13 August 2024

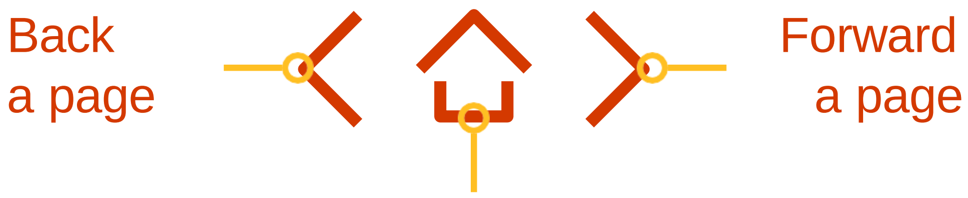
Beyond 2030: Celtic Sea

Navigation

To help you find the information you need quickly and easily we have published the report as an interactive document.

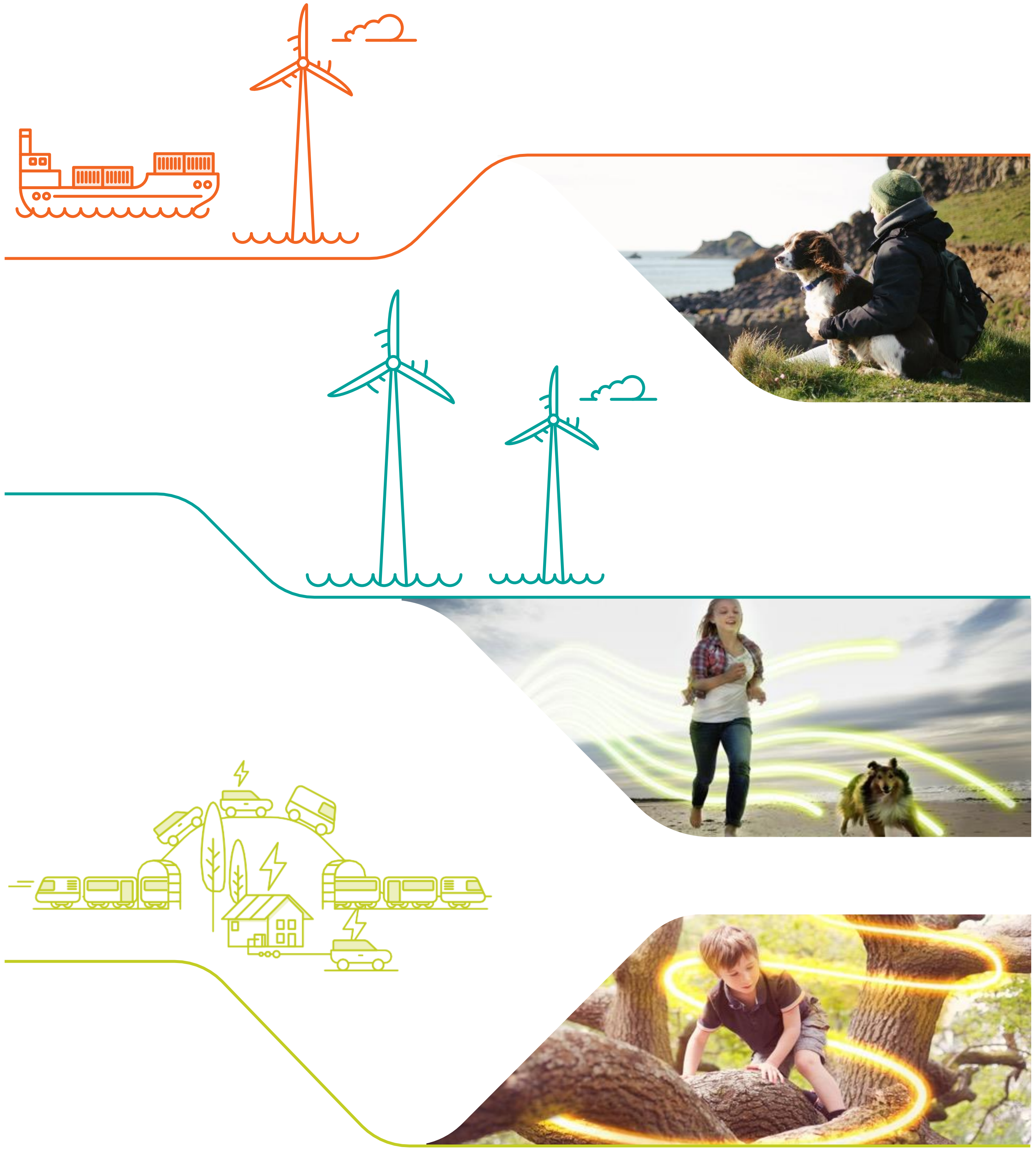
Download the PDF in Acrobat Reader to view all interactivity.

Page navigation explained



From here you can navigate to any part of the publication

Contents



Executive Summary

Executive Summary

According to our *Future Energy Scenarios (FES)*[1], the UK electricity demand is going to grow substantially out to 2050. To meet net zero, we must adapt our network to accommodate a rapidly changing mix of electricity generation while ensuring a safe and reliable supply of power to homes and businesses.

The UK Government has set out an ambition to decarbonise the power system by 2030. Offshore wind is likely to be vital to achieving this target and to sustaining a clean power system beyond 2030 to enhance energy security and achieve net-zero greenhouse gas emissions by 2050.

In 2023, The Crown Estate (TCE) announced their Floating Offshore Wind Leasing Round 5. We have completed a design exercise which facilitates the connection of up to 4.5 GW of floating offshore wind, enabling one of the largest floating wind initiatives in the world. TCE has identified that this will provide enough clean, renewable energy for more than four million homes. We are also aware that in the *2023 Autumn Statement*[2] the previous UK Government set an ambition to unlock space for a further 12 GW of capacity by 2050 in future rounds in the Celtic Sea.

We were asked by the Department for Energy Security and Net Zero (DESNZ), to carry out a design exercise to recommend how to connect the Celtic Sea floating offshore wind to the onshore network. In designing connections for these wind farms, we look at a combination of factors: total cost, deliverability and operability, community and environmental impact.

We have taken a unique approach in the Celtic Sea compared to other design exercises. For the first time, working closely with TCE, we have created a holistic network design for a fixed area of seabed before any wind farm project developers have been identified through a seabed tender. This approach has allowed us to manage over 20 GW of capacity in the connection queue which might otherwise be competing for sought after space on the grid. It has created a blueprint for how we as the Electricity System Operator (ESO) and TCE will work together in the future.

[1]https://www.nationalgrideso.com/future-energy/future-energy-scenarios-fes
[2]https://www.gov.uk/government/publications/autumn-statement-2023/autumn-statement-2023-html#backing-british-business-1

Beyond 2030: Celtic Sea / Executive Summary 05

Executive Summary

Holistic Network Design Follow Up Exercise (HNDFUE): Celtic Sea Final Design Recommendation

The proposed design (Figure 1) offers advantages in terms of environmental impact and community impact when compared to other designs we have considered and has the lowest level of known risk to its timely development and delivery of the designs. A key factor in this recommendation was the indication that no new overhead lines would be required to connect these wind farms. We consider the proposed design makes efficient use of the current wider transmission infrastructure, compared to other options. The route to the landing points also avoids several designated environmental areas in South Wales.

The proposed design provides opportunity for the projects to support the Government to meet its net-zero targets. It enables the growth of the UK's offshore wind sector and has the potential to boost regional economic growth in South Wales and South West England. Independent research - the *Celtic Sea Blueprint*[3] - suggests up to 5,300 new jobs and up to £1.4 billion could be generated for the UK economy by galvanising the supply chain and infrastructure opportunities arising from the development of new floating wind farms off the coasts of South Wales and South West England.

Based on the estimated delivery dates provided for this exercise, we believe the connections points could all be available by 2035 or in some cases sooner. These dates could change as designs are developed or national policies evolve.

We have engaged with a wide range of stakeholders throughout the process, including a community working group with representatives of Councils across the Celtic Sea region. Designs may still need to be refined to ensure impacts on communities are minimised and wider benefits are seized upon for both connection and transmission works.

Category	Key
New offshore network infrastructure (HVDC)	
New offshore network infrastructure (HVAC)	
Existing network upgrade	
Transmission Interface Point	
Celtic Sea PDA	
Existing Network	

Note: all routes and options shown on this map are for illustrative purposes only.
The network upgrade works shown were based on the onshore assessments conducted for HNDFUE: Celtic Sea

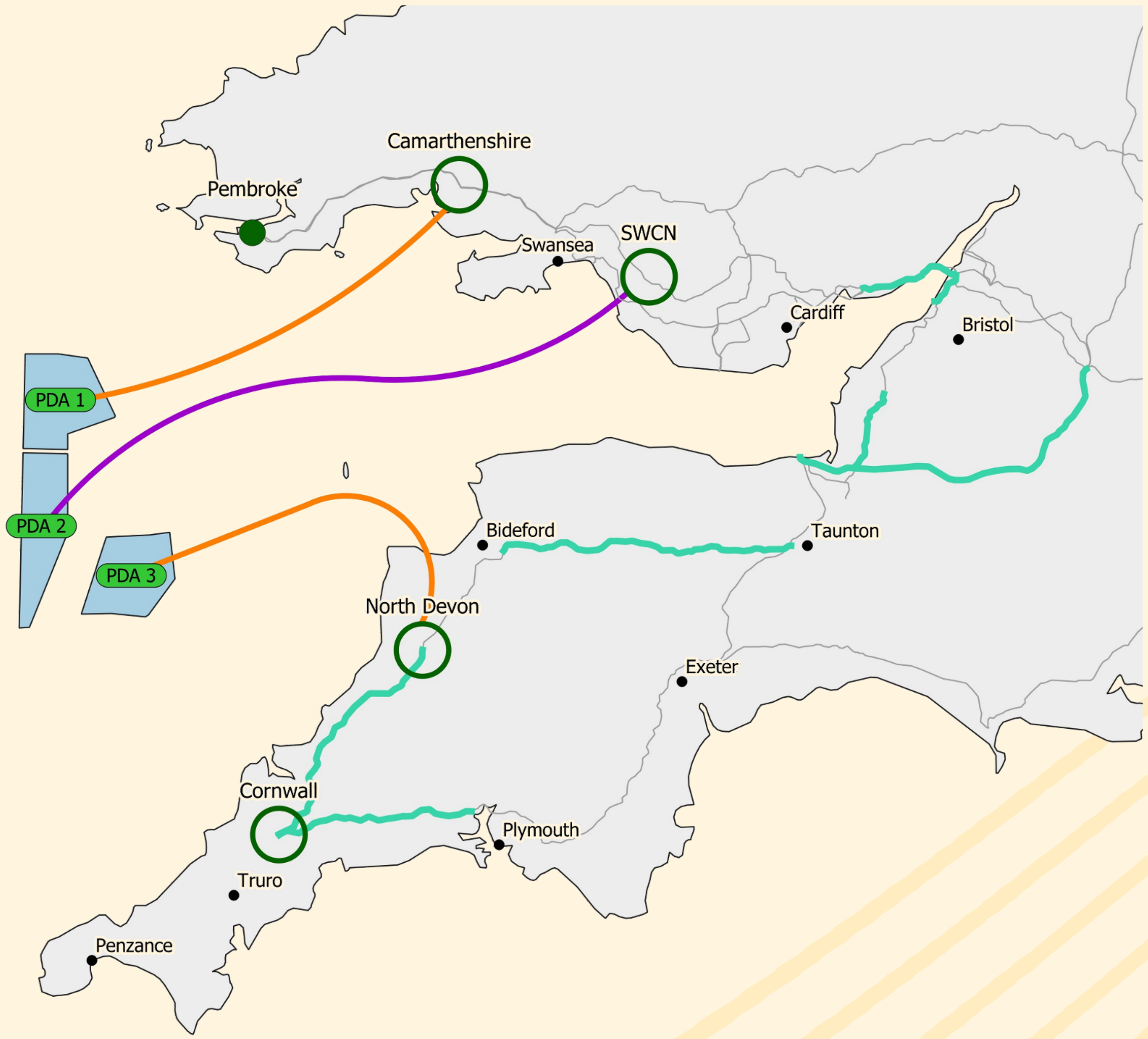


Figure 1: The Celtic Sea Final Design Recommendation

Maps are illustrative and subject to change through Detailed Network Design

[3] https://assets.ctfassets.net/nv65su7t80y5/nDXSS9l3qvtscyxa1rlwq/ded23422bbc04bf6a8753cc3623f0016/Celtic_Seas_Blueprint_final_report_Feb2024.pdf

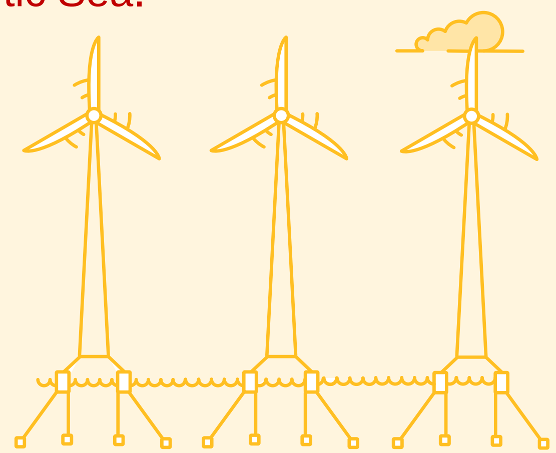
Beyond 2030: Celtic Sea / Executive Summary 06

Executive Summary

Key Messages

1

Our design facilitates the connection of The Crown Estate's (TCE) Floating Offshore Wind Leasing Round 5, with an opportunity to create up to 4.5 GW of renewable energy capacity in the Celtic Sea.



This proposed design is an early step in enabling TCE's Celtic Sea Floating Offshore Wind Leasing Round 5, one of the largest floating wind initiatives in the world. Once operational, it will connect into the South West and South Wales with enough green power for over four million homes.

2

Our design creates opportunities for South Wales and the South West regions to continue to play an important part in Great Britain's green industrial revolution.

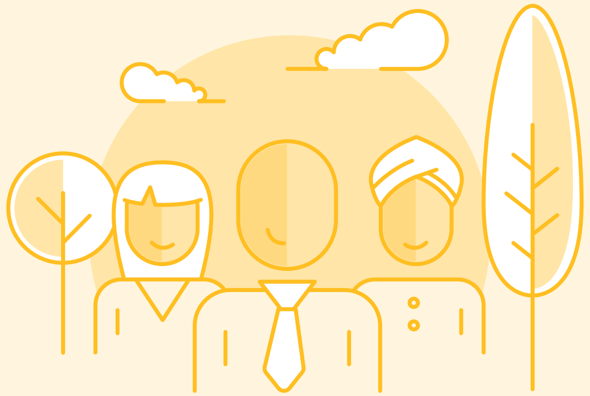
These proposals recommend creating new substations to connect in Carmarthenshire, South Central Wales and North Devon. An independent study[4] suggests the associated supply chain could include 5,300 new jobs and up to £1.4 billion generated for the UK economy.

3

The connections into South Wales and South West England can provide a catalyst for coordination with future green energy developments in the area.

Our recommendation has taken into consideration other regional energy and industrial drivers to complement these where possible. We have also thought about future leasing rounds in the Celtic Sea and believe our recommendation retains opportunity for future growth.

4



We have recommended a design that balances cost, deliverability, operability and impact on local communities and the environment.

In consultation with a range of stakeholders, our recommended design presents less impact on the environment and community than others we considered, with no new overhead lines indicated to connect these wind farms. We consider the design makes efficient use of the current wider transmission infrastructure, compared to other options.

[4] https://assets.ctfassets.net/nv65su7t80y5/nDXSS9l3qvtscyxa1rlwq/ded23422bbc04bf6a8753cc3623f0016/Celtic_Seas_Blueprint_final_report_Feb2024.pdf

Beyond 2030: Celtic Sea / Executive Summary 07

Executive Summary

Taking forward the recommendation

Alongside this recommendation, in August 2024 we are expecting TCE to issue an Invitation to Tender for qualified and registered bidders, followed by an auction process. This is expected to result in agreements for lease of the seabed to successful developers to deliver the floating offshore wind projects described in this document.

Given the radial configuration, Ofgem does not intend to produce a separate asset classification publication. Once the successful developers are identified, we will work with each developer to produce connection contract offers allowing the projects to connect to the electricity network.

We will also work with the host Transmission Owner (TO), National Grid Electricity Transmission (NGET), to continue development on relevant works for this recommendation as it progresses into the detailed network design stage. At this next stage more detail will need to be determined by the TO on location of substations and work on the existing transmission network to facilitate the connection of the new floating offshore wind farms.

Once the offshore project developers are identified they will also need to determine more specific cable routing and confirm their detailed designs and technology choices.

Local communities can expect further consultation and engagement from both NGET as the host TO, and the project developers as work continues. We will continue to work with these parties, and stakeholders, through these next steps.

We also intend to continue to work closely with TCE for consideration of seabed leasing opportunities and the associated network designs to meet the future offshore wind generation ambitions.

Beyond 2030: Celtic Sea / Executive Summary 08

Introduction

ESO

Introduction

As the Electricity System Operator (ESO), we ensure there is enough electricity supply to meet demand second by second, 365 days a year. Although we do not own Great Britain's transmission assets, we work with the Transmission Owners (TOs) and other stakeholders to strategically design the offshore network and support the TOs by making recommendations for onshore network development. We are making these design choices and recommendations on one of the fastest decarbonising electricity grids in the world.

We work in partnership with UK and Devolved Governments, the Office of Gas and Electricity Markets (Ofgem), The Crown Estate (TCE) and industry to guide Great Britain on what energy resources, markets, and networks are required to securely accelerate the transition away from fossil fuels into new energy technologies and economies.

Through this Holistic Network Design Follow Up Exercise (HNDFUE) for TCE’s Floating Offshore Leasing Round 5 (Celtic Sea) we have undertaken another step in the direction of a net-zero electricity system.

NESO

In Autumn 2024, we are transitioning into an independent public corporation named the National Energy System Operator (NESO). We will be responsible for planning Britain’s electricity and gas networks and operating the electricity system.

Beyond 2030: Celtic Sea / Introduction 10

Introduction

The Celtic Sea Leasing Round is a nationally significant 4.5 GW of floating offshore wind power that will connect directly into the transmission network.

The electricity transmission network is often compared to Great Britain's motorways. It is used to transport high voltage electricity over long distances, ensuring cities and towns are connected and supplied. This high voltage electricity is then moved through distribution networks, which can be thought of like the country's A and B roads, before it is then converted into a lower voltage for homes and businesses to use every day. Great Britain has three onshore TOs that own, maintain, and develop the transmission network. National Grid Electricity Transmission (NGET) is the TO responsible for England and Wales. There are also several offshore developers that own the assets that connect offshore wind farms to the transmission or distribution network.

Our Holistic Network Designs

In 2020, the UK Government launched the Offshore Transmission Network Review (OTNR) which was designed to remove barriers and accelerate progress towards reaching the UK's net-zero targets for offshore wind development. As part of this review the Department for Energy Security and Net Zero (DESNZ) published the Holistic Network Design (HND) Terms of Reference (ToR)[5], which is a set of high-level principles by which offshore network should be designed to.

It has been our role to implement the ToR, which changed how offshore wind project connections are developed in Great Britain. The image map of Great Britain shows the current extent of seabed leases for offshore wind projects, highlighting the Celtic sea (Figure 2). Previously, developers looked to connect individually to the network in a piecemeal fashion. We now take a strategic view of how projects can coordinate and better connect into the network following the methodology outlined in the HND ToR.

In delivering against this ToR, we have since released the following publications creating two holistic network designs:

- *The Holistic Network Design: Pathway to 2030 report - July 2022*
- *Beyond 2030 report - March 2024*

The network recommendations laid out in these reports are designed to be built upon one another, with the Beyond 2030 network design building on top of the Pathway to 2030 baseline and published as a *'follow up exercise*'. Between them they set out proposals to develop a network for Great Britain which charts a course to facilitate up to 86 GW of offshore wind up to and throughout the 2030s. This represents £112 billion of network investment across Great Britain and would enable our wind fleet to be larger than all of Europe's fleet combined.

In July 2024, during the development of the HNDFUE Celtic Sea publication, the Government announced its mission to deliver clean power by 2030, with the aim of achieving energy independence and lower bills for Great Britain. To support this aim, we have been asked to provide advice regarding areas that need to be accelerated to support this ambition. We will publish this advice later this year.

Category	Key
Offshore wind in scope for coordination	
Offshore wind to be assessed for coordination in the future	
Offshore wind previously assessed for coordination	
Previous offshore wind leasing rounds	
Existing Network	

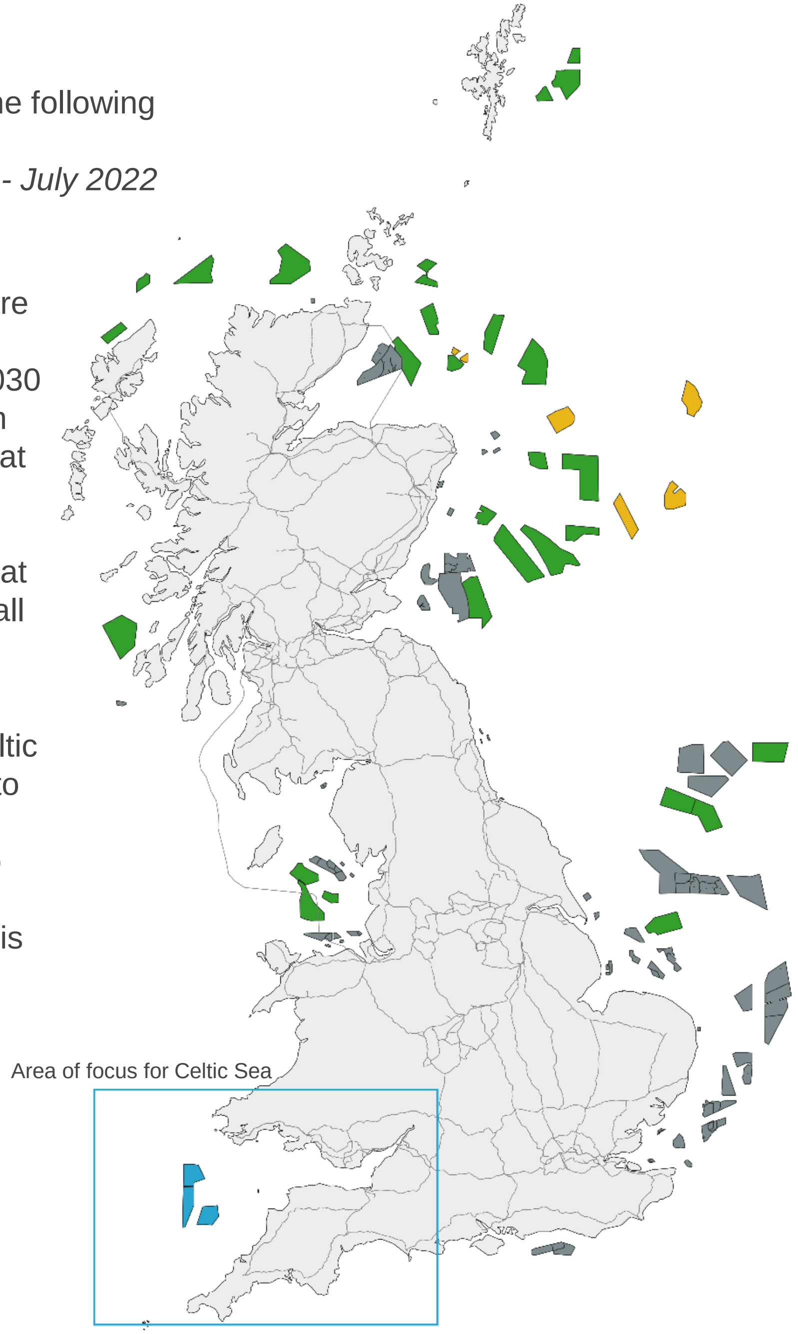


Figure 2 : Offshore wind farms across Great Britain, highlighting the Celtic Sea Projects

Maps are illustrative and subject to change through Detailed Network Design

[5] https://assets.publishing.service.gov.uk/media/64ef6dc513ae15000d6e30de/otnr-hnd-fue-tor.pdf

Beyond 2030: Celtic Sea / Introduction 11

Introduction

HNDFUE: Celtic Sea

We have created the HNDFUE: Celtic Sea design, which builds again on our previous reports but focuses on coordinating the connections of The Crown Estate's Celtic Sea Floating Offshore Wind Leasing Round 5. This consists of three large Project Development Areas (PDAs) in the Celtic Sea between Wales and the South West. These three floating offshore wind development areas could be up to 1.5 GW each, with a total of up to 4.5 GW of generation to be connected into the transmission network. We outline the HNDFUE: Celtic Sea network design recommendation in this report including a summary of the performance against the design criteria set out in the HNDFUE ToR, comparing against the shortlisted designs to provide context. We provide a comprehensive account of our design process including a detailed account of our strategic option appraisals in the *HNDFUE: Celtic Sea Technical Annex*.

What is floating offshore wind?

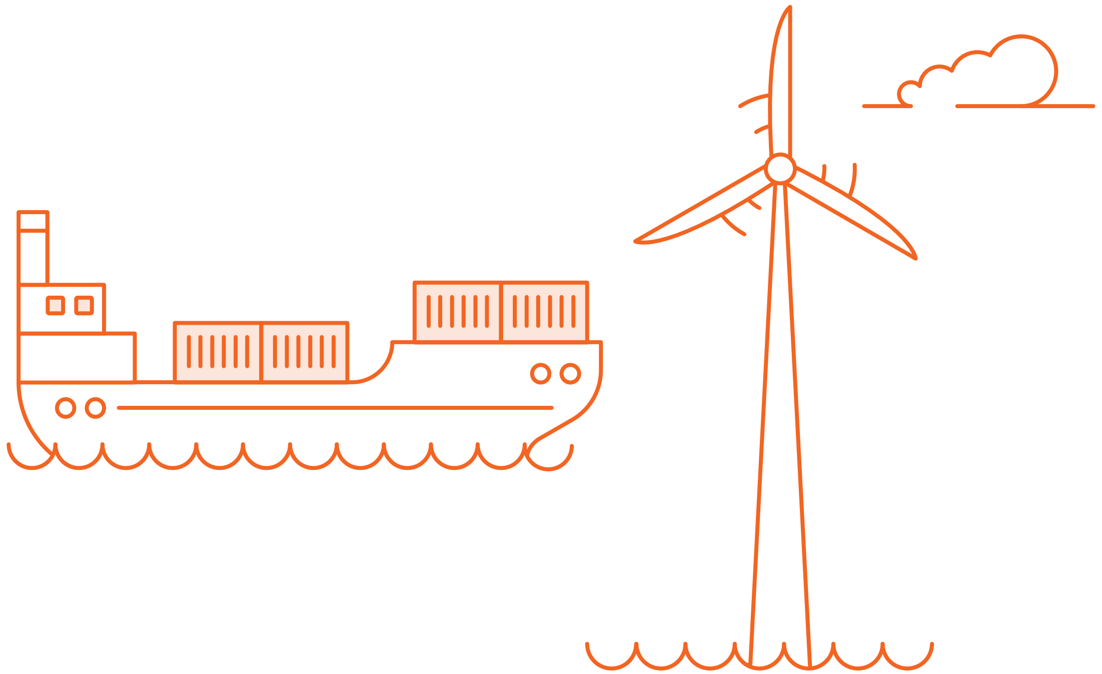
Traditionally offshore wind turbines have been fixed to the seabed on structures which could not be installed in deep seabed locations. Floating wind uses the same turbine design as standard fixed offshore wind, the main difference is that flexible anchors, chains and cables are used to secure the platform to the seabed. An advantage of this technology is that floating wind farms can be positioned in deep sea areas where wind resource may be higher and there is more space for larger turbines that can generate a greater amount of energy.

Beyond 2030: Celtic Sea / Introduction 12

Introduction

The HNDFUE: Celtic Sea is unique to other holistic network design (HND) activities previously undertaken as developers have yet to bid for the PDAs that we are designing the connection to for the exercise. Previous HND activities coordinated connections to PDAs that had been successfully bid for by a developer. The Crown Estate's Invitation to Tender (ITT) for the Celtic Sea Round 5 takes place after this exercise concludes. This sequencing allows developers to make a more informed bid based on the network recommendations, reducing risk.

We have always engaged with a broad range stakeholders. For the first time in our holistic network design activities, we also worked with a group of representatives from local councils across South Wales and the South West. We used this group to discuss our optioneering exercises and invite feedback which we considered as part of our design development. We incorporated this new approach into our governance process for the exercise.



Supporting Growth

The three Celtic Sea Projects in the Celtic Sea Leasing Round 5 will bring a substantial amount of economic activity to Wales and South West England, with specialised port infrastructure likely required to facilitate this emerging floating offshore wind industry. Independent research - the *Celtic Sea Blueprint*[6] - suggests up to 5,300 new jobs and up to £1.4 billion could be generated for the UK economy by galvanising the supply chain and infrastructure opportunities arising from the development of new floating wind farms off the coast of South Wales and South West England.

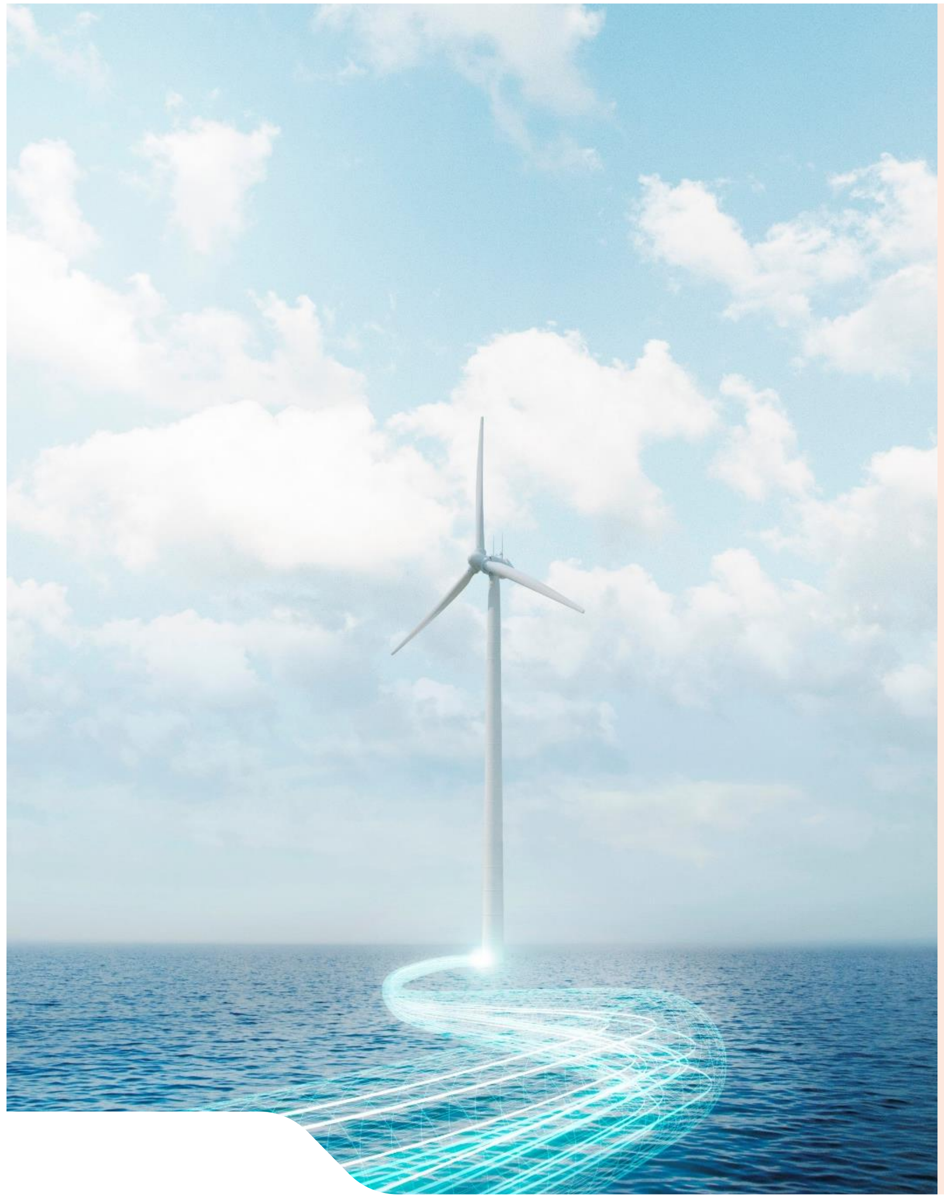
Supporting Net Zero

Connecting 4.5GW of floating offshore wind into South Wales and South West England throughout the 2030s, enough power for approximately four million homes, is another step in supporting the UK's *Sixth Carbon Budget*. Connecting the Celtic Sea Projects into Wales would also make significant contributions to Welsh renewable energy targets. Connecting two of the Celtic Sea Projects at 3 GW would generate almost a third of the forecast Welsh demand in 2035. We have assessed dates for our recommendation based on information available at the time of analysis. These dates could change as designs are developed or national policies evolve.

[6]https://assets.ctfassets.net/nv65su7t80y5/nDXSS9l3qvtscyxa1rlwq/ded23422bbc04bf6a8753cc3623f0016/Celtic_Seas_Blueprint_final_report_Feb2024.pdf

Beyond 2030: Celtic Sea / Introduction 13

Introduction



For more details, please see our suite of documents that explore our processes and recommendation in greater detail.

1. ***Celtic Sea Technical Annex***
   Our *Celtic Sea Technical Annex* sets out our design considerations for the Celtic Sea recommendation in greater detail. It outlines the benefits of each of our shortlisted designs and how we made our final recommendation. It also discusses the alternative designs we considered.

2. ***Pathway to 2030***
   The HND provides a recommended offshore and onshore design for a 2030 electricity network which sets out an integrated approach for connecting 23 GW of offshore wind to Great Britain.

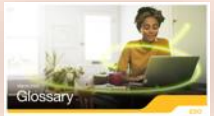
3. ***Beyond 2030***
   The Beyond 2030 Report builds on top of the HND and makes a set of network recommendations throughout the 2030s. The report recommends a set of offshore and onshore network upgrades which total an additional £58 billion of direct investment in our electricity networks. It facilitates the connection of an extra 21 GW of offshore wind.

4. **Glossary**
   Our standalone glossary explains the more technical terms used across the suite of documents.

Celtic Sea Technical Annex

Pathway to 2030

Beyond 2030 report



Glossary

Beyond 2030: Celtic Sea / Introduction 14

Connecting the Celtic Sea

ESO

Creating a design recommendation

To create a holistic design recommendation, we have developed a process that assesses a broad range of options, taking into consideration our four design objectives (see Figure 4). All of which need to be balanced to meet the requirement for a holistic design.

Critical to our process is bringing our stakeholders along the journey with us. This allows us to not only allow people to understand and challenge our decision making and design process, but also to learn from their varied experiences and responsibilities and feedback into our process and recommendations.

Our design process

Our holistic network design process consisted of five key phases (see Figure 3). Our process was developed in collaboration with Transmission Owners (TOs), offshore wind farm developers, environmental bodies, government and local councils. We have also considered feedback from stakeholders involved in developing the first Holistic Network Design (HND).

In making our recommendation, we considered 21 unique design options, as well as several variations and sensitivities, for connecting the Celtic Sea wind farms into the transmission network. These included a wide variety of designs, exploring ways of coordinating connections between leasing areas and different configurations of connection from the wind farms to shore.

We also explored connections into 23 interface points, some of which already exist on the onshore electricity network, and some of which would be new substation sites. Many of the existing substations have limitations in how much capacity can be connected, and so new interface points had to be considered across South Wales and the South West.

The design process is an iterative process, whereby a range of designs are developed and assessed to understand their performance against the four design criteria; the best performing designs are shortlisted throughout the process with further iterations and refinements carried out to come to a final recommended design.

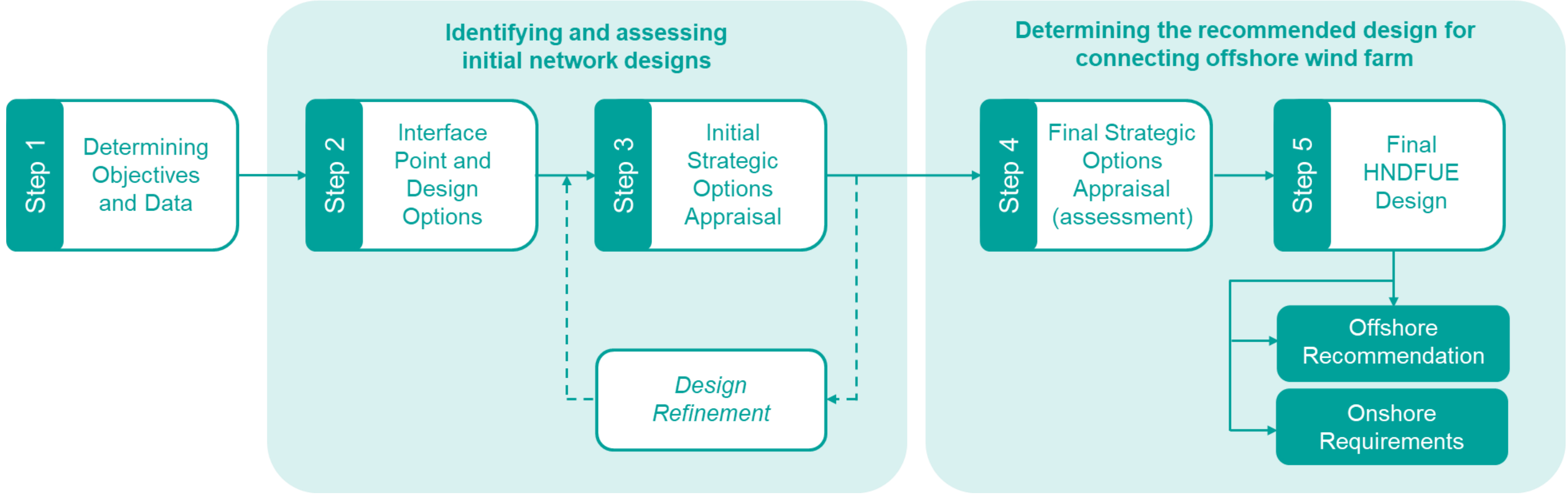


Figure 3: Holistic design network process

Part 1: Connecting the Celtic Sea

Our recommendation is at an early phase of connection design development. We are in the strategic optioneering phase of the Detailed Network Design (DND) process (Level 2 in Figure 5), to coordinate the connection of several areas earmarked for offshore wind generation at given capacities. The connections into the transmission network are appraised against four design objectives.

Objective	Our approach
Economic and efficient	We used **economic assessment tools** to determine the optimal economic design from a wide range of proposed options, ensuring the best value for consumers.
Deliverable and operable	We applied a **deliverability assessment framework** that considered a range of factors including supply chain of technologies, construction timeframes and consenting challenges ensuring our design is delivered in a timely and practical way.
Considers impact on environment	We conducted **assessments of environmental constraints** using a range of geospatial data sources to determine the location and sensitivity of environmental constraints. We did this in consultation with Statutory Nature Conservation Bodies (SNCBs) ensuring our design minimises the impact, where possible, on the natural environment.
Considers impact on communities	We conducted **assessments of community constraints** using a range of geospatial data sources to determine the location and the sensitivity of community constraints, ensuring our designs minimise the impact, where possible, on local communities that host this infrastructure.

Figure 4: Our four design objectives

The DND will include planning and consenting phases and will follow this exercise. These are conducted by the party responsible for developing each asset (for example the TO or offshore developer). They will analyse and undertake a more detailed assessment, refining the design where appropriate. It is during this process that statutory consultations and relevant environmental assessments will take place. We would expect that responsible parties consult with communities when these recommendations become more refined.

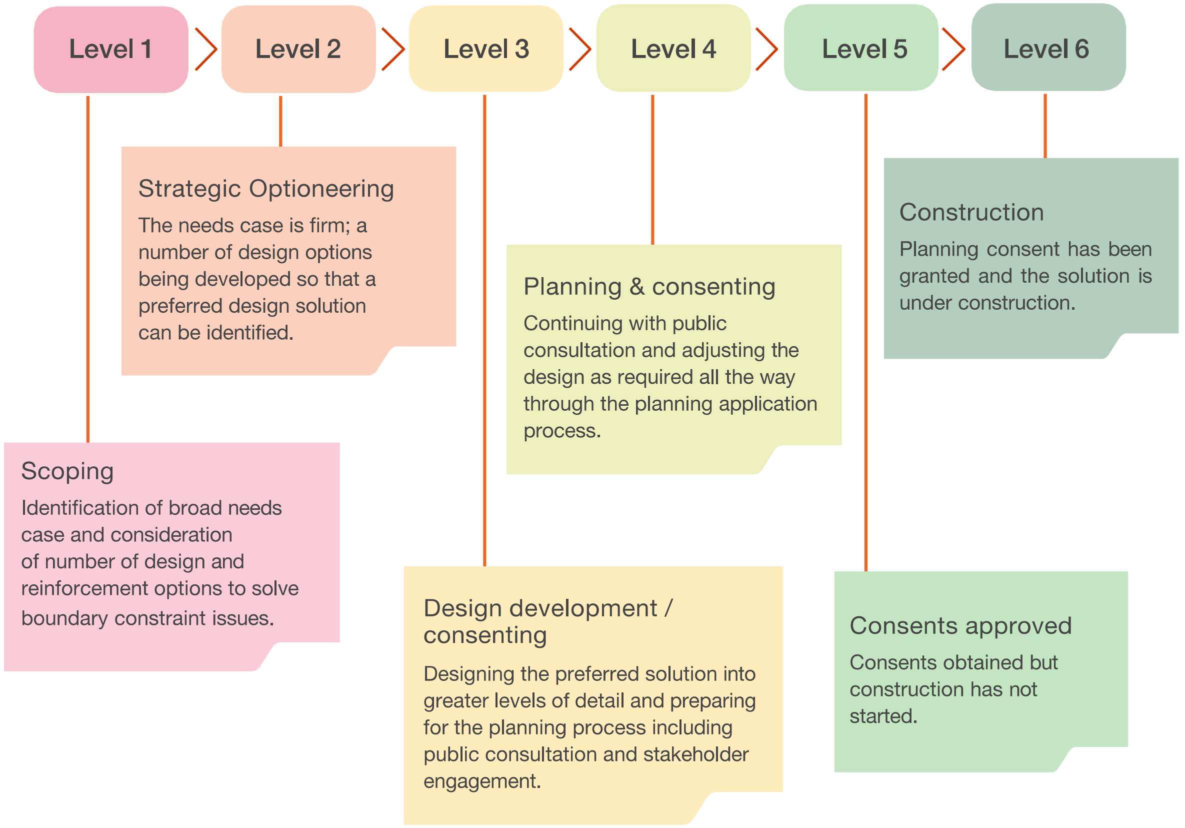


Figure 5: The DND process

Beyond 2030: Celtic Sea / Connecting the Celtic Sea 17

Stakeholder engagement

We have undertaken the evaluation against our design criteria in collaboration with a range of project stakeholders who have the relevant expertise and interest in this stage of network design. TOs, in scope developers' representatives for environment and for community have all contributed to inputting evaluation of our designs, helping us create the Final Recommendation. We have held a series of webinars, workshops and regular meetings with these stakeholders to gather information that we further appraise and consider as part of our option development. We would like to thank all of those who have contributed to this exercise and for their valuable feedback which has helped shape our process and outcome.

Beyond 2030: Celtic Sea / Connecting the Celtic Sea 18

Part 2: Developing shortlisted designs

Our design criteria helps us balance the impacts of new infrastructure with the benefits it can bring. We assess a wide range of current data to understand possible impacts on the environment and community earlier in the project development process, alongside economic and deliverability and operability assessments. This allows for better coordination between potential network solutions and enables our design to reduce the overall effect of new transmission infrastructure where it is possible to do so.

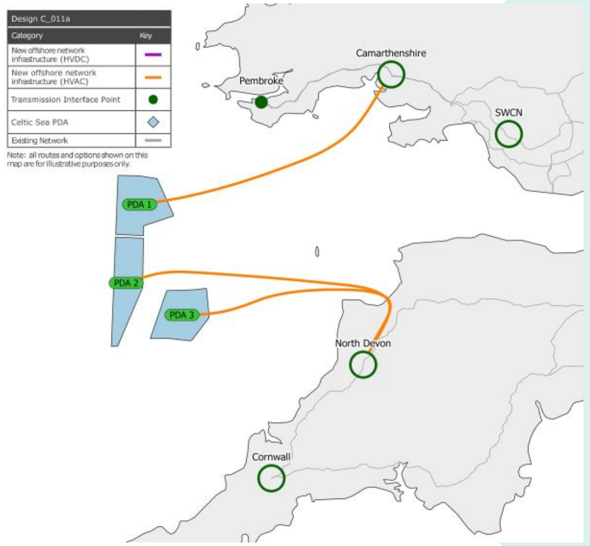
We use a broad and high-level methodology to complete this design exercise. The offshore wind developers and the Transmission Owner (TO) are responsible for building and maintaining the offshore assets and onshore networks. They take forward our recommendation and work on the Detailed Network Design (DND) to refine and improve on the high-level design.

The economic assessments we perform, alongside the other appraisals, analyse a range of forecast costs that may be passed on to energy bill payers. New infrastructure ultimately costs consumers money and we need to ensure best value, keeping in mind the need to give equal consideration to all four design objectives.

This balanced and holistic approach will help us to deliver against Great Britain's legally binding decarbonisation targets in a way that considers the impact on the environment, our communities, and every consumer.

Beyond 2030: Celtic Sea / Connecting the Celtic Sea 19

Part 3: Our shortlisted designs

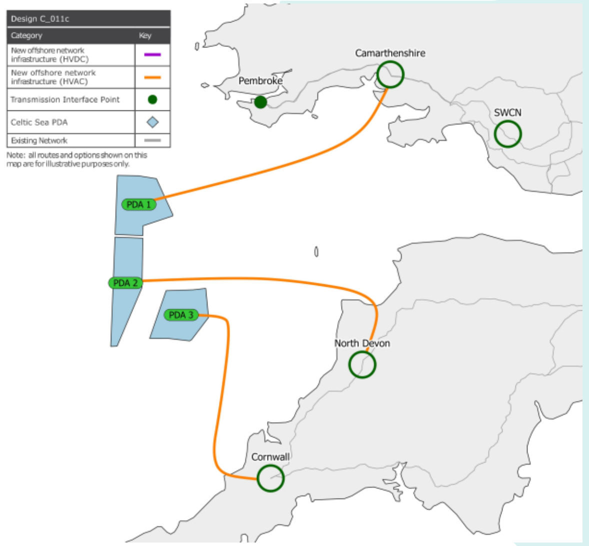


C_011a

Interface points: Carmarthenshire and North Devon.

We developed this design to test the concept of 3 GW into the South West of England and 1.5 GW into South Wales. All Project Development Areas (PDAs) are connected using a high voltage alternating current (HVAC) link connecting to a nearby interface point. We used this design to explore connections for PDA 1 to a proposed substation in Carmarthenshire and PDA 2 and 3 both into a notional site in North Devon.

Cable lengths are also an important factor when looking at the deliverability of designs. Greater cable lengths can often require additional compensation equipment along the route to ensure the power can travel longer distances (see information box for further details). We considered the cable lengths in this design to be in the range where standard solutions can be applied to deliver the connection at a lower cost.



C_011c

Interface points: Carmarthenshire, North Devon and Cornwall areas.

We used this design to explore an alternative concept to C_011a to connect 3 GW into the South West of England and 1.5 GW into South Wales. The main difference in this design is that we moved the PDA 3 link from North Devon to an indicative site in Cornwall to determine any differences to the onshore transmission network. We considered the cable lengths in this design to also be in a range where additional substantial voltage compensation would not be required (see information box).

PDA

PDAs are defined areas of seabed with fixed boundaries and geographical locations that define the maximum allowable extent of the floating offshore wind farms.

HVAC

High voltage alternating current is a type of electricity that flows back and forth in a cable and is used to transmit power over long distances.

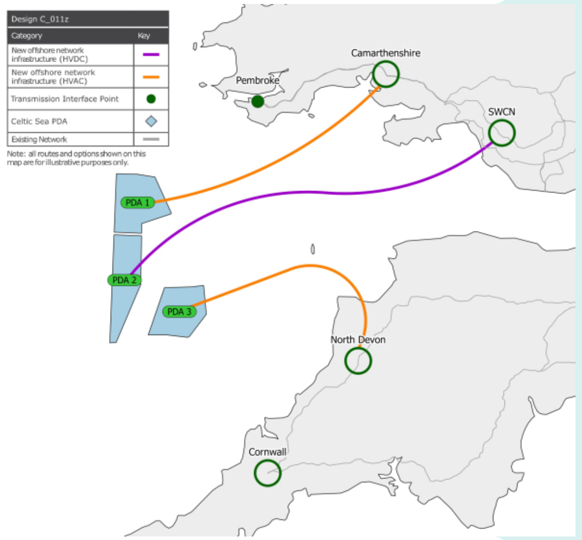
Mid-point compensation

Mid-point compensation is a method used in long-distance power transmission, where equipment is placed halfway along the power line to help boost voltage and reduce losses. This means power is moved more efficiently, especially for very long HVAC lines, where losses increase with distance.

Maps are illustrative and subject to change through Detailed Network Design

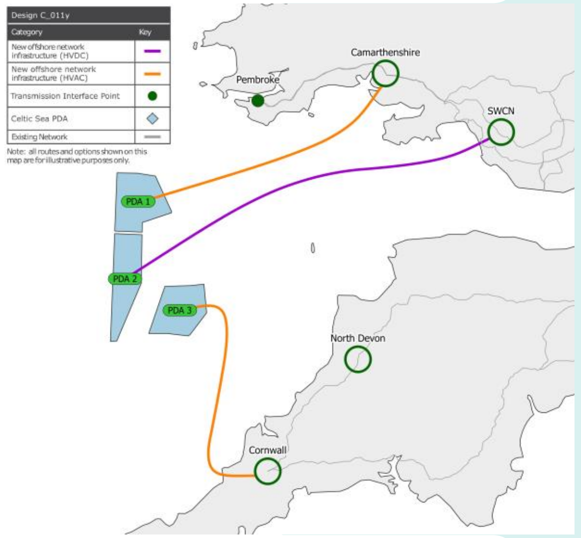
Beyond 2030: Celtic Sea / Connecting the Celtic Sea 20

Part 3: Our shortlisted designs



C_011z

Interface points:
Carmarthenshire, South Wales Connection Node, and North Devon



C_011y

Interface points:
Carmarthenshire, South Wales Connection Node and Cornwall

We used this design to investigate a conceptual connection of 3 GW into South Wales and 1.5 GW into the South West of England. The South Wales Connection Node (SWCN) was chosen for a new substation location due to its proximity to existing onshore circuits, development opportunity and ability to landfall cables.

We considered a distinguishing factor in this design to be the use of high voltage direct current (HVDC) technology. A benefit of this type of technology compared to high voltage alternating current (HVAC) is that it can carry electrical power over longer distances without the need of mid-point compensation mentioned above. We have considered the need for HVDC converter substations in our designs. This is because our onshore transmission network uses HVAC, therefore the power generated offshore would need to be converted to HVDC to travel long distances and then be converted back so that is can be used in our onshore network. However, these converter stations do have an impact across the four design objectives, as they are similar in appearance to a commercial warehouse.

C_011y has many of the strengths of C_011z above, however, we used this design to explore an alternative way to connect 3 GW into South Wales and 1.5 GW into the South West of England. For this design we moved the PDA 3 link from North Devon to an indicative Cornwall location to test any variations compared to C_011z.

More detail on other less-favoured designs is available in the *Technical Annex* to this document.

HVDC

High voltage direct current is a type of electricity that flows in one direction and is used to transmit power over very long distances, even farther than HVAC and incur less power losses than an equivalent HVAC line.

Converter stations

A converter station is a facility that changes electricity from HVDC to HVAC or vice versa. This is necessary because HVDC is good for sending power over long distances, but most homes and business use HVAC.

Maps are illustrative and subject to change through Detailed Network Design

Beyond 2030: Celtic Sea / Connecting the Celtic Sea 21

Part 4: Appraisals

We supplemented the assessments in our design process across all four design objectives with feedback from a number of stakeholder groups, with the aim of enriching our understanding in each area. We have collected this through regular discussions with our stakeholders, both individually and within specially created working groups. We have used this additional information to support and refine our shortlisted designs.

Deliverability and operability

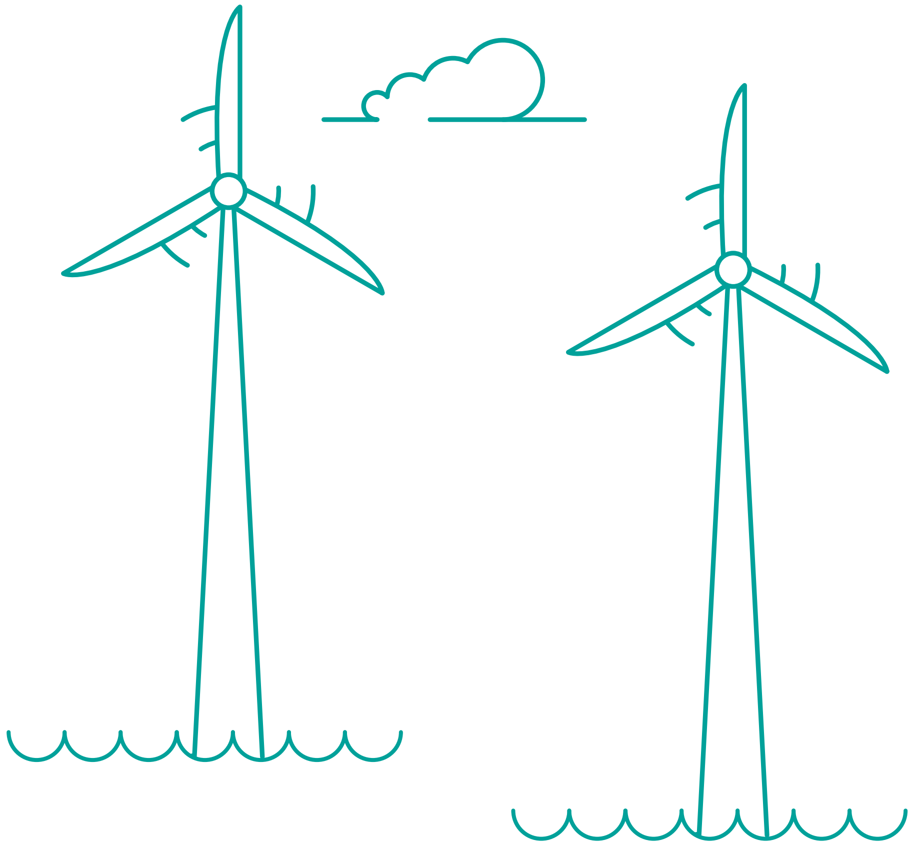
We found that designs that rely on high voltage alternating current (HVAC) technology (C_011a and C_011c) could be considered more conventional and favourable in terms of deliverability. However, as we have identified, both these designs indicated the need for a new overhead line in the South West. When we looked at the design holistically, we considered the combined effect of this made these designs a greater risk from a deliverability perspective.

For C_011a we identified that the design may face challenges in having two proposed offshore wind farm sites landing onshore at the same location in Devon. We considered the opportunities in coordinating the construction here because the location has limited space and is also the preferred landing point for another major project. We were concerned, however, that if the number of cables required for any of these projects increased this would create challenges as there are space constraints at the landfall.

C_011c on the other hand needs a new substation in the Cornwall area. Additionally, to reach the substation there are potentially physical constraints that would make connecting into the Cornwall area more difficult than some alternatives.

Designs C_011y and C_011z are not reliant upon the construction of a new overhead line, however, both will need a new substation in South Wales. C_011y will also need one in the Cornwall area. These designs use high voltage direct current (HVDC) technology for one connection into South Wales, which is a less-familiar alternative to AC, and needs an onshore converter station.

We found that by reducing the number of new substations required, avoiding both the need for a new overhead line in the South West, and the potential physical constraints of connecting into Cornwall – or having two connections into Devon – the routes and landfall locations for C_011z bypass a number of challenges that are apparent in the other three designs.



Beyond 2030: Celtic Sea / Connecting the Celtic Sea 22

Enivronment

After appraising the environmental design objective, we identified that advantages of one design over another depending on whether offshore routes crossed environmentally protected sites, and how sensitive those sites are to cables being installed.

We found the best offshore designs were ones that either minimised the number of interface points where cables come ashore or reduced the number of cables, and therefore trenches, that would be needed. C_011a only uses two landing points, while C_011y and C_011z reduce the number of cables needed by using high voltage direct current (HVDC) technology for one of the routes. Fewer trenches would mean less disturbance to habitats and species between wind farm sites and interface points.

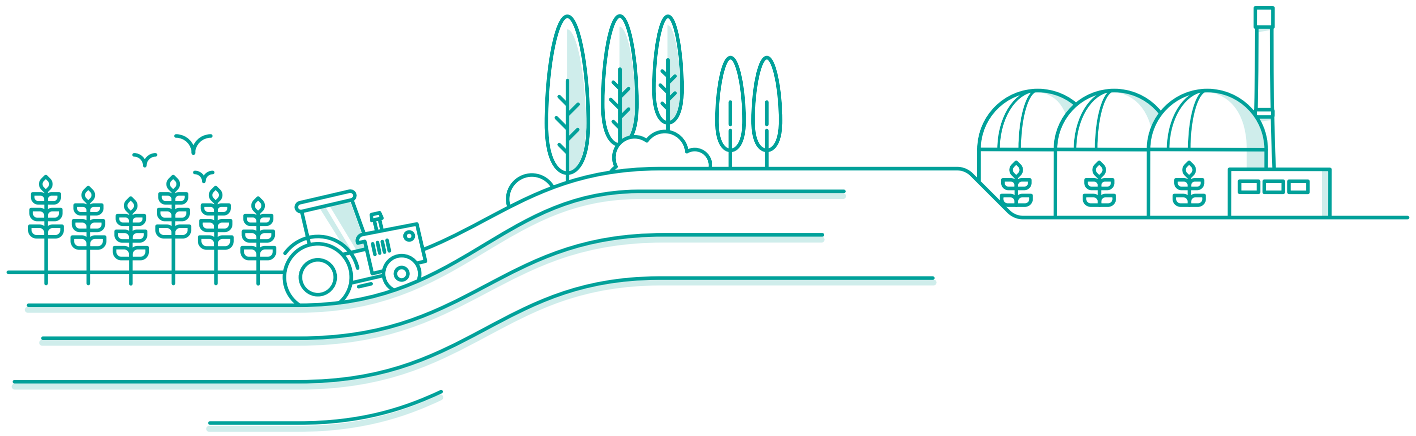
When we looked at onshore impacts, it was clear all designs needed new substations due to the constraints at the existing substations in South Wales and South West England. We worked with the Transmission Owner (TO) to understand where there may be opportunities to align our designs to locations where investment is already being considered, even at an early scoping level (for example for other connections). This promotes efficient network growth and offers a chance to reduce the environmental footprint of designs through coordination.

We identified opportunities for alignment with the wider network needs to reduce the overall environmental footprint in Carmarthenshire and North Devon. Design C_011a only required these two interface points, and so, if coordination could be achieved when landing in Devon, this design could lessen the overall environmental impact when compared to the other designs, which have three interface points. C_011c and C_011y both require an additional substation in the Cornwall area.

Designs C_011y and C_011z utilised a new connection in South Wales (South Wales Connection Node (SWCN)). We found the approach to this area avoided a number of more sensitive environmental constraints present on the approach to other interface points. We considered some of the existing land use around the Port Talbot area as providing opportunities for a lower impact when looking forward to future potential growth in the area.

When considering the impact of reinforcements to the onshore network we discovered that designs connecting 3 GW to the South West (C_011a and C_011c) require a new overhead electricity line in the region, specifically to enable the connection of HNDFUE: Celtic Sea. We considered that the need for a new overhead line increases the environmental footprint of these two designs. By contrast, designs with 3 GW into South Wales (C_011y and C_011z) do not show the need for a new overhead line to be built to connect the generation based on the studies carried out by the TO at this stage. We considered this a significant distinguishing factor for the environmental design objective.

We recognise that HNDFUE: Celtic Sea is one of several future potential demands on the onshore transmission network, and therefore further infrastructure may be necessary and recommended in the future for other connections in this region.



Part 4: Appraisals

Economic

When we completed our economic assessments, it was clear that C_011z and C_011y cost more to deliver than either C_011a or C_011c. The main reason for this was the use of HVDC cable, which is currently a more expensive technology according to the data we had available. We saw these higher costs being associated with the supporting offshore and onshore infrastructure required to convert from HVDC to HVAC.

We saw that the least expensive designs use only HVAC technology, which is more readily available and does not need to be converted for transmission on our electricity network in the same way. However, the impacts seen across other design objectives indicate the least expensive solution does not score highest across all factors considered.

We also recognised with designs connecting 3 GW into the South West that there may be additional specific operational services costs. We had not quantified this as part of our methodology due to how much can be forecast at this strategic phase. We therefore considered the risk that the cost of the more economic designs (C_011a and C_011c) could increase under some scenarios.

Beyond 2030: Celtic Sea / Connecting the Celtic Sea 24

Part 4: Appraisals

Community

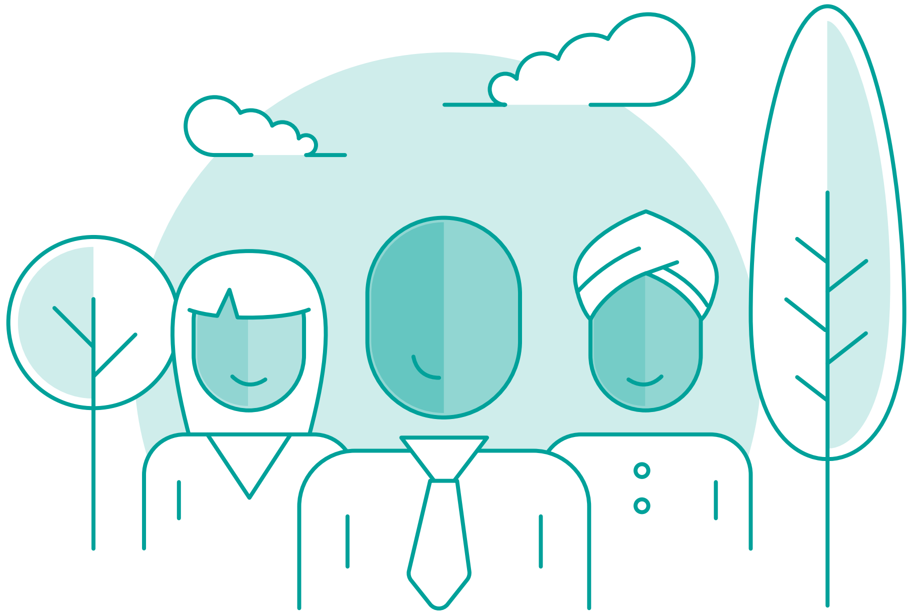
We found the offshore routes performed well against the community objective across all four designs. Of the four routes used, the two in South Wales avoid significant community constraints, while in the South West some significant sites such as heritage coasts and trails cannot be avoided at landfall.

We did identify those designs that connect two of the offshore wind farms into the South West (C_011a and C_011c) showed higher community impact. We found the indicated new overhead line in the region increased the onshore impact on local communities and cultural heritage assets.

We identified the most favourable designs from the community objective are those that connect two proposed offshore wind farms into South Wales (C_011z and C_011y) because fewer onshore reinforcements are needed, and so there would be less interference with local communities and cultural heritage assets both during construction and longer term.

All designs rely on connections to substation sites that are not yet built or consented. The volume of connection application in the area has been increasing, and the TO has been considering a pipeline of works to facilitate these connections with new connections nodes. We have worked with the TO to identify which regions have an existing need for a new substation. Carmarthenshire and North Devon are two such areas. The potential to align HNDFUE Celtic Sea with these areas is considered an advantage. This is because alignment with other infrastructure needs could lead to a more coordinated approach to locating new substations.

Doing so would reduce the number of substation sites required to be built for the sole purpose of delivering HNDFUE Celtic Sea. This helps to reduce the potential footprint of the Celtic Sea design. All shortlisted designs make use of the opportunities to align with the wider network needs in Carmarthenshire and North Devon. C_011c and C_011y both require an additional substation in the Cornwall area, while C_011y also needs an additional substation in South Wales (SWCN), although a substation in this area also presents an opportunity to increase the available capacity for future leasing rounds. C_011a relies solely on the Carmarthenshire and North Devon locations. C_011z needs the addition of a third substation at SWCN, although a substation in this area also presents an opportunity to increase the available capacity for future leasing rounds.



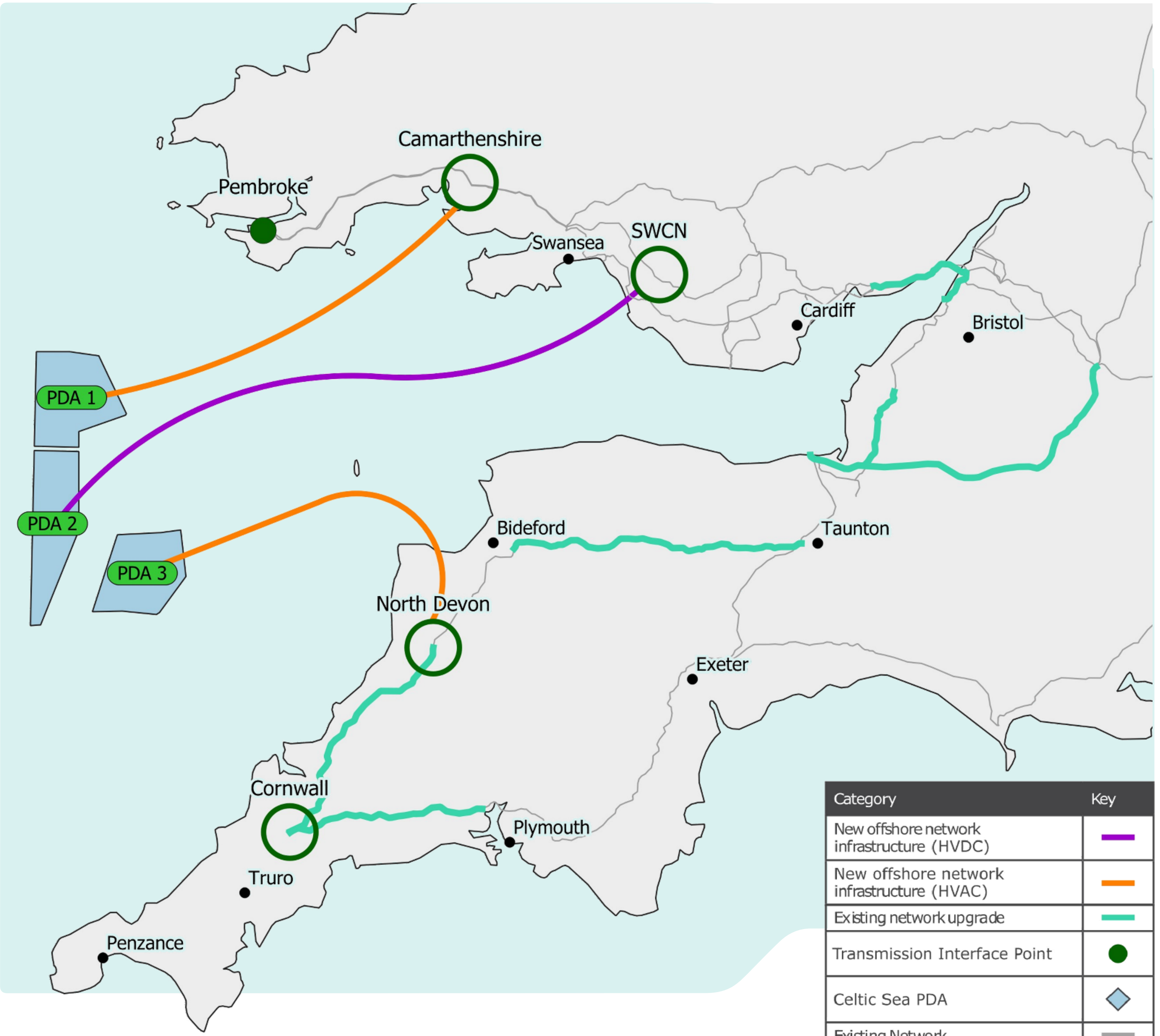
Beyond 2030: Celtic Sea / Connecting the Celtic Sea 25

Part 5: The Recommendation

Our Recommended Design connects 3 GW into South Wales and 1.5 GW into the South West. Each of the proposed offshore wind farms has its own connection to the onshore electricity network, with Project Development Area (PDA) 2 being a high voltage direct current (HVDC) connection into the potential new South Wales Connection Node (SWCN). Meanwhile, connections from PDA 1 and PDA 3 use high voltage alternating current (HVAC) technology with routes to Carmarthenshire and North Devon. Design C_011z performed favourably compared to the other shortlisted designs when balanced across all four design objectives and has the lowest level of known risk to its timely development and delivery of the shortlisted designs.

While our Recommended Design is less economic than some others we have considered, it does offer advantages in terms of environmental impact and community impact. We considered that the HVDC connection to a new SWCN does add some cost and complexity in terms of the deliverability and operability, however the route to the landing point does avoid several designated environmental areas. The reduction of onshore works is also an advantage for our recommendation. Some of the other designs did indicate onshore reinforcement in the South West in the form of a new overhead line to meet the specific need of the Holistic Network Design Follow Up Exercsie (HNDFUE) Celtic Sea, however our Recommended Design did not. We recognise that HNDFUE Celtic Sea is one of a number of future potential demands on the onshore transmission network, and therefore further infrastructure may be necessary and recommended in the future for these regions. This would be determined through the usual network planning process.

Customer demand for grid connections is rising and increasing capacity can bring wider benefits to local and regional industries. Connection of the HNDFUE Celtic Sea to substation sites which are located strategically, to address multiple needs, is an advantage. Our Recommended Design makes use of two such sites in Carmarthenshire and North Devon, while a new connection hub in South Wales will allow more major projects to connect in these regions, further boosting local economic growth and aligning with Welsh policy on green jobs and net zero. It could also pave the way for the connection of future offshore wind developments. This would be subject to further assessments of the onshore network.



Category	Key
New offshore network infrastructure (HVDC)	
New offshore network infrastructure (HVAC)	
Existing network upgrade	
Transmission Interface Point	
Celtic Sea PDA	
Existing Network	

Note: all routes and options shown on this map are for illustrative purposes only.
The network upgrade works shown were based on the onshore assessments conducted for HNDFUE: Celtic Sea

Maps are illustrative and subject to change through Detailed Network Design

Beyond 2030: Celtic Sea / Connecting the Celtic Sea 26

Part 5: The Recommendation

We did identify some other interface points with similar opportunity for growth from infrastructure, such as in Cornwall. The designs for this phase of Celtic Sea offshore wind did not perform quite as well as our recommendation across our design objectives. We do acknowledge the role that we, as the Electricity System Operator (ESO) may yet have to play in these areas. We will work with stakeholders through our work on the Regional Energy Strategic Plan (RESP) to look at and facilitate economic benefits in the region.

Building infrastructure has an impact. In developing the design, we have considered the location of interface points to reduce the impact on the environment and local communities. The HVDC connection of PDA 2 to South Wales reduces the overall number of cables in the marine environment, and we have assumed buried cables will be used for all routes from offshore platforms to the onshore transmission interface point. This is a significant reduction of visual impact compared to using overhead lines.

The Celtic Sea Round 5 is the first phase of broader floating offshore wind development in the region. Further, potentially larger developments of offshore wind could be deployed by 2050. Our recommendations make the most efficient use of the current onshore network, when accounting for other projects scheduled to be connected. The creation of a new SWCN could help to facilitate further economic growth. We also hope to carry forward what we have learned to any future designs in this region and continue to collaborate closely with the Transmission Owner (TO) and The Crown Estate (TCE) among other stakeholder groups.

Beyond 2030: Celtic Sea / Connecting the Celtic Sea 27

Next Steps

ESO

Next steps

What happens next

Concurrent with the publication of this recommendation in August 2024, we are expecting The Crown Estate (TCE) to issue an Invitation to Tender for qualified and registered bidders, followed by an auction process. This is expected to result in agreements for lease of the seabed to successful developers to deliver the floating offshore wind projects described in this document.

Given the radial configuration, Ofgem does not intend to produce a separate asset classification publication. Once the successful developers are identified, we will work with each developer to produce connection contract offers allowing the projects to connect to the electricity network. Our unique approach with the Celtic Sea will allow us to efficiently manage and remove more than 20 GW of registered connection capacity with little anticipated disruption to other customers and connections.

We will also work with the host Transmission Owner (TO), National Grid Electricity Transmission (NGET), to continue development on relevant works for this recommendation as it progresses into the Detailed Network Design stage.

We also intend to continue to work closely with TCE for consideration of seabed leasing opportunities and the associated network designs to meet the future offshore wind generation ambitions.

Beyond 2030: Celtic Sea / Next steps 29

Get involved in the debate on the future of energy and join our LinkedIn group:
Future of Energy by National Grid ESO

For further information on ESO publications please visit: **nationalgrideso.com**

Write to us at:

**Electricity System Operator, Faraday House,
Warwick Technology Park, Gallows Hill
Warwick, CV34 6DA**

@National GridESO

National Grid ESO

National Grid ESO

Email ESO

ESO

[7] These documents are: *Celtic Sea Technical Annex, Pathway to 2030 and Beyond 2030*
[8] https://assets.publishing.service.gov.uk/media/64ef6dc513ae15000d6e30de/otnr-hnd-fue-tor.pdf