the sections presented in the consultation document. We would be pleased to meet with Scottish Government to discuss this response should they consider this helpful.

Section A: **The Current Position**

2 Scotland is fortunate to have access to a substantial offshore wind resource.[3] If this resource were to be fully exploited, Scotland's offshore waters could yield over 169GW of renewable energy (46GW of fixed offshore wind and 123GW of floating wind).[4] However, wind power is also strongly variable, both in terms of seasonality as well as temporally. This intermittency means that storage solutions become important in ensuring a continuous supply of energy.[5]

1 Royal Society of Edinburgh (2019) *Scotland's Energy Future* [online] Available at: http://www.rse.org.uk/wp-content/uploads/2019/06/Energy-Report-for-Web-2.pdf

2 Scottish Government (2019) The Global Climate Emergency – Scotland's Response: Climate Change Secretary Roseanna Cunningham's statement [online] Available at: https://www.gov.scot/publications/global-climate-emergency-scotlands-response-climate-change-secretary-roseanna-cunninghams-statement/

3 Offshore Wind Scotland (undated) *Welcome to Offshore Wind Scotland* [online] Available at: https://www.offshorewindscotland.org.uk/

4 The Offshore Valuation Group (2010) *The Offshore Valuation: A valuation of the UK's offshore renewable energy resource* [online] Available at: https://www.offshorewindscotland.org.uk/

5 Royal Society of Edinburgh (2019) *Scotland's Energy Future* [online] Available at: http://www.rse.org.uk/wp-content/uploads/2019/06/Energy-Report-for-Web-2.pdf

3 Despite this remarkable potential, the Draft Offshore Wind Policy Statement lists an industry-driven target of only 8GW of installed offshore capacity by 2030[6], to be followed by a trajectory towards an unspecified amount by 2050 to contribute to the Committee on Climate Change's estimation of 75GW of installed offshore wind needed to support the UK's transition to net-zero emissions by this date.[7] The target of 8GW by 2030 may also be compared with a target of 40GW in UK waters by 2030 as stated in the Conservative Party manifesto from December 2019.[8]

4 It is unclear from the consultation document whether Scottish Government intends to develop Scotland's offshore wind sector in order to continue meeting the immediate needs of the domestic market, in which case the 8GW target is nearer to what would be required, or whether it wishes to achieve both energy self-sufficiency for Scotland and to position Scotland as a major exporter of electricity to Europe. If the latter two situations are to be the case, the target needs to become correspondingly more ambitious.

5 It is also argued the proposed level of ambition is not enough to draw sufficient additional industry investment into Scotland's offshore sector. As stated, the document gives a target of 8GW of offshore wind capacity to be deployed by 2030. Given that 10MW turbines will rapidly become the industry standard, this rate of deployment could be regarded as the addition of approximately one installation of approximately "Beatrice"[9] size (which has a capacity of 588MW) per year to Scotland's waters. In practice, this would involve the deployment of a little more than 10MW (in other words, a single 10MW turbine) per week, which could easily be done.

6 It would be difficult for companies to justify the expenditure of setting up operations in Scotland at this very conservative rate of deployment, particularly given the competition coming from projects to the south which can benefit from less prohibitive planning conditions; significant cost reductions arising from closer proximity to onshore substations connected within stronger parts of the transmission network; and lower transmission network use of system charges arising from closer proximity to key demand centres. It was also recently announced that onshore solar and wind projects could become re-eligible to bid for funding in future rounds of Contracts for Difference (CfD) auctions, following a four-year suspension.[10] All of these factors can serve to dissuade businesses from investing in Scotland's offshore wind sector when there are more economically enticing opportunities to be found to the south and onshore.

7 We strongly suggest the proposed target for offshore wind energy generation be reconsidered and made more ambitious. Doing so will accelerate Scotland's and indeed the UK's quest to reduce greenhouse gas emissions, enable Scotland to become a major player in the European market, and promote the economies of scale necessary to build a thriving offshore industry. It will be important to ensure these targets are regularly reviewed, and if necessary, revised, to keep Scotland on track to decarbonise according to statutory timescales and to take account of changing market circumstances. However, as stated above, we also recognise that greater ambition is heavily predicated on Scottish Government swiftly fostering the necessary market conditions to allow the offshore wind energy sector to flourish in the nearer term. Until this is achieved, a significant proportion of this added ambition could likely be delivered by focusing on floating wind energy installations, which are less affected by some of the constraints currently posed on fixed-bottom structures. These are discussed in greater detail under Section C (Future Position).

6 According to the consultation document, Scotland currently has 902MW of installed, operational offshore wind generating capacity: Robin Rigg (174MW), Levenmouth Turbine (7MW), Hywind Scotland (30MW), EOWDC, Aberdeen (93MW), Beatrice (588MW), and the Beatrice Demonstration (10MW – in the process of being decommissioned). In addition, 1166MW of capacity are currently under construction.

7 Committee on Climate Change (2019) Net Zero – The UK's contribution to stopping global warming [online] Available at: https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf

8 Conservative and Unionist Party (2019) The Conservative and Unionist Party Manifesto 2019 [online] Available at: https://assets-global.website-files.com/5da42e2cae7ebd3f8bde353c/5dda924905da587992a064ba_Conservative%202019%20Manifesto.pdf

9 This refers to Beatrice Offshore Wind Farm. Beatrice Offshore Windfarm Ltd (undated) About [online] Available at: https://www.beatricewind.com/about

10 BEIS (2020) Contracts for Difference for Low Carbon Electricity Generation – Consultation on proposed amendments to the scheme [online] Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/869778/cfd-ar4-proposed-amendments-consultation.pdf

8 It will also be critically important to ensure that additional deployment of offshore wind does not exacerbate the already significant global biodiversity crisis. Greater monitoring and research activity can assist with quantifying the magnitude of any impacts on nature, helping to inform subsequent decision making. Potential impacts on wildlife are discussed in greater detail under Section B (Barriers to Deployment).

9 The RSE would have expected offshore wind and the need to reinforce the electricity transmission network to accommodate increased exports of renewable energy from Scotland to have received attention in the recently published Phase 1 report by the Infrastructure Commission for Scotland.[11] Given this report and the forthcoming National Infrastructure Strategy will influence how infrastructure projects are prioritised in Scotland, we would hope that wind power, both onshore and offshore, is given consideration in the finalised version, particularly regarding its relationship to infrastructure plans for related sectors such as heat and transport.

Section B: **Barriers to deployment**

Interconnectivity

10 Scotland's energy ambitions are currently severely impeded by an aging and geographically limited transmission network which is incapable of absorbing the added pressure that greater offshore deployment would introduce to the system, though it is understood that asset replacement plans are underway. Coupled with comparatively steep transmission costs due to Scotland's distance from large demand centres in the south, this serves as a significant deterrent to offshore companies looking to establish projects in Scotland. In order to support increased levels of energy generation, attract investment, maintain the reliability of electricity exports to the UK, and establish Scotland as a key energy provider to Europe, the existing transmission infrastructure would need to be fortified and expanded. This includes building additional connections from offshore projects to land as well as building better interconnections to Europe, taking into account the need to minimise impacts on the seafloor by making best use of space.

11 However, gaining public support for the construction of additional overhead lines, which would be the most cost-effective approach to increasing network capacity, could be challenging. A coordinated approach to expanding offshore transmission facilities could both enhance network capability and bring economic benefits by enabling direct connections with offshore wind farms, though the feasibility of building this type of multi-terminal network is currently hampered by regulatory obstacles. Further, the tension between reducing transmission charging costs and maintaining low costs for consumers must be adequately resolved, particularly as Ofgem has a duty to protect the latter on a whole of the UK basis. In addition, there is a growing need for a carefully researched view on interconnection methods both in terms of intra wind installations and at the bulk onward transmission level. There is no general agreement, at present, as to the use of AC or DC for networking, the placement of converter stations, and the consistent use of DC transmission. There are also implications here for capital expenditure (CapEX), operating expenditure (OpEx), and transmission charging.

11 Infrastructure Commission for Scotland (2020) Phase 1: Key findings report – A blueprint for Scotland [online] Available at: https://infrastructurecommission.scot/storage/247/FullReport_200120a.pdf

Impacts on wildlife

12 The potential for adverse effects on seabird populations of international importance due to offshore turbines has led to a moratorium on developments on the Smith Bank and the consultation mentions other problem areas. To help quantify the scale of potential impacts on key species, one of the turbines in the Kincardine floating array, off the Aberdeenshire coast, has been fitted with a dtbird© system as part of the post-consent monitoring regime.[12] The dtbird© system remotely collects data on bird encounters with turbines. It uses video and thermal cameras to record the movement of birds in an envelope enclosing the turbine rotor. All birds entering the envelope are tracked until they leave. Data obtained over one year is currently being analysed and the monitoring system is to be extended to all turbines in the array in order to continue building the evidence base. The company is working with Marine Scotland to determine how best to continue the analysis and share the results for the benefit of all stakeholders.

13 In general, we recommend that greater investment be directed towards integrated and strategic environmental monitoring across the whole of the existing and future Scottish fleet of turbines, ensuring linkages to broader scale monitoring at the UK level. For example, offshore wind developments in the Forth and Tay offer an opportunity to develop a strategic research programme of global significance, given their proximity to existing long-term seabird populations on the Isle of May and Bass Rock. Effective monitoring and research are crucial to understanding the interactions between wildlife and offshore infrastructure, helping to avoid both significant impacts on the natural environment as well as unnecessary delays to deployment by informing effective design and spatial planning. A commitment to environmental protection and enhancement can also serve to engender public trust in the industry.

Government intervention

14 Evidence from countries such as Norway and Denmark suggests that the future success of Scotland's offshore wind sector is highly contingent on an appropriate degree of government intervention, both in terms of financial support but also through a more deliberate application of statutory powers to facilitate the growth of a local supply chain, increase corporate confidence in investment, and mandate research and development. The Draft Offshore Wind Policy Statement does not appear to take full advantage of the levers Scottish Government has at its disposal to achieve the above outcomes. These are discussed in further detail under Sections D (Supply Chain) and F (Innovation and Cost Reduction).

Section C: **Future Position**

Wider energy context

15 It is not immediately obvious where Scotland's offshore wind policy is situated within the context of its broader Energy Strategy.[13] There needs to be a coherent holistic approach taken to energy planning, with system modelling of scenarios to understand how changes enacted in one area could impact another. For example, the need to deliver an increasingly large proportion of Scotland's heating requirements using low-carbon solutions will have clear implications for renewable energy production, transmission, and storage. Decarbonising our transport sector will introduce similar pressures on our present energy system. It is therefore recommended that the Draft Offshore Wind Policy Statement clarify how offshore wind energy is integrated within Scotland's national Energy Strategy as well as paying heed to the demands that decarbonising heat and transport will place on the sector.

12 dtbird (undated) Home page [online] Available at: https://dtbird.com/index.php

13 Scottish Government (2017) Scottish Energy Strategy: *The future of energy in Scotland* [online] Available at: https://www.gov.scot/publications/scottish-energy-strategy-future-energy-scotland-9781788515276/

Floating wind technologies

16 Floating wind has emerged as a promising alternative to fixed-bottom offshore wind structures. Floating installations have added flexibility in that they can be deployed in much deeper waters, thus allowing access to faster and more consistent wind speeds[14] and helping to minimise potential conflicts with other marine environment users. They are less visually intrusive and can reduce some of the environmental impacts associated with traditional offshore infrastructure, e.g. seafloor disturbance.[15] There is also potential to transform floating wind installations into havens for marine life as well as supporting the cultivation of mussels and other sessile animals for small-scale commercial harvesting.[16]

17 However, there remains a price disparity between floating and fixed offshore wind structures which limits the competitiveness of floating technologies at this time. This is reflected in the fact that, during the CfD auction held in September 2019, fixed-bottom offshore wind projects secured a record-breaking low price of £39 (2012 price) per megawatt hour (MWh).[17] While fixed-bottom offshore structures may never be entirely obsolete, we welcome the UK Government's proposal to provide dedicated financial support for floating wind as part of its suggested reforms to the CfD scheme. We therefore recommend that Scottish Government capitalises on this proposed change to CfD funding allocations as well as its extant leadership and intellectual property in the field of floating offshore wind technologies to rapidly grow the sector and enable Scotland to fulfil more ambitious offshore energy generation targets, as discussed under Section A (Current Position). Any CfD funding should also allow for an appropriately funded research and monitoring programme to ensure environmental protection and enhancement.

Section D: **Economic Opportunities – Supply Chain**

18 While the construction of offshore wind turbines and their associated infrastructure could generate jobs in the short term, the development of a local supply chain for operation and maintenance (O&M) services will provide Scotland with a higher value and more sustainable source of economic benefit. Further, in the absence of industry standardisation in the early days of the offshore wind sector, turbine manufacturers and their respective suppliers evolved in tandem to address common design challenges, such that it is now difficult for new suppliers to disrupt these enduring, synergistic relationships. The RSE was pleased by a recent announcement by Scottish Government and Crown Estate Scotland that offshore developers will be required to specify how they plan on utilising local supply chains as part of the conditions for granting leases, helping to ensure contracts remain in Scotland.[18] Similarly, whole life carbon costs could be made a mandatory consideration during the assessment of project tenders, thereby giving further advantage to local suppliers of materials.

19 There is also potential to upgrade existing port infrastructure on both the east and west coasts as part of supply chain development, particularly deep water facilities for offshore wind. For example, Lochinver or Kinlochbervie functioned as major fishing ports and could be repurposed to support offshore energy activities. This could help to revitalise coastal communities that have suffered economic hardships and population loss in the wake of declines in the fishing industry. As Scotland is currently facing significant rates of depopulation among its rural and island communities, such an initiative could help to ensure these communities remain viable and encourage inward migration.

14 WindEurope (2018) *Floating offshore wind energy: a policy blueprint for Europe* [online] Available at: https://windeurope.org/policy/position-papers/

15 International Renewable Energy Agency (2016) *Floating Foundations: A Game Changer for Offshore Wind* [online] Available at: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2016/IRENA_Offshore_Wind_Floating_Foundations_2016.pdf

16 Buck, B.H., Ebeling, M.W., & Michler-Cieluch, T. (2010) Mussel cultivation as a co-use in offshore wind farms: Potential and economic feasibility. Aquaculture Economics and Management 14(4):255-281 [online] Available at: https://www.researchgate.net/publication/233291985_Mussel_cultivation_as_a_co-use_in_offshore_wind_farms_Potential_and_economic_feasibility

17 RenewableUK (2019) *Record-breaking renewables auction provides biggest step yet towards net zero emissions* [online] Available at: https://www.renewableuk.com/news/470678/Record-breaking-renewables-auction-provides-biggest-step-yet-towards-net-zero-emissions-.htm

18 Scottish Government (2020) Offshore wind summit [online] Available at: https://www.gov.scot/news/offshore-wind-summit-1/

20 With the deployment of a large fleet of wind turbines comes the opportunity to amass a significant quantity of data on turbine operations, ambient environmental conditions, and records of repairs and maintenance performed to date. All this information is invaluable in informing the development of wind farms both domestically and abroad in order to make them more efficient and cost-effective as well as minimising their environmental impacts. Good data is also the key to effective condition monitoring and remote operation of offshore wind farms. This is a large potential market and Scotland could potentially position itself as a global leader in the commercialisation of offshore data, given it already has a thriving digital sector which projections suggest is poised to become one of Scotland's fastest growing economic sectors.[19] The potential for data innovation within the offshore wind energy sector could be an area for Scotland's Data Delivery Group[20], The Data Lab[21], or a similar organisation to explore.

21 The establishment of a Scottish supply chain for the European offshore industry relies on the development of a positive trading relationship post-Brexit.

Section E: **Economic Opportunities – Skills**

22 Scotland already has in place extensive infrastructure to support skills development, including a strong tertiary education sector and the work of Skills Development Scotland (SDS), Scotland's national skills agency. In particular, there could be a significant role for colleges in terms of linking with industry to develop tailored and practical training programmes to prepare graduates to enter the sector. The Energy Skills Partnership (ESP) is a good example of collaboration between industry and colleges that is aimed at increasing Scotland's capability and capacity to meet industry demand for skills in energy, engineering, and construction.[22] Given the above, there is also a timely and important opportunity to make the connection between this consultation and the vision and ambition for Scotland's colleges as set out in the recently published Cumberford-Little report.[23]

23 The Offshore Petroleum Industry Training Organization (OPITO) is the international, not-for-profit, industry-owned skills body for the offshore oil and gas sector.[24] Working in cooperation with governments, national oil companies, operators, and contractors, OPITO provides accredited training to develop the expertise of the energy workforce. Given the inherent similarities between the offshore wind and petroleum sectors in terms of skills required, it would be useful if this training could be broadened to include modules covering the offshore wind energy industry. Alternatively, through the work of ESP and industry partners, a similar industry-owned training organisation aimed exclusively at the offshore wind energy sector might be established.

24 The RSE welcomes the Scottish Offshore Wind Energy Council's (SOWEC) acknowledgement of the need to understand the anticipated demand for skills in Scotland, including the need for the sector to become more inclusive by increasing gender diversity and BAME representation. We would expect any corresponding campaigns aimed at addressing these issues to be monitored to ensure their effectiveness.

19 Digital Scotland (2019) Scotland's Digital Technologies: Summary Report 2019 [online] Available at: https://www.skillsdevelopmentscotland.co.uk/media/43306/scotlands-digital-technologies-summary-report.pdf

20 Data Delivery Group (undated) Overview [online] Available at: https://www.gov.scot/groups/data-delivery-group/

21 The Data Lab (undated) About Us [online] Available at: https://www.thedatalab.com/about-us/

22 ESP (undated) About ESP [online] Available at: https://esp-scotland.ac.uk/about-esp/

23 One Tertiary System: Agile, Collaborative, Inclusive (2020) [online] Available at: https://view.pagetiger.com/inlhij/1

24 OPITO (undated) What we do [online] Available at: https://www.opito.com/about-us/what-we-do

25 The square-cube law denotes the relationship between surface area and volume as a shape's size increases or decreases. In the case of wind turbines, increases in energy capture resulting from longer blades (surface area increase) tend to be negated by the extra costs brought on by increasing the volume of the structure. Jamieson, P. & Branney, M. (2012) Multi-Rotors; A Solution to 20 MW and Beyond? Energy Procedia 24:52-59

Section F: **Innovation and cost reduction**

25 While the offshore wind industry could be said to be maturing, the technologies themselves are comparatively immature due to constantly changing deployment conditions and market demands. Longstanding issues include overcoming the restrictions arising from the square-cube law[25] as turbines continue to increase in size, achieving further cost reductions, and improving recycling procedures, particularly given that turbines use rare earth metals[26] as well as large quantities of other valuable materials. Furthermore, improvements to the installation, operation, and maintenance of offshore wind installations are also required. These examples illustrate the fact that the term 'innovation' does not necessarily have to mean the rapid emergence of wholly novel concepts. It should also be understood to mean the steady, incremental improvement of existing technologies.

26 There is a significant amount of research already occurring in the field of offshore wind energy which neither goes to full scale proving nor is adopted by industry. To this end, it becomes important to ensure a mechanism for effective knowledge exchange between researchers and developers. The Energy Technology Partnership (ETP) is a successful example, acting as a broker between academia and external organisations and industry.[27]

27 Delivering government investment in a coordinated way is more conducive to seeing nascent technologies progress through the Technological Readiness Levels (TRL) than dispersing support across a larger number of smaller-scale projects without any strategic consideration. However, it will be important to ensure targeted investment does not monopolise funding and research capacity in a few key bodies. Working relationships between research centres should be constructive and lead to genuine collaboration.

28 The importance of demonstration sites must not be overlooked since successful field demonstration is vital in determining whether or not industry will adopt particular technologies. This is one area in which Scotland may unfortunately be lagging behind other countries which have state-owned demonstration facilities that can hasten the maturation of emerging technologies. We recommend that Scottish Enterprise or another suitable organisation explore how Scotland could increase its demonstration capacity in the short term.

29 There are several models through which innovation and research and development (R&D) could be funded. For example, the French Institute of Petroleum (Institut Français du Pétrole – IFP), created in Strasbourg in 1922 by ministerial decree, was funded by a tax levied on each tonne of crude oil extracted from "mines."[28] Such an assured stream of funding enabled the Institute to become a leader in petroleum research. A similar approach was adopted in Scotland from 1990 to 1998 with the creation of the Petroleum Science and Technology Institute (PSTI) in Edinburgh, which created research partnerships between Scottish universities and offshore industries with funding derived from oil production. The PSTI evolved into the Industry Technology Facilitator (ITF) in 1999.[29] It is important to specify that any support for R&D should ideally be in the form of cash and not in kind, in order to maximise its impact. Crown Estate Scotland could also consider embedding mandatory monetary contributions for R&D into their conditions for leasing.

30 The Intermediate Technology Institutes were a Scottish Government initiative that was intended to create new high-technology start-ups and to stimulate the growth of business expenditure on R&D.[30] Although the scheme misjudged the realities of the Scottish market and failed in practice, the lessons learned from them could help to instruct government on how to devise a programme to encourage research and development across the offshore renewables sector.

26 The most common are neodymium and dysprosium. Peak Resources (2019) Wind industry prepares for 'bottlenecks and price hikes' in rare earth metals [online] Available at: https://www.peakresources.com.au/news/wind-industry-prepares-for-bottlenecks-and-price-hikes-in-rare-earth-metals/

27 Energy Technology Partnership (undated) About the Energy Technology Partnership [online] Available at: https://www.etp-scotland.ac.uk/AboutETP/About.aspx

28 ALCEN group (undated) Institut Français du Pétrole Energies Nouvelles – Past and present [online] Available at: https://www.connaissancedesenergies.org/fiche-pedagogique/ifp-energies-nouvelles

29 Offshore Technology (2017) *An insight into funding Oil and Gas innovation with the Industry Technology Facilitator* (ITF) [online] Available at: https://www.offshore-technology.com/features/insight-funding-oil-gas-innovation-industry-technology-facilitator/

30 Brown, R., Gregson, G., & Mason, C. (2015) *A Port-Mortem of Regional Innovation Policy Failure: Scotland's Intermediate Technology Initiative* (ITI). Regional Studies 50(7):1260-1272 [online] Available at: https://www.tandfonline.com/doi/full/10.1080/00343404.2014.985644

Hydrogen

31 Offshore wind projects could facilitate the corresponding development of a hydrogen industry for Scotland, further diversifying Scotland's energy sector as well as contributing to energy resilience. The process involves hydrogen being produced through water electrolysis, integrated into an offshore wind turbine installation, and transported ashore via pipelines or ships.[31] In addition to being a means of transporting energy, hydrogen pipelines can also serve as storage units, helping to deliver flexibility of supply and overcome the perennial challenge of daily variations in energy demand. There is also the possibility to store massive quantities of hydrogen offshore and onshore in depleted fields, to balance interseasonal demand variations.[32] Currently, the cost of electrolysis is currently so high as to preclude commercial use compared to much lower cost production of hydrogen from chemical splitting of methane, sourced from the UK or Norwegian offshore. There also remains a longer term need for further research into hydrogen embrittlement of welds and structures, hydrogen permeation, and hydrogen compression. This could create additional value for offshore wind by production of hydrogen offshore and pipelining to the UK grid.

32 The hydrogen that is harvested could also become a feasible alternative to diesel fuels, which is particularly relevant as Scotland looks to decarbonise its transport sector.[33] There is also the potential to harness hydrogen energy to heat Scottish homes, thereby reducing the significant carbon footprint of this sector. Any excess could be exported abroad to help establish Scotland as an international supplier of hydrogen.

The recently launched North East Carbon Capture, Usage, and Storage Alliance (NECCUS) will focus on capturing CO_2 emissions from industry facilities at the St Fergus Gas Terminal near Peterhead, as well as the concomitant production of hydrogen. The creation of NECCUS represents a significant new chapter for CCS and hydrogen technologies in Scotland, marked by a £320M allocation to decarbonise industry and a further £800M for transport and storage infrastructure in the March 2020 UK budget.[34] The Scottish Government can build on this momentum by building hydrogen production considerations into its future offshore wind policies.

33 The RSE recommends that, when embarking on any programme of coordinated marine planning, sites be assessed on the basis of their suitability to support both wind and hydrogen operations. For example, this could mean selecting hydrogen storage areas where deep injection could cause minor movement of bedrock at the seabed, but still support the installation of hydrogen pipelines. Seabed-mounted wind electricity would be excluded from such areas in case of foundation damage, but floating offshore turbines could be readily mounted.

31 The idea of offshore wind energy being transported to shore in the form of hydrogen is, in our experience, being most actively explored by Dutch electricity and gas network utilities around their North Sea Wind Power Hub project: https://www.tennet.eu/our-key-tasks/innovations/north-sea-wind-power-hub/

32 Heinemann, N., Booth, M.G., Haszeldine, R.S., Wilkinson, M., Scafidi, J. and Edlmann, K., 2018. *Hydrogen storage in porous geological formations–onshore play opportunities in the midland valley* (Scotland, UK). International Journal of Hydrogen Energy 43(45): 20861-20874 [online] Available at: https://www.researchgate.net/publication/328225219_Hydrogen_storage_in_porous_geological_formations-Onshore_play_opportunities_in_the_Midland_Valley_Scotland_UK

33 The Committee for Climate Change's Net Zero – The UK's contribution to stopping global warming report included a scenario that envisaged hydrogen becoming the main fuel source for heavy goods vehicles and off-road vehicles such as those used in the construction sector, and, in the form of ammonia, shipping by 2050.

34 Farmer, M. (2020) UK 2020 Budget announces funding for carbon capture schemes [online] Available at: https://www.offshore-technology.com/news/uk-budget-2020-carbon-capture/

Additional Information

Any enquiries about this Advice Paper should addressed to Daria Tuhtar
(email: dtuhtar@therse.org.uk).

Responses are published on the RSE website (https://www.rse.org.uk/)

The Royal Society of Edinburgh, Scotland's National Academy, is Scottish Charity No. SC000470

Advice Paper (Royal Society of Edinburgh) ISSN 2024-2694

The Royal Society of Edinburgh

KNOWLEDGE MADE USEFUL