The Institution of Engineering and Technology

Offshore energy infrastructure landscaping – UK and neighbouring waters

Looking at offshore wind, interconnectors, hydrogen, carbon capture and storage (CCS) and stakeholders

In partnership with

Renewables Consulting Group

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Offshore energy infrastructure landscaping – UK and neighbouring waters is published by the Institution of Engineering and Technology.

Please note that the views expressed in this publication are not necessarily those of the IET. The guide only intends to identify the relevant issues and to inform a public policy debate around the topic, rather than to provide a definitive solution.

The IET Energy Panel would welcome any comments you may have on the contents of this guide, and your ideas for future energy publications. Please get in touch by emailing **sep@theiet.org**.

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1. About this report

The offshore energy sector will be critical to the UK's net-zero goals. This report has been produced by the IET to provide input on how we can better understand and coordinate our national interests in offshore energy. Written for developers, consultants, Professional Engineering Institutions (PEIs), non-governmental organisations, coastal communities, local authorities, government, and regulators, we discuss the need for a more joined up and holistic approach.

Following discussions with a number of stakeholders, who have approached us, it has become clear that, most have very limited visibility of the multiple facets of the challenges we face, as we seek to deliver targets for offshore wind, interconnection, carbon capture, hydrogen production, marine energy projects, as well as managing our oil and gas legacy.

This report looks at the need for a more integrated approach for the deployment of offshore networks, as a key infrastructure enabler for net zero. This is a preliminary landscaping report in the IET Lighthouse series considering the finite offshore resources, multiple users, co-ordination challenges, conflicting parallel regulations, regional imbalances, and the need to develop co-ordinated plans at pace while maintaining momentum of current activities.

Without clear co-ordination (whether market, regulatory, stakeholder, economic etc.), the opportunity to maximise the benefits of all existing and emerging technologies in the transition to net zero, will be constrained.

This report was commissioned by the IET Energy Policy Panel, an expert group that creates thought leadership and policy advice, to inform Government and other key stakeholders. The authors of this report are Elaine Greig and Maxwell Clarke.

Elaine Greig is a director at Renewable Consulting Group (RCG) and has over 25 years' experience in the electrical power and renewables industry. Elaine has led major infrastructure projects and has a solid and broad understanding of engineering, consenting, legal, commercial and stakeholder matters. Elaine is also a key volunteer on the IET Energy Policy Panel.

Maxwell Clarke is an analyst and researcher supporting market analysis and technical advisory work for RCG, across all renewable energy technologies and territories. He specialises in global offshore wind market intelligence and has experience in early-stage project development and stakeholder engagement.

2. Recommendations

Based on the main findings of this report, we have outlined several key action areas, to achieve a more integrated approach for the deployment of offshore networks as a key infrastructure enabler for net zero. These include:

1	There is a very clear shared interest in the optimum use of the offshore resource, and studies on the opportunities of optimised systems are publicly available. The how needs to be resolved.
2	Some industry parties have a whole energy agenda, others asset only. Suitable incentives must be identified to engage the full energy industry in planned coordination.
3	The Baltic experience has shown that, with good co-ordination, appropriate legislation and proper planning, co-ordinated systems are achievable. The learning from this and other case studies and experiences, needs to be considered within energy policy, regulatory and market framework reviews.
4	The offshore space is limited, and under heavy demand for use and protection – there needs to be a more joined up and holistic approach.
5	Non-energy regulation can incentivise development in a manner contrary to optimised energy systems design; this needs to be addressed.
6	There are at least 50 high-profile industry initiatives with over 500 participants in various interest groups, and a significant number of smaller, particular interest or localised parallel initiatives. Of these initiatives, there are 16 key groups actively progressing offshore network integration. There is surprisingly little overlap between these groups. Informing the wider stakeholder group, illuminating the synergies and opportunities for better integration, must be a priority.
7	It is imperative to differentiate between offshore site finding planning and optimum onshore connection points, but both must be considered in a co-ordinated energy system which recognises the twin challenges of climate and environment.

3. Introduction

The UK has set an ambitious target to install 40 GW of offshore wind by 2030. The current UK offshore wind portfolio including projects in development has a capacity of 40.2 GW. To reach the Government target, all of the potential capacity in the portfolio would need to be installed by 2030. With a typical nine-year development period from site identification to construction completion, the sites need to be identified and commenced immediately.

Beyond the 2030 target, additional capacity of renewable energy, including offshore wind, will be required to meet the further target of net zero by 2050[1].

A strategy to efficiently deploy new renewable energy and grid networks, whilst adapting existing oil and gas infrastructure soon to be made redundant, is to move towards an integrated offshore grid and coordinate landfall of cables and pipelines.

We have been approached by several parties, aware of the current constraints on common cable landing locations. These pressures on cable landings, across the UK, will increase in response to the new targets. Alternate technologies, such as CCS and hydrogen, are also expected to seek similar infrastructure access.

Interested parties may not be aware of what work has been or is being undertaken to alleviate these constraints. Parties may only be familiar with, or restricted by, their scope and remit - rather than how their activity interacts with and impacts the whole system.

We have been asked if we can facilitate an over-arching knowledge sharing exercise. The first step in this is to map the company interests, the active groups leading change, and relevant stakeholder groups. This report is that landscaping report.

This report was prepared for us, and core elements were presented publicly at a webinar on 08 Dec 2020. In this fast-moving field, since that date, key updates have been observed:

- The BEIS-led Offshore Network Transmission Review (ONTR) published its terms of reference and members list (17 Dec 2020). This is a key UK group, that whilst substantially domestic and offshore wind, does touch upon trans-national interconnectors in its longer term outlook. Footnotes have been added where numbers would change through inclusion of this as a key group.
- A number of additional important reports have been published. These are included within the key reading list.
- Industry background statistics constantly move. The relevant figures have been updated to show January 2021 background data.

[1] https://www.theccc.org.uk/publication/sixth-carbon-budget

4. UK offshore infrastructure connection points

Development in renewable energy, oil and gas industries is primarily focused on the North Sea, with abundant resources for all sectors, as well as connection options for continental Europe.

- To date offshore infrastructure development has primarily been focused around the North Sea, owing to strong resources and development potential for both the oil and gas industry and UK offshore wind sector.
- Future integrated energy development opportunities are also more focused on the North Sea area due to the potential connection opportunities to the continental European grid and offshore wind projects in development in Belgium, The Netherlands, Denmark and Norway.
- Observing the mapped landfall of cables and pipelines at points in the North West of England, North East of Scotland, Humber and Norfolk areas, suggests landfall of cables and pipelines within the vicinity of, or indeed at the same point as, other offshore assets. Offshore wind connection in the UK remains prevalent in the East Anglia region, where concerns have been raised by stakeholders over the ability of the onshore grid to accommodate future offshore development. There are currently 22 GW of projected offshore wind (OSW) in development off the coast of East Anglia, despite only 10 GW of additional grid capacity available in the region, and landfall locations are already proving contentious with requests for co-ordination from many sources.

Figures 1 and 2 illustrate that oil, gas, offshore wind, interconnector pipelines and cables do make landfall in similar places around the UK, although sites can be close but not identical.

North East Scotland cable and pipeline density

The multiple gas pipelines converging in North Eastern Scotland feed into the St Fergus Gas terminal. It should be noted that the proposed NorthConnect interconnector is planned to make landfall at a substation near Boddam, approximately eight miles from the gas terminal. One of the key concerns raised by local stakeholders of future offshore project development is the continuous establishment of new cable routes and landing points when there are existing infrastructure facilities in the same vicinity.

North East Norfolk cable and pipeline density

The convergence of gas pipelines connecting to the UK in North East Norfolk make landfall at the Bacton Gas Terminal. As with the gas and cable landing points in North East Scotland, the planned cable landing point for the Norfolk Vanguard offshore wind project is within a short distance of the existing gas terminal at Bacton, but not at the same site. The offshore wind farm cables will instead make landfall approximately four miles away at a site near Happisburgh.

Other

There are other pinch points in the Irish Sea, and elsewhere in East Anglia where more are expected to emerge as development of offshore wind and interconnector projects continues.

Figure 1: UK offshore cable landing points.

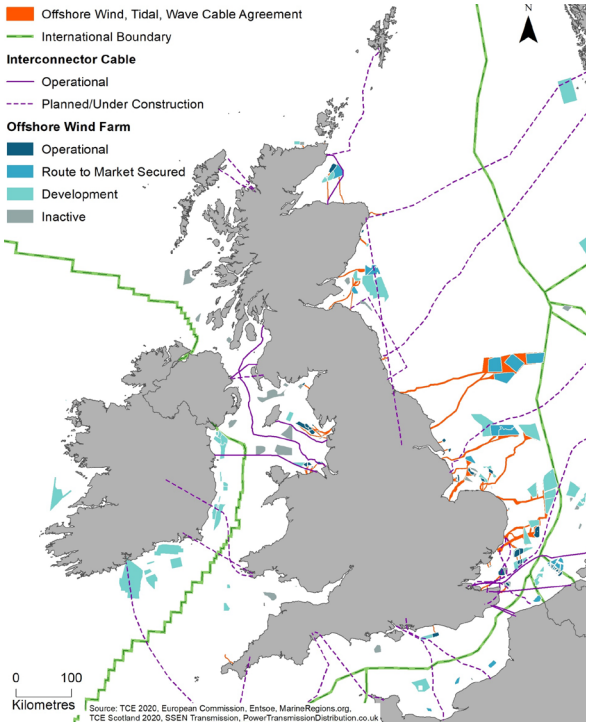
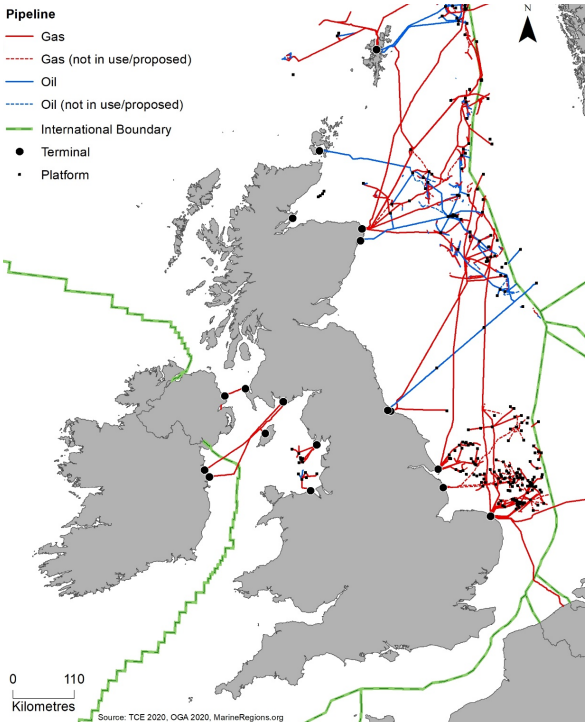


Figure 2: UK offshore oil and gas pipeline landing points.



5. North Sea offshore grid connection models

Continental European states have largely adopted a model of centrally planned transmission networks, potentially increasing opportunities for state coordination on an integrated system.

Aside from the UK, offshore grid development and connection in Europe is, for the most part, designed and operated by nationally appointed Transmission System Operators (TSOs). Offshore wind developers bid to establish projects in pre-defined sites with the TSOs assisting in early site development and the export system of the project. Additionally, TSOs for the Belgian, Dutch, German and Danish markets are actively exploring hybrid offshore wind projects in the UK, combined offshore wind projects with shared transmission systems through hub systems, interconnectors and energy islands. See Figure 3, 3a and 3b.

Figure 3

Country	Offshore grid coordinator	Pursuing UK hybrid projects
United Kingdom	Project developers	✓
France	RTE	–
Belgium	Elia	–
Germany	Tennet / 50Hertz (Elia Group) / Amprion	✓
Netherlands	Tennet	✓
Denmark	Energinet**	✓
Ireland	EirGrid*	–
Norway	Statnett***	–
Sweden	Project developers	–
Iceland	Landsnet****	–

***Ireland**
The Irish Government is currently in public consultation to establish a grid connection model for future offshore wind developments. Both developer-led models and plan-led models have been proposed, with the Government openly favouring a plan-led option. The model was due to be finalised in December 2020.

****Denmark**
Denmark has traditionally required projects grid connection to be managed by the TSO Energinet. Large-scale offshore wind project sites are also established and leased by the Government. However, developers can propose their own project sites in open-door bids. For the upcoming Thor auction, the grid connection will also be built by the successful site developer.

*****Norway**
Norway's grid connection model for the upcoming Utsira Nord and Sørlige Nordsjø II has not been detailed publicly.

******Iceland**
Yet to establish offshore grid connection model.

Figure 3a

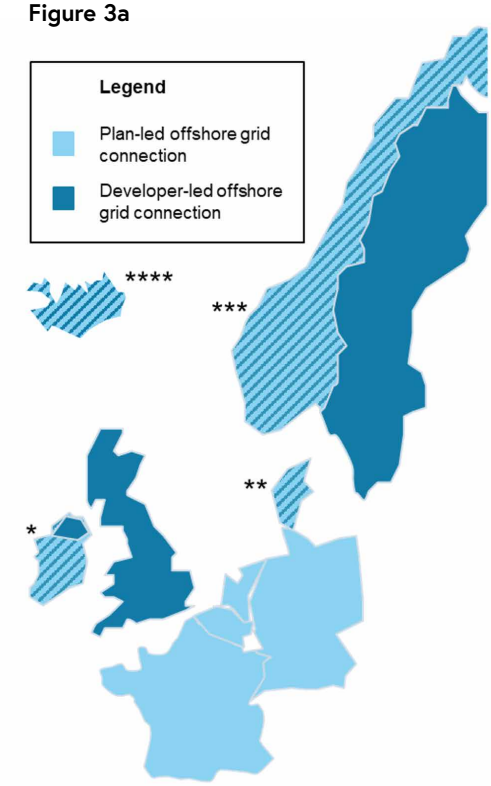
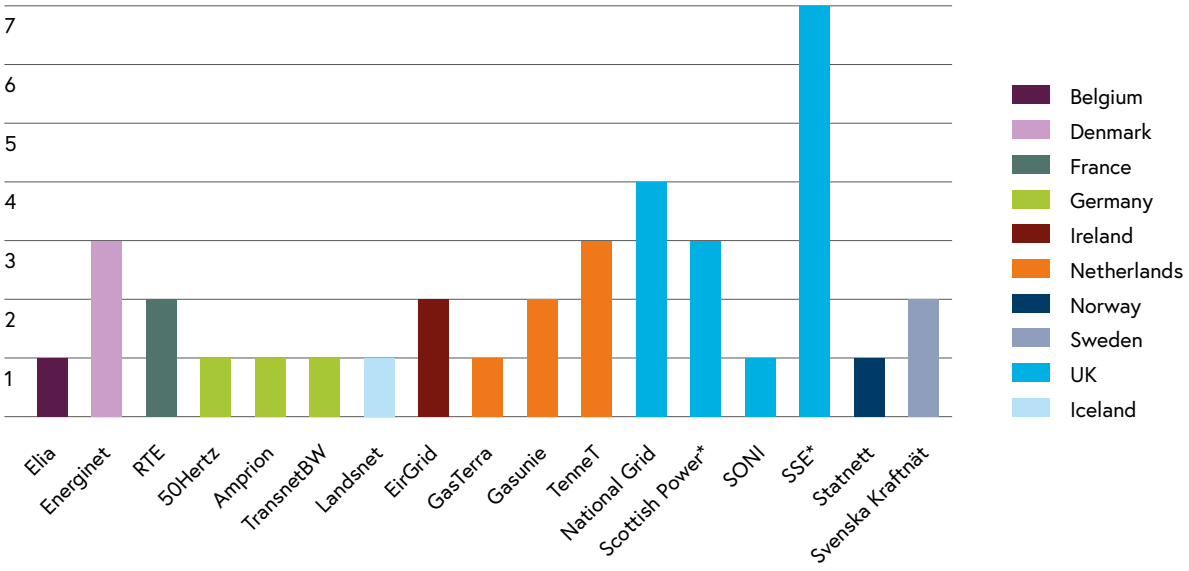


Figure 3b: Electricity and gas TSO participation in European integrated grid coordination.



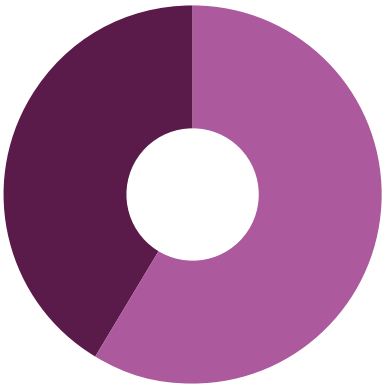
*Covers generation and transmission company interests.

6. UK offshore wind ownership trends

Leading project developers in the UK are active in markets with centrally planned grid models. Some developers, such as Iberdrola, Vattenfall and RWE are actively pursuing shared project grid connections.

An observable majority of UK project owners don't maintain a market share in North Sea countries where offshore wind project development (and thereby grid connection) is centrally coordinated. However, owners who do operate in both the UK and Europe, the Middle East and Africa (EMEA) plan-led markets control a significantly greater market share of the UK portfolio. This is a result of experienced offshore wind developers developing and maintaining capacity in the UK as the lead project owner, as well as being active in the wider EMEA market. See Figure 4.

Figure 4: Offshore wind project owner market presence (by number of owners).

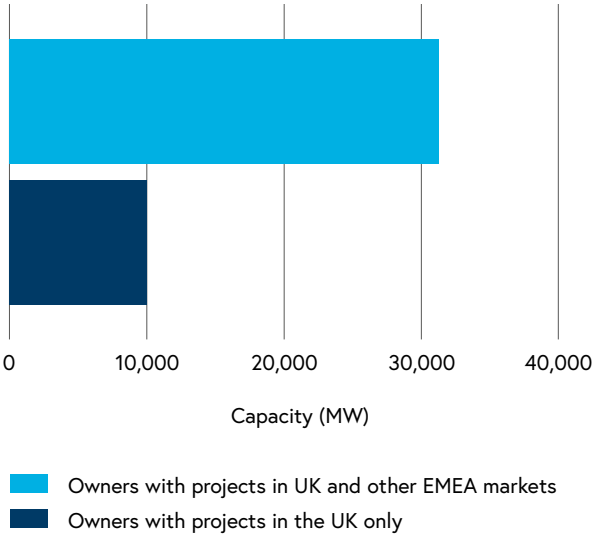


Owners with projects in the UK only 59%

Owners with projects in UK and other EMEA markets 41%

Whilst more project owners in the UK do not have experience in offshore wind markets where grid connection is centrally planned, the key players who continue to develop large scale projects are open to operating in centrally planned markets, as demonstrated by their activity in the wider EMEA region. See Figure 5.

Figure 5: UK offshore wind capacity by project owner market activity.



Though plan-led market development in UK offshore wind is not necessarily required for future offshore infrastructure integration, engagement with Transmission System Operators (TSOs) from European markets will be required for hybrid offshore wind and interconnector development. Leading UK developers have demonstrated that they have experience developing offshore wind in markets where they don't control the transmission system development, indicating coordination with European TSOs on hybrid projects would be easily feasible. See Figure 6.

Figure 6: UK project owners active in North Sea plan-led markets.

Project owners	North Sea MW Portfolio Capacity
Vattenfall	3375
Orsted	3129
RWE	1526
Iberdrola	1331
Mitsubishi Group	899
EDF	859
Enbridge	663
Sumitomo	552
Macquarie	487
SWM	382
Siemens	265
CTG	230
TRIG	225
PKA	143
Kirkbi A/S	100
Equinor	96
PGGM	28
PFA Pension	6
Total	6

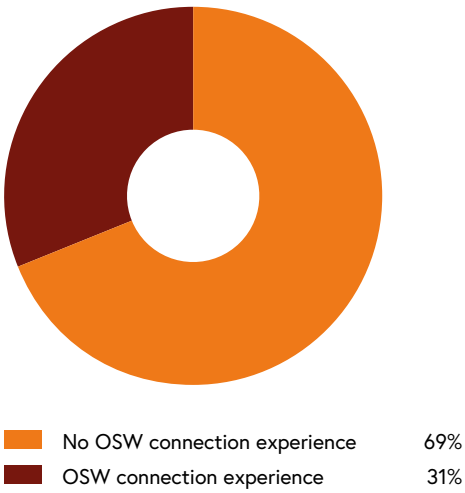
7. UK subsea transmission developers - cross sector activity and grid integration coordination

Despite the translation of technology, interconnector developers are largely absent from the offshore wind market, primarily due to deregulation.

Whilst major offshore wind developers active in the UK do have experience operating in centrally planned offshore wind markets, the overlap of interconnector owners and offshore wind project developers is significantly smaller. Only 31% of subsea transmission (excluding generator connection) developers in the UK have sister company experience in connecting offshore wind projects to the grid. To enable future development, more cooperation between interconnector developers and offshore wind players may be required to actively encourage the establishment of integrated offshore wind projects in the UK. See Figure 7.

Due to European deregulation and the separation of companies with generation and transmission assets, Scottish and Southern Energy (SSE), Scottish Power and Vattenfall's interconnector and offshore wind development activity streams are controlled by two separate entities.

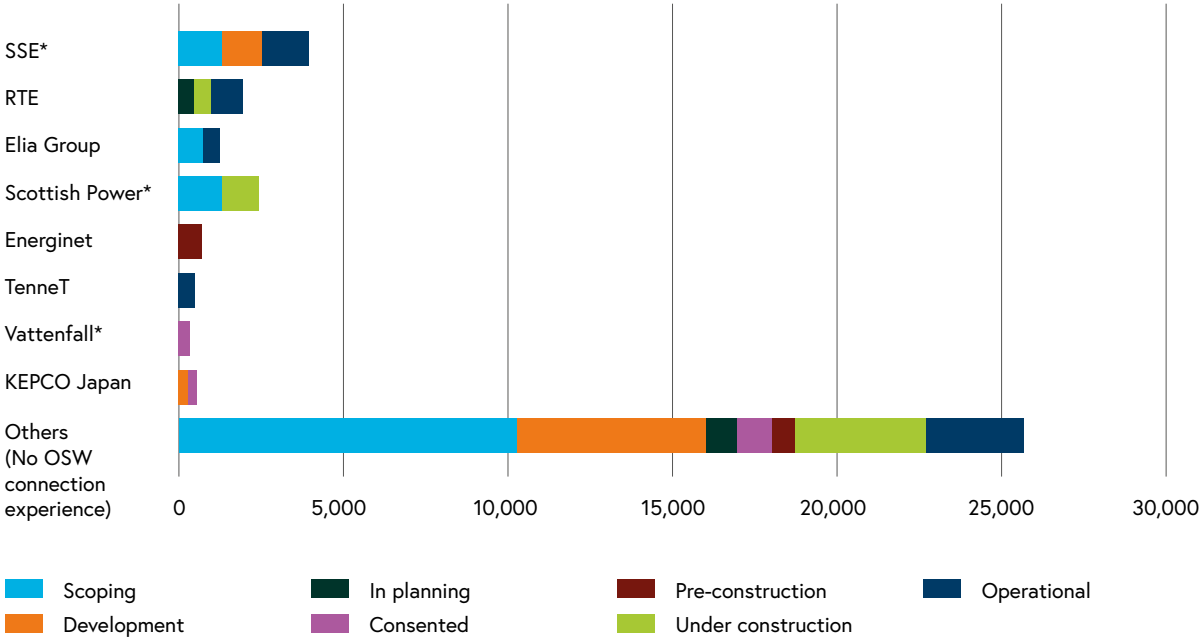
Figure 7: Active UK subsea transmission (grid-to-grid) project owners by offshore wind transmission connection experience (MW).



It is however important to note that companies controlled by their parent organisation are active in the offshore wind market and would be directly affected by future energy integration. These parent organisations hold broader energy agendas that will likely support their respective subsidiaries in the prospect of developing an integrated offshore network. See Figure 8.

UK interconnector developers have not been heavily involved in coordinated offshore network integration projects. As well as a notable lack of cross-sector market presence from UK subsea transmission developers, there is also a lack of participation in coordination efforts on integrated grid development. Furthermore, UK subsea transmission developers that are actively pursuing integrated offshore grid development are for the most part, the same companies and groups that are active in the offshore wind and transmission network markets. A clear trend has emerged that interconnector developers lacking offshore wind connection experience have not been involved in the coordinated development of an offshore grid that would support future integration. This is undoubtedly a natural consequence of de-regulation. See Figure 9.

Figure 8: UK subsea transmission (grid-to-grid) project owners by capacity.*



* Subsea transmission excludes generator connections (OFTO, pre-OFTO or equivalent). Capacity is shown by volume that also has experience in generator transmission connections, or no OSW connection experience. Capacity owned by SSE, Scottish Power and Vattenfall is controlled by grid connection subsidiaries, separate from the respective offshore wind development business arms.

Figure 9: UK subsea transmission project owners coordinated grid efforts.

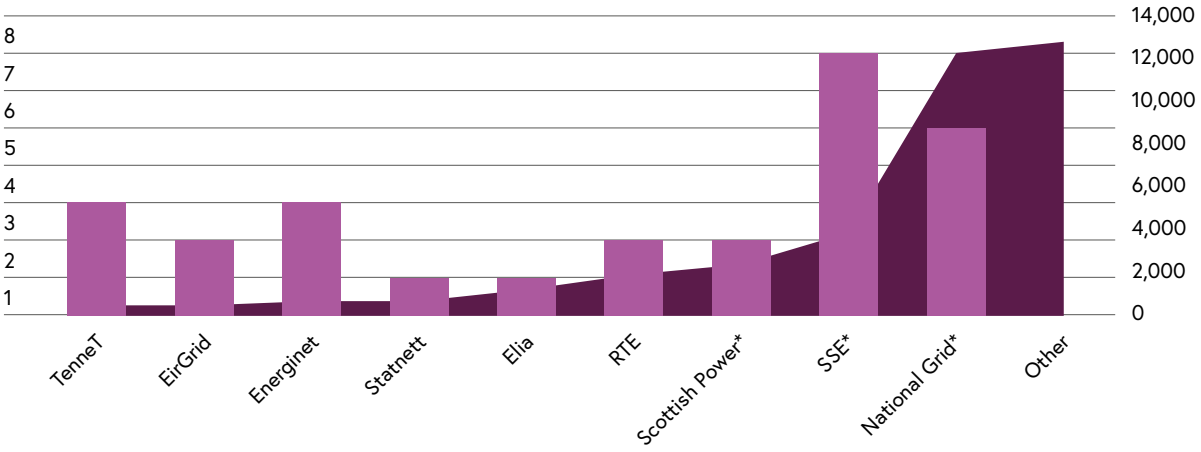


Figure 10: Grid owners - group participation and capacity.

Owner	Number of key groups participated in	Capacity (MW)
National Grid*	5	12483.3
SSE*	7	3961.3
Scottish Power*	2	2445.3
AQUIND		2000
RTE	2	1966.6
Aminth Energy		1400
Cronos Energy		1400
iCON Infrastructure		1400
Elia	1	1250
Getlink Group		1000
OPIC Energy		750
Energinet	3	700
Statnett	1	700
EirGrid	2	500
Element Power		500
Mutual Energy		500
TenneT	3	500
Alderney RE		466.6
Transmission Investment		466.6
Agder Energi		350
E-CO Energi		350
Lyse AS		350
Vattenfall*#		350
Landsvirkjun		333.3
Allianz Capital Partners		280
Frontier Power		280
Greenage Power		280
KEPCO Japan		280
Meridiam		280

High — Low No = Number of key groups participated in

* Capacity owned by National Grid, SSE, Scottish Power and Vattenfall is controlled by grid connection subsidiaries, separate from the respective offshore wind development business arms. Capacity owned by National Grid Ventures and National Grid Electricity Transmission have been recorded as 'National Grid'.

Swedish developer Vattenfall is active in both offshore wind and interconnector development in the UK and around Europe but was not a participant in the coordinated working groups and initiatives observed. Vattenfall is however active in lateral integration of offshore wind and interconnectors, developing UK offshore wind projects with hub-based transmission networks, as well as developing the Kriegers Flak offshore wind and interconnection hybrid project in between Denmark and Germany.

8. UK oil and gas operators cross-sector activity

Some leading oil and gas players have transitioned into the renewables sector, many remain committed to legacy assets.

Comprehensive offshore integration will include the mobilisation of existing oil and gas pipelines and potentially offshore platforms to diversify the offshore energy mix. Platform electrification is already seen as a potential solution to reduce offshore emissions, with Norwegian developer Equinor reaching Financial Investment Decision (FID) on the Hywind Tampen floating wind project in 2020 following government approval. The project will utilise eight floating turbines directly transmitting power to platforms in the Snore and Gullfaks oil fields in the Norwegian North Sea. Plans have also been proposed to establish hydrogen electrification and production facilities on offshore platforms as well as carbon capture and storage (CCS) facilities.

Key oil and gas development players have begun to transition into the renewables sector and are therefore well positioned to integrate oil and gas assets with renewable energy technology. Indeed, Shell, the largest oil and gas operator in the North Sea by area of operation, is currently pursuing offshore wind projects in the Netherlands that will support hydrogen electrolysis. Other offshore wind players such as Total, Equinor, Sumitomo and Scottish Power are active in the North Sea oil and gas market and therefore likely to favour a transition to an integrated network, although it should be noted the renewables, oil and gas businesses of these respective companies are substantially separate. See Figures 11 and 12.

Most of the oil and gas operation remains controlled by firms with no public interest in offshore wind, and many are simply asset operators, and therefore unlikely to transition to the renewable energy sector in the near future. Such firms may be open to the transformation of legacy oil and gas assets but will need to be engaged in meaningful coordination efforts to fully realise integration opportunities. See Figure 13.

Figures 11 and 12: North Sea oil and gas (O&G) operators by area covered and OSW activity.

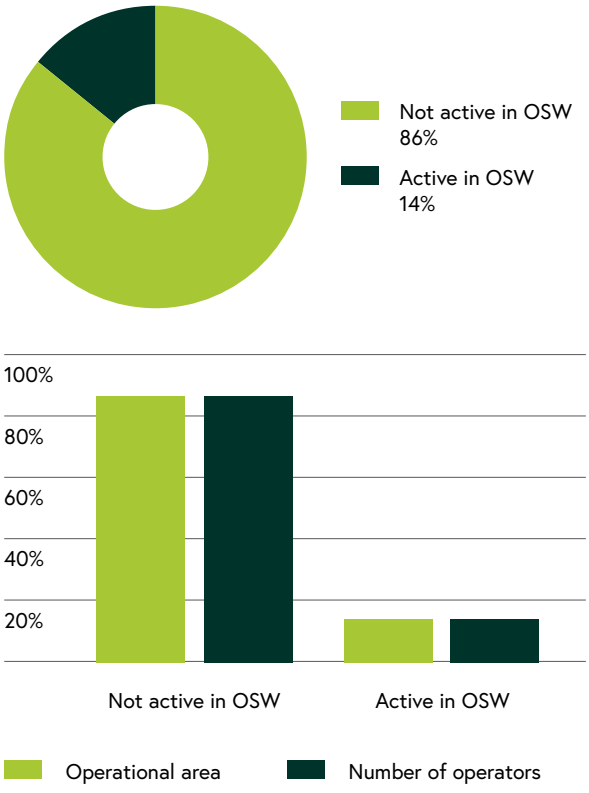


Figure 13: O&G market participants OSW and O&G activity comparison.

Developer/ Owner	EMEA offshore wind pipeline capacity (MW)	North Sea oil and gas operational area (km²)
No OSW Experience		64,929,212,728
Shell	396	3,695,371,613
Equinor	4039	1,699,607,705
Total	904	1,670,776,983
BP	Active in other OSW markets	1,442,573,120
CNOOC	Active in other OSW markets	674,300,370
Eni	494	558,745,218
KNOC	Active in other OSW markets	277,382,999
Sumitomo	160	181,382,326

9. Barriers to integrated offshore networks

Core Electricity Regulatory Regimes (UK implementation of de-regulation using competition leads to segmentation)
De-regulation means different parties must work together, as no party can own transmission and generation. The Baltic region has shown that this does not need to be a barrier, however the UK's current method of market-based implementation, whilst open to co-ordination, dis-incentivises it. Parallel vertically integrated companies would have faced a similar coordination problem from a different perspective.

Parallel Regulatory Regimes – require incremental development – conflict to holistic design and implementation
There are a number of regulatory regimes in place, which need to be aligned to achieve a coherently designed offshore energy network. Currently many regimes consider within the parameters they are given, which are contradictory to what may be their optimum ultimate aim as a collective. The separation due to electricity de-regulation also limits cohesive action.

Contracts for Difference (CfD) – UK

The contracts for difference scheme, whilst benefitting offshore wind project development to date, poses a barrier to future integrated development by way of imposing a cap on the amount of capacity allocated in a tender round. The current structure of the CfD means offshore projects within similar geographies struggle to be developed on a coordinated timeline, as the capacity cap prohibits one project developer from securing a route to market for a series of large capacity projects that support a shared connection. As only one project in a potential development cluster can be developed in line with the timeline imposed by the CfD round, coordinated development of projects with a shared transmission network is discouraged. This is because the risk associated with projects yet to receive a route to market through CfD is extremely high in comparison to the one potential phase that may obtain offtake capacity.

Habitats Regulations (HRA) - EU

The current plan-level habitats regulations for offshore wind development in the UK dictates that project development is spread across separate areas of seabed, in order to preserve the habitat in areas of potentially dense offshore wind development. Similarly to the CfD scheme, this approach limits coordinated project development for shared transmission systems, as only a limited amount of capacity in a development area can progress according to the timeline set by the HRA. This impacts upon leasing arrangements (R4, Scotwind) and site selection. In order for the UK to reach net zero by 2050 it is assumed that up to 50 GW in offshore wind capacity will need to be installed in UK waters. Ultimately the technical potential for fixed bottom offshore wind development – more suitable for integrated grid connection than floating development – limits the areas of seabed that are able to support projects. In order to facilitate the necessary capacity growth, especially through an integrated development system, offshore wind projects will need to be constructed within areas that can allow for shared grid connection, inevitably not conforming to HRA restrictions.

Disparate interest groups – conflict vs co-ordination
There are many interest groups, with many perspectives, however as this report has shown, the overlaps between these groups are severely limited.

Appropriately focussed marine spatial planning
Integration of the European offshore grid, through the continued development of interconnectors in a radial pattern or an integrated approach will require coordinated planning with prospective interconnected countries. In European offshore grid development, as well as prior oil and gas infrastructure development, marine spatial planning has emerged as both a constraint to development and an area in which a coordinated approach is required for future development and co-existence of sea uses and countries with North Sea and Irish Sea coastline.

10. Key groups for supporting future offshore network integration

There are 16 particularly relevant projects, working groups and initiatives which have been identified, that are actively pursuing offshore integration in UK waters. Groups were considered based on several participants (with at least three required), end goal of the project, and recent activity. See Figure 14.

The two top tier groups, North Sea Wind Power Hub (NSWPH) and Northern Endurance Partnership, are the strongest examples of key players in their respective sectors collaborating on project assets that would be part of an integrated grid in UK waters. NSWPH, despite not currently having a UK based member, has expressed keen interest in working with UK stakeholders.

Second and third tier groups are examples of collaboration that have either directly informed integration projects and policy development or are promoting collaboration between industry players in direct reference to integration and integrated marine spatial planning. Other groups in addition to the core 16 are shown in Figure 15.

There is a notable bias towards the North Sea, with much of the Irish Sea activity 10 years old and thus not currently represented.

Figure 14: Key collaborative organisations for UK offshore integration.

Tier one – UK waters grid integration and future technologies project co-ordination						
North Seas Wind Power Hub (4)				Northern Endurance Partnership (21) - Net Zero Teesside and ZeroCarbon Humber		
OSW / ITC				CCS / H2		
Tier two – Integration policy development groups and transnational integration co-ordination (suggested touchpoints)						
Offshore Co-or-dination Project (3) - NationalGrid, Ofgen and BEIS	UKCS Energy Integration Project (69)	Offshore Wind Indus-try Council (OWIC) (19)	PROMOTioN (14)	SEA North Seas Energy (6)	North Sea Energy Partners (24)	NECCUS (40)
OSW	OSW / O&G / ITC	OSW	OSW / ITC	OSW / MSP	OSW / ITC / CCS / H2	OSW / O&G / CCS
Tier three – Technology-specific coordination and policy development						
ENTSO-E	National and European Wind Energy Associations	NetZero Teeside	Zero Carbon Humber	NorthSEE Project	SimCelt	EMODnet*
ITC	OSW	CCS	CCS	MSP	MSP	MSP

Offshore Wind (OSW) · Interconnector (ITC) · Hydrogen (H2)
Oil and Gas (O&G) · Carbon Capture and Storage (CCS) · Marine Spatial Planning (MSP)

Values in brackets are the number of participants in each grouping.

*Excluded from participation data due to number of partners.

The above table was presented at the IET 08 Dec 2020 webinar, the subsequent ONTR group is therefore not included, and may be considered a separate Tier 2 group, albeit an evolution of some of those groups already listed.

Other relevant networks and groups

There are several organisations and projects outside of the 16 highlighted as key groups active in the UK and European energy sectors that have an interest in offshore integration. A group may not be mapped because of the nature of its main goals, public profile, or apparent status.

- Industry-NGO crossover – some groups have been specifically set up to build shared understanding.
- Relevant parallel lobbying organisations – certain groups ought to be involved, because the lobbying for their own industry will effect energy systems planning, but they may not be yet. The Offshore Renewables Joint Industry Programme (ORJIP) demonstrates precedent for good shared work by the offshore wind industry, however as this is environmentally focussed, it may result in the opposite preferences to energy systems planning. The Dutch shipping association may be the front runner in shipping interest bodies engaging directly with offshore wind.
- Regional networks – often with many members, a regional focus, and connections to national policy.

The list of companies and groups recognised here is not exhaustive of those with a potential interest in offshore networks, however, it serves to demonstrate the significant number and spread. The key companies involved in the Tier two groups are represented in scattered fashion across these groups, but due to number and data availability, these have not been fully mapped.

Figure 15: Other relevant networks / groups.

Industry-NGO crossover groups
ENSTO-E NDSG
The Renewables Grid Initiative
Relevant parallel lobbying organisation examples
BMAPA
Ocean Energy Europe
Oil and Gas UK
ORJIP
UK Chamber of Shipping
KNOC
Regional networks
Inn2POWER (collection of groups)
Aberdeen Renewable Energy Group
Celtic Sea Alliance
Celtic Sea Floating Wind Cluster
DeepWind
East of England Energy Zone
EnergySouth2East
Greater South East Energy Hub
LEPs
Norfolk and Suffolk All Energy Industry Council
North East Energy For Growth Strategy
North West Coastal Forum
Scotland LCI Transition Programme
Scottish Offshore Wind Energy Council
Team Humber Marine Alliance
The Energi Coast Cluster

10.1 Key group selection criteria and similarities

Key groups were identified based on public exposure and relevance to offshore networks and corresponding technologies.

Tier one – Projects

The North Sea Wind Power Hub (NSWPH) and Northern Endurance Partnership have been identified as prominent coordinated initiatives to develop projects that would be part of an integrated offshore network in future.

The NSWPH is at an advanced concept stage, led by the Dutch, German and Danish TSOs (TenneT and Energinet). The NSWPH has expressed interest in attracting coordination from UK companies and stakeholders. The partners are well placed to make progress.

The Northern Endurance Partnership is a UK based project that would mobilise oil and gas technology and infrastructure as part of an integrated carbon capture and storage system. Founder partners are BP, Eni, Equinor, Shell and Total, and National Grid. The group are responding to the Government's Industrial Decarbonisation Challenge. The participants are actively transitioning to offshore wind and therefore likely to support the integration of oil and gas technologies with renewable technologies and low carbon projects.

Tier two – Policy development

Tier two projects and initiatives are examples of coordination directly targeting offshore network policy coordination and company interaction, targeted at identifying opportunities, barriers, and directing possible resolution options. They are typically small, select, groups.

Two of the projects listed, the Offshore Coordination Project and UKCS Energy Integration Project, have concluded but were active within the last six months and feature leading developers and government bodies cooperating to understand and develop policies to support integration. Other groups included in Tier two are prominent fora between high profile developers coordinating on technologies that are driving offshore network integration, such as offshore wind expansion and integration with carbon capture and storage (CCS), hydrogen and interconnector developments.

The Offshore Wind Industry Council (OWIC), for example, runs two working groups of specific interest to this scope. Such sub-groups are not separately identified and listed.

Most of the companies involved in Tier one projects have representation on one or more Tier two groups. The groups are linked to many more government departments, energy developers, supply chain players and working groups, though not necessarily each other, and commonality of membership is low.

Due to the reach granted by Tier two, this is a key touch-point level.

Tier three - Lobbying

Tier three groups are membership groups with specific interest areas, which may be technology, function, region, and have vested interests in overarching coordination efforts, and have the remit to participate in, but not lead, on wider integration efforts. Tier three groups may lobby with differing priorities for the benefit of their members, whilst recognising the bigger picture considerations.

Companies represented at Tier one and Tier two are also represented at Tier three, but likely within selected sectors rather than across the field. Tier three groups also include further organisations that don't have other representation. There are weak connections between groups, even if the same company is represented on different groups, it is likely to be different, disconnected personnel.

- The European Network of Transmission System Operators for Electricity (ENTSO-E) group represents transmission system operators from across Europe and helps shape European policy on transmission integration.
- Marine spatial planning groups such as SIMCelt in Ireland and the NorthSEE project bring together groups instrumental in supporting future marine spatial planning coordination.
- Wind energy associations in European markets are key lobbying parties representing growth.

10.2 Pending groups and initiatives

A multitude of key organisations and groups acting outside of multi-lateral industry led projects are also key to integrated offshore network development.

East Anglia MPs

Offshore grid integration has been highlighted as a solution to potential development issues facing the East Anglia. There is currently 22 GW of projected offshore wind development off the coast of Norfolk and Suffolk, with only 10 GW available additional grid capacity in the region. Shared offshore grid connection and transmission landfall coordination is therefore crucial to smooth project development.

In response to the potential of projects to overwhelm the grid, and voicing concerns of local stakeholders opposed to more disruptive major onshore construction works, five MPs representing East Anglia constituencies submitted a letter to the UK government arguing against continued offshore wind development in the current radial framework. The MPs for North Norfolk, Mid Norfolk, South Suffolk, Broadland, and Suffolk Coastal instead proposed a ring main transmission system that would combine transmission systems for future offshore wind farms. The concept was rejected by offshore wind developers who have continued to plan for projects to be built with their own offtake mechanisms.

Coordination with the MPs in an area pertinent to offshore network development will be vital in both recognising the constraints of offshore connection point planning and influencing government policies on integration.

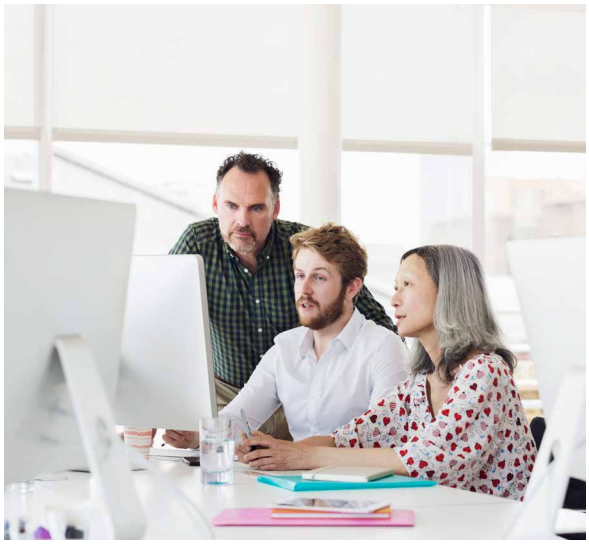
Individual companies and bilateral arrangements

Bilateral partnerships have not been included within the projects or working groups, because the list would then be much longer, and these don't represent industry wide collaboration. Companies undertaking partnership projects tend to be represented in the groups identified.

One example, of particular interest to UK participants and thus not listed, is the National Grid and TenneT plans to develop combined grid solution offshore wind farms connecting the UK and the Netherlands, announced in September 2020. National Grid is also currently developing the Nautilus interconnector alongside Belgian TSO Elia. The multi-purpose interconnector (MPI) will similarly connect offshore wind farms in the English Channel and Southern North Sea to the Belgian and UK grid networks.

Individual companies and research institutes in the UK and wider European markets set up specifically to address this subject have also not been listed as co-ordination groups. Such companies include SuperNode, and other members of the CurrENT group, and the Supergrid Institute.

Some research funds targeting wider offshore wind development or energy systems development may receive submissions crossing the wider energy objectives; however, all possible sources of initiative funding have not been surveyed.



EU policy development groups and other relevant companies

The European Union has established Trans-European Networks (TENs) to assist in policy development across various sectors. The Trans-European Network for Energy (TEN-E) has identified priority corridors for energy development in Europe and set up working groups at a ministerial level to address key issues, including the North Seas Offshore Grid (NSOG), North-south electricity interconnections in western Europe (NSI West Electricity) and North-south gas interconnections in Western Europe (NSI West Gas), all of which shape policy relating to integrated networks in UK waters.

The TEN-E is considered separately to industry coordination efforts on network integration, since companies active in the offshore infrastructure sector are not participants in TEN-E projects. Engagement with working groups such as NSOG, NSI West Electricity and NSI West Gas will however be important in shaping policies that support offshore network integration. As coordination on policy will be vital to integrated project development, continued dialogue between the UK government with TEN-E and other relevant EU groups should be maintained after the UK leaves the European Union in January 2021.

In November 2020, the European Commission released a strategy for utilising offshore renewables to reach future net-zero targets. As part of 'a new approach to offshore renewable energy and grid infrastructure' the Commission and EU member states will develop a framework to enable TSOs to make anticipatory investments in offshore grids to prepare for future upscaling and development. There will also be a framework under the TEN-E regulation for long-term offshore grid planning from the TSOs.

10.3 Transnational integration project participation

The UK is understandably home to the most companies identified as being involved in grid coordination efforts for its own surrounding sea areas. Outside of the UK, the Netherlands stands out as the country with by far the largest concentration of companies looking at North Sea integrated grid connections.

Whilst the potential Dutch influence on the sector is unsurprising (owing to active development of interconnectors with the UK), planned integration efforts by offshore grid operators and geographic potential for integration, there is a comparative lack of coordination with Danish companies and government groups.

Of the EMEA offshore infrastructure markets, Denmark has most rapidly advanced combined grid solutions and integration, with the ongoing development of the Kriegers Flak hybrid offshore wind and interconnection project, as well as official planning for energy islands to support up to 3 GW of new offshore capacity by 2030. See Figure 16 for the distribution of companies and organisations participating in initiatives and working groups to assess grid connection and integration to the UK.

Across Europe, participation from national governments, local governments, Local Enterprise Partnerships (LEPs), and TSOs is understandably limited due to the smaller number of TSOs and national government entities that would be considered key stakeholders in comparison to local groups. Developers dominated several participants as a result of the focus on developer led initiatives.

An assessment of wider networks such as the Industry-NGO crossover groups, parallel lobbying organisation examples and regional networks significantly decreases the percentage of developers involved as a share of overall initiative participants. Widening the net increases the number of supply chain and research participants, as the groups include more business networks and research groups. The Other categorisation includes local communities and local stakeholder groups, as well as corporate institutions such as legal and risk management firms.

Figure 16: Project participation by organisation sector.

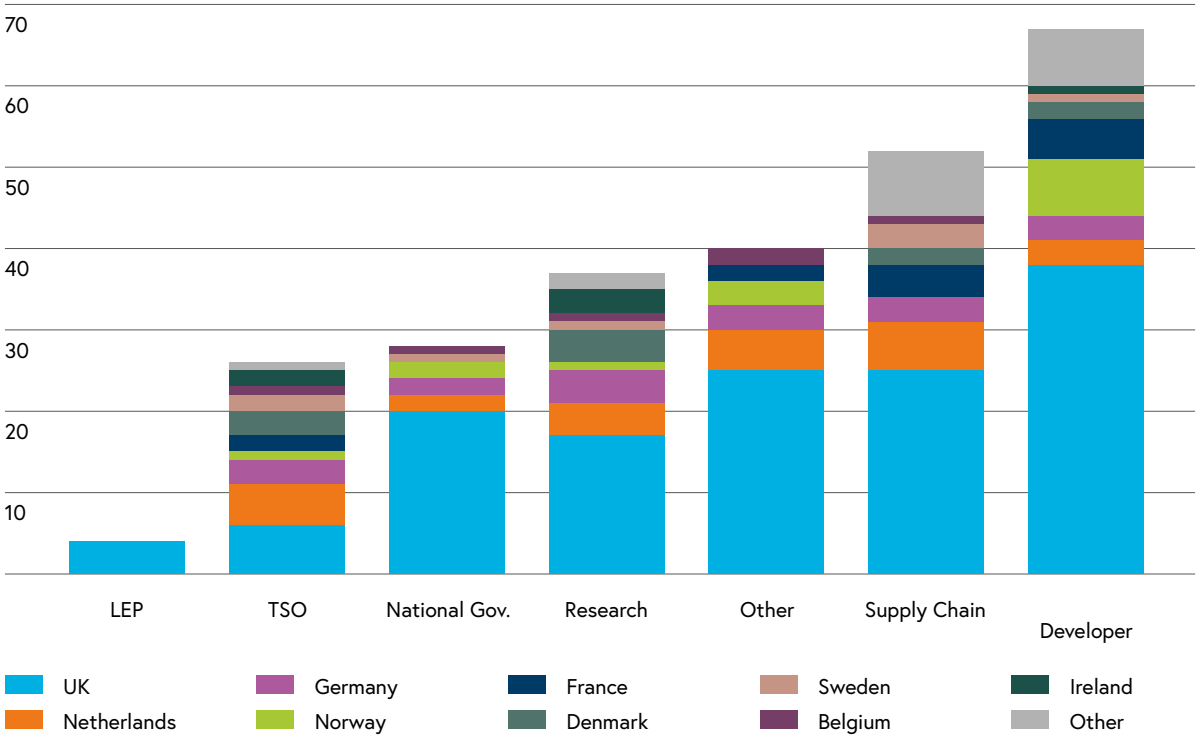
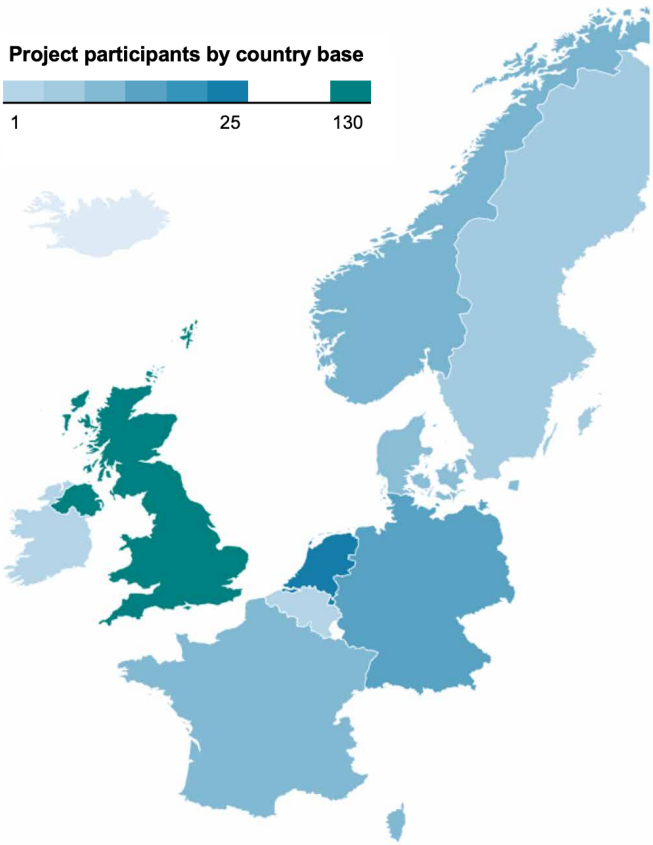


Figure 17: Project participants by country base.



11. North Sea and Irish Sea grid integration activity

This study has recorded and assessed the impact of companies and working groups actively pursuing grid integration in the UK and surrounding seas, to identify companies and groups at the centre of integration activity. See Figure 18.

A detailed appraisal of the participants in each of the key groups identified demonstrates that whilst leading offshore wind, and oil and gas developers do participate in the broadest selection of initiatives and programmes, connections between the groups is still low. Excluding partners of EMODnet, who are predominantly research groups and universities, of the 194 different organisations involved in key groups on integration, only 20 participated in at least three separate initiatives.

Not only was there a lack of companies involved in a cross section of key groups, those who were participants or partners in different initiatives largely limited themselves to projects focused on their own technology streams. BP and Eni, despite recently entering the offshore wind industry, were only involved in the Humber region projects promoting carbon capture technology and didn't participate in any offshore wind or integration specific groups.

Of the leading project developers, SSE, Equinor, Shell and Total participated in the largest number of different initiatives and projects. The companies participating in multiple groups is unsurprising, as each maintain interests in multiple technologies that contribute to offshore network integration, including offshore wind, oil and gas, transmission networks and carbon capture and storage. Equinor are notably key players in the adaptation of oil and gas assets for integrated networks in Europe and are currently developing the world's first offshore wind farm to directly power offshore platforms.

The presence of TSOs Energinet, TenneT and the National Grid amongst the most active companies in integration projects reflects the important role TSOs have in integrated network development. Energinet, TenneT and the National Grid are all currently exploring combined grid solution offshore wind projects.

Company participation was observed to be focused around the North Sea, likely due to the available resources for all technologies and opportunities for connection with the European grid. Whilst there are opportunities for integration in the Irish and Celtic Seas, and these have been studied in the past, the reduced energy resource and connection opportunities mean fewer working groups and initiatives are active in the area.

Figure 18: Organisations participating in at least three key groups.

#	Company / Group	Sector / Role	Number of 'key groups' attached to
1	SSE	Offshore Wind Developer; TSO	7
2	National Grid	TSO	5
3	Equinor	Oil and Gas; Offshore Wind Developer	5
4	Shell	Oil and Gas; Offshore Wind Developer	5
5	Total	Oil and Gas; Offshore Wind Developer	5
6	BEIS	National Government	4
7	Scottish Government	National Government	4
8	BP	Oil and Gas; Offshore Wind Developer*	3
9	Centrica Storage	Oil and Gas	3
10	Eni	Oil and Gas; Offshore Wind Developer*	3
11	Energinet	TSO	3
12	SHOM	National Government	3
13	TenneT	TSO	3
14	University of Sheffield	Academic	3
15	RWE	Offshore Wind Developer	3
16	Oil and Gas Technology Centre	Research	3
17	Scottish Power	Offshore Wind Developer; TSO	3
18	University of Aberdeen	Academic	3
19	University of Strathclyde	Academic	3
20	Crown Estate Scotland	National Government	3

*Both Eni and BP are yet to establish or acquire offshore wind projects in the North Sea or Irish Sea. The two companies are however active in the sector, with project ownership in other regions and joint ventures set up to develop offshore wind projects in the near future.

The above table is based upon Figure 14, and thus does not include the subsequent ONTR membership. Inclusion of ONTR would push some listed parties further up the list, with SSE now reaching eight, and increase the list to 22, adding The Crown Estate (TCE) and Ofgem as each participating in three identified key groups.

12. Marine spatial planning

Due to the congested use of both the North and Irish Seas, comprehensive and coordinated marine spatial planning will be required to facilitate integrated offshore network development.

Coordinated marine spatial planning is central to integrated grid development in the North Sea, Irish Sea and Celtic Sea. Offshore infrastructure deployment in all technologies is subject to stringent marine spatial planning laws at a local level. Project site locations and cable/pipeline routes have a determinable impact on other sea users. To date, offshore wind project development in the UK has not been required to engage with marine spatial plan stakeholders from other countries, as projects are within UK waters with no infrastructure stretching into other jurisdictions. Interconnector projects have thus far been simple point-to-point developments only necessitating bi-lateral coordination. A fully integrated offshore grid of the future will require coordination on sea usage from all North Sea countries, where interests from a variety of sectors, including but not limited to: freight and passenger transport, national defence concerns, offshore infrastructure development and miscellaneous sea use such as fishing.

Whilst European countries with coastline are obligated to follow the European Union Maritime Spatial Planning Directive, stakeholders in each state will have different priorities influencing final marine spatial planning within their jurisdiction. Marine spatial plans are legally binding documents for sea users and must be adhered to in offshore infrastructure planning and permitting. Uncoordinated marine spatial planning is therefore highly likely to hinder integrated offshore network planning, as different development plans may be required for different aspects of a single project in order to accommodate the permitting guidelines of any jurisdiction a prospective project may enter.

Active participation in working groups to investigate integrated grid connection in UK waters, the North Sea and Irish Sea is heavily biased towards academic and research institutions, developers of offshore infrastructure, and supply chain players.

Statutory and non-statutory groups (and their equivalent bodies in other countries) involved in the planning of cable landings for offshore projects in the UK make up just 21.3% of all participants in grid integration projects, although the percentage when limited to UK organisations is slightly higher at 21.5%.

Four countries with interconnection projects to the UK – France, the Netherlands, Germany, Denmark and Norway – don't have statutory stakeholders directly participating in relevant working groups. See Figure 19.

Of the working groups surveyed, the clear trend emerged that for the most part, participant involvement in assessment of or planning for offshore integration was limited to one group.

However, of the groups that participated in at least two different coordination efforts, the percentage of recognised key non-statutory stakeholders and statutory stakeholders for cable landing development increased. Environmental non-governmental organisations (NGOs) and other interested parties are more likely to engage with Maritime Spatial Planning (MSP) groups and initiatives than technical groups.

Of the UK's 27 coastal counties with current or planned offshore cable or pipeline connection points, only two, Kent and Suffolk, have looked at integrated grid connection solutions at a council level. In Scotland, the Government run Highlands and Islands Enterprise Agency has also been involved in offshore infrastructure and MSP coordination. See Figure 20.

Figure 19: Engagement of key stakeholders in working groups.

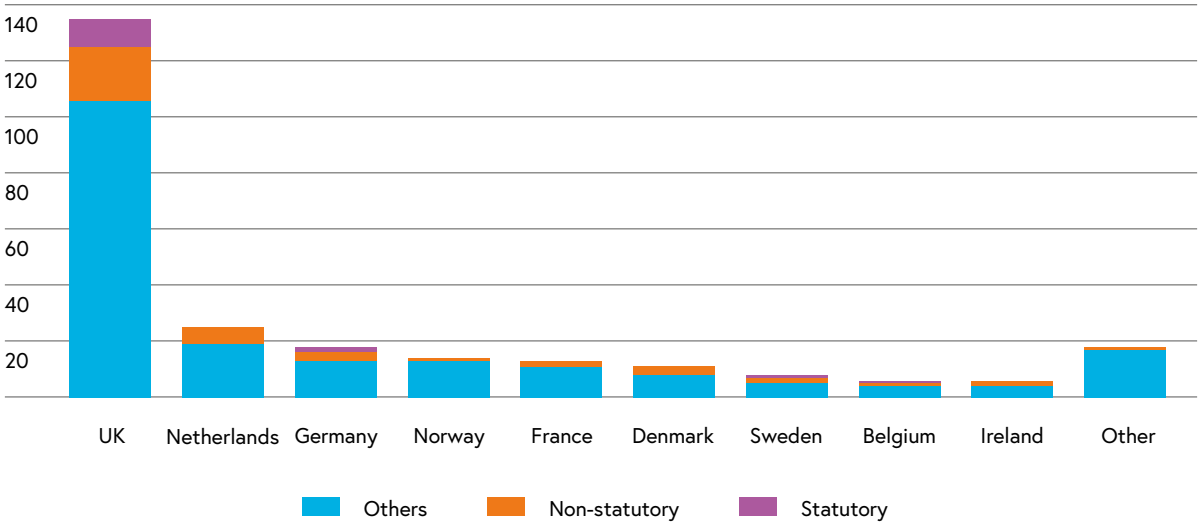
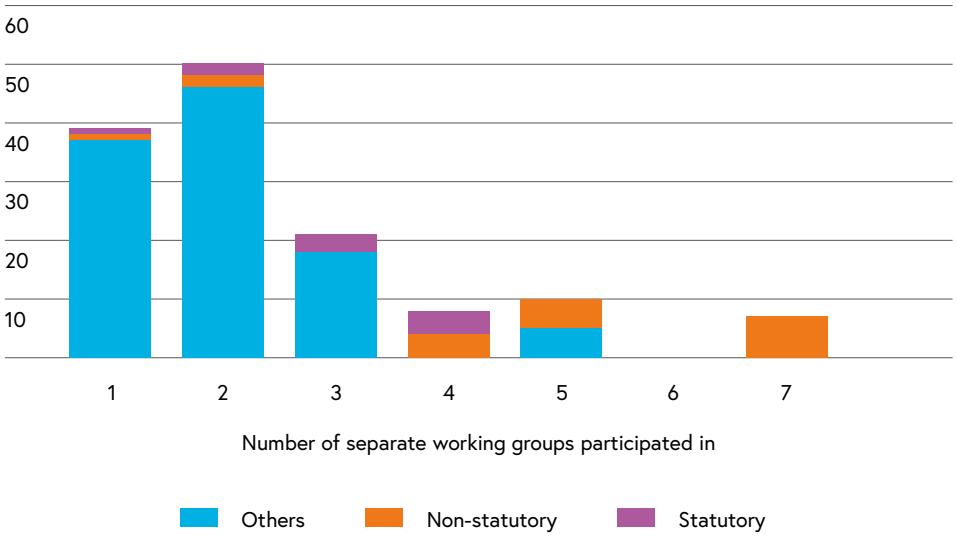


Figure 20: Working group participation by stakeholder status (UK organisations only).



13. Local enterprise partnerships

Local enterprise partnerships (LEPs) play a key role in organising local councils and stakeholders. Coordination with LEPs on future offshore network landing points will assist in formulating a comprehensive understanding of requirements for grid integration.

LEPs play a key role in offshore infrastructure and connection to coastal communities. Not only are they a prominent touch point for local supply chain players to access the industry and gain exposure, they also provide a platform for local lobbying groups to obtain support on issues pertaining to grid development and offshore connections.

LEPs from across the UK are progressing carbon neutral agendas and subsequently are in a strong position to leverage their respective members to support offshore integration. Moreover, in the South East of England, where integration is seen as a promising solution to alleviate stress on the regional electrical grid, LEPs have clustered together to form the EnergySouth2East group.

This group is an example of coordination at a local level with the expressed interest of promoting a low carbon grid. The group presents recommendations and conclusions to the UK Government, based on member feedback, covering organisations linked with LEPs in areas of prominent offshore wind, oil and gas landfall and connection.

Another key function of LEPs is to assist government in coordinating funds to support local development. To advance grid integration in the future, local enterprises will need to be positioned to work with new offshore infrastructure projects operating from and connecting to their coastal communities.

LEPs therefore can assist local supply chain players and councils in engaging with key firms in the offshore industry to support future integration development in a manner that best accommodates local interests. See Figure 21.

Initiatives led by LEPs covering low carbon grid development and offshore energy were surveyed, and the organisations involved were identified.

As is to be expected, the principal focus of LEPs was towards supply chain and service industries and local Government, on account of the primary function of the LEPs themselves. Due to the nature of offshore infrastructure development, national government and project developers will need to be consulted more directly in future engagement on offshore integration.

The Other category predominately covers local businesses that may be impacted by network integration, but unlikely to contribute to project development. See Figure 22.

Figure 21: Organisation participation in LEP-led low carbon and energy projects.

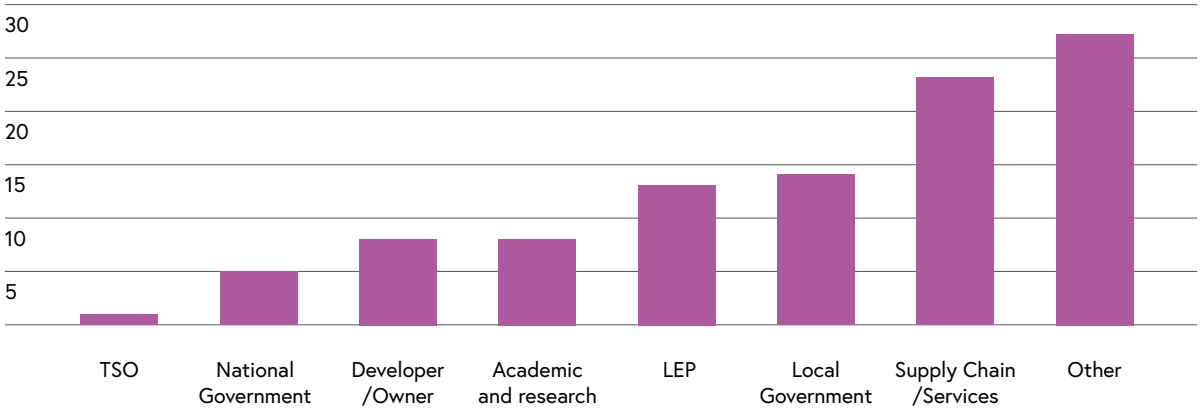


Figure 22: LEPs and other relevant local networking groups.

LEP and relevant groups	Counties covered
Buckinghamshire LEP	Buckinghamshire
Cambridge and Peterborough Combined Authority	Cambridgeshire
Coast to Capital	West Sussex
Cornwall and Isles of Scilly LEP	Cornwall
East of England Energy Zone*	East Anglia
Energi Coast*	Durham, Northumberland, N. Yorks.
Enterprise M3	Hampshire, Surrey
Enterprise Partnership LEP	N. Yorks., E. Yorks., York
Greater Lincolnshire LEP	Lincolnshire, South Humber, Rutland
Greater London Authority	Greater London
Hertfordshire LEP	Hertfordshire
Humber LEP	Hull, East Yorkshire
Liverpool City Region LEP	Cheshire
Locate in Kent LEP	Kent
New Anglia LEP	Norfolk, Suffolk
NORTH EAST LEP	Durham, Northumberland
North of Tyne Combined Authority	Northumberland
OxLEP	Oxfordshire
South East Enterprise Partnership	East Sussex, Essex, Kent
South East Midlands LEP	Bedfordshire, Northamptonshire
Tees Valley Unlimited	Durham
Thames Valley Berkshire LEP	Berkshire

14. Case study one – UK energy integration project participants

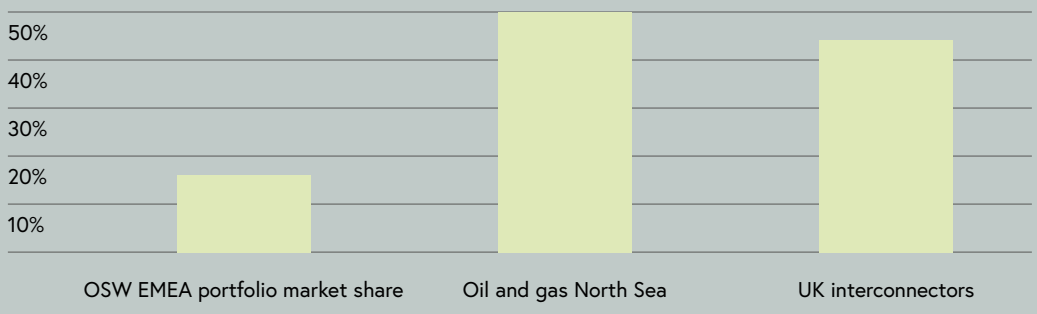
The UK Continental Shelf (UKCS) Energy Integration project, completed in August 2020, provides a strong example of organisations from all relevant industries cooperating to understand integrated grid development.

The UK Energy Integration project is the strongest example of a dialogue between key industry players on the development of an integrated offshore network in the North Sea. The group features major participants from relevant sectors, including companies targeting development of both offshore wind and hydrogen, whilst maintaining oil and gas operations, such as Shell, BP, and Total. See Figure 23.

Other firms with cross market project development interest, such as Eni and EDPR are also notable participants. Crucially, the project also includes supply chain players such as Subsea 7, Aker Solutions (also branching out into offshore wind development), ABB and others. Supply chain engagement is necessary to understand the challenges of implementing new technologies.

However, the presence of the supply chain players is diminished by their overall market share, with only companies active in the offshore wind market representing a sector of hundreds of organisations. A diverse range of offshore wind players are also present, such as floating foundation developers Aker Offshore (through Aker Solutions) and Principle Power, as well as Shell, currently developing a hybrid offshore wind, hydrogen and floating solar project in the Dutch North Sea.

Figure 23: Participants by market share in key sectors.



A primary benefit of the UK Energy Integration project is the collaboration of key stakeholders from the UK and their interaction with notable industry players. Collaboration between offshore infrastructure firms and groups such as BEIS, the Oil and Gas Authority, The Crown Estate, Crown Estate Scotland and the Scottish Government, will allow industry expertise and future development strategy to support policy making decisions and implementation of an integrated offshore network in future. See Figure 24.

There is some presence of hydrogen project developers on the initiative panel, including offshore developers who have expressed an interest in the technology, as well as Principle Power, whose Kincardine Floating Offshore Windfarm Limited (KOWL) floating project in Scotland will support the Dolfyn development. However, Ørsted, developers of the Gigastack 100 MW hydrogen project, are not a participant. There is also a lack of turbine original equipment manufacturers (OEMs) who would be necessary in fully understanding how offshore wind turbine generators (WTGs) can support green hydrogen generation.

Figure 24: Participants by market share in key sectors.

Organisation	Country	Role	Key initiatives participated in
SSE	UK	OSW / TSO	**7**
National Grid	UK	TSO	**5**
Shell	UK/NL	National Gov.	**5**
Total	France	OSW / O&G	**5**
BEIS	UK	National Gov.	**4**
Scottish Government	UK	National Gov.	**4**
Crown Estate Scotland	UK	National Gov.	**3**
BP	UK	OSW / O&G	**3**
Centrica Storage	UK	O&G	**3**
Eni	Italy	OSW / O&G	**3**
RWE	Germany	OSW	**3**
The Oil and Gas Technology Centre	UK	Academic and Research	**3**
University of Aberdeen	UK	Academic and Research	**3**
University of Strathclyde	UK	Academic and Research	**3**
Companies involved in two initiatives (17)	-	-	**2**
Companies only involved in UKCS Energy Integration Project (38)	-	-	**1**

15. Case study two – Baltic region

The Northern European offshore wind markets of Denmark, Germany and Sweden are all actively progressing integrated offshore wind development and can provide lessons to the UK.

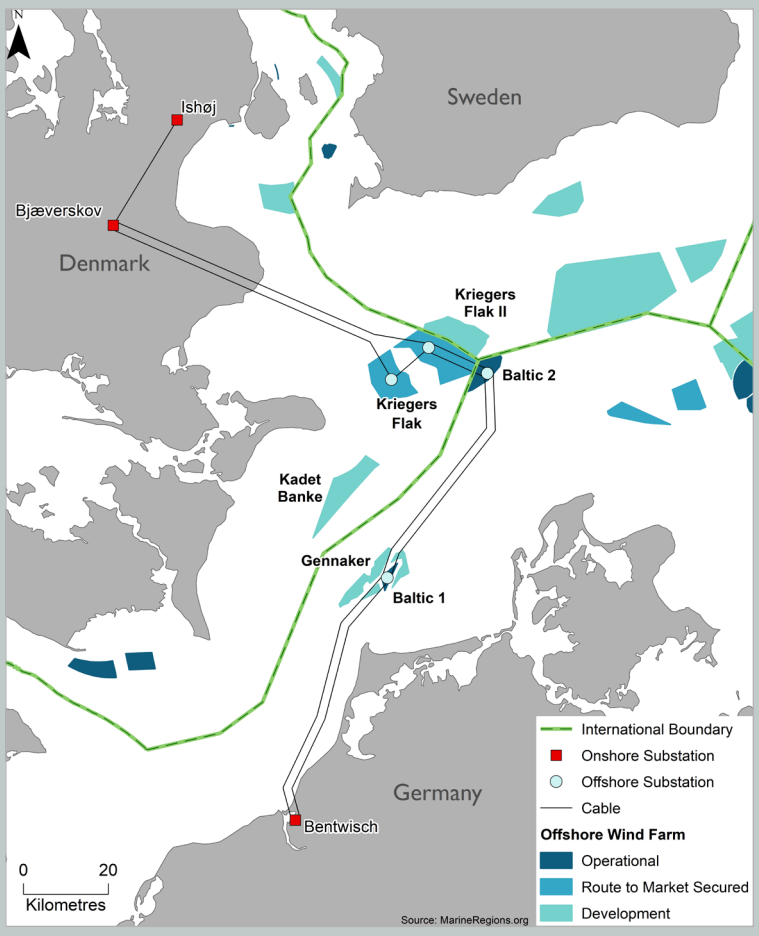
Far-shore offshore wind and the Kriegers Flak project

The soon to be completed Kriegers Flak combined grid solutions (CGS) project will be the first integrated offshore wind project in the world. The 604.8 MW project will transmit power to both Denmark and Germany, with the hybrid interconnector developed by TSOs in the respective markets, Energinet and 50Hertz. The interconnector was commissioned in October 2020 with the offshore wind farm forecast to be completed in early 2022. If successful, the project will demonstrate the realised potential of combined grid solutions for offshore wind development and encourage future integration cooperation from Energinet, 50Hertz, Elia Group and Vattenfall, all of whom are assessing the potential or already developing additional CGS projects.

Currently there are no CGS projects in advanced development in the UK. Scottish Power Renewables' East Anglia Hub project has been partially consented and will combine the EA 1 North, EA 2 and EA 3 projects through one offtake system. However, each windfarm is being developed to account for the likely possibility of consenting for the projects on different timescales, hindering coordinated deployment that would support a hub system.

Indeed, whilst key stakeholders in the UK market, including government authorities involved in offshore leasing, such as BEIS and the OGA, are actively assessing paths towards an integrated grid, the current framework for offshore wind development continues to favour radial solutions. Elsewhere in Europe, particularly the Baltic region, governments in Denmark have initiated plans for energy islands and other integrated grid solutions that remove barriers to combined integration and offshore development. See Figure 25.

Figure 25: Kriegers Flak project site and interconnector route.



Lessons learnt

The Kriegers Flak project, despite being a leading example of a combined grid solution project, has experienced numerous delays and demonstrated the importance of early project development. Initial plans for the project began in 2010 with commissioning of the 604.8 MW offshore wind farm and interconnector originally scheduled for 2018. As a result of adjustments to the subsidy mechanism for the project and other permitting delays the commercial operation of the project is unlikely to be realised before 2022.

The 12-year timescale to deliver just one CGS project demonstrates the need for early development works, if there is hope of using integrated offshore networks to support the UK Government target of 40 GW installed offshore wind capacity by 2030, or indeed net zero by 2050.

The Danish Government has recognised the need for early government planning to realise an integrated offshore grid, announcing the energy island hub plans in July 2020. The plans proposed a reasonable timeline of delivery of up to 3 GW of capacity by 2030, with the potential to increase to 10 GW at a later date. Notably the Danish Government began investigating the energy islands concept in 2017 with the North Sea Wind Power Hub (NSWPH).

The 13-year development schedule for a future integrated offshore network in Denmark factors in experience gained from the Kreigers Flak Project, as well as the capacity increase from a 604.8 MW to a 3,000 MW CGS project. Whilst it can be assumed that UK stakeholders and industry players will advance their own knowledge of the necessary requirements for an integrated grid, there is yet to be CGS project built in the UK from which the Government can gain local expertise and experience to support future integrated grid development.

16. Key stakeholder future offshore wind development assessments

In 2019 and 2020 key stakeholders, BEIS and the National Grid, published reports about future offshore wind development scenarios. Both assessments are part of ongoing assessments of development strategies.

Favours radial offshore wind project development	Favours integrated offshore wind project development
OWIC – Enabling efficient development of transition networks for offshore wind targets (November 2019)	
Report did not present favours for continued radial offshore wind development.	Cable landing points thus far focused on offshore wind project site location, as opposed to grid optimisation. This has meant multiple projects constructing transmission networks in similar areas, causing unnecessary environmental damage and inconvenience to local stakeholders.
	Onshore grid planning has not kept pace with radial offshore wind development. East Anglia is a focal point, with 22 GW of projected OSW development and only 10 GW available for additional grid capacity. Similar issues are present for the Humber Region.
	Recommends extension of existing transmission assets to a lifetime of 60 years. Completion of NGESO electrical standards review to understand how offshore transmission networks could be extended and more widely used. Increase collaboration between offshore wind, maritime and industrial sectors to increase renewable energy uptake in near-shore industry facilities.
National Grid ESO – offshore coordination report (September 2020)	
UK must invest in HVDC circuit breaker technology in order to move to an integrated approach. The technology is currently under-developed outside of China where it is at a demonstration phase. Integration without HVDC circuit breakers is possible, but considerably more lengthy and costly process than assumptions used in the report.	An integrated approach has the potential to save consumers 18% (£6bn) between 2020 and 2050, based on assumptions used. Savings greatest where OSW is connecting to the onshore grid in areas nearing maximum grid capacity such as East Anglia and the Humber Region.
Full integration is not likely achievable before 2030 with offshore wind projects already in development, delaying apparent cost savings of integrated system.	Potential environmental impact of an integrated approach is a 50% reduction in cables and onshore landing points, although new cable landing points would be larger.
There is a negligible difference in overall carbon intensity for the generation fleet for radial and integrated scenarios out to 2050.	Integrated systems would allow power to be transferred directly from generators to power centres through central planning.

17. Conclusion

In summary, this landscaping report has shown that there is a finite amount of available space in the offshore environment, and many demands upon it, whilst requiring suitable protections. Whilst this is well known to developers and operators within these environments, it is often a surprise to many who view the seas as large areas and are unaware of usage.

There is a very clear shared interest in the optimum use of the offshore resource, and several groups have undertaken, and are undertaking, comprehensive studies on what an optimum offshore environment might look like. Knowing how to get there however, is less studied.

Electricity deregulation has led to a clean separation of owners who have an overall energy and zero carbon objective, and owners who are simply operating an asset for an income. This is also seen in the oil and gas environment, where some parties have a carbon development agenda, and others are simply operating an asset to end of life. The mechanism of implementing deregulation in the UK by Ofgem using competitive markets, leads to less opportunity for planned coordination, as can be seen in the Baltic example.

In parallel to electricity and energy regulation, there are other regulatory frameworks that incentivise dispersed and uncoordinated development, by reviewing upcoming projects piecemeal, and awarding capacity on an incremental basis, whether for power purchase agreement (PPA), environmental considerations, or other.

There are at least 50 high-profile industry initiatives with over 500 participants in various interest groups, and a significant number of smaller, particular interest or localised parallel initiatives that have not been mapped. Certain interest regions attract more groups than other lesser interest regions. Of these initiatives, there are 16 key groups actively progressing offshore network integration. There is, however, surprisingly little overlap between these groups. It is not clear at present to what extent each group is aware of the other groups, and the potential for differing perspectives, and thus conflict and delay, as plans develop.

The Baltic experience has shown that, in a market where there is no market competition and generation, and transmission owners can work together to develop a coordinated multipurpose system, the development has still taken 15 years from concept to fruition.

18. Reference material and further reading

Several studies researching the potential benefits of offshore wind integration and the necessary steps required to deliver an integrated offshore grid were selected. However, in this fast-moving environment, there are more emerging every month, and such a study as this can never hope to capture all or provide an exhaustive up to date list.

The industry literature overwhelmingly supports offshore grid integration as a solution to maximise potential energy offtake in UK waters and meet the target of net-zero carbon emissions by 2050. However, integration is predicated in many studies on the immediate development of an integrated grid, with an apparent sudden transition to a coordinated offshore network.

Whilst stakeholders and project developers may all favour an integrated grid both for UK and European, Middle Eastern and African projects, a transition to a new system of development is currently hamstrung by technology limitations and technology specific development policies. Moreover, the benefits of integrated developments are not necessarily immediate to all transitions to net zero.

The National Grid ESO – Offshore Coordination Report issued in September 2020 found that there was a negligible difference in overall carbon intensity for the generation fleet for radial and integrated scenarios out to 2050.

Review of reports looking at coordination

All the reports had very similar scopes, which are early stage art of the possible, and rationalising what an optimised system might look like. They had different depths, perspectives and measurement indicators, however all covered to some degree the benefits of co-ordination.

All the reports support grid integration, and wider co-ordination. Some measured effects on carbon, some pricing, others on impacts. Together they make a comprehensive suite of knowledge.

No key omissions were noted, though it is clear some future key stakeholder interest groups have yet to enter the fora. Rather, a clear requirement is for the next steps, or how, such a designed system could be achieved, and how long this might take.

Key literature (most useful publicly available reference sources)

- Aurora Energy Research – Hydrogen in the Northwest European Energy System (September 2020)
- BEIS – Enabling efficient development of transition networks for offshore wind targets (November 2019)
- BEIS – Offshore Transmission Network Review (August 2020)
- BEIS - Offshore Transmission Network Review Webinar update (December 2020)
- BEIS – Offshore Wind Sector Deal (March 2019)
- Climate Change Committee (CCC) – 6th Carbon budget (December 2020)
- Dept. Housing, Planning and Local Gov. (Ireland) Towards a Marine Spatial Plan for Ireland (December 2017)
- Energinet - The ideal market design for offshore grids: a Nordic TSO perspective (November 2020)
- ENTSO-E Position on Offshore Development Market and Regulatory Issues (October 2020)
- European Commission – An EU strategy to harness the potential of offshore renewable energy for a climate neutral future (November 020)
- European Commission – Environmental baseline study for the development of renewable energy sources, energy storages and a meshed electricity grid in the North and Irish Seas (August 2017)
- Irish Offshore Operators Association – Submission to Government on IOOA member companies in Ireland's
- MMO – RFP for protections on Marine Habitats (2020)
- National Grid ESO – Offshore Coordination Report (September 2020)
- National Grid ESO - Phase 1 Final Report - Offshore Coordination Project (December 2020)
- NSEC – Coordination of tenders for offshore wind in the North Seas (December 2017)
- NSEC – North Seas Energy Clusters (September 2017)
- Ofgem - Decision making for future energy systems: Incorporating rapid change and future uncertainties (December 2020)
- OGTC and OREC – Reimagining a net zero North Sea – An integrated Energy Vision for 2050 (November 2020)
- Policy Exchange – The Future of the North Sea: Maximising the contribution of the North Sea to Net Zero and Levelling Up (November 2020)
- The Crown Estate – R4 Stakeholder Feedback (2018)
- The Oil and Gas Authority – UKCS Energy Integration: Final Report (August 2020)
- The Oil and Gas Technology Centre – Closing the Gap: Technology for a Net Zero North Sea (September 2020) low-carbon energy transition (November 2019)

Key publicly available project mapping and resources

- EMODnet GIS Resource[2]
- Oil and Gas Authority – UK offshore resource mapping: details of all lease agreed offshore infrastructure projects[3]
- Policy Exchange – The Future of the North Sea: Maximising the contribution of the North Sea to net zero and levelling up GIS data[4]
- RCG GRIP Database (comprehensive offshore wind project analysis, forecasting and site locations)
- TCE Marine Cadastre GIS resource

[2] https://www.emodnet.eu/en
[3] https://ogauthority.maps.arcgis.com/apps/webappviewer/index.html?id=cb3474a78df24139b1651908ff8c8975
[4] https://policyexchange.org.uk/publication/future-of-the-north-sea/

19. About the IET

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