Beyond 2030: INTOG

December 2024

NESO
National Energy System Operator

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Executive Summary

To support this ambition of the North Sea Transition Deal (NSTD) and with the additional aim of boosting offshore innovation, Crown Estate Scotland (CES) launched the Innovation and Targeted Oil and Gas (INTOG) offshore leasing round in August 2022.

Offshore wind has been identified as a critical technology in achieving net-zero greenhouse gas emissions by 2050. By coupling this technology with high-emissions industries, such as oil and gas production, the energy industry can substantially reduce its carbon footprint.

Connecting existing energy industries with these new emerging sectors such as floating offshore wind will allow everyone in the energy industry to move towards a net-zero future together. This relationship creates a link that allows for the retention and retraining of existing jobs and safeguarding economic opportunities while laying the groundwork for future transition.

The National Energy System Operator (NESO) has carried out a holistic network design (HND) exercise to recommend how to connect a collection of in scope INTOG projects to the onshore electricity network. In determining the recommended design presented in this report, we considered four network design objectives on an equal footing: total cost, deliverability and operability, community impact and environmental impact.

North Sea Transition Deal

The NSTD aims to reduce greenhouse gas emissions by 50% by the year 2030. A key enabler of this is the progressive decarbonisation of oil and gas platforms in the UK Continental Shelf.

Our analysis has shown that the electrification of offshore oil and gas platforms enabled by the connection of INTOG projects in line with our recommended design has the potential to achieve an emissions reduction of up to a peak of 3.5 million tons of CO_2 per year in the early 2030s. **This is the equivalent carbon reduction of taking over 2.4 million cars off the road for a year[1].**

[1] Average CO2 emissions of newly registered cars, DfT: www.gov.uk/government/publications/new-car-carbon-dioxide-emissions

Executive Summary

Recommended Design

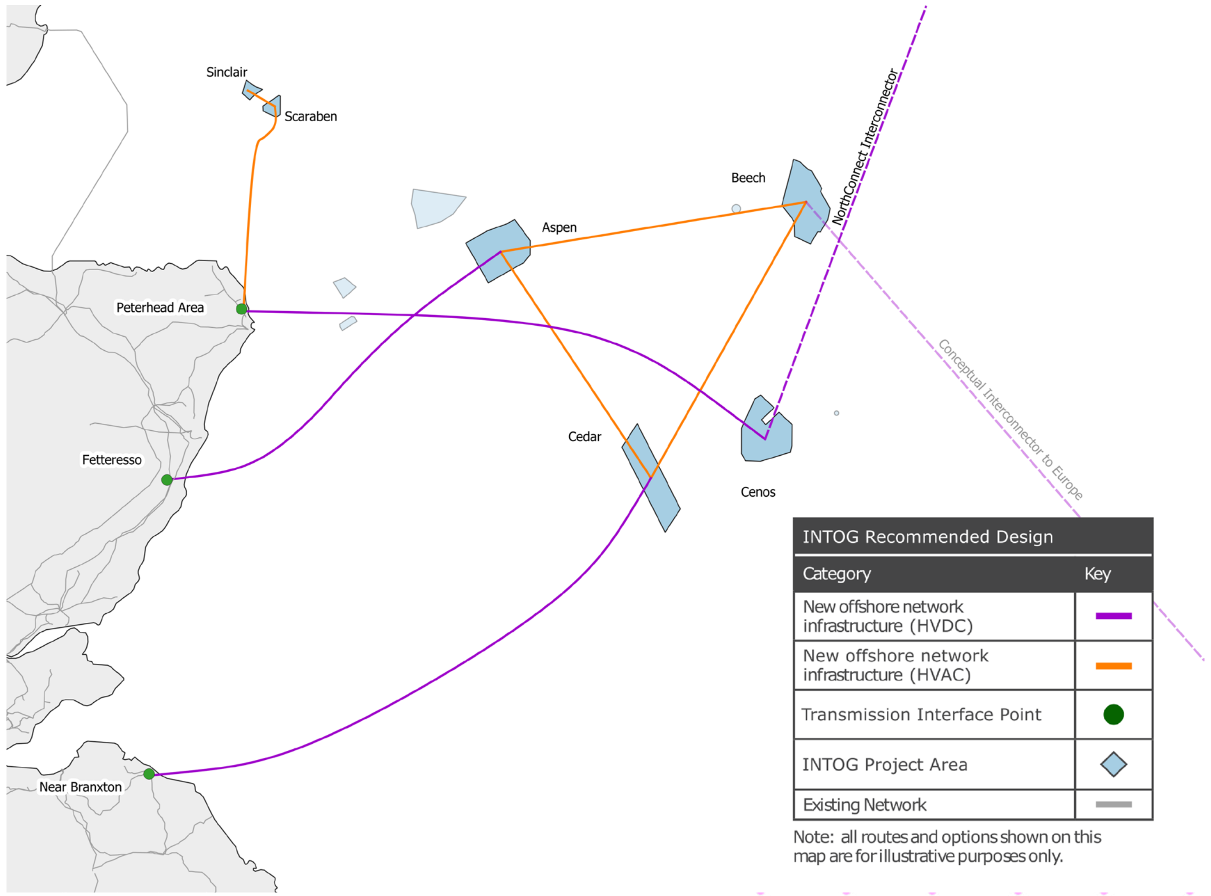
Our recommended design allows developers to focus on building their demand connections as soon as they can, enabling the decarbonisation of offshore oil and gas platforms. This lays the foundation for the Targeted Oil and Gas (TOG) projects to connect and export excess power later as soon as the network allows.

Through this recommended design, we aim to unlock the decarbonisation potential of INTOG and support the ambitions of the NSTD. This design allows both project types within INTOG to meet their lease requirements, and to support the wider NSTD.

The Innovation (IN) sites connect to the onshore network through a coordinated shared circuit to shore. This unlocks their potential as a testbed for innovative floating offshore wind technology.

We have engaged with a broad range of stakeholders while determining this recommended design, including representatives from regulatory bodies, national and devolved government, environmental stakeholders and Transmission Owners (TOs).

Figure 1: **Recommended INTOG design**



Executive Summary

Key Messages

01

The INTOG design enables opportunities for innovation in floating offshore wind...

The recommended design connects innovation projects in a manner which retains the benefits of offshore project coordination, while providing flexibility for the projects to be designed, built and operated to create a testbed for new innovative offshore wind technologies.

02

The INTOG design enables North Sea oil and gas platforms to decarbonise through electrification...

The recommended design enables TOG projects to connect to the onshore network to provide electricity to offshore oil and gas platforms to electrify and decarbonise. Our design provides a connection that reduces impact on the environment and local communities, while remaining deliverable, economic and efficient.

03

The INTOG design facilitates the earliest electrification for offshore industries...

Using onshore interface points with the earliest availability dates, the oil and gas demand can be connected as soon as possible, with the opportunity coming later to export electricity to the onshore grid. This maximises the emission reduction benefits, although we do acknowledge the later export creates risks for developers. This is a first step, with more work to follow on generation export dates and opportunities in onshore transmission acceleration, Clean Power 2030 and Connections Reform.

04

The INTOG design connects projects that contribute to our wider net-zero targets...

All projects within the INTOG leasing round can make a meaningful contribution to the UK's wider net-zero targets. Innovative new offshore wind technologies will expand industry knowledge of this technology type, and the decarbonisation of offshore oil and gas can unlock large emissions reductions and support jobs in the North of Scotland as the energy industry transitions to a net-zero future.

Executive Summary

Next Steps

This recommendation represents the first step in realising the aims of the INTOG leasing round. Following the publication of this recommended design, we will continue to work closely with the wind farm developers to update their existing connection contracts to align with our design recommendation. This process will be led by NESO's customer connection teams in close collaboration with the relevant TO for each connection site.

Where frameworks relevant to the design are still in development, such as multipurpose interconnectors (MPIs), we will continue to work with government departments, TOs and wider stakeholders to apply them to the relevant areas of the recommended design.

NESO is currently undergoing the final preparatory work for an industry-wide connection reform programme, and these projects will be assessed under the new assessment processes associated with this in 2025, for both the demand and generation elements of each project. When combined with the outcomes of Clean Power 2030 and desire for transmission acceleration this recommendation can be seen as a first step with opportunities for strategic acceleration.

We will also continue to work closely with the Department of Energy Security and Net Zero (DESNZ), CES, with the Office of Gas and Electricity Markets (Ofgem) and the North Sea Transition Authority (NSTA) to support the continued development of innovative offshore technologies and the wider electrification of oil and gas production in the North Sea.

Introduction

Introduction

The National Energy System Operator (NESO), is an independent public corporation at the centre of the energy system taking a whole-system view to create a world where everyone has access to reliable, clean and affordable energy.

The challenge

Tackling climate change is truly the challenge of our generation; addressing energy security, sustainability and affordability for everyone is at the forefront of the global agenda and drive to meet net zero.

It is our job to transform the whole-energy system to meet these challenges and transition to a low-carbon future, embracing new technologies and cleaner generation sources, always with the cost to the consumer in mind.

We are at the heart of the energy landscape, energised by collaboration, curiosity, and innovation; creating a future where everyone has access to clean, affordable, reliable energy. We embrace the opportunity to be the catalyst for the energy transformation, working hand in hand with government and industry, for the benefit of communities across the nation.

Through this design process for Crown Estate Scotland's (CES) Innovation and Targeted Oil and Gas (INTOG) leasing round, we are continuing to build towards a future net-zero energy system.

Introduction

The INTOG leasing round is designed to fulfil two aims: to aid progress against the North Sea Transition Deal (NSTD) by enabling offshore wind farms to electrify North Sea oil and gas platforms, and to provide a platform for innovative offshore wind technologies. To achieve this, the projects included in this leasing round are categorised as either Innovation (IN) or Targeted Oil and Gas (TOG).

IN projects are small scale wind farms that have a capacity of 100 MW or less. These will showcase new and innovative offshore wind technologies such as floating offshore wind turbines.

TOG projects have the additional aim of supplying renewable power to offshore oil and gas platforms. This can reduce or remove their on-site fossil fuel powered generation used on platforms for providing heat and power. The TOG projects in scope for this design exercise are all large-scale projects of at least 1 GW, and in addition to a connection to the onshore network to export the power they generate, this onshore connection will also be used as a backup power source for 'electrified' oil and gas platforms to ensure security of supply during periods of low wind.

Our holistic network design process is guided by a set of high-level principles collectively known as the Terms of Reference (ToR), which were determined by the Department for Energy Security and Net Zero (DESNZ) as part of the Offshore Transmission Network Review (OTNR).

We have implemented the ToR through our design recommendation for INTOG, and this builds on top of previous design recommendations we have made for other projects as part of the *Pathway to 2030, Beyond 2030 and Beyond 2030: Celtic Sea publications.* The map in Figure 2 shows a current view of the seabed leases for offshore wind farms, and highlights those considered for coordination in both this document and the previous publications mentioned above.

In Scope Projects

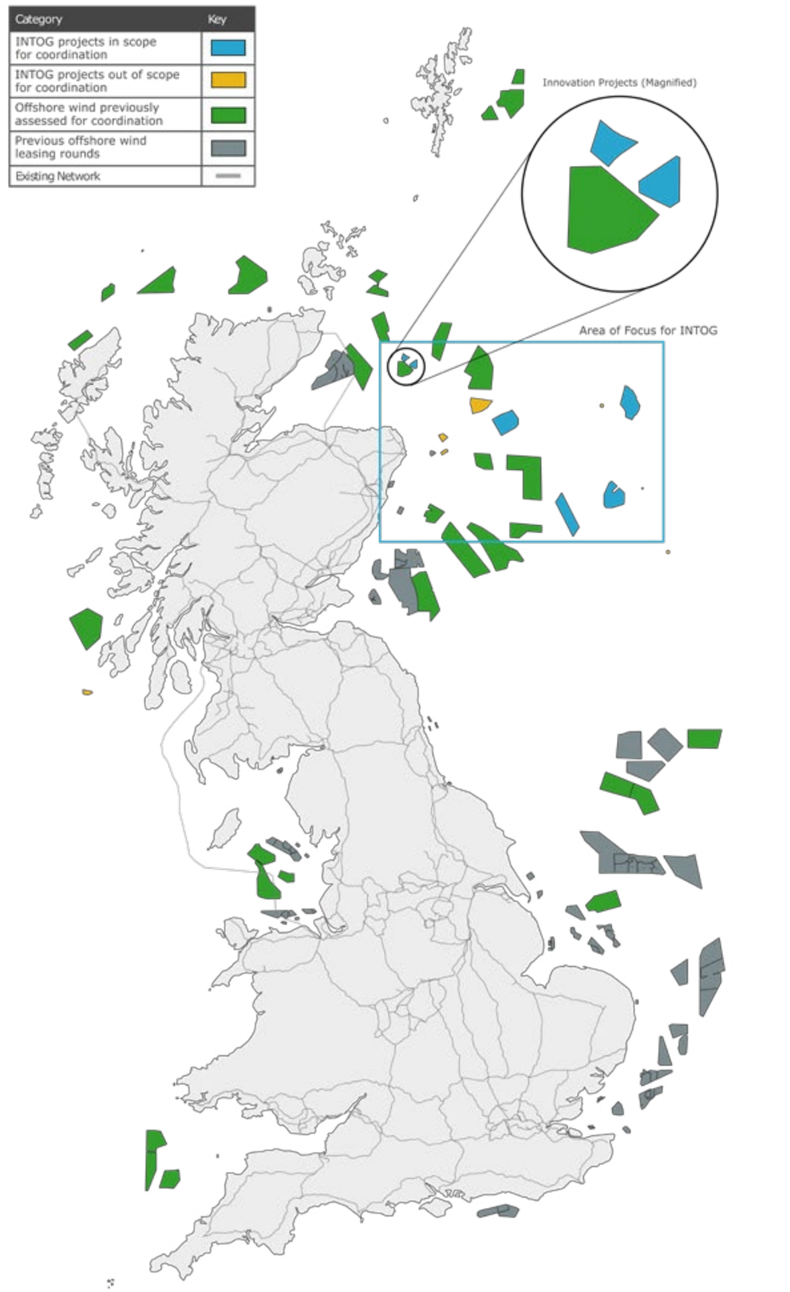
While the INTOG leasing round includes twelve different projects, there are only six in scope of this design process.

Projects were selected as either in scope or out of scope at the beginning of the INTOG process. Projects were designated as out of scope, and therefore not eligible for consideration in this process, when the potential benefits of coordination would either be minimal, or the project was deemed to be too far progressed to be altered as part of this design process.

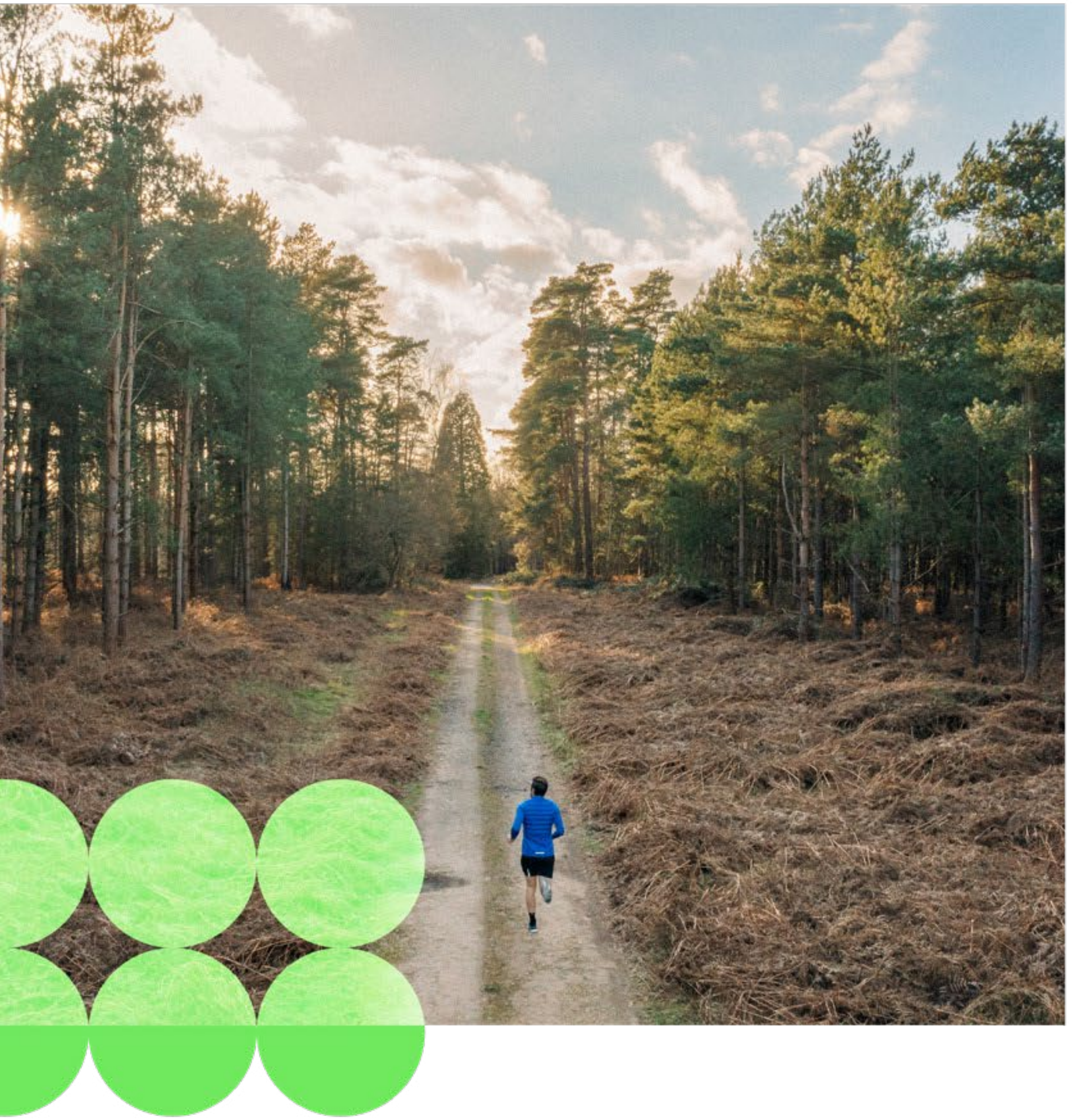
Some TOG projects are also intended to be islanded, meaning they directly supply oil and gas platforms with no intended connection to shore. These projects are also out of scope of this design process.

The NorthConnect interconnector, a planned interconnector between Scotland and Norway, was also included in scope of the INTOG design process to evaluate the potential benefits of coordination with an interconnector.

Figure 2: Offshore wind projects in Great Britain



Introduction



For more detail on our network design processes and wider recommendations, there is a suite of additional publications that explore this. The *Pathway to 2030* and *Beyond 2030* documents were published by the Electricity System Operator (ESO), the predecessor to NESO.

1. INTOG Supplementary Report

The *INTOG Supplementary Report* provides greater detail on our design recommendation for INTOG. It also outlines the performance and appraisal results of each shortlisted design, and the decisions taken to reach our final recommendation.

2. Pathway to 2030

The Holistic Network Design (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.

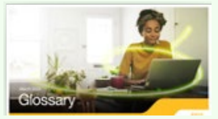
4. Glossary

The standalone *Glossary* explains the more technical terms used across the suite of documents.

INTOG Supplementary Report

Pathway to 2030

Beyond 2030 Report



Glossary

Connecting INTOG

Connecting INTOG

Determining a Recommended Design

To determine the recommended Innovation and Targeted Oil and Gas (INTOG) design, we carried out a design process that takes place over five steps, as shown opposite. This process was first implemented at the beginning of the wider Holistic Network Design Follow Up Exercise (HNDFUE) and was developed in collaboration with our key stakeholder groups, including representatives from regulatory bodies, government, environmental stakeholders and Transmission Owners (TOs). We also considered feedback received from the development of the first Holistic Network Design (HND).

When developing our design recommendation, we considered a total of 52 unique designs to connect both the Innovation (IN) and Targeted Oil and Gas (TOG) projects. Design variations and sensitivity tests of some of these designs were also explored in addition to this initial longlist of designs.

Designs were split into IN designs and TOG designs for assessment in this process, based on the category of projects they considered. The IN and TOG projects were considered separately due to differences in both geographic location and project scale between the two project types.

A longlist of six design options were considered for the IN projects, evaluating several different levels of coordination. This was then evaluated in the initial strategic options appraisal (ISOA) stage, and narrowed down to two design options for analysis at the final strategic options appraisal (FSOA) stage.

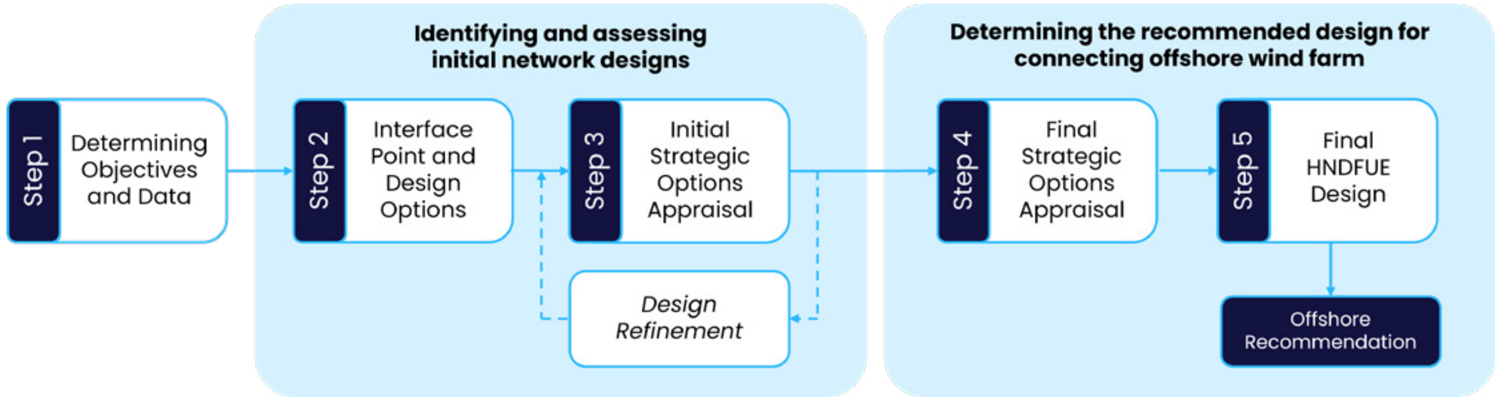
A larger longlist of 46 design options were considered for the TOG projects. Designs for these projects were drafted and assessed across six categories, testing various combinations of interface points used and levels of coordination for both offshore wind projects and the NorthConnect interconnector.

Interface Points

When developing the initial longlist of designs, 14 different interface points were considered for connection for the TOG sites. These were located across the North East coast of the Great Britain and included a combination of existing and new substations.

A singular interface point was considered for the IN projects. Due to the smaller size of these projects and their location off the Moray coast, there were less interface points available in this region. In addition to this, both IN projects had progressed existing plans to connect at this singular interface point, and it was determined that there was no advantage to be gained across any of our design objectives by moving this connection to a further interface point.

Figure 3: HNDFUE Process



Connecting INTOG

Determining a Recommended Design

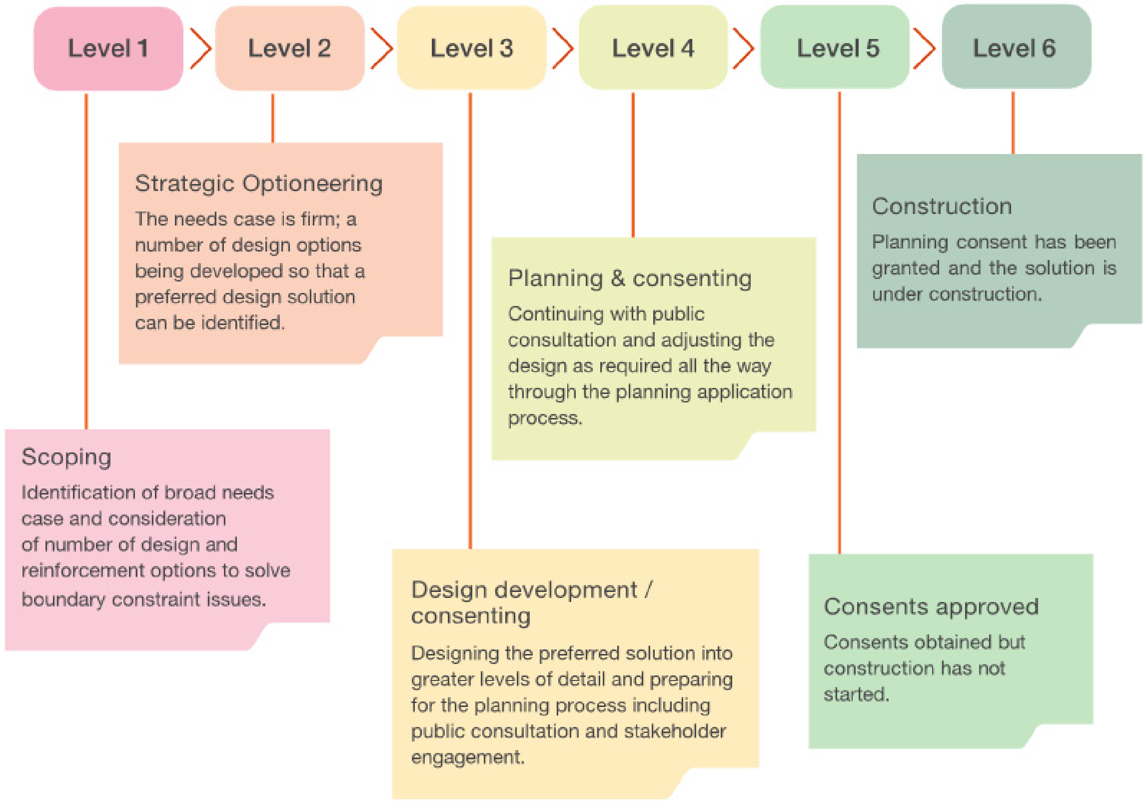
Table 1 shows the network design objectives that designs were assessed against throughout the INTOG design process. We are directed by the Terms of Reference (ToR) to consider these objectives on an equal footing. By assessing our network designs against these four design objectives, we aim to balance the benefit that offshore wind can bring with the potential impacts of developing it.

Table 1: Network 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 the 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.

The design recommendation presented in this document is at an early stage of development. Within the wider context of project development stages shown in Figure 4, the INTOG design process can be considered as Level 1, where a number of design options have been considered.

Figure 4: Project design stages



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Determining a Recommended Design

When carrying out our design appraisals and assessments, and ultimately determining the final recommended design, we have worked closely with a range of stakeholder groups who were able to provide specific expertise and advice across our design objectives.

We conducted 82 stakeholder meetings throughout the INTOG design process, and received 18 individual pieces of formal feedback from those consulted, which has allowed us to make better informed choices at every stage of this process.

Figure 5: Examples of stakeholders consulted

- Transmission Owners
- Regulatory and Governmental Bodies
- Statutory Nature Conservation Bodies
- Technology Providers and Trade Associations
- Devolved Government
- Crown Estate Scotland
- In Scope Developers

Connecting INTOG

Developing and Shortlisting Designs

In our initial strategic options appraisal (ISOA), we carried out high-level analysis on each of the shortlisted designs for both the IN and TOG projects to determine a shortlist of designs to be passed on for further, more detailed analysis at the final strategic options appraisal (FSOA) stage.

Once all designs appraisals were complete, the design longlist was narrowed down to a shortlist for both sets of designs. The IN designs were considered as a whole, and once poorly performing designs were discounted two designs were shortlisted.

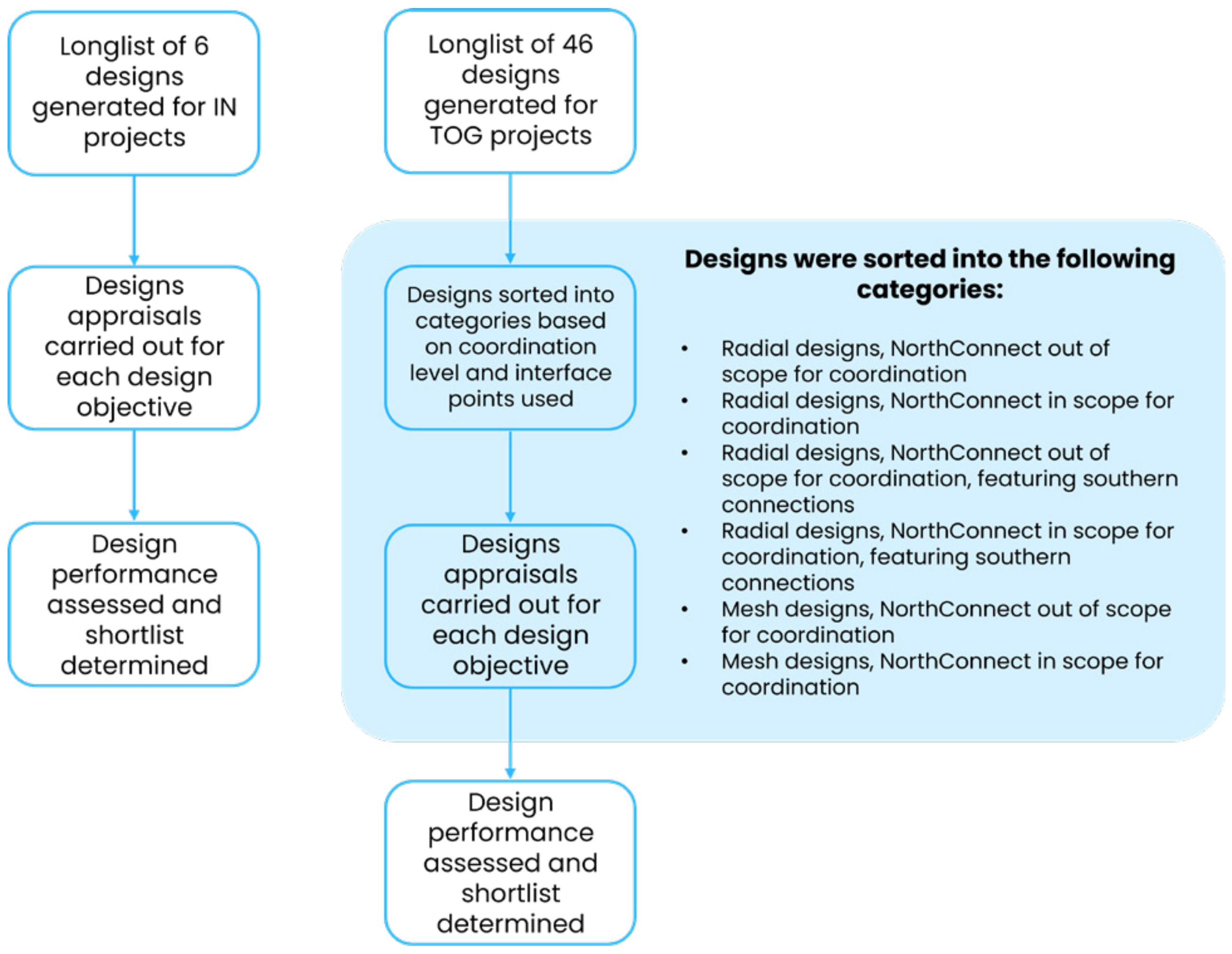
To aid the shortlisting process, and to manage the increased size of the TOG design longlist, the TOG designs were sorted into six categories, and then each category assessed as a distinct group, with a single shortlisted design being determined from each for a total of six shortlisted TOG designs. These categories were chosen to test three key factors in the TOG designs: topology type, coordination with NorthConnect, and southern connections.

The topology types tested here were radial designs, where projects connect directly to shore without interacting or coordinating with projects from other developers, or mesh designs, where there is coordination and interaction between developers and their respective projects.

Coordination with the NorthConnect interconnector was also tested here to determine and quantify the benefit of projects forming a coordinated solution with NorthConnect, exploring the impact on both connection timescales and the ability to export power to additional markets.

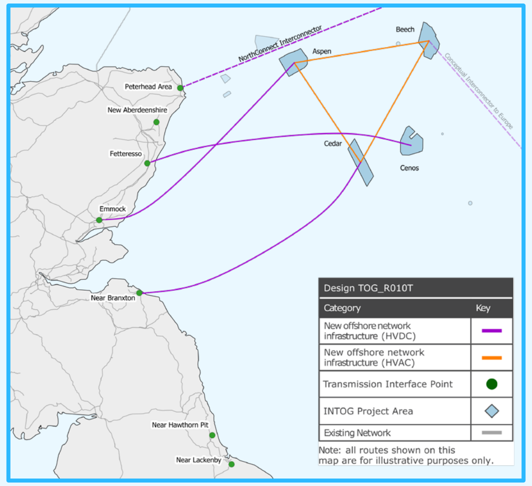
Lastly, the impact of designs connecting further down the coast in North East England was tested to determine if there were any efficiencies in power flow to be gained by connecting closer to demand centres further south in England.

Figure 6: **INTOG design process**



Connecting INTOG

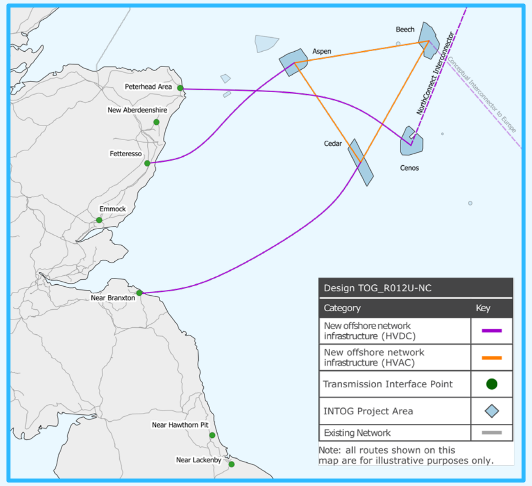
Radial Shortlisted Designs (TOG)



Design TOG_R010T

This design is a radial design, featuring less interaction between developers. The NorthConnect interconnector is out of scope for coordination, meaning it does not coordinate with any projects in this design and connects as per its independent position.

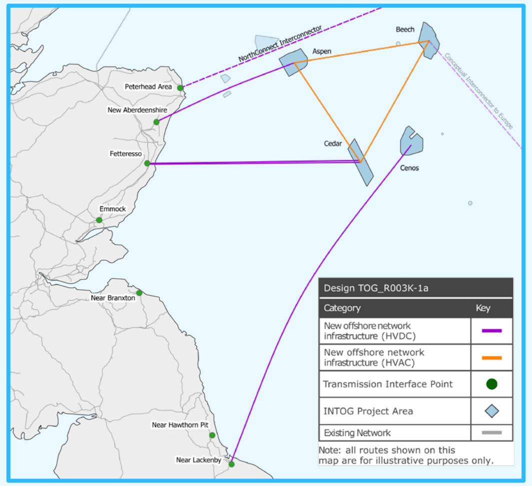
The design provides a connection to Fetteresso for Cenos. Cerulean projects Aspen and Cedar connect to Emmock and Near Branxton respectively.



Design TOG_R012U-NC

This design is a radial design, featuring less interaction between developers, however the NorthConnect interconnector is in scope for coordination and forms a coordinated solution with the Cenos project to connect to Peterhead.

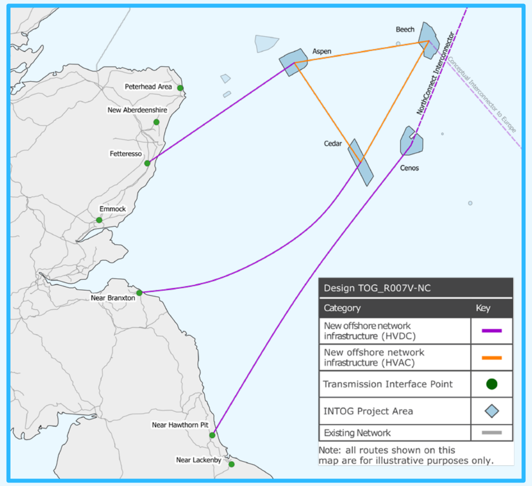
Cerulean projects Aspen and Cedar connect to Fetteresso and Branxton respectively.



Design TOG_R003K-1a

This design is a radial design, featuring less interaction between developers. The NorthConnect interconnector is out of scope for coordination, meaning it does not coordinate with any projects in this design and connects as per its independent position.

The design provides a connection to Lackenby for Cenos. Cerulean projects Aspen and Cedar connect to New Aberdeenshire and Fetteresso respectively.



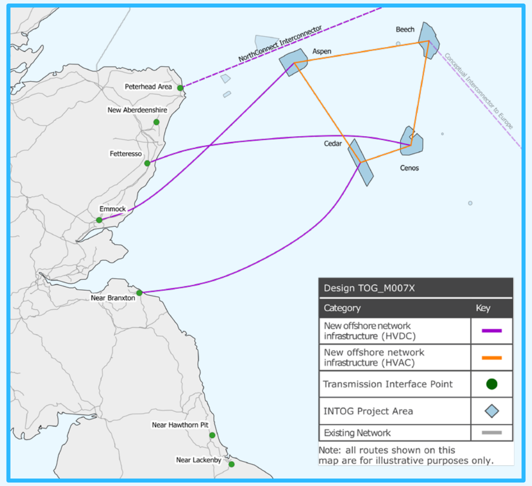
Design TOG_R007V-NC

This design is a radial design, featuring less interaction between developers, however the NorthConnect interconnector is in scope for coordination, and forms a coordinated solution with the Cenos project to connect to Peterhead.

The design provides a connection to Fetteresso and Near Branxton for the Cerulean projects Aspen and Cedar.

Connecting INTOG

Mesh Shortlisted Designs (TOG)

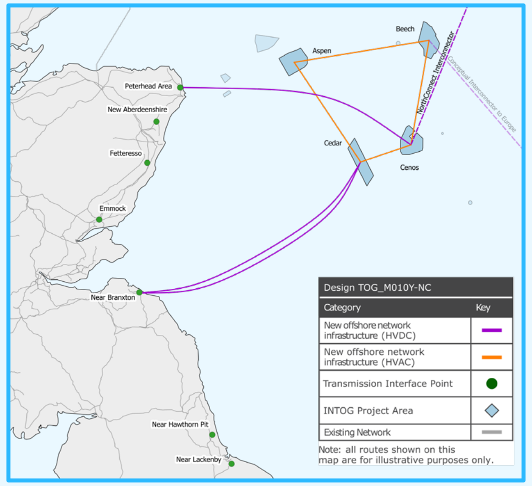


Design TOG_M007X

This design is a mesh design, featuring coordination between different TOG developers. The design provides a connection to Fetteresso for Cenos.

Cerulean projects Aspen and Cedar connect to Emmock and Near Branxton respectively. The AC ring between the Cerulean projects is widened to include the Cenos project through an extra link.

The NorthConnect interconnector does not coordinate with any projects in this design and connects as per its independent position.



Design TOG_M010Y-NC

This design is a mesh design, featuring coordination between different TOG developers, as well as the NorthConnect interconnector in scope for coordination.

The design provides a connection to Near Branxton for the Cerulean project Cedar. The NorthConnect interconnector coordinates with the Cenos project and forms a coordinated solution connecting to Peterhead.

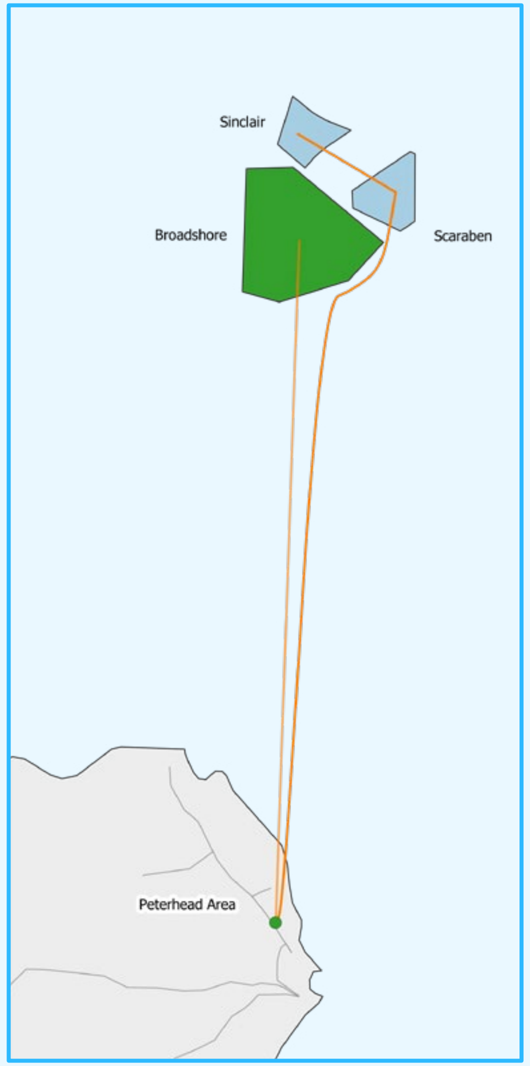
Radial and Mesh Designs

Designs drafted throughout this process and shown in this report are classified as either radial or mesh designs. Radial designs feature less coordination between different developers, whereas mesh designs include at least one offshore link connecting projects belonging to different developers.

The projects named Aspen, Beech and Cedar are all being developed by the same developer. At the beginning of our design process, this developer presented plans to link all three projects in an offshore mesh network. These plans are reflected across both radial and mesh designs.

Connecting INTOG

Shortlisted Designs (IN)



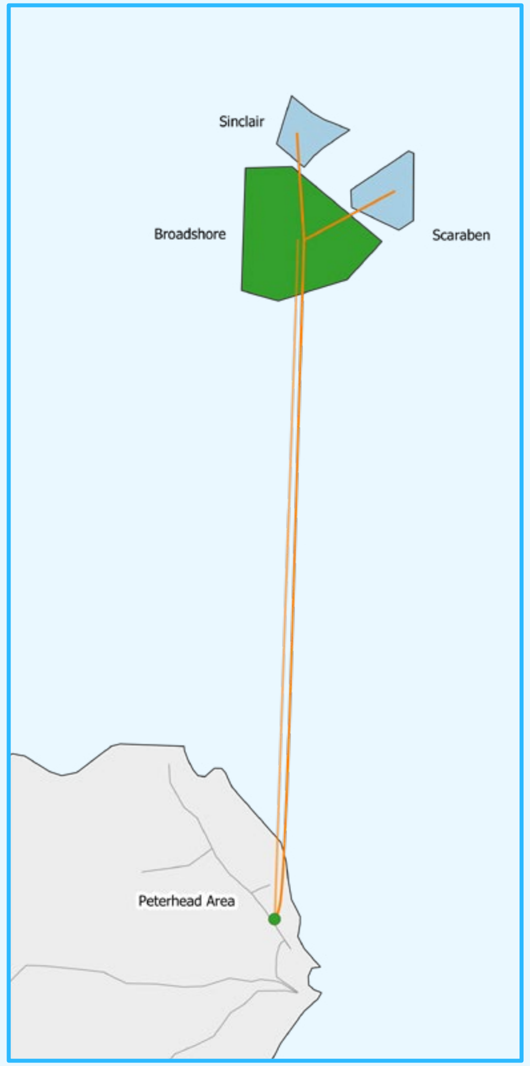
Design IN_002

This design is a coordinated design, featuring coordination between the Sinclair and Scaraben projects, but no coordination with the nearby Broadshore project.

This design was initially shortlisted in the ISOA due to strong performance across the network design objectives when compared to other IN designs, and was shortlisted alongside design IN_004 to facilitate a more detailed analysis of the benefits of coordination with Broadshore.

Design IN_002	
Category	Key
New offshore network infrastructure (HVDC)	
New offshore network infrastructure (HVAC)	
Transmission Interface Point	
INTOG Project Area	
Broadshore Project (ScotWind)	
Existing Network	

Note: all routes shown on this map are for illustrative purposes only.



Design IN_004

This design is also a coordinated design, featuring coordination between both the Sinclair and Scaraben projects and the Broadshore project.

Once coordinated, the total capacity of all three projects is greater than the planned export cable for Broadshore, meaning a second cable is needed to export power to shore. This cable is assumed to follow the same route to shore and connect at the same onshore substation as the Broadshore project in the Peterhead area.

Design IN_004	
Category	Key
New offshore network infrastructure (HVDC)	
New offshore network infrastructure (HVAC)	
Transmission Interface Point	
INTOG Project Area	
Broadshore Project (ScotWind)	
Existing Network	

Note: all routes shown on this map are for illustrative purposes only.

Connecting INTOG

Design Appraisals

As part of the FSOA analysis, designs in the shortlist were subject to detailed further analysis and appraisal across each of the four design objectives. This information was also supplemented with input from our stakeholder groups, which was used to both verify and supplement our assessment of the shortlisted designs.

Deliverability and Operability

The six designs were appraised against the deliverability and operability methodology which considers topics both from an offshore and onshore perspective. The appraisal considers topics such as design complexity, technology, supply chain, system outages and onshore works. Additionally, for INTOG we considered the earliest available indicative transmission interface point (TIP) dates to meet the 2030 demand requirement for the TOG platforms.

The TIP locations prioritised in Scotland benefitted from the fact that either they were existing sites, planned extensions to existing sites or new sites that were already planned. The TIP sites prioritised in Scottish and Southern Electricity Networks – Transmission's (SSENT) area were Peterhead, Longside, Fetteresso, Emmock and New Aberdeenshire while Near Branxton was preferred in Scottish Power Transmission's (SPT) area. Other TIP locations were also investigated during the ISOA stage, but were less favourable due to either their later availability dates, costs, location or environmental topographical constraints at landfall for export cables. Two TIP locations were appraised in National Grid Electricity Transmission's (NGET) area; Near Hawthorn Pit and Near Lackenby. These appraisals were carried out using information provided during the HNDFUE ScotWind design process.

Two designs with high voltage direct current (HVDC) links that landed further south in North East England (R003K-1a and R007V-NC) were deemed unable to meet the 2030 demand requirement due to the indicative reinforcement works identified, and so were ranked fifth and sixth. There are also additional challenges with the long HVDC link from Cenos could result in many HVDC cable crossings with earlier projects from the ScotWind leasing round. The remaining four designs only had connections to the SSENT and SPT areas, which had the earliest available TIP dates.

The mesh designs M007X and M010Y-NC were ranked as third and fourth in this objective, due to increasing design complexity and staging requirement between developers. The mesh designs had advantages that should potentially enable all four TOG projects to meet the demand requirement by 2030 from only TIP connection. However, the design would have implemented significant offshore infrastructure; large high voltage alternating current (HVAC) switching stations, and multiple HVDC platforms situated in one development area which would be challenging to deliver.

The two top ranking designs R012U-NC and R010T were classed as radial designs as the two developers were not interconnected. The advantages of these designs included less design complexity, no staging between different developer projects and shortest available export cables to the TIPs. The recommended design R012U-NC was the most advantageous for these reasons and additionally saving an additional export cable to existing Peterhead 400 kV by coordinating the Cenos and NorthConnect project.

The IN developer had counterfactual designs to Longside substation with each project seeking a separate connection. The alternative designs we assessed included coordination with Broadshore using HVDC and HVAC only to Longside 132 kV against the deliverability and operability methodology. The recommended design IN_002 benefitted by coordinating the two IN projects to one bay at the existing Longside 132 kV substation.

Connecting INTOG

Design Appraisals

Environment

When appraising the shortlisted TOG options, we assessed the designs based on the likelihood of each design – and each individual connection within that design – interacting with environmental constraints, and the sensitivity of those constraints to the infrastructure. Designs were assigned a BRAG (Black, Red, Amber, Green) rating based on the outcome of these assessments. In completing these appraisals, we found that designs were all either lightly or moderately constrained from an environmental perspective. None of the options shortlisted were appraised as being severely environmentally constrained. This means that, while all designs would likely interact with some environmental constraints, it is likely that any significant issues could be overcome through careful route planning.

We found that the best performing designs utilised well-coordinated routes to avoid overcrowding in certain environmental sites. Designs R012U-NC and M010Y-NC for example, combine some elements of the design together in order to avoid multiple interactions with the Southern Trench marine protected area (MPA).

Another important factor driving our decision-making process was whether or not designs required new reinforcements. We identified that designs which connected to England – designs R003K-1a and R007V-NC – would potentially require additional network reinforcements in the form of new overhead lines. We considered designs requiring new overhead lines as less preferable, given the increased interaction with environmental constraints this would introduce.

Additionally, we noted that some designs – particularly M007X and R010T – used multiple, separate routes through a single environmental constraint. We did not consider these designs to be the most optimal use of the marine space in terms of interactions with environmental constraints.

Of the remaining designs – M010Y-NC and R012U-NC, we could identify very little difference in terms of their interactions with environmental constraints. Both designs were considered to be of a similar level of impact.

For the IN designs, we found there was little separating the shortlisted designs in terms of the environmental design objective. The main difference between the two came down to the number of offshore cables. IN_002 connected the two IN projects while IN_004 kept them separate. We considered that the coordination within IN_002 could potentially reduce the marine footprint of the project, which was an advantage over alternative designs.

Connecting INTOG

Design Appraisals

Community

There were various elements considered when appraising designs against the community objective, such as overall route length, ability to avoid community constraints and onshore reinforcements required to facilitate the design. We found that the offshore routes performed well across most of the TOG designs with four shortlisted designs avoiding all significant community constraints. This included the following designs: R010T, R012U-NC, M007X and M010Y-NC.

The two TOG designs that did not perform as well offshore for the community objective were R003K-1a and R007V-NC. This was due to these designs' inability to avoid all significant community constraints such as urban areas at landfall within the route to Lackenby, the Formartine and Buchan Way National Trail unable to be avoided for routeing into Machair. For R007V-NC it was found that within the routes to Hawthorn Pit the Durham Heritage Coast and areas of National Trust land cannot be avoided.

Overall, we found that due to a reduction in cables making landfall in the recommended design this resulted in the shortest overall offshore route length making R012U-NC the best performing design for the community objective.

The indicative onshore works that were identified for TOG designs again were relatively similar, following the same pattern as the offshore works with R010T, R012U-NC, M007X and M010Y-NC. These designs were all identified as triggering indicative reinforcements that were identified in *the Beyond 2030 Report*: NHNC, PKUP and BKUP. Designs R003K-1a and R007V-NC also required these onshore reinforcements but with the addition of indicative works in the North East of England. Therefore, any increase in onshore reinforcements will have a negative impact on the overall community objective.

We found with the innovation designs there were no large differentials between the five longlist designs or the two eventual shortlisted designs. Of the shortlisted designs both designs performed similarly, with IN_002 being slightly better. The only community constraint identified with IN_002 was the Formartine and Buchan Way National Trail within the route to Peterhead which cannot be avoided. This constraint was also identified in IN_004 as it cannot be avoided when connecting to Longside 132 kV.

Connecting INTOG

Design Appraisals

Economics

To evaluate the economic cost of the shortlisted TOG designs, we considered a range of factors. These included the costs of the proposed offshore network, the indicative costs of any potential onshore network reinforcements, as well as additional system constraint costs needed to manage the TOG power generation. Importantly, for TOG, we also considered the cost savings due to the reduction in the cost of emitting carbon because of the electrification of the offshore oil and gas platforms.

Our studies found a cost range between the most expensive and least expensive design option of £5.7 billion, and we found that in a number of cases, the leading differentiator was the cost of the respective offshore network. However, other factors also played a key role, in particular the savings from carbon emissions from the oil and gas platforms.

Of the six designs considered in the FSOA, the radial design, R003K-1a, is ranked as the most expensive option. In common with the second most expensive option, R010T, both designs have high offshore network costs, together with low-carbon emission savings from the electrification of the oil and gas platforms and high constraint management costs.

The offshore costs are high because of the long lengths and high capacities of the HVDC circuits, used to connect the projects onshore. The designs also have low-carbon emission savings from electrifying the oil and gas platforms due to relatively late connection dates.

The radial design, R007V-NC, is ranked as the third most expensive, or fourth-best option. This design has a medium offshore network cost, together with medium-carbon emission savings.

The meshed design, M007X is ranked as the third-best option. The design has a high offshore network cost, however it also has the highest available carbon emission savings due to early and coordinated connection dates. The coordination between the two offshore TOG projects, Cerulean and Cenos, permits electrification of all of the oil and gas platforms at the earliest of the individual project connection dates.

The radial design, R012U-NC is ranked as the second-best option from an economic perspective. This design has a low offshore network cost, due in part to it having the shortest HVDC circuits compared to other designs. This contributes to a low overall cost, despite having relatively low-carbon savings due to the later connection dates.

The meshed design, M010Y-NC is ranked as the least expensive option from an economic perspective.

This design has the least expensive offshore network cost, due to the short and low-capacity HVDC circuits, together with the highest available carbon-emission savings due to the early and coordinated connection dates. It also has the lowest constraint management costs.

To evaluate the economic cost of the IN designs, we considered solely the costs of the proposed offshore networks. Because the projects were relatively small and all proposed designs connected to the same part of the onshore network, there was no difference in the required onshore network reinforcements nor system constraint costs to manage the power flows on the onshore network.

Of the two shortlisted designs assessed at FSOA stage, IN_002 was marginally cheaper than IN_004 by £6 million due to the slightly less extensive offshore circuit requirements.

Connecting INTOG

Final Recommended Design

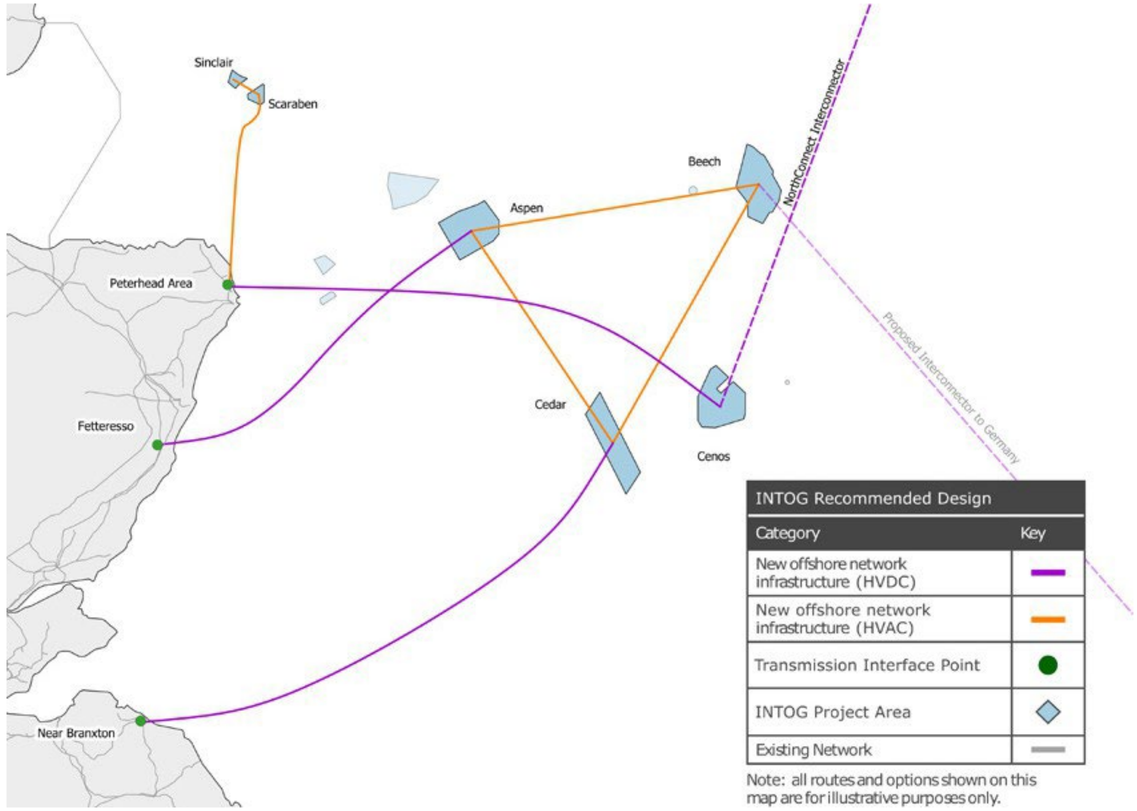
Our final INTOG recommended design provides bay availability to all TOG projects by 2030, and a coordinated yet flexible connection for both IN projects. As the IN and TOG elements of INTOG were assessed separately, our recommendation is therefore the combination of the final recommended designs for each.

The TOG element of this design features three HVDC connections from the in scope TOG projects to shore. The Cerulean projects Aspen and Cedar connect to Fetteresso and Near Branxton respectively. The NorthConnect interconnector coordinates with the Cenos project and forms an offshore hybrid asset (OHA) connecting to Peterhead.

The TOG element of this design performs well across both environment and community, due to a reduction in cables making landfall and a lower proportion of interface points in sensitive areas. This design was therefore ranked joint first in both objectives when compared with other designs in the shortlist. This design also performs well economically, due to the benefits of coordination with NorthConnect. The benefit of the earliest possible connection for both projects result in substantial carbon cost savings, where the projects can support decarbonisation of the oil and gas platforms, and coordination with NorthConnect allows an additional export path for generation. This design performed second best out of all the shortlisted designs, second only to design TOG_M010Y-NC in this regard. This design also performs well in deliverability and operability, due to lower offshore complexity when compared to mesh designs and was ranked first in this objective.

The IN element of this design features coordination between the two IN projects, and then a direct link to Longside 132 kV. The IN element of this design was recommended based on two key factors. Firstly, the slightly better performance across the design objectives demonstrated that it would represent a marginally better solution than IN_004. Secondly, it was determined during the course of the FSOA analysis that developing the additional cable required in both designs as a separate link, rather than a bundled solution, would allow the project to proceed with more flexibility when both constructing and operating the IN projects. By not bundling these projects with the nearby SW_NE6 project, this allows them the flexibility to realise the separate innovation goals of the INTOG leasing round in a separate manner to SW_NE6.

Figure 7: Recommended INTOG design



Next Steps

Next Steps

Following the release of this recommendation, we will continue to work with the Transmission Owners (TOs), Crown Estate Scotland (CES) and relevant governmental and regulatory stakeholders to support this recommendation as it proceeds through the detailed network design (DND) phase. Where frameworks are still in development for elements of the design, such as offshore hybrid assets (OHAs), we will continue to work with the Office of Gas and Electricity Markets (Ofgem) to develop these and with the TOs to apply them to the relevant areas of the recommended design.

The next step for the projects in scope of the Holistic Network Design Follow Up Exercise (HNDFUE), Innovation and Targeted Oil and Gas (INTOG) design exercise is to now update their current connection contracts to those that match the final design. This process will be led by our customer connections teams and will feature input and coordination from the developers and TOs. As the National Energy System Operator (NESO), we are coordinating an industry-wide Connections Reform programme under which these projects will be assessed in 2025.

The INTOG projects and recommended design will form the input to our future onshore network planning processes and the outcome of this will be published in a future "refresh" report within the *Beyond 2030* suite of documents.

NESO was commissioned by the Secretary of State for Energy Security and Net Zero to provide advice on how clean power can be delivered by 2030. The INTOG design was developed prior to this commission. INTOG remains a key enabler of a low-carbon energy future in 2030 and beyond, and our recommended design enables these benefits in a rapid, yet holistic manner.

Get in Touch

Email us with your views on the *Beyond 2030: INTOG Report* at box.offshorecoord@nationalenergyso.com and we will get in touch.

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Beyond 2030: INTOG is part of a suite of documents prepared by NESO. Visit neso.energy for more information.

National Energy System Operator (NESO) Legal Notice

[2] These documents are: INTOG Supplementary Report, Beyond 2030: Celtic Sea, Pathway to 2030 and Beyond 2030
[3] assets.publishing.service.gov.uk/media/64ef6dc513ae15000d6e30de/otnr-hnd-fue-tor.pdf

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