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Sea breeze: Measures to ensure a collaborative and cost-efficient future for offshore wind in Europe

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Introduction

Europe aims to halve its greenhouse gas emissions by 2030 and reach net-zero by 2050. Electrification is identified as the single most effective route to achieve this ambition, with a predicted increase in electricity demand of as much as 150% by 2050 compared with today's levels.[2] To meet this objective, the transition to renewables needs to be accelerated well before 2050, with fossil fuels replaced in the power sector and phased out in industry, transport and heating via direct and indirect electrification. Offshore wind will have a major role to play in delivering these targets, with the European Union Commission's scenarios indicating that it will need to meet around 25% of electricity demand by that time. This implies an offshore wind capacity of up to 450GW — a 20-fold increase on where we are today.

The European Commission is expected to present its offshore wind strategy in October 2020, setting out a credible pathway to delivering the 2050 targets. Just what the strategy will contain is uncertain; however, there appears to be a host of issues to be addressed — mobilising the necessary finance and development capacity, permitting, management of maritime space, developing a transnational approach to project selection and, the subject of this report, the development of the necessary onshore and offshore grid connections and related changes to electricity market design.

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[2] European Commission. (2018, 28 November). *A Clean Planet for all: A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy*. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0773&from=EN

Achieving 450 GW of offshore wind capacity by 2050 is a challenging prospect, even though the target itself represents a relatively small proportion of Europe's economically attractive potential, estimated to be up to 1,360 GW.[3] The location of that potential suggests that more than half of the required capacity will be found in the North and Baltic seas, 60% of which is currently unavailable for offshore wind development. Even with a rethink of maritime spatial arrangements, delivering the necessary offshore wind capacity implies a clustering of projects. This will rapidly render the currently applied practice of connecting individual wind farms to the onshore grid on a radial point-to-point basis impractical.

In addition to the difficulties in harvesting and bringing wind energy ashore in the quantities envisaged, there is the issue of delivering that energy to Europe's demand centres. Europe's transmission system was built around fossil-fuel-fired generation that is rapidly disappearing, and the transmission system is not well placed to service a generation mix with a large amount of offshore capacity.

A first best solution

The most efficient and cost-effective approach to delivering the Green Deal offshore wind targets would almost certainly involve a fully integrated transnational mechanism with the capacity required to meet those targets. This would be allocated to Europe's various maritime areas — the North and Baltic seas and Atlantic and Mediterranean coasts. Supported by coordinating organisations for each maritime area, such as the North Seas Energy Cooperation (NSEC), countries with seacoasts in each area would then cooperate to select the most cost-effective staircase of projects to meet these targets. The most cost-effective offshore transmission design to bring the associated energy to shore and provide appropriate levels of interconnection capacity could then be determined. In turn, this would inform onshore transmission design and the reinforcements necessary to deliver offshore energy to Europe's demand centres.[4] Incumbent TSOs (transmission system operators), or third parties, would then plan to build out the necessary offshore and onshore transmission projects in timescales consistent with the delivery of the Green Deal targets. An example of how WindEurope believes the offshore wind capacity necessary to meet the Green Deal targets for 2050 would be allocated is illustrated in Figure 1.[5]

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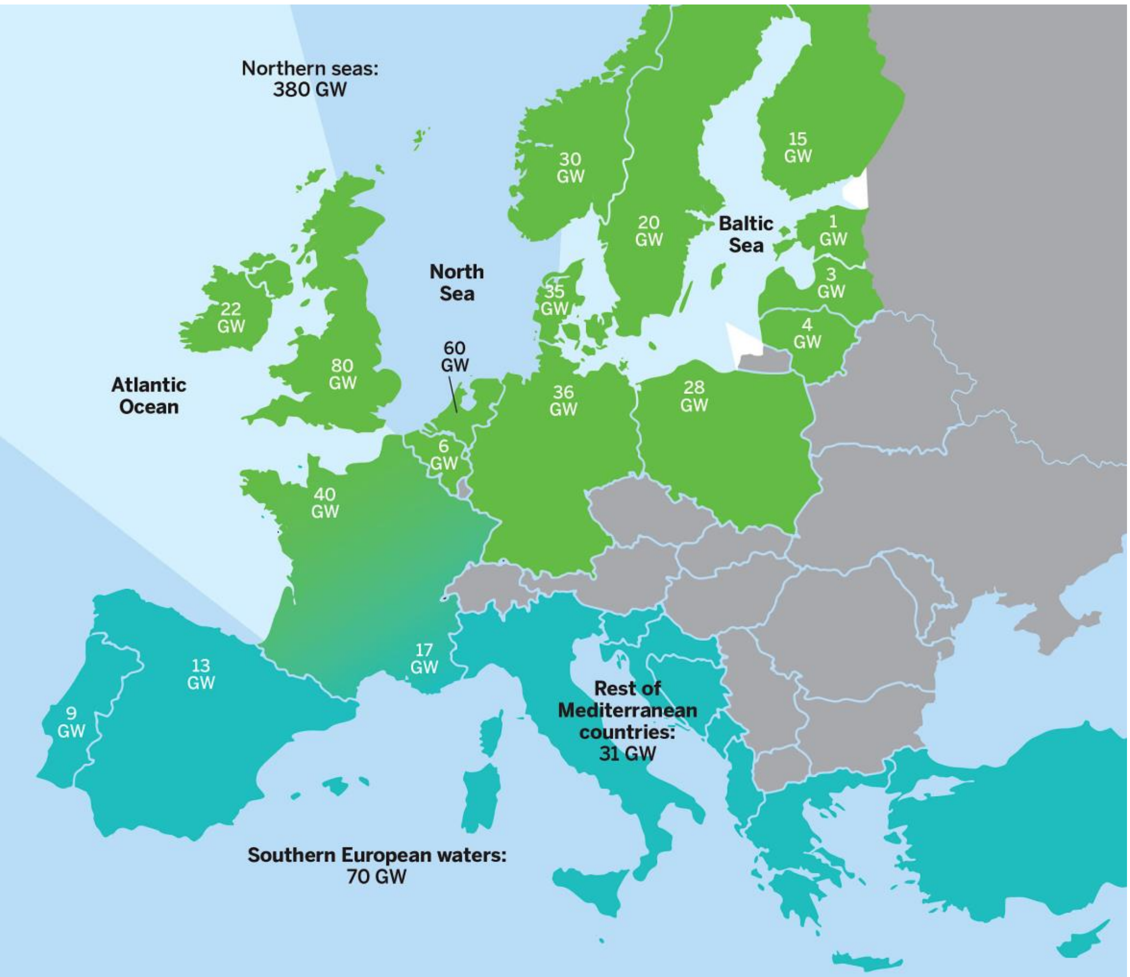
[3] Economically attractive capacity is defined by WindEurope as capacity with a LCOE of €65/MWh (2030) or less. See WindEurope. (2017, June). *Unleashing Europe's offshore wind potential: A new resource assessment*. BVG Associates. https://windeurope.org/data-and-analysis/product/unleashing-europe-s-offshore-wind-potential/

[4] An example of an integrated approach to the development of the transmission infrastructure necessary to facilitate offshore wind's contribution to the Green Deal targets is Amprion's Eurobar concept – a modular approach that would allow step by step development by many international partners. See Amprion. (2020, 24 June). *Climate protection by innovation*. https://www.amprion.net/Bilder/Netzjournal/2020/Eurobar/Eurobar_Handout_final_EN.pdf

[5] Freeman, K., Frost, C., Hundleby, G., Roberts, A., Valpy, B., Holttinen, H., Ramíez, L. & Pineda, I. (2019). *Our Energy, our future: How offshore wind will help Europe go carbon-neutral*. BVG Associates for WindEurope. https://windeurope.org/about-wind/reports/our-energy-our-future/

Figure 1. Possible disposition of offshore wind capacity to meet the Green Deal 2050 targets



Source: Freeman, K. et al. (2019). *Our energy, our future: How offshore wind will help Europe go carbon-neutral.* WindEurope has granted permission to use this information.

Though Member State energy planning must be carried out within a European context and a cooperative, regional approach is already embedded in European infrastructure planning via the TEN-E Regulation, ENTSO-E's 10-year planning process, and the Regional Coordination Centres (RCCs) established by the recast Electricity Regulation, we are still some ways away from a fully coordinated approach to offshore wind development. Currently, offshore wind development is a purely national matter with individual Member States. The Member States have been developing projects to meet their voluntary national contributions to the 2030 EU renewable target that reflect national resource availability and technology preferences. These national pledges, set out in Member State National Energy and Climate Plans (NECPs), show considerable differences in ambition. Significant differences also exist in national regulatory frameworks and practices. The Energy and Climate Governance,[6] however, envisages moving

[6] Official Journal of the European Union. (2018, 11 December). *Regulation (EU) 2018/1999 of the European Parliament and of the council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council*. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R1999&from=EN

beyond the national approach in case the national contributions are not sufficient to reach the EU target or when Member States do not meet their own pledged contributions. In the latter case, nonperforming Member States should make additional measures to close the 'delivery gap.' The European Recovery Package proposed by the Commission brought forward the idea of EU renewable energy system tenders to make up for the slowdown of national tenders and plans to procure 15 GW of wind and solar in the next two years. The new Renewable Energy Financing Mechanism published in September 2020 envisages regular renewable tenders managed by the Commission and financed by 'contributing Member States to catch up with their commitments.'[7] It would increase the cost-efficiency of investments and allow, for example, landlocked states to contribute to offshore wind as well.

Some Member States or third countries favour a highly centralised project development approach with transmission connections provided by the national TSO, while others are favouring a more developer-led approach with transmission connections open to tender. National seabed leasing and tender processes operate according to different timetables and have different planning horizons. These and other differences in both regulation and process make coordination between neighbouring countries more difficult and present a barrier to the regional approach necessary to deliver the Green Deal targets in the most cost-efficient manner.

Measures to support a more coordinated approach

The development of offshore wind, with several Member States having an economic interest in each maritime area, cries out for an integrated and coordinated approach to delivery. Achieving an integrated European mechanism for the delivery of the Green Deal offshore wind targets will, however, require significant regulatory change. Though developing the desired regulatory framework will take time, there are issues that can be addressed now to facilitate that change and enable cooperation among neighbouring Member States. Although this report does not attempt to catalogue everything that needs to be done in this regard, the following paragraphs focus on some specific issues where actions taken now could remove some of the regulatory and other barriers standing in the way of a more coordinated regional approach. These issues include:

- Allowing for regional harmonisation of various offshore support mechanisms, auction, leasing and connection process adopted by Member States, differences that currently threaten to prevent the coordination necessary to efficiently achieve Europe's offshore wind ambitions.
- Developing a regulatory framework that more effectively encourages a shared approach to offshore connection. Although radial connections have proved useful thus far, they will be increasingly impractical in many situations as developments move farther offshore and the number and density of projects increase.

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[7] European Commission. (2020, 17 September). *European Green Deal: New financing mechanism to boost renewable energy*. https://ec.europa.eu/info/news/european-green-deal-new-financing-mechanism-boost-renewable-energy-2020-sep-17_en#:~:text=The%20European%20Commission%20has%20published,from%20the%20start%20of%202021.&text=Commissioner%20for%20Energy%2C%20Kadri%20Simson,the%20share%20of%20renewable%20energy

- Moving to a more contestable approach to offshore (and eventually onshore) transmission investment. The ability of wind farm developers and third parties to construct connections will depend on investment costs. The capital and construction capabilities of TSOs are limited, and there are many other calls on those capabilities. Given the scale of transmission development necessary to meet the Green Deal targets, other sources of capital and construction capacity need to be developed.
- Creating market designs that could encourage the development of hybrid offshore wind farm connection and interconnector projects that, where appropriate, could yield additional savings in transmission investment.[8] Issues include the definition of bidding zones and the allocation of transmission rights and curtailment.
- Considering the extent to which "power to gas" projects could reduce onshore and possibly offshore connection costs. Electrolysis is forecast to become economically attractive compared with steam reforming. If this bears out, electrolysis plants could yield significant savings in the transmission investment necessary to meet Green Deal targets while at the same time reducing CO_2 emissions.

Offshore regulatory framework and seabed leasing arrangements

The regulatory frameworks for offshore wind developed by individual Member States vary substantially across Europe. There are differences in the design of support schemes, auction and tendering processes, the granting of seabed rights and arrangements for delivering offshore connections. Furthermore, national auctions and tendering processes are not synchronised and have different planning horizons. Unless addressed, these differences will impede progress towards regional or maritime-area coordination and make meeting the Green Deal offshore targets more difficult. That very different regulatory regimes have evolved is useful in one respect, however: we have the opportunity to compare these different practices and identify a best practice regulatory regime.

Table 1[9] summarises, at a high level, a few regulatory process aspects of project selection adopted by some Member States that border on the North Sea, including:

- Support mechanisms.
- Approach to project selection.
- Seabed surveys.
- Leasing and connection.
- Possible parallel routes to development outside the standard auction process.

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[8] Weichenhain, U., Elsen, S., Zorn, T. & Kern, S. (2018, December). *Hybrid projects: How to reduce costs and space of offshore development. North Seas offshore energy clusters study*. Roland Berger GmbH. https://op.europa.eu/en/publication-detail/-/publication/59165f6d-802e-11e9-9f05-01aa75ed71a1/language-en?WT.mc_id=Searchresult&WT.ria_c=37085&WT.ria_f=3608&WT.ria_ev=search

[9] North Seas Energy Cooperation. (2017, December). *Support schemes for offshore wind: Emerging best practices.* https://ec.europa.eu/energy/sites/ener/files/documents/171207_sg3_paper_offshore_wind_support_schemes_emerging_best_practices_f.pdf

Table 1. High-level comparison of some regulatory aspects of Member State project selection

	Offtake remuneration	Auction process, centralised or decentralised	Auction excludes or includes connection
England and Wales[10]	Auction. Sliding premium/Contract for differences.	Developer led. Developer obtains all key consents.	Includes connection.
Germany[11]	Auction. Sliding premium/Contract for differences.	Centrally led. Federal Maritime and Hydrographic Agency determines suitability of development sites.	Excludes connection. TSO responsible for financing and construction of offshore substation and connection. TSO liability for delays but pass through any cost to end customers.
The Netherlands	Auction allowing tenders with subsidy and tenders without subsidy. Feed-in tariff (SDE+).	Centralised. Permits & licences awarded to winning bid.	Excludes connection. TSO responsible for financing and constructing offshore substation and cables to shore. TSO liabilities for delays.
Denmark	Auction based on premium feed-in tariff. Developer sells energy to the market.	Centralised. Permits and licences awarded to winning bid. Parallel 'open door' process allows developer to submit unsolicited application	Offshore substation and cables to shore responsibility of developer and included in bid.
Belgium	Competitive auction. System of Green. Certificates in exchange for output.	Centralised. Permits and licences awarded to winning bid.	Excludes connection. TSO responsible for financing and construction of offshore substation and cables to shore. Capped TSO liabilities for delays.

Support mechanisms

As far as support mechanisms are concerned, a degree of uniformity already exists. Most North Sea countries employ some form of competitive process for project selection, where bidders compete to deliver projects requiring the least support, usually based on premium feed-in tariffs or contract for differences. This has led to an impressive trend of falling support prices. In fact,

[10] Scotland has a parallel and similar process.

[11] Offshore wind farms commissioned after 31 December 2020 are subject to a new permit regime under the Offshore Wind Energy Act.

some recent auctions have been 'subsidy free' and have become something of a 'beauty contest,' with winning bids selected on the basis of project design and process rather than minimum cost. Differences in support mechanism design, however, still makes direct comparison of projects necessary for an integrated regional approach difficult.

Project selection

In other areas, however, more significant differences in regulatory frameworks exist. One such area is site selection and development, with countries taking either a centralised or decentralised approach.

In the centralised approach adopted by most North Seas countries, pre-investigations and site selections are undertaken by the leasing authority prior to the leasing auction, leading to predefined offshore wind projects. Bidders then compete to construct and own these well-defined projects and can focus on minimising project cost. With the decentralised model adopted by Great Britain, the project developer is responsible for selecting and investigating potential sites and projects within the leasing area stated by the leasing authority. This approach gives established developers with good surveying skills a competitive advantage but, compared with the centralised approach, arguably disadvantages the entry of new developers. The two approaches also give rise to very different planning horizons due to the time required to complete the site investigation and selection process either before or after the auction process. For example, the fourth leasing round about to get under way in Great Britain assumes project commissioning around 2029, while the 2019 Netherlands leasing round assumed project commissioning in 2025.

One danger in the centralised approach may be that experienced developers are better placed than the leasing authority to identify the most promising projects. To mitigate this danger, Denmark operates an open door policy where, in parallel with the main auction process, developers have the opportunity to use their expertise to identify promising projects that might otherwise be missed by the centrally led tendering process. This approach appears to have merit.

Developer or TSO-led connection

Another significant issue is whether developers are required to include the cost of transmission connection when bidding, or whether connection is treated separately. An advantage of including transmission connection in the auction bidding process is that the developer has control of both connection and wind farm development and can therefore avoid unhelpful delays in either. Another significant advantage is that the developer has every incentive to minimise the cost of connection, whereas, if the connection is the responsibility of the incumbent TSO, this may not be the case. A study commissioned for Ørsted notes that the cost of German offshore transmission, which is provided by the relevant TSO, is twice that of Great Britain, which has a contestable developer-led approach to the provision of connection. The report notes that, while some of the cost differences are attributable to distance from shore and technology, almost 30% of the cost reduction can be attributed to the competitive approach adopted by the British model.[12] German TSOs have no competition and no real incentive to minimise costs, being able to pass on all associated costs to the consumer — including any liquidated damages associated with delayed commissioning. In this regard, it is instructive to note that six out of the seven offshore connections provided by German TSOs in 2016 experienced commissioning delays, with an average delay of one year per project.

Recommendations

Harmonisation around best practice is key. If a truly regional approach to delivering Europe's offshore wind targets is ultimately to be adopted, with Member States cooperating to meet regional rather than national targets in the most cost-effective fashion, a high degree of harmonisation in support measures, project selection and development processes will be required. There is no fundamental reason why Member States should adopt different practices, and regional bodies such as the North Sea Energy Cooperation and the Baltic Energy Market Interconnection Plan are ideally placed to identify best practices and encourage harmonisation around those practices.

Processes should encourage new entry. Given the magnitude of the task in hand, encouraging new developer capacity to engage in the competitive process will be crucial. In this respect, the centralised approach to selecting project developers — where most of the survey, site selection and permitting activity is performed by the leasing agency — seems preferable to the decentralised approach that arguably gives established developers an advantage. Developers can then focus on bidding competitively to build well-defined projects. To avoid the danger of a centralised approach, where the leasing agency effectively designs the offshore wind project and may not always identify the most promising projects, an open-door policy as operated by Denmark seems to have value.

Transmission connection should be developer-led. Given the potential savings in connection costs and the advantage to developers of having control over the timing of both the wind farm project and connection, auctions that require bidders to tender for both are to be preferred. If, however, wind farm development and transmission connections are to be developed separately, both should be the subject of a competitive process. This should at least ensure that connection costs are minimised. Evidence suggests that the alternative of TSO provision increases both cost and risk of delay.

Shared connection and hybrid schemes

With relatively few exceptions, offshore wind farms have so far been connected to the onshore transmission system by unique radial connections. While wind farm projects have been reasonably well dispersed and close to shore, unique radial connection has been appropriate. No issues of third-party access or anticipatory investment are raised, and where connection has been a developer responsibility, the development of the wind farm project and grid connection can be fully coordinated. Unique radial connections, however, are likely to become increasingly impractical as the number and density of projects increases. As we progress towards delivering

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[12] DIW Econ. (2019, May). *Market Design for an efficient transmission of offshore wind energy*. Ørsted Offshore Wind. https://diw-econ.de/en/publications/studies/offshore-wind-energy/

the Green Deal targets, the unavoidable tendency of projects to cluster and move farther offshore will result in unique project connections becoming increasingly inefficient and lead to unnecessary investment. Furthermore, as coastal onshore transmission networks tend to be weak and connection points limited, continuing with an individual approach will eventually lead to an inability to land the necessary cables due to space, environmental and capacity restrictions. In fact, this is already an issue in some areas, such as the northwest and southeast coasts of Great Britain.[13] Resistance by local communities to further landings, or to the reinforcement of coastal networks necessary to alleviate these restrictions, risks jeopardising installation rates necessary to meet the 2050 targets.

Multi-user hubs and hybrid projects

For these reasons, increasing attention is being given to multi-user hubs, where two or more wind farms connect to an offshore substation and share connection capacity to shore. As projects move farther offshore and the cost of connections increase, the savings associated with shared connection increase.[14] Advantage can also be taken of the natural diversity between connected projects to achieve economies in connection capacity. Power to gas (P2X) projects or storage could be connected to multi-user hubs without adding to electrical connection capacity requirements. Overtime, and given the necessary long-term coordinated planning between neighbouring countries, multi-user hubs could be developed into hub and spoke or hybrid assets that serve to connect wind farms and provide interconnector capacity.

Hybrid schemes offer the prospect of further savings in investment costs. A recent report for the European Commission indicates that the development of hybrid schemes could result in a further 10% reduction in investment costs compared with developing interconnection and offshore connections separately.[15] Ultimately, the hub and spoke or hybrid concept could develop into a fully meshed and resilient offshore transmission grid.

Continuing a developer-led or contestable approach to connection

The development of multi-user hubs and projects that combine connection and interconnection imply the need for coordinated planning. It is estimated that the offshore transmission capacity necessary to deliver the Green Deal 2050 targets will be equivalent to twice that of the current German onshore transmission system. Delivering this offshore capacity efficiently, virtually from scratch, will require a high degree of regional system design oversight. This could be provided by regional coordination organisations such as the North Seas Energy Cooperation, ENTSO-E via its 10-year transmission planning process (TYNDP) or some other regional entity

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[13] Offshore Wind Industry Council. (2019, November). *Enabling efficient development of transmission networks for offshore wind targets*. https://www.ofgem.gov.uk/ofgem-publications/161477

[14] An analysis published in 2011 suggested that connecting 114 of the 321 wind farms then to be in operation by 2030 to multi-user hubs would yield savings of around €14 billion. See De Decker, J., Kreutzkamp, P., Cowdroy, S., McGarley, P., Warland, L., Svendsen, H., Völker, J., Funk, C., Peint, H., Tambke, J., von Bremen, L., Michalowska, K. & Caralis, G. (2011, October). *Offshore electricity grid infrastructure in Europe*. 3E. https://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/offshoregrid_offshore_electricity_grid_infrastructure_in_europe_en.pdf

[15] Weichenhain et al, 2019.

established for the purpose. Whichever option is chosen, this system architect will be required to identify the optimum offshore network topology and the incremental development necessary to accommodate the growth of wind capacity en route to delivering the Green Deal targets. Given the huge cost of developing the necessary offshore networks, estimated as being in the region of €200 billion by 2050, the need for a cost-effective provision will be paramount.[16] Given the savings in investment costs to date achieved through a contestable approach to provision, that is, where the wind farm developer is responsible for connection rather than the TSO, it will be important to ensure developers or other entities with the necessary skills and capabilities are able to compete in the provision of multi-user hubs and hybrid projects. TSOs do not have unlimited financial and delivery capacity and have many demands on that capacity related to onshore transmission development. Given the magnitude of the task at hand, it will be important to allow other sources of investment and commissioning to enter the market.

The offshore transmission operator (OFTO) regime for Great Britain (GB) provides an example of how developer-led construction of transmission connections can be implemented in Europe's unbundled regulatory framework and of the savings in investment costs that can be accrued (see Example 1). Although the regime has been successful in promoting developer-led build-out of unique radial connections, there is a realisation that it is unlikely to deliver shared access or hybrid connections. Ofgem is therefore working with National Grid ESO, the GB electricity system operator, and the offshore industry to understand how the current regime will need to be modified to embed the principle of contestability into arrangements for constructing multi-user hubs and hybrid schemes. This could be achieved by either allowing developers to propose multi-user hubs or hybrid projects in the existing auction and tender processes operated by Member States or by introducing separate auctions for the connection where developers, TSOs or third parties could compete.[17]

Example 1: Great Britain offshore transmission regime

National Grid ESO, the electricity system operator of the onshore GB transmission system, is also designated as the system operator for all offshore transmission. However, there is no designated single transmission owner for offshore transmission assets. Under the current offshore regime, wind farm developers have the option of designing and constructing offshore connections or enlisting an offshore transmission operator (OFTO) to do so. Regardless of who builds the assets, the OFTO will be responsible for the ongoing ownership and operation of the connections. Three basic models (illustrated in Figure 2[18]) are possible:

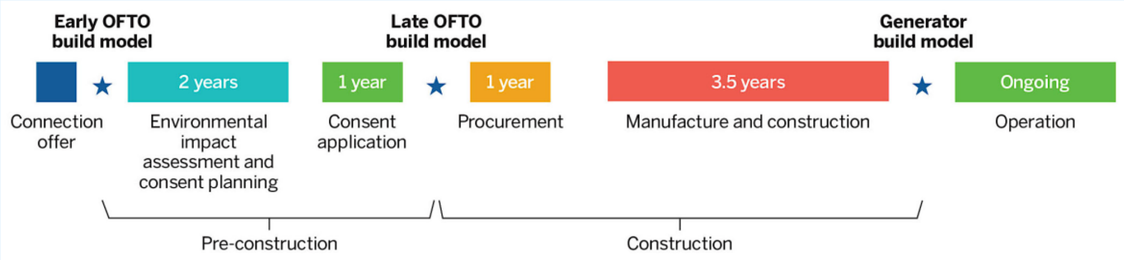
- Early OFTO build, where the OFTO is responsible for preconsenting, permitting and construction.
- Late OFTO build, where the OFTO procures and constructs the transmission assets.
- Generator build, where the generator undertakes all aspects of asset delivery and transfers ownership on commissioning.

16 Freeman et al, 2019.

17 Ørsted draft report yet to be published.

18 Ofgem. (2018, January). *Update on competition in onshore electricity transmission.* https://www.ofgem.gov.uk/publications-and-updates/update-competition-onshore-electricity-transmission

Figure 2. Indicative timing of early OFTO, late OFTO and generator build models



Source: Ofgem & DECC. (2010). *Government response to consultations on offshore electricity transmission*.

A competitive tender process allows entities to bid for a licence to become an OFTO of a particular offshore network or connection, which entitles them to earn a regulated rate of return on the costs of building and/or owning the offshore assets. To date, no OFTO has opted to construct offshore assets, and all connections have been generator-built, with the assets transferred on commissioning at a transfer value determined by Ofgem, reflecting the economic and efficient costs that ought to have been incurred by the developer. Essentially, bidders compete via the tender process to bid the lowest rate of return on that asset value.

Having bought the offshore assets, the OFTO recovers its revenue from the ESO in accordance with the 20-year revenue stream agreed through the tender process. The ESO recovers this revenue by applying transmission charges to the offshore assets, to be paid by the offshore generator owner.

A contestable approach to delivering transmission projects need not be confined to offshore networks. In fact, an outcome of Ofgem's Integrated Transmission Planning and Regulation project is the introduction of a process to competitively tender the construction of high-value onshore transmission assets in an attempt to replicate the savings achieved through the offshore transmission regime.[19]

There are other examples of jurisdictions embracing a competitive approach to transmission provision, for example, the Electric Reliability Council of Texas (ERCOT) Competitive Renewable Energy Zone (CREZ) process. Based on a transmission plan developed by the Texas ISO, ERCOT, some 3,600 circuit miles of 345-kV transmission, was competitively tendered to link five resource zones and 19 GW of wind capacity to the principal load centres (see Example 2).

Example 2. The Texas CREZ projects

The ERCOT market in Texas is a competitive, nodal wholesale market with full retail competition and a peak load of about 75 GW; it is electrically isolated, connected to the rest of the North American grid by five DC interties. The region has exceptional onshore wind resources, principally concentrated in west Texas and the Panhandle, sparsely populated regions far from the major load centres in eastern and southern Texas. By 2005, it was apparent that further development of the wind resource would be severely constrained by a lack of transmission infrastructure. In that year, the state legislature passed Senate Bill 20 authorizing the regulator and ERCOT to identify Competitive Renewable Energy Zones (CREZ) and to develop a transmission plan that would anticipate development of the resource and export to the main load centres as seen in Figure 3.[20]

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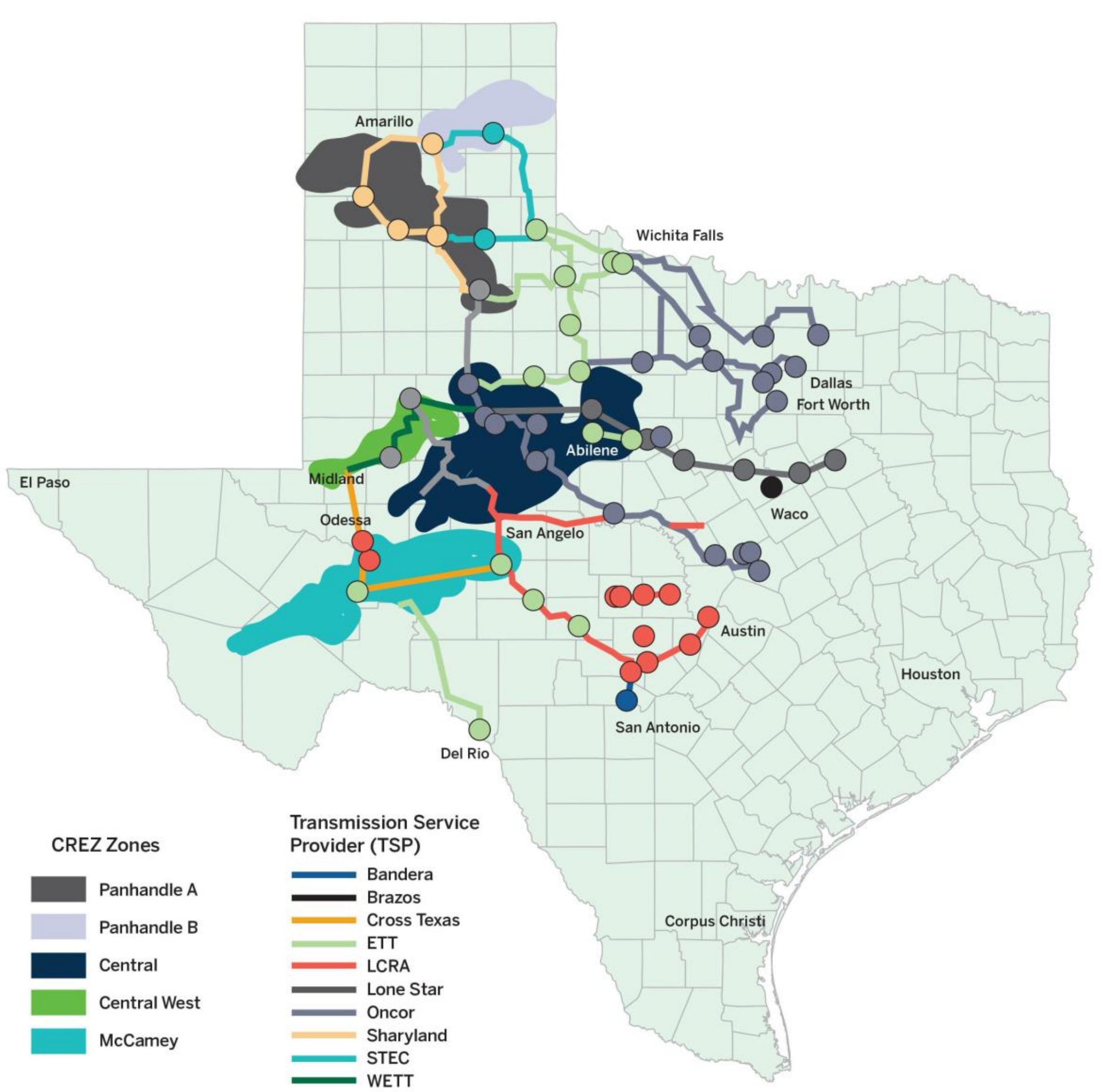
[19] Ofgem, 2018.

[20] Lasher, W. (2014, August). *The competitive renewable energy zones process.* ERCOT. https://www.energy.gov/sites/prod/files/2014/08/f18/c_lasher_qer_santafe_presentation.pdf

Figure 3. Texas Competitive Renewable Energy Zone (CREZ) projects



Source: Lasher, W. (2014, August). *The competitive renewable energy zones process*.

The regulator initiated the project in 2007. Five resource zones were identified, and ERCOT was directed to proceed with transmission planning. ERCOT ultimately settled on a plan for 3,600 circuit miles of new 345-kV transmission interconnecting the five resource zones and connecting the entire region to the eastern and southern grids (see Figure 3), dimensioned to enable about 19 GW of wind capacity (of which 6.9 GW already existed), with a budget of $6.8 billion and a target completion date of 31 December 2013. The project was awarded competitively in segments in early 2009 to 10 incumbent and new entrant transmission service providers. All segments of the project were permitted and completed on budget by February 2014. The costs of the project are to be recovered from all ERCOT consumers on their electricity bills, which in 2014 was expected to cost an average of $70-$100 per year per customer over 15-20 years. The project has been a success, with wind curtailment reduced from 17% in 2009 to 0.5% in 2014 and installed wind capacity growing from 4.8 GW in 2007 to 22 GW by the end of 2018.

Although projects may to some extent be scalable, issues such as anticipatory investment seem likely to arise with connections initially needing to be oversized to accommodate the development of subsequent wind farm capacity in the same area. This would also require arrangements to ensure that a developer-led multi-hub project would not be penalised for delivering connection capacity over and above that required for the first connected wind farm; in other words, the issue of anticipatory investment would need to be addressed. As European unbundling rules would require a developer to transfer ownership of a multi-user hub, once commissioned, to either an incumbent TSO or independent TO (transmission owner), the developer would also need assurance that the transfer price fully reflected all efficiently incurred costs. The developer would also need assurance that any subsequent transmission charges applied only to that portion of the hub's capacity necessary to connect the first commissioned wind farm project and that the first wind farm to connect was not disadvantaged compared with projects that subsequently connected to the hub.

Recommendations

If the offshore transmission network necessary to accommodate the Green Deal targets is to be delivered at minimum cost with least risk of stranded assets, regional system architects will be required for each maritime area to identify the network topology required and a pathway to delivery.

Given the potential cost of developing the offshore transmission network necessary to deliver the Green Deal targets, regulatory frameworks should be developed that facilitate a contestable approach to the development of shared access and hybrid connections so that the associated savings can be captured. The regulatory framework will need to provide for anticipatory investment where necessary. If the potential 30% savings in investment costs associated with a contestable approach to connection are to be realised, developers will need to see a positive business case for their involvement. If not, they will continue to favour unique radial connections. A developer investing in a shared access or hybrid project will need to be protected from the risk of subsequent projects not being developed. Developers will also need assurance that they will not be disadvantaged by the evolution of transmission charges as additional capacity is connected.

Legal and market issues associated with hybrid schemes

Hybrid schemes fulfil two purposes: the connection of wind offshore capacity and the provision of interconnector capacity between two Member States. A hybrid scheme may be established directly or developed from a hub arrangement via the addition of a circuit to another Member State or bidding zone. It has an immediate advantage over radial and multi-user hub connections in that higher load factors are possible. While the load factor of radial or multi-user hub designs is governed by the load factor of the wind capacity connected to them, any unused capacity can be made available for market trading with a hybrid scheme.

Legal status of hybrid schemes

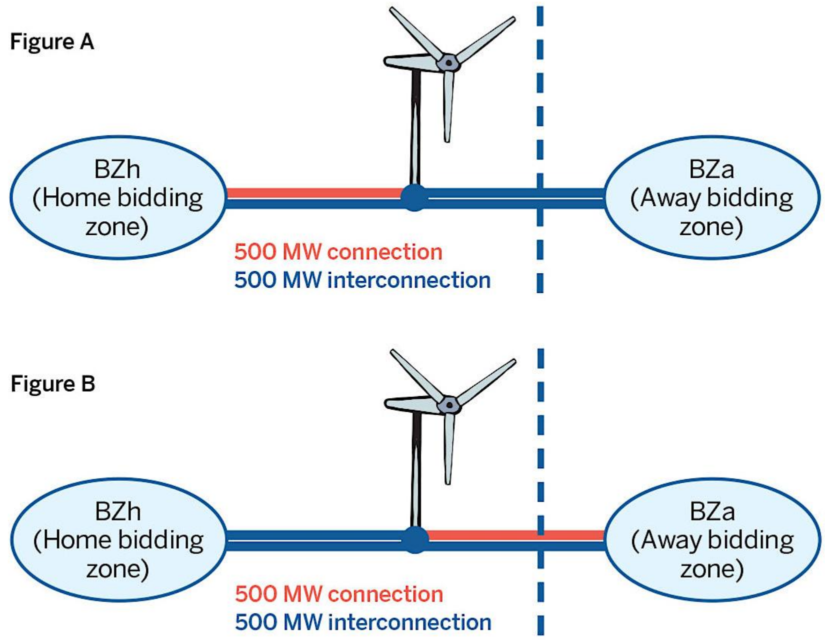
Notwithstanding the potential of hybrid projects, the recast Electricity Regulation 2019/942 is silent on how they should be regulated despite the fact that Recital 66 of the Regulation requires that such schemes should be accommodated. In fact, Europe's current legislation deals with the two functions of a hybrid project — connection and interconnection — quite differently. For example, it is possible to impose use of system charges on wind farm connections but not on interconnection. Furthermore, Regulation 2016/1719, which establishes a guideline on forward capacity allocations, requires that interconnector transmission rights are auctioned either explicitly or implicitly while access rights on wind farm connections can be allocated in the sense that they form part of the connection agreement between wind farm owner and TSO.

The legal status of hybrid schemes in national law is also unclear. In the UK, for example, an OFTO can transmit electrical energy under its transmission licence but cannot engage in market-to-market energy transfers. Under Dutch law, the purpose of an offshore network is considered to be the transmission of energy to the national grid, while interconnectors are defined as cross-border networks connecting two countries. It is unclear whether these definitions allow or prohibit hybrid projects. The status of hybrid projects under German law is also unclear.

Market issues associated with hybrid schemes

Recognising the dual role of a hybrid interconnector, the combined assets can be thought of as a two-lane motorway: the slow lane representing the capacity connecting the wind farm to the onshore transmission and the fast lane representing the interconnector capacity. Four possible options can be envisaged. First, as illustrated in Figure 4a, the wind farm is assumed to be connected to its home electricity market and bidding zone, that is, the market or zone of the Member State in whose jurisdiction it is located. Second, as illustrated in Figure 4b, the wind farm could be allocated to the market at the remote end of the interconnector. Third, the wind farm could be allocated its own bidding zone as illustrated in Figure 5. The fourth option, illustrated in Figure 6, is a combination of options 4a and 4b, with the wind farm having the option of being associated with either of the markets connected via the interconnector. Each of the four options has its pros and cons, and each results in a different allocation between use of system and congestion income.

Figure 4. Wind farm connected to its home (a) or away (b) bidding zone



The first option (Figure 4a), which is the model used for the only European hybrid scheme in existence at the present time,[21] appears to be the least complicated — for example, removing issues about which Member State offshore support scheme (if any) should apply. In the example shown in Figure 4a, the wind farm would pay for transmission use of system charges on the 500 MW of slow lane capacity connecting it to its home onshore transmission system and would bid into its home electricity market, receiving the cleared home market price. Assuming that its home market price was higher than the market price at the remote end of the interconnector, energy would flow towards the home market. However, flows between the wind farm and the remainder of the home bidding zone would limit the interconnector capacity across the bidding zone boundary that could be offered to the market, with any congestion income flowing to the owner of the interconnection assets.[22] If, however, the market clearing price at the remote end of the interconnector was higher than the home end, the interconnector capacity offered to the market would be increased with congestion revenue received by the asset owner. This could also potentially increase, depending on the price differential between the two bidding zones. Option 1 (Figure 4a) is the nearest to current practice, treating the wind farm as it if were radially connected. The wind farm would pay transmission use of system charges on the connection capacity and, in common with all generation in the home market, would have the option of purchasing transmission rights to gain access to potentially higher prices in the remote bidding zone.

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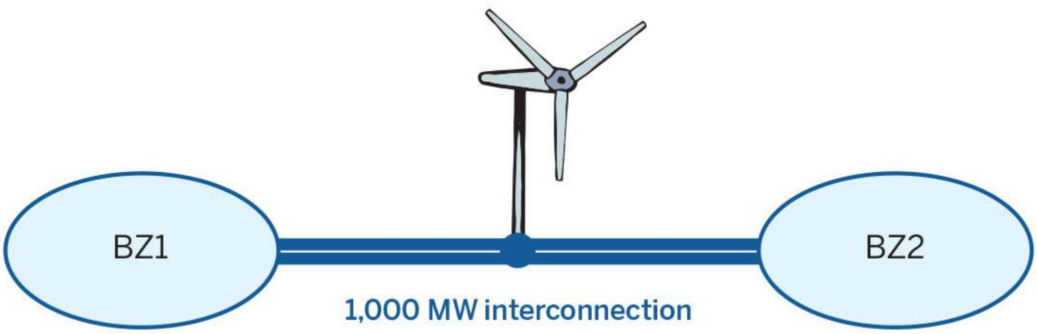
[21] The Kriegers Flak-Combined Grid Solution project will connect the Danish region of Zealand with the German state of Mecklenburg-Western Pomerania via two offshore wind farms, German Baltic 2 and Danish Kriegers Flak. The project is expected to start trial operation in 2020.

[22] Congestion revenues equal the product of the price differential between the two bidding zones and the flow across the interconnector.

Alternatively, the second option (shown in Figure 4b), would be for connecting to the market at the remote end of the interconnector in an attempt to gain access to higher energy prices. The wind farm would again pay transmission charges on 500 MW of slow lane connection capacity, and the interconnector capacity available to the market would be constrained as in Figure 4a. In order to eliminate any potential competitive advantage or disadvantage, it seems appropriate that the wind farm should benefit from any support mechanism operating in the market where it might opt to connect rather than applying in the jurisdiction where it was sited. However, the home jurisdiction should arguable retain any renewable credits generated by the wind farm.

The third option of allocating the offshore wind farm to its own bidding zone illustrated in Figure 5 has the disadvantage that the wind farm will always access the lowest market clearing price of the two connected bidding zones. Interconnector capacity offered to the market would be maximised and congestion income also potentially increased depending on bidding zone price differentials. As with the first option (Figure 4a), the wind farm would have the option of purchasing transmission rights to access market clearing prices at either end of the interconnector. As with Figure 4a, the wind farm should benefit from the support system that applied in the jurisdiction to which it was situated.

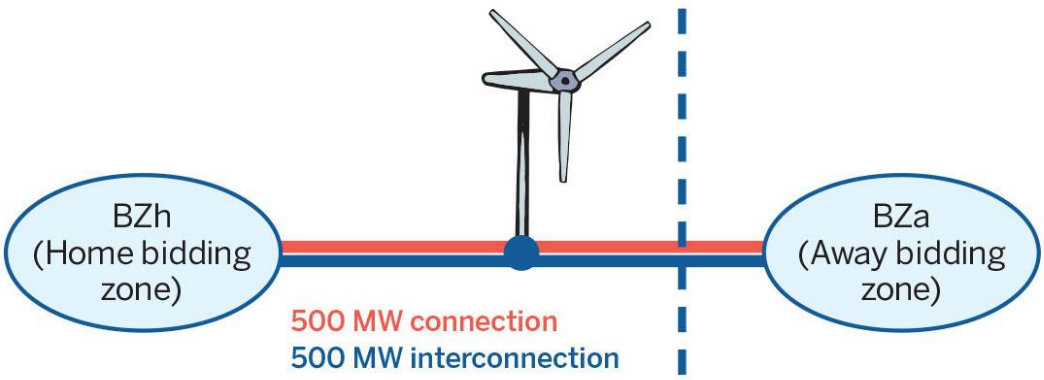
Figure 5. Wind farm allocated its own bidding zone



Although arguably coming closest to the European target market model, which assumes that bidding zones should reflect constraint boundaries rather than national borders, it seems at least doubtful that allocating a windfarm to its own bidding zone would encourage developers to propose hybrid connections. The fact that only the lowest of the two interconnected market prices could be accessed and the need to purchase transmission rights to access the higher bidding zone market price would seem to be a significant financial obstacle.

The fourth (Figure 6) option has similarities with Figures 4 and 5 but would allow the offshore wind farm to have access to either electricity market in exchange for paying transmission use of system charges on the connection capacity to both markets, that is, the slow lane capacity in both directions. Assuming that the wind farm always chose to connect to the market with the highest clearing price, then the interconnector capacity offered to the market would be constrained as in option 1 (Figure 4a), with congestion revenues potentially reduced depending on the price differential between the two bidding zones. In fact, the reduction would be greater as presumably the wind farm would permanently associate with the higher clearing price market. On the other hand, the transmission use of system income available to the owner of the hybrid assets would be doubled, providing the asset owner with some compensation for any loss of congestion income.

Figure 6. Wind farm with access rights to both bidding zones



As the wind farm enjoys equal access to either of the interconnected markets, this option raises the issue of which support mechanism should apply: Should the support system used by the jurisdiction in which the wind farm is located apply? Or should that associated with the market to which the wind farm happens to be connected at a particular moment in time apply? The first support mechanism is the simplest but could be considered discriminatory, particularly if the home market compensation scheme was more generous than operating at the other end of the interconnector. The alternative mechanism avoids any issues of discrimination at the expense of some additional complication. There would, of course, be no issue in the ideal situation of the support systems of both markets being harmonised.

Recommendations

The legal status of hybrid schemes needs to be defined in both European and national law. This would best be achieved by recognising that hybrid schemes have a dual function: the connection of wind farm capacity and market-to-market trading. Recognising this dual role would then allow current legislative requirements to be applied to each role separately. In other words, transmission charges and access rights could be applied to that capacity of a hybrid scheme allocated to wind farm connection, while transmission rights for the remaining capacity could be allocated via auctions.

Of the four market options considered here, the fourth option (Figure 6), which grants access to both interconnected markets, seems most likely to encourage offshore wind development, but it could be considered discriminatory as it would remove the need for the wind farm to purchase transmission rights in order to access higher market prices. The reduction in interconnector capacity and congestion rents would be no more than with option 1 (Figure 4a), where the wind farm is connected to its home market, while use of system income is doubled. If, however, allowing access to both interconnected markets is considered too discriminatory, the second option — allowing a hybrid-connected wind farm that opts to connect the remote bidding zone permanently in order to access higher market prices — could be adopted. The third option (Figure 5), where the wind farm is allocated its own bidding zone, is considered unlikely to encourage offshore wind farm development as only the lowest market prices would be accessed.

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