Offshore Coordination Project

Published Date - 30 September 2020

Closing Date - 28 October 2020

nationalgridESO

Navigation

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

Pop-ups & Rollovers

Click or Roll over highlighted text or the ⊕ symbol to reveal extra content or take you to a different section

Page navigation explained

Back a page

Forward a page

Return to contents

From here you can navigate to any part of this publication - for example, this will allow you to find your place quickly and easily after you have followed an internal link

www

Click on orange text to go to the appropriate webpage.

Executive summary

Welcome to our consultation on the costs and benefits of a more coordinated approach to connecting offshore electricity infrastructure. This document also includes a report on holistic planning of the offshore transmission network and proposals for changes to the offshore connections' regime.

Last year saw a major milestone in the UK's energy revolution as the Government passed a law requiring the UK to ensure net zero greenhouse gas emissions across all sectors by 2050. Offshore wind has a significant role to play in this, as the Government has ambitions for 40 gigawatts (GW) by 2030 and our 2020 Future Energy Scenarios (*FES*)[1] suggest between 83 and 88 GW of network-connected wind is needed by 2050 in order to deliver the net zero greenhouse gas emissions target.

Around 10 GW of offshore wind has been installed in Great Britain, primarily over the last decade. Delivering the anticipated levels would require more than quadrupling the pace at which that was delivered and up to an eightfold growth in overall scale, as illustrated in Figure 1. The number of interconnectors with other countries is also projected to rise, with the *FES* including up to 27 GW by 2050, up from 6 GW today.

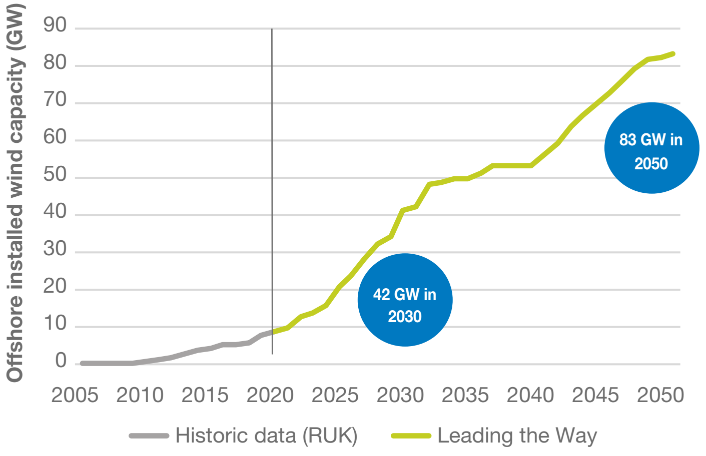


Figure 1 Growth in connected offshore wind capacity since 2000 to present day (source: RenewableUK), and projections out to 2050 under the Leading the Way future energy scenario (source: 2020 Future Energy Scenarios)

One of the challenges to delivering the ambition in the timescales required will be ensuring that the offshore transmission network enables this growth in a way that is efficient for consumers and takes account of the impacts on coastal communities and the environment.

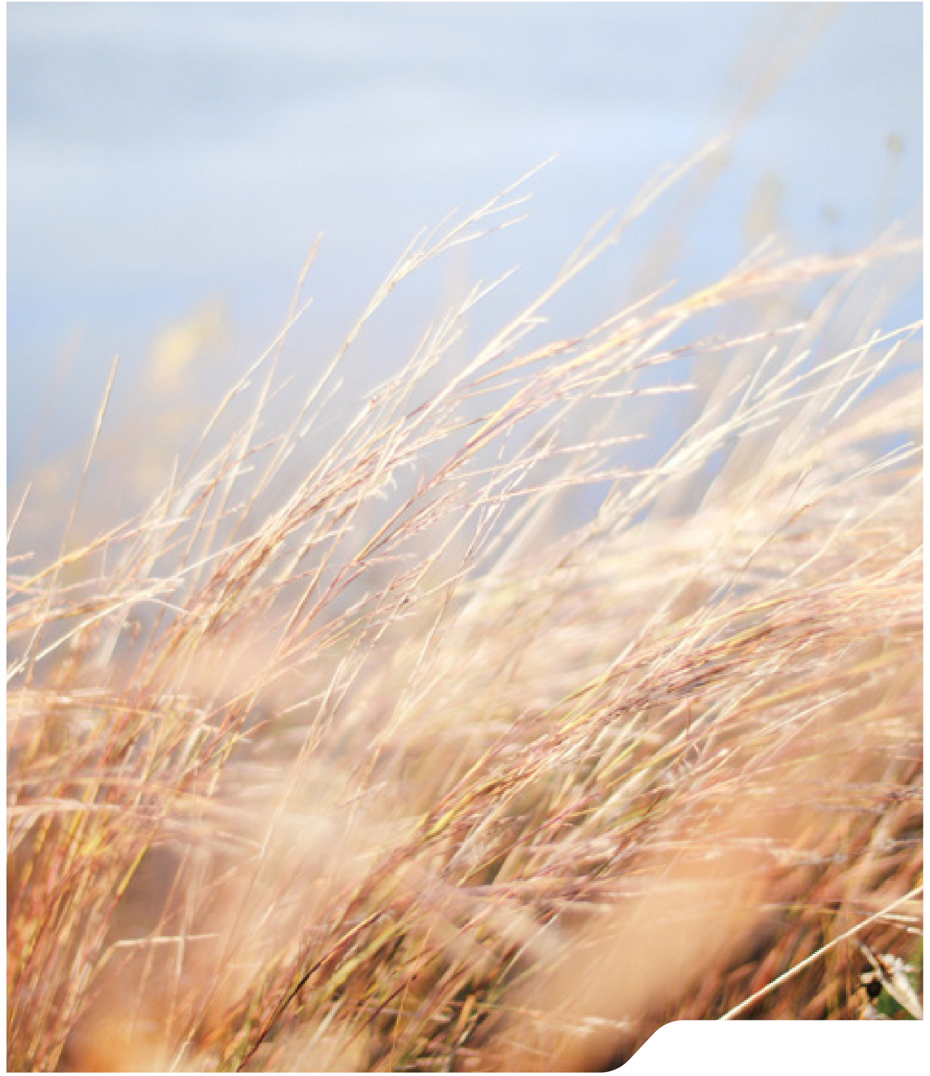
The ESO Offshore Coordination project has been examining a more coordinated approach to offshore network development, including the connections required and technology availability, and assessing the costs and benefits of such an approach. This consultation is a key milestone in this project. Here we set out a vision and assessment of a conceptual integrated network, presenting evidence for the Department of Business, Energy and Industrial Strategy (BEIS) Offshore Transmission Network Review and subsequent work of BEIS, Ofgem and other project partners.

1 www.nationalgrideso.com/future-energy/future-energy-scenarios/fes-2020-documents

Executive summary

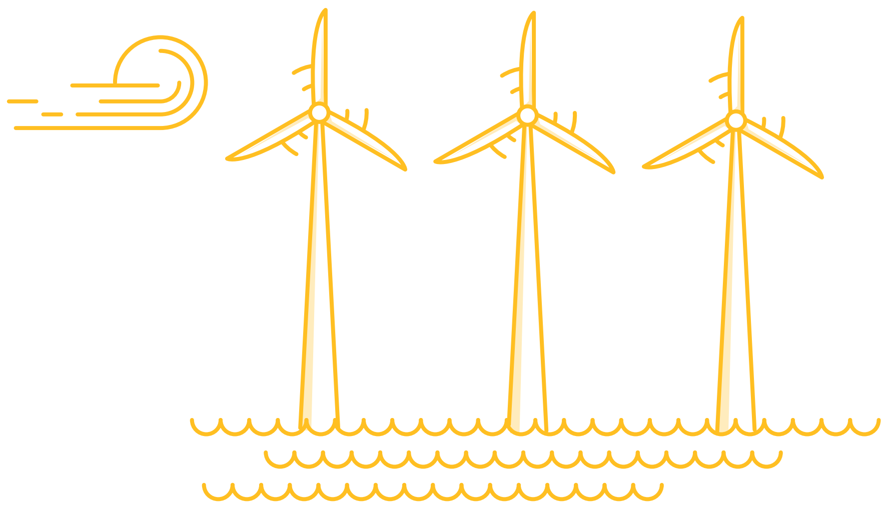
The key messages from our consultation and three supporting documents are:

- The report findings are the first step within the BEIS-led Offshore Transmission Network Review. Decisions and actions to move from a vision into a plan and reality will need to progress with urgency to increase the chance of realising the benefits by 2030. Some changes to achieve an integrated network can take place within the current regime, others will require more significant changes.
- Our analysis suggests that an integrated approach offshore has the potential to save consumers approximately **£6 billion, or 18 per cent**, in capital and operating expenditure between now and 2050, based on the assumptions used. The savings are greatest (up to 30 per cent) where high levels of offshore wind needs to be connected to parts of the onshore network already nearing operational limits, or where wind farms are located far from shore.
- There are potentially significant environmental and social benefits with an integrated approach, as the number of onshore and offshore assets, cables and onshore landing points could potentially be reduced by around **50 per cent**, albeit that some of these assets would be somewhat larger.
- The majority of the technology required for the integrated design is available now or will be by 2030. However, a key component to release the full benefits of an integrated solution are high voltage direct current (HVDC) circuit breakers. A targeted innovation strategy in Great Britain, along with support for early commercial use, could help progress HVDC circuit breakers to commercial use and establish Great Britain as a world leader in offshore grids.
- Changes to the offshore connection regime will encourage and drive more coordination in the short, medium and long term. By making these changes it will enable the barriers to coordination to be removed and allow for collaboration to determine the overall best solution that takes into account costs and environmental impacts. Changes are required to the assessment process for the location of offshore connections, the investigation of packaging connection offers with other elements such as seabed leases, and a review of where liabilities sit for offshore connections.



Offshore Coordination Project / Executive summary 04

Executive summary



It is important to note that the designs we set out in this consultation document and supporting material are conceptual and based on one future energy scenario. Further analysis and design, along with an appropriate legislative and regulatory model, will be required to take these from a concept to a plan to reality and therefore realise the potential benefits we set out in this document.

Full integration before 2030, as envisaged in our analysis, may not be achievable where projects are already at an advanced stage of development. This would impact the extent to which the number of onshore landing points can be reduced by 2030 and potential savings by 2050.

In developing the consultation document, we have engaged with and acted on feedback from a wide range of stakeholders, and this has shaped the content of this document and our three supporting reports. We would now like your views on the proposals in this consultation. If you would like to provide feedback, please refer to the How to Respond section to find out how.

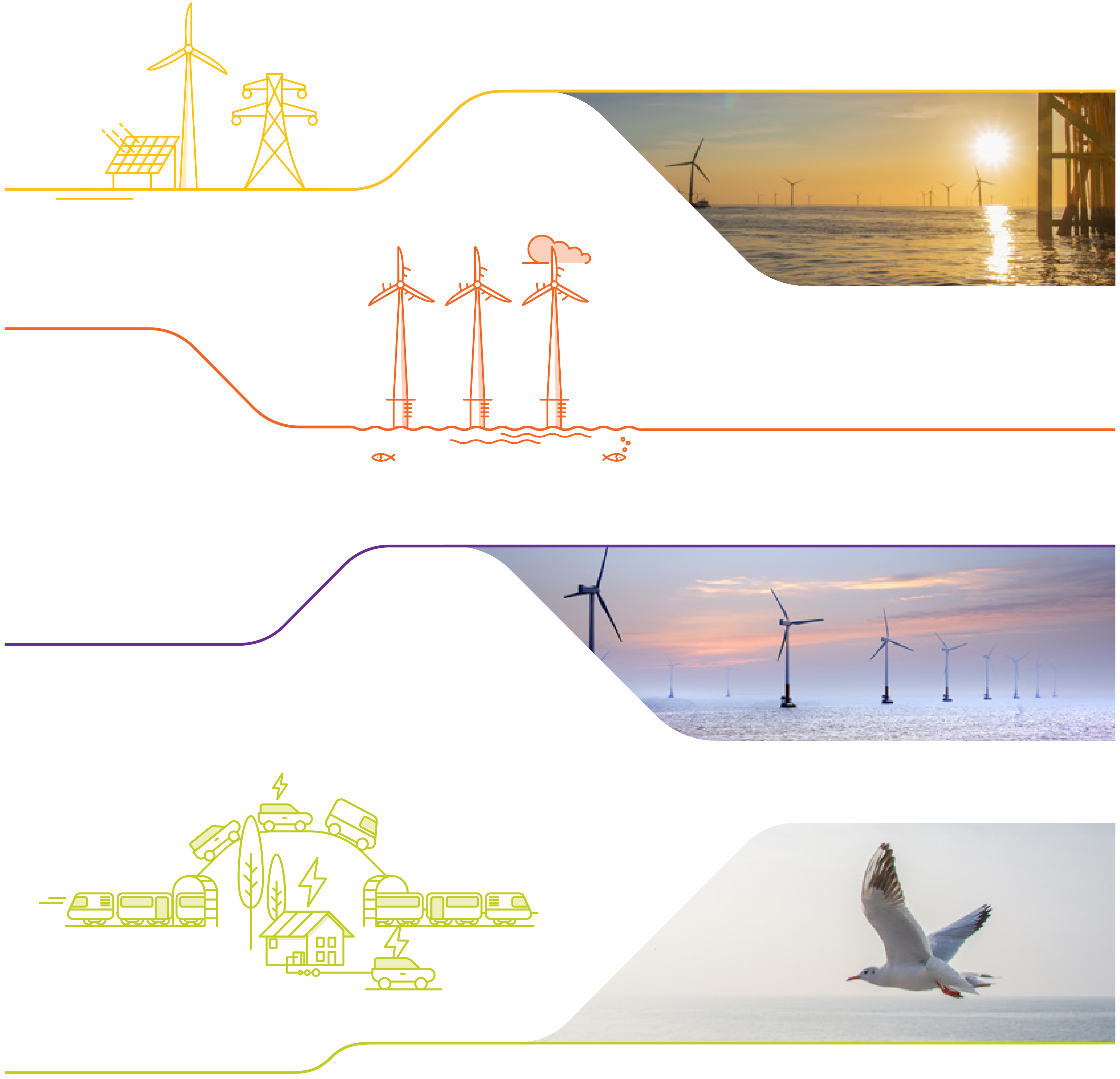
Following the closure of this consultation on 28 October 2020, we will review your feedback and use it to finalise the three reports for Phase 1 of the project ahead of publication of the final versions by the end of 2020:

- **Cost-benefit Analysis Report** compares more coordinated offshore network with the current individual, radial approach; and
- **Holistic Approach to Offshore Planning Report** assesses and presents conclusions on the key areas of technology and technical consideration related to the design of integrated offshore networks;
- **Offshore Connections Review Report** recommends changes to the offshore connections process

This first phase of work lays the foundations needed by a wide range of organisations to take the decisions, and identify the steps, for an integrated approach to an offshore transmission network. It presents evidence for the Department of Business, Energy and Industrial Strategy (BEIS) Offshore Transmission Network Review and subsequent work of BEIS, Ofgem and other project partners. We recognise that following the publication of this piece of work any subsequent steps will require a collaborative approach across a wide range of parties to progress an integrated approach.

Offshore Coordination Project / Executive summary 05

Contents



Introduction

The current approach to designing, building and connecting offshore wind farms was developed when the technologies involved were at the early stages of deployment at scale. Regulation was designed to de-risk the delivery of offshore wind by providing project developers with the option of building the associated transmission assets to bring the energy onshore. To date, the existing offshore regime has been successful in connecting 10 GW of offshore wind to the Great Britain electricity system. The current regime for developing and connecting offshore wind generation incentivises developers to connect individually, with competition used to reduce costs rather than promote coordination.

In 2015 the Integrated Offshore Transmission Project (East) Final Report (IOTPE)[2] concluded that there was no clear benefit to the adoption of an integrated design approach. However, at that point the anticipated level of offshore wind generation was not expected to exceed 10 GW by 2030. Since then, the Government's commitment to meeting net zero greenhouse gas emissions has significantly raised expectations on the level of offshore wind anticipated. It is now uncertain whether the existing regime can deliver the current levels of ambition in the timescales required, in a way that is efficient for consumers and appropriate for coastal communities and the environment.

In February 2020 Ofgem published its Decarbonisation Action Plan[3], which set out a number of actions for Ofgem. Through Action 3, Ofgem committed to exploring a more coordinated, efficient system of offshore transmission and, more specifically, to working with us to ensure we rigorously assess the options for coordination of offshore transmission. This includes analysis of the likely costs and benefits, which the final report that follows on from this consultation will fulfil. On 15 July 2020 the Minister for Business, Energy and Clean Growth launched the Offshore Transmission Network Review[4]. The review brings together the organisations with a key role in this area, including Ofgem, the Crown Estate and ourselves. The objective of the Review is to identify the most appropriate way to deliver the transmission infrastructure for offshore wind farms; balancing environmental, social, and economic costs and benefits. In addition, the recent Climate Assembly report[5] highlighted that choice and fairness for local communities must be allowed and also highlighted the support for offshore wind, with 95 per cent of participants supporting it.

The draft outputs in this consultation inform the workstreams within BEIS's Offshore Transmission Network Review and represent our progress in delivering the commitment in Ofgem's Decarbonisation Action Plan. This document sets out a vision and assessment of a conceptual integrated network, providing evidence to inform the BEIS project and subsequent work of BEIS, Ofgem and other project partners, including potentially ourselves. To progress further, decisions will be required on whether to progress with an integrated approach, any changes needed to the current regime and a plan developed to confirm and implement subsequent steps.

2 www.nationalgrideso.com/document/125331/download
3 www.ofgem.gov.uk/publications-and-updates/ofgem-s-decarbonisation-action-plan
4 www.gov.uk/government/publications/offshore-transmission-network-review
5 www.climateassembly.uk/report

Introduction

The designs we set out in this consultation document and supporting material are conceptual and at a high level, based on one future energy scenario, Leading the Way. This scenario was selected as this meets the Government's ambition for 40 GW of offshore wind by 2030 as well as net zero by 2050. However, all three future energy scenarios that meet net zero include significant levels of offshore wind. Further analysis and design along with an appropriate legislative and regulatory model will be required to take these from a concept to a plan to reality and therefore realise the potential benefits we set out in this document. With the pace of development shown in the *FES*, the greatest benefits will be seen from taking forward an integrated approach from as early as possible. Our analysis assumes that there is a level of integration between 2025 and 2030, and this is what would be an ideal scenario to deliver maximum integration. However, from a practical point of view some of the assumed integration in the earlier stages of the designs may not be possible in reality, where projects are already at an advanced stage of development. Therefore, full integration before 2030, as envisaged in this analysis, may not be achievable and changes may need to happen in a phased way for projects connecting in that period. This will impact on the extent to which the number of onshore landing points can be reduced by 2030 and potential savings by 2050. Many projects due to connect ahead of 2030 will have connection agreements already in place and we will work with the relevant TOs and developers to continue to progress on the basis of those agreements. However, we appreciate there may be appetite from some developers for a voluntary opt in approach and would welcome discussions on this in relation to ESO processes. BEIS and Ofgem would also welcome conversations on this, as invited in their recent open letter[6].

Please note that we are continuing to refine the cost-benefit analysis results and will also take account of feedback received in response to this consultation. As a result, the figures in the cost-benefit analysis are likely to change between this version and the final document we publish following this consultation.

Offshore Coordination Project / Introduction 08

6 www.gov.uk/government/publications/increasing-the-level-of-coordination-in-offshore-electricity-infrastructure-beis-and-ofgem-open-letter

Introduction

1 Cost-benefit Analysis

2 Holistic Approach

3 Connections process review

This document sets out our views in three areas:

Cost-benefit Analysis of a more coordinated offshore network compared to the current individual, radial approach. We invite your feedback on the outputs presented to help shape the final version;

Invite feedback to inform final document

Holistic Approach to Offshore Transmission Planning on which we would welcome any evidence to support or challenge the accompanying report Holistic Approach to Offshore Planning; and

Invite feedback to inform final document

Recommended changes to the offshore connections process on which we welcome your feedback on the appropriateness and priority of the actions set out.

Invite feedback to inform final document

Document overview:

This document provides a summary of these reports and highlights the key messages from them. For each of these areas, supporting reports are available. The detailed reports on the first two topics are produced by our consultancy partners, DNV GL (Det Norske Veritas - Germanischer Lloyd) in conjunction with the National HVDC (High Voltage Direct Current) Centre and EPNC (Electricity Power Network Consultants Limited). Please note that the technology unit cost information has been removed from the 'Holistic Approach to Offshore Transmission Planning' report as it is confidential.

How it all fits together:

Cost-benefit Analysis Report*

Inputs

- Environmental impacts
- Local authority survey
- Stakeholder views

Holistic Approach to Offshore Transmission Planning Report

Inputs

- Conceptual designs of GB network
- Technology unit costs
- Power system analysis

Offshore Connections Review Report

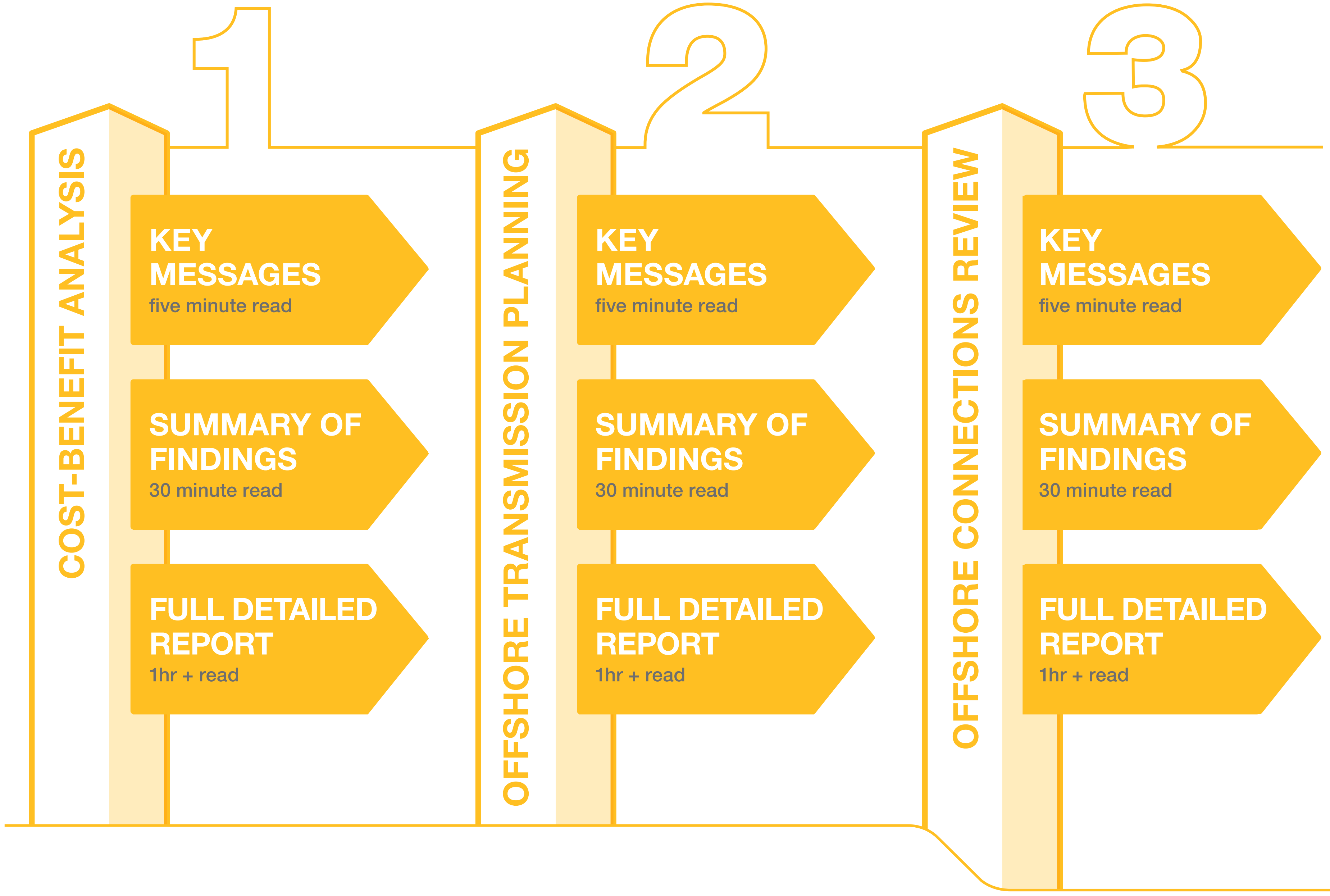
Inputs

- Internal & external stakeholder input

*The full CBA framework can be found in the full report.

Offshore Coordination Project / Introduction 09

Navigating the consultation document



To assist with understanding, each of the three elements of this consultation is presented in different levels of granularity, so you can decide the level of detail you want to access. We recommend reading our key messages if you have five minutes, our summaries if you have thirty minutes and one of our detailed reports should you have a couple of hours.

To view the glossary click here

Offshore Coordination Project / Introduction 10

Key messages

Key messages

Overall

- These report findings are the first step within the BEIS-led Offshore Transmission Network Review[7]. Decisions and actions to move from a vision into a plan and reality will need to progress with urgency to increase the chance of realising the benefits by 2030. Some changes to achieve an integrated network can take place within the current regime, others will require more significant changes.

Cost-benefit Analysis

- Our analysis at this stage suggests that an integrated approach offshore has the potential to save consumers approximately **£6 billion, or 18 per cent**, in capital and operating expenditure between now and 2050, based on the assumptions used. The savings are greatest (up to 30 per cent) where high levels of offshore wind needs to be connected to parts of the onshore network already nearing operational limits, or where wind farms are located far from shore.
- There are potentially significant environmental and social benefits with an integrated approach, as the number of onshore and offshore assets, cables and onshore landing points could potentially be reduced. Taking account of assumptions made in our analysis, we estimate this could result in around **50 per cent** fewer by 2050 in the Integrated option assessed.

More detailed planning and analysis is needed to refine the assessment and turn our conceptual designs into more specific network plans. The Integrated design also has more flexibility in the location of the landing points due to the use of HVDC connections, providing greater potential for them to be located in less environmentally and socially sensitive areas. However, the associated infrastructure is likely to be larger than for individual, radial connections.

7 www.gov.uk/government/publications/offshore-transmission-network-review

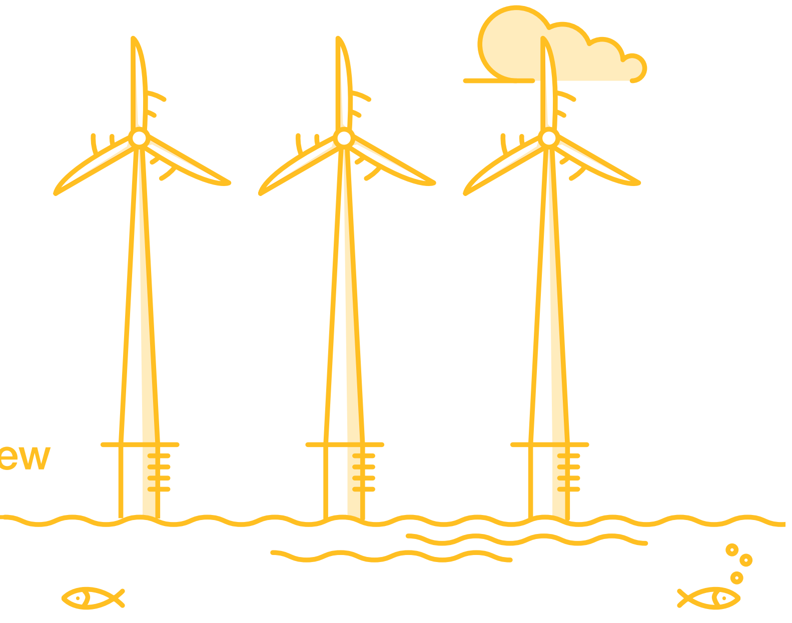
Offshore Coordination Project / Key messages 12

Key messages

Holistic Approach to Offshore Transmission Planning

- The majority of the technology required for the Integrated option is available now or will be by 2030. However, a key component to release the full benefits of an integrated solution are HVDC circuit breakers. They need progress to commercial use in Europe by 2030, beyond their current use in projects in China. A targeted innovation strategy in the UK, along with support for early commercial use, could help support this progression and establish the UK as a world leader in offshore grids. If HVDC circuit breakers are not available in time, an integrated approach can still be progressed. However, there would be more network infrastructure required, coming at an additional cost. This would also have the potential to increase the likelihood of network faults and therefore impact on system reliability and operability.

- A review of the Grid Code to clearly identify areas of required offshore performance for integrated offshore networks is essential. An assessment of the costs and benefits of better aligning the Security and Quality of Supply Standard (SQSS) infeed loss limits for offshore networks with the onshore network would potentially allow further integration if the costs do not outweigh the benefits. If this change was taken forward, there would be benefit in cables up to 1.8 GW in capacity being progressed to commercial use in Europe.



Offshore Connections Review

- Changes to the offshore connection regime will encourage and drive more coordination in the short, medium and long term. By making these changes it will enable the barriers to coordination to be removed and allow for collaboration to determine the overall best solution that takes into account costs and environmental impacts. Changes are required to the assessment process for the location of offshore connections (the CION[4]), the investigation of packaging connection offers with other elements such as seabed leases and a review of where liabilities sit for offshore connections.

Offshore Coordination Project / Key messages 13

4 Connection and Infrastructure Options Note www.nationalgrideso.com/document/45791/download

Collaborative approach

A collaborative approach

Since the launch of the Offshore Coordination Project, we have taken a collaborative approach. We understand that a project with such wide scale stakeholder impact requires collaboration to ensure its success. This consultation is informed by the engagement we have had with stakeholders so far; your views have shaped our thinking and have been incorporated before we put pen to paper. We have engaged with relevant stakeholders from stakeholder groups such as interconnectors, on and offshore transmission owners, offshore developers, technology providers, local authorities, environmental groups and others.

We have been listening to your feedback and where we have not been able to make changes in line with stakeholder views, we have explained our reasoning. We have produced two feedback documents following our key engagement events, which can be found in Annex 4.

Offshore Coordination Project / Collaborative approach 15

How do I respond?

We welcome your feedback to this consultation. We have highlighted questions throughout the document, responses to which will help us shape the work going forward. We also welcome general feedback. This can be provided in a couple of ways, as explained below.

Written feedback

We have provided a response form containing the questions that we have asked throughout the document. Please complete and submit the form to box.OffshoreCoord@nationalgridESO.com by no later than **28 October 2020**. We would like to publish the feedback submitted in writing as well as summaries of the feedback provided in workshops. If you would like your response to be treated as confidential and not published please indicate this where highlighted on the response form.

Verbal feedback

We understand that formal, written feedback can take time and we would like to take an interactive approach. Feedback provided verbally will be treated in the same way as that received in writing. We are hosting workshops and you can also speak to us directly and ask us any questions. These will be on the following dates:

- **Offshore Connection Review**
  6 October 2020 and 15 October 2020
  We have been pulling together all of the great ideas and feedback we have heard from you over the last few months. This session will dive into the connection review report and provide the opportunity for you to ask questions and provide feedback.

- **Cost-benefit Analysis**
  13 October 2020 and 14 October 2020
  We have been working closely with you through each milestone we have reached in the lead up to the draft cost-benefit analysis document that we will be consulting on. This session will be a deep dive into the document and will provide you with the opportunity to ask questions and provide feedback.

- **Holistic Approach to Offshore Transmission Planning**
  8 October 2020 and 13 October 2020
  This session will dive into the technology available now and in the future for an integrated option, the Great Britain network designs and the messaging from our power system analysis and again provide you with the opportunity to ask any questions and provide feedback on the report.

To sign up to a workshop email us here

Offshore Coordination Project / Collaborative approach 16

What happens next?

Following the closure of this consultation we will review your feedback and use it to finalise the three reports (Holistic Approach to Offshore Planning Report, Draft Cost-benefit Analysis Report and Offshore Connections Review Report) for Phase 1 of the project ahead of publication of the final versions of these documents by the end of 2020.

This first phase of work lays the foundations needed by a wide range of organisations to take the decisions, and identify the steps, for an integrated approach to an offshore transmission network. **We recognise that following the publication of this piece of work any subsequent steps will require a collaborative approach across a wide range of parties to progress an integrated approach.**

Offshore Coordination Project / Collaborative approach 17

Summary of findings

Please note that we have started this section with the Holistic Approach to Offshore Transmission Planning to aid the flow of the findings as the analysis feeds into the Cost-benefit Analysis Report.

The Holistic Approach to Offshore Transmission Planning Report assesses and presents conclusions on the key areas of technology and technical consideration related to the design of integrated offshore networks. The findings from this report have informed the subsequent cost benefit analysis that has been completed.

This report has been developed by experts in this field and has incorporated feedback provided by stakeholders throughout its development.

A high-level overview of the key content of the report and the insights from these areas can be found in the following pages. A fuller explanation of all the technical analysis completed and the resulting findings and conclusions can be found in the report itself.

Overview of the integrated network option compared to the status quo

For our analysis, we defined two alternate approaches to connecting the levels of offshore wind capacity set out in the *FES* Leading the Way (LW) Scenario. The first of these sets out a vision of how an integrated network could look in 2030 and 2050 (called the Integrated option). This was then compared to the maintaining the status quo, which extrapolates current project activity into the future, primarily using radial high voltage alternating current (HVAC) and HVDC connections.

The Integrated option connects a number of individual wind farms located in a similar geographical area, via the shared use of offshore transmission infrastructure. As would be expected, there is most opportunity for integration where new wind farms and interconnectors are located in a similar geographical area. For the Integrated option the impact on the onshore network is minimised as electricity can be more readily transported via offshore cables closer to the areas of demand, than for the status quo option.

A summary of the differences between design approaches for the status quo and Integrated options are set out in Table 1.

Status quo – Project by project transmission build up	Integrated – Transmission asset sharing enabled
Requirements for each project considered separately	Takes account of possible future requirements
Only considers point-to-point offshore network connections	Considers a range of connection options including multi-terminal/ meshed HVDC and HVAC options
Individual project optimisation and transmission (HVAC or HVDC) decision	Considers whole system optimisation and transmission technology decisions
Onshore and offshore network designs are considered separately	Considers effect on onshore system as part of offshore design development
Interconnectors are designed and connected separately	Possibility that interconnector/ bootstrap capacity can be shared by an offshore wind farm
Local community impacts are managed on a project by project basis	Local community impacts considered on an overall impact basis

Table 1 Design approaches for the status quo and integrated options

Offshore Coordination Project / Summary of findings 19

Holistic Approach to Offshore Transmission Planning Report

These high-level design approaches have been used to provide an indicative view of what could be possible with the current and projected technology available and in line with the current network security standards.

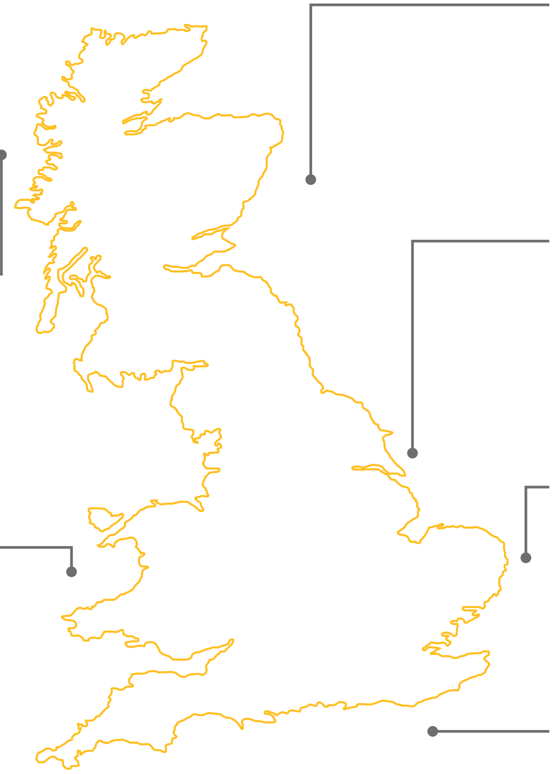
Turning these into detailed designs, with specific routes and landing points, would require further detailed analysis and data inputs. For example, this could include the consideration by location of onshore and offshore environmental constraints, the economics and practicalities of connecting to the onshore network at specific landing points, the suitability of the seabed to accommodate cabling, more detailed analysis on the impact on system operability, the deliverability from a consenting and supply chain point of view and the impact on local communities and the environment.

For both approaches we have assumed that the Government's ambition for 40 GW of offshore wind by 2030 is met, 83 GW is in place by 2050, 22 GW interconnectors are in place in 2030 and 27 GW in 2050, based on the Leading the Way Future Energy Scenario. This excludes the offshore wind in Leading the Way that transports its energy to land as hydrogen, uses other storage technologies offshore, or powers offshore demand such as oil and gas platforms[10].

To perform our analysis, we split the waters around Great Britain into six regional offshore wind development zones. Figure 2 shows the regional installed offshore wind capacities from 2020 to 2050 in Leading the Way.

LW Scenario Total Installed Capacity

- 2050 → 83.1 GW
- 2030 → 42.0 GW
- 2025 → 23.9 GW
- 2020 → 9.6 GW



North Scotland	
2050	18 GW
2030	6.5 GW
2025	2.5 GW
2020	0.8 GW

N Wales & Irish Sea	
2050	15.4 GW
2030	3.7 GW
2025	2.7 GW
2020	2.7 GW

East Scotland	
2050	9.3 GW
2030	5.1 GW
2025	2.8 GW
2020	0 GW

Dogger Bank	
2050	10.8 GW
2030	7.6 GW
2025	4.5 GW
2020	0.4 GW

Eastern Regions	
2050	27.5 GW
2030	17.4 GW
2025	10.1 GW
2020	4.4 GW

South East	
2050	2.1 GW
2030	1.7 GW
2025	1.3 GW
2020	1.3 GW

Figure 2 Regional installed offshore wind capacity up to 2050

Offshore Coordination Project / Summary of findings 20

10 We have only included the offshore wind in the Leading the Way scenario that is connected to the onshore electricity transmission system, with the energy transported to shore as electricity. There is an additional 24 GW of offshore wind from which the power is used directly for the production of hydrogen offshore. We have assumed this hydrogen-specific capacity is not connected to the transmission system so therefore not included in the network designs.

2030: High-level comparison of the Integrated network option to the status quo

Figure 3 compares the Integrated and status quo approaches in 2030. Similarly Figure 4 compares them in 2050. For both timeframes, the maps set out for an incremental level of growth from 2025 onwards and how the Integrated and status quo options result in different overall solutions for connections to the Great Britain onshore network.

In 2030, as shown in Figure 3, the Integrated option significantly reduces the number of connections in those areas with the highest deployment of offshore wind. This is most noticeable in the east of England and north and east of Scotland, reducing clusters of radial connections down to a few, coordinated connections.

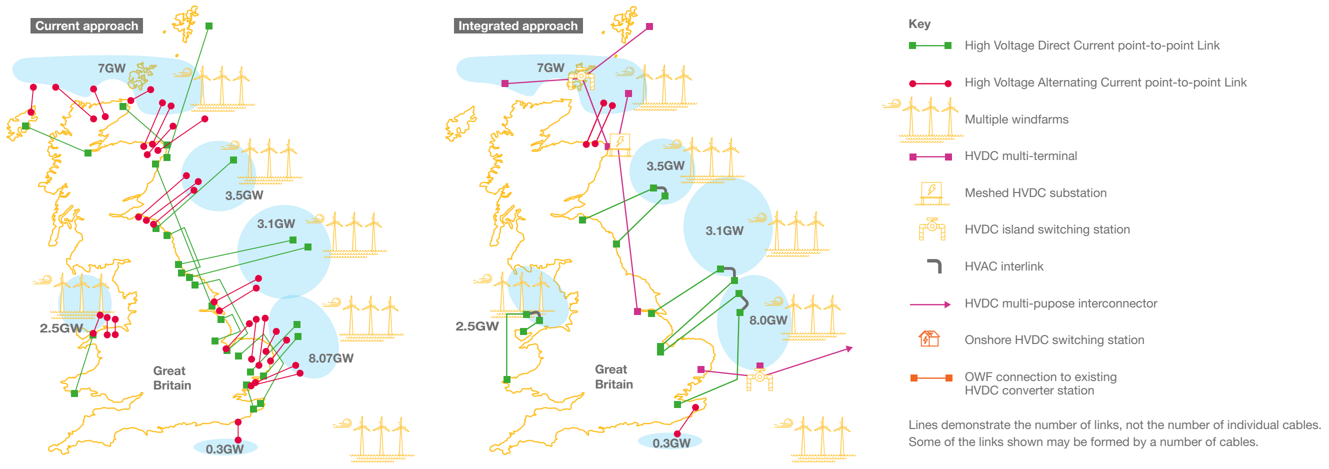


Figure 3 Status quo and Integrated Great Britain network designs in 2030

Please note, for Figures 3 and 4:

- The conceptual designs assume that all of the transmission system reinforcements recommended to proceed in the *Network Options Assessment* for 2020[11] are built, up to and including in 2028. They therefore do not appear in the designs.
- Existing infrastructure and new projects that are planned to connect to the onshore network prior to 2025 are assumed to have been built as planned so are not included in the designs.
- Whilst projects due to connect from 2025 onwards are included in the designs, this may not be achievable in reality and changes may need to happen in a phased way for projects connecting before 2030. This will impact on the extent to which the transition from the status quo to Integrated option will be achieved by 2030 and subsequently 2050 and therefore the extent to which the number of landing points can be reduced, the amount and location of network required both onshore and offshore and the cost-benefit analysis.
- Individual lines represent indicative cable corridors, which where relevant will include several cables, rather than single cables. Multiple cables landing in a single location will require larger onshore infrastructure than individual cables and will take up a greater area of seabed. The lines should not be taken to be specific cable routes.
- These are conceptual network designs and further detailed analysis of many factors such as more detailed planning, coordination and operational analysis are required to turn these into specific plans to take forward. Consideration of further future energy scenarios, least worst regret analysis on the approach to take, seabed analysis and the impact on the environment and coastal communities would also be needed.

Offshore Coordination Project / Summary of findings 21

Click to jump to enlarged diagram

11 www.nationalgrideso.com/research-publications/network-options-assessment-noa

2050: High-level comparison of the integrated network design approach to the status quo approach

By 2050, as shown in Figure 4, the integration of wind connections into new multi-purpose interconnectors, together with integration into existing interconnectors, is considered within these integrated designs. This further reduces the number of connections.

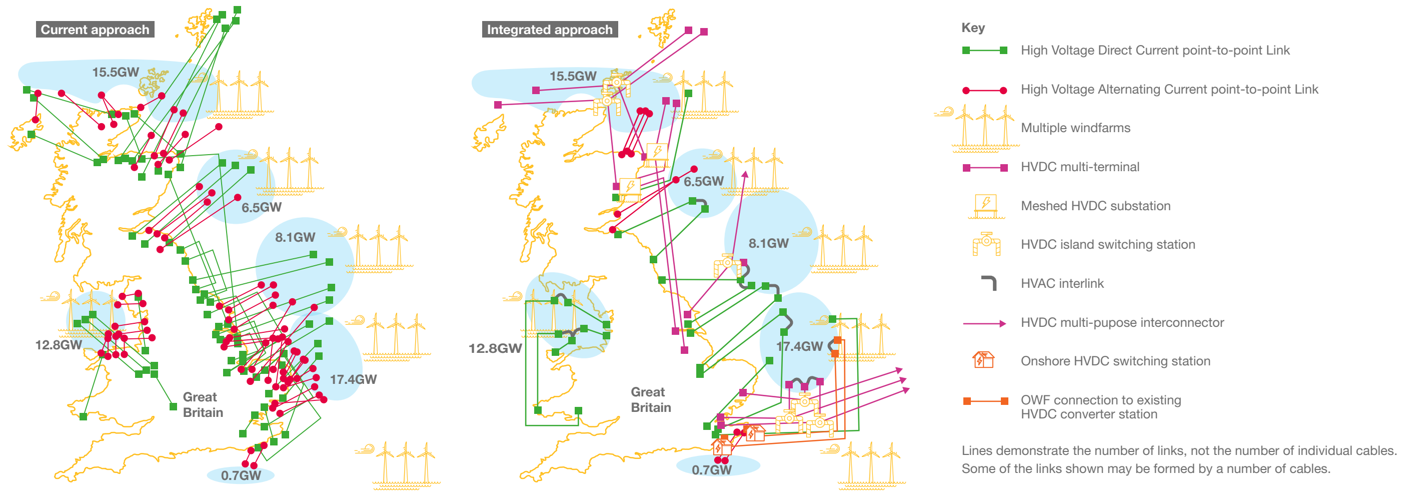


Figure 4 Status quo and Integrated Great Britain network designs in 2050

Click to jump to enlarged diagram

Technology barriers and system risks to achieving the integrated option

In order to progress towards an integrated solution in the required timescales, our work has highlighted the following key barriers and risks that there would be benefit from being overcome. Apart from the highlighted change to the Grid Code, an integrated approach could be implemented without progress on any of these recommendations. However, greater benefits to consumers, the environment and coastal communities would result if these developments are taken forward. These can be divided into technology availability and system risks.

Technology Availability

The majority of the technology required for the Integrated option is available now or will be by 2030. However:

1. There is a need for HVDC circuit breakers (DCCBs) to be progress to commercial use in Europe. DCCBs have been used in three projects in China but not at transmission levels in Europe. Almost all the HVDC systems in operation today have been developed as point-to-point systems without the use of circuit breakers. The Integrated option utilises DCCBs in two locations in Scotland, which we consider the optimal approach for transporting electricity further south. However, an integrated design can be developed in alternative ways if DCCBs are not available. If this was the case there would be additional network infrastructure required, coming at an additional cost. This would also have the potential to increase the likelihood of network faults and therefore impact on system reliability and operability.

2. Higher capacity HVDC submarine and underground cables need to be brought to commercial use in Europe to enable the power transmission from offshore to onshore at the capacities envisaged in the Integrated option if the change to the SQSS standard highlighted below is made. The proposed Integrated option assumes that individual cables with capacities of 1.8 GW are available by 2040. Two such cables together in a bi-pole arrangement will allow connections of 3.6 GW. Currently, the highest individual HVDC cable capacity that is widely available is 1.4 GW, with higher capacities limited in supply options.

A targeted innovation strategy and support for early commercial use, for example through pilot projects where manufacturers can robustly test and iteratively improve their products, could help support the progression of both technologies. There would also be benefit from the initiation of a coordinated process between energy companies, equipment manufacturers and standards organisations to consider options for the standardisation of offshore network designs, the development of functional specifications for technology currently available and to encourage the deployment of DCCBs to European standards in line with the required timing for offshore development timeframes.

Our assessment is that there are no other material HVAC or HVDC critical technology or asset dependencies that would impact development of an offshore integrated network.

Offshore Coordination Project / Summary of findings 23

Impact of System risk on Offshore Integration

In order to deliver the benefit of the Integrated option we have identified that some changes are required to technical network codes and standards. Work to understand these changes and their impact should commence immediately to reduce the likelihood of missed opportunities.

Grid code

A review of the Grid Code[12] to clarify rules in relation to integrated HVDC-connected offshore windfarms will be essential. The rules for wind generation units set out in the existing Grid Code do not fully account for the characteristics of offshore wind farms connected to integrated HVDC offshore transmission networks through meshed connections.

A review of the existing Grid Code, considering a number of technical and commercial challenges for meshed HVDC connections, would ensure rules are clear for offshore wind farms connecting in that way.

Security and quality of supply standard (SQSS)

An assessment of the costs and benefits of better aligning the limits for offshore networks in the SQSS[13] with the onshore network would potentially allow further integration, if the costs do not outweigh the benefits.

The current SQSS effectively limits offshore connections to 1.32 GW normal loss of power infeed risk. Some onshore generation and network assets have a higher, 1.8 GW limit, as infrequent infeed loss. A review of the SQSS would investigate the costs and benefits for better alignment of the limits that apply to onshore and offshore networks. If changes to the infeed loss are progressed, there will be corresponding operational changes and costs associated with the requirement for an increased reserve holding.

It is also likely further changes to the SQSS will be required for an Integrated offshore network and these should be assessed and progressed as well.

Offshore Coordination Project / Summary of findings 24

12 www.nationalgrideso.com/industry-information/codes/grid-code
13 www.nationalgrideso.com/industry-information/codes/security-and-quality-supply-standards

Analysing the impact of offshore integrated designs on the onshore system

We have completed high-level power system analysis of the two offshore connection approaches to determine their impact on the power flow distribution across the onshore transmission network, using the six regions set out in Figure 2.

These simulations provide a high-level indication of how the alternate offshore network designs impact the power transfers across onshore boundaries, and it allows the identification of areas where network reinforcements might be required. This is significant as boundary capacity is one of the main factors that influences the operation of Great Britain's onshore system and the planning needs for the future.

The power system analysis focused on flows of electricity around the network at a high level. Further analysis would be required to assess the impacts on system stability and dynamic performance.

The key conclusions from the power system analysis were that the growth of installed offshore wind capacity and demand forecast between 2025 and 2050 will lead to more power flowing through the onshore network, including the boundaries used for network planning. However, in the Integrated option, 15 to 20 per cent less power flows through the onshore network in 2030 due to more of the power being transported to demand centres via the offshore network.

This rises to between 35 and 60 per cent in 2050, dependent on the region. This difference is reflected in the larger number of network constraints in the status quo option, requiring extensive reinforcements to the onshore network to allow normal operational conditions, thereby incurring higher investment costs than in the Integrated option. These higher onshore network investment costs are reflected in the cost-benefit analysis.

Feedback Questions:

Do you agree with our assessment of the key technology and system risk barriers coming from the Holistic Approach to Offshore Transmission Planning Report?

Do you have any proposals on how to most effectively bring the technology to market for when needed?

Do you have any additional evidence to inform the assessment we have made?

Do you have any further feedback on the report?

How to respond

Offshore Coordination Project / Summary of findings 25

Cost-benefit Analysis Report

Approach to the cost-benefit analysis

The cost-benefit analysis assesses the two offshore network options against the key performance indicators (KPIs) set out on the following pages. The first option, referred to as the status quo (or Counterfactual[14]), assumes that nothing changes in approach between today and 2050 in regard to planning or processes. The second option, referred to as the Integrated option, assumes that works offshore are coordinated, and shared assets bring the energy onshore where appropriate. Both options assume that there are developments in the availability of technology such as larger HVDC converters and cables.

The cost-benefit analysis scores the ten KPIs summarised in this section in three different ways, depending on the types of data being measured:

1. Monetised elements, which include the capital expenditure (capex) and operating expenditure (opex) costs of different types of transmission assets;
2. Quantified elements, such as carbon intensity variation between options; and
3. Qualified elements, which include considerations such as the impact on local communities from a social and environmental perspective.

This hybrid approach results in a score card with a mix of monetised comparators and qualified and quantified scores.

A summary of the outputs of the cost-benefit analysis are set out in this section, with more detail provided in the supporting Cost-benefit Analysis Report.

We have engaged with a wide variety of stakeholders, using open webinars, group workshops and bilateral meetings. The feedback from such sessions, direct questionnaires and question and answer sessions have contributed to the cost-benefit analysis.

We will take account of feedback received in response to this consultation to aid us in refining our report. As a result, the figures may change between this version and the one we publish in December 2020.

Response form click here

14 Please note that the full, supporting cost-benefit analysis document refers to the status quo option as the counterfactual throughout

Offshore Coordination Project / Summary of findings 26

Overview

Overall, there is a greater benefit from the Integrated option across the criteria assessed. This is specifically in the Social/Local Impacts, Environmental Impacts, Capital Expenditure (capex) costs and Operating Expenditure (opex) costs.

There are potentially significant capital cost benefits to the Integrated option compared to the status quo option - up to £5.5 billion out to 2050 (19 per cent reduction) - with a £1 billion reduction (14 per cent) in operational costs[15], based on the assumptions used. The extent of these cost savings varies across the different regions considered. The Integrated option also has the potential to significantly mitigate the environmental impact both offshore and onshore and also reduce the impact on the local communities as a result of a reduction in onshore and offshore infrastructure and number of landing points. Taking account of the assumptions made in our analysis, we estimate this could be around a 50 per cent reduction in total assets required for the Integrated option compared to the status quo.

The integrated design also has potentially more options for the location of the landing points due to the use of HVDC connections, allowing greater potential for them to be located in less environmentally and socially sensitive areas. However, the associated landing site infrastructure for HVDC is likely to be larger than for individual, radial connections and greater cable lengths will of course come at additional cost.

Whilst both the Integrated and status quo options are compliant with the SQSS there are potentially additional benefits to the Integrated option. These include reducing the impact of network faults by offering power an alternative route to market in the event of partial network failure, potentially avoiding consequential boundary reinforcements and the ability to actively re-distribute power across Great Britain, lessening the operational impact of outages and improving voltage management.

For some of the considerations assessed there is not a significant difference between the options. For example, the overall carbon intensity of the Great Britain generation fleet and the curtailment of renewable energy are very similar for the status quo and Integrated options out to 2050.

15 Please note we have added the capital and operating expenditure together and rounded down to £6 billion in the key messages. This £6 billion is roughly 18 per cent of total costs.

Offshore Coordination Project / Summary of findings 27

Capital expenditure (capex)

Capex includes elements such as the cost of obtaining permits, conducting feasibility studies, obtaining rights-of-way, land, preparatory work, designing, dismantling, equipment purchases and installation. The capex costs are based on discounted 2020 prices.

Our analysis suggests that the capital costs of the Integrated option have the potential to be £5.5 billion, or 19 per cent, lower than the status quo option, based on the assumptions used. There are differences in costs between the six regions considered, which are driven by the technology choices, the volume of wind that is connected, and the onshore network capabilities.

Where there is a large volume of wind generation to be connected to areas of the onshore system that are already approaching operational limits, or when offshore windfarms are located at larger distances, the Integrated option delivers greater benefits in terms of reduced capex. This is applicable to the Eastern Regions, East Scotland and North Scotland.

In some regions there are smaller differences between the options. The current, radial HVAC approach is more efficient where the distances are shorter and/or where the volumes of wind are low, for example in the North Wales & Irish Sea region. As the volume and distance of offshore connections increases, the integrated option becomes increasingly cost effective. The regions in which the benefits are highest are also those with the fastest earlier deployment. There is therefore benefit from moving to an integrated approach as soon as possible.

The comparative capital costs of the two options are set out in Table 2 below with the percentage difference being the cost of the integrated option compared to the status quo.

Region	Status quo capex, £m	Integrated capex, £m	Percentage difference
Dogger Bank	£6,064	£5,355	12%
Eastern Regions	£7,521	£5,263	30%
East Scotland	£3,709	£2,623	29%
North Scotland	£7,859	£6,382	19%
North Wales & the Irish Sea	£3,720	£3,650	2%
South East	£126	£126	0%
Total	**£29,000**	**£23,339**	**19%**

Table 2 Capital costs of the two network designs across the six regions assessed, £ million discounted to 2020 prices.

Please note that these overall capital costs differ from other recently published reports as they cover different elements of offshore wind. For example, other analysis such as that by Aurora[16] and the National Infrastructure Commission[17] assess the total costs of projects and Contract for Difference returns needed. They therefore include the costs of elements such as the wind turbines that go above the network considerations we have assessed and are relevant to this project.

16 www.auroraer.com/insight/reaching-40gw-offshore-wind
17 www.nic.org.uk/studies-reports/renewables-recovery-and-reaching-net-zero/

Offshore Coordination Project / Summary of findings 28

Operating expenditure (opex)

Opex is based on the projects' operational and maintenance costs. The opex figures are based on discounted 2020 prices.

Our analysis suggests that between 2025 and 2050 opex costs are £1 billion or 14 per cent lower in the Integrated option.

The reduction in opex costs for the Integrated option is not as significant as for capex as the Integrated design uses more HVDC components, which generally have higher operating costs than HVAC equipment. This higher cost on a unit basis is outweighed in the overall picture by the significant reduction in the number of assets required in the Integrated option compared to the status quo. The profile of opex spend is set out in Figure 5.

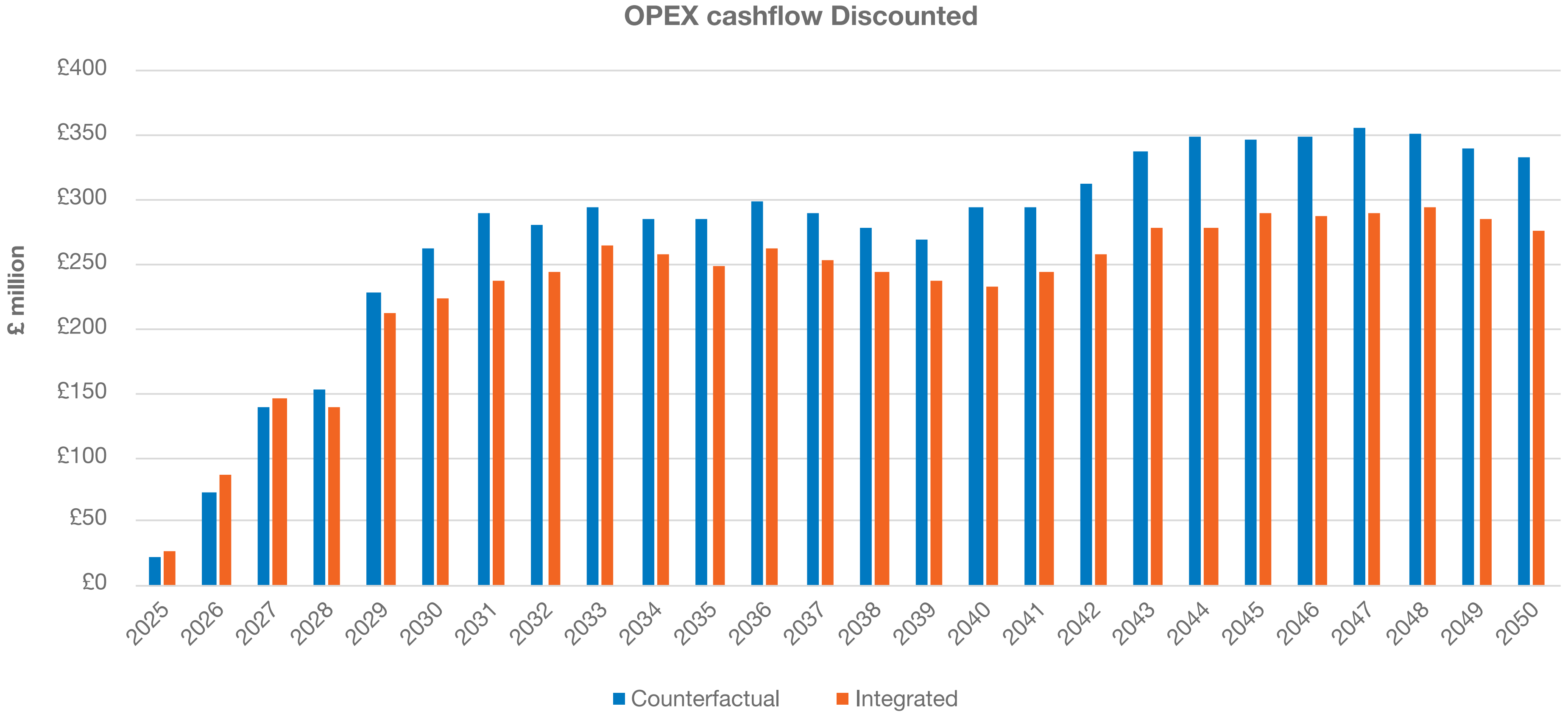


Figure 5 Operational costs of the two network designs across all of Great Britain, in £ million discounted to 2020 prices.

System Costs

The System Costs are those costs directly incurred by the generator in the production of energy and by the ESO in managing the system. These are ultimately passed onto consumers.

Our analysis indicates that by 2050 there is only a marginal difference between the Integrated and status quo options. For both options the constraint costs are less than half a per cent of the total generation costs.

Renewable Energy Integration

This KPI assesses the impact of the two options on the generation volumes of existing renewable power plants, unlocking existing and future renewable generation, and minimising curtailment of electricity produced from renewable sources.

Similar levels of renewable energy generation are facilitated in the two options; the volumes are set out in Table 3. The difference increases slightly over the years, although it remains small.

	Renewable Generation TWh			Renewable Generation Capacity Curtailed TWh		
	2030	2040	2050	2030	2040	2050
Status quo	290	417	561	65	65	88
Integrated	289	418	552	67	64	96

Table 3 Estimated renewable generation in assessed years, in TWh per year

Offshore Coordination Project / Summary of findings 30

Carbon intensity variation

The carbon intensity variation is the change in carbon dioxide (CO_2) emissions in the power system influenced by the two options. This is a consequence of differences in the dispatch of generation and unlocking renewable energy potential. All figures are shown in million tonnes of CO_2 (Mtonnes) per year.

The carbon intensity of the two options is very similar out to 2050, which is set out in Table 4. The difference is not material, with slightly higher emissions in the Integrated option than in the status quo.

	2030	2040	2050
Status quo	16.7	6.9	2.6
Integrated	16.7	6.8	2.6

Table 4 Variation of carbon intensity of the Great Britain generating fleet (Mtonnes)

Grid losses

This KPI reflects the annual onshore grid losses, accounting for the losses incurred in the onshore transmission system.

As can be seen from Table 5, the total annual Grid Losses as a percentage vary only marginally between the integrated and status quo options in our analysis. Additionally, the percentage of total generation lost also does not increase overtime in our analysis.

	2030	2040	2050
Status quo	2.2%	2.0%	2.1%
Integrated	2.0%	1.9%	2.7%

Table 5 Total annual Grid Losses as a percentage of Total Generation

Taken together our analysis indicates that total annual Grid Losses are not a relevant factor by which to choose an option and neither are they likely to be an increasing challenge as the capacity of offshore wind increases on the Great Britain network.

Offshore Coordination Project / Summary of findings 31

Security of supply – Adequacy, Stability and Resilience

Security of supply split into three components:

- Adequacy assesses each option's ability to satisfy the consumer demand and system's operational constraints at any time, in the presence of scheduled and unscheduled outages of generation and transmission components or facilities.
- Security is defined as each option's ability to withstand disturbances arising from faults and the unscheduled removal of equipment without further loss of facilities or cascading failures.
- Resilience is an assessment of the power system's ability to withstand faults and recover after a fault has occurred.

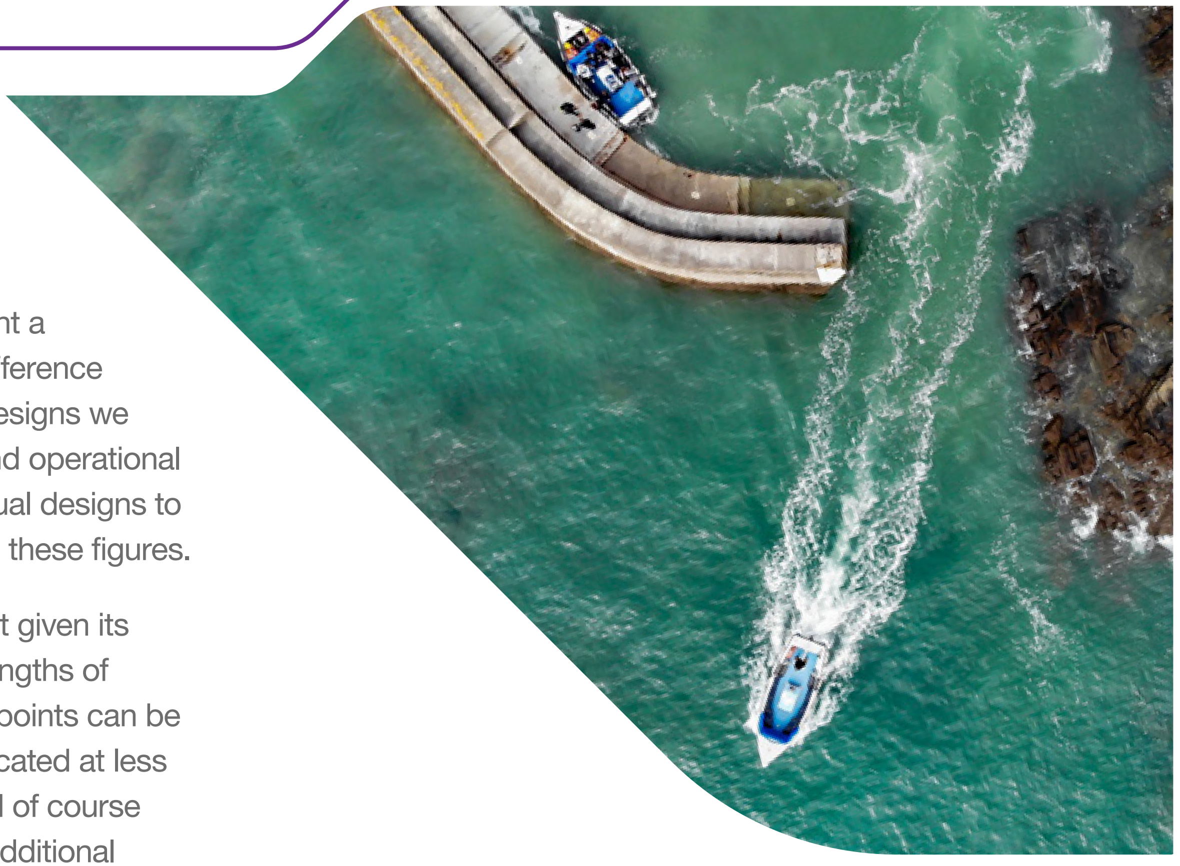
For all of the Security of Supply KPIs mentioned above, our analysis indicates that both options are compliant with the relevant industry codes and requirements.

Whilst both options are compliant, there are a number of areas where the Integrated option provides benefits over and above the status quo option. These include:

- Reducing the impact of network faults by offering power an alternative route to market in the event of partial network failure;
- Avoiding consequential boundary reinforcements, which otherwise are needed in the status quo option; and
- Reductions in the operational impact of outages and improving the voltage management (e.g. the ability to generate power flow to suppress high volts), and other support services (e.g. dynamic system support) as a result of the ability to actively re-distribute power across Great Britain.

Offshore Coordination Project / Summary of findings 32

Cost-benefit Analysis Report



Environmental

Based on the assessment of the scale of assets required and the estimated number of landing points there is likely to be a significant reduction in the impact on the onshore and offshore environment and socially with the Integrated option.

On the basis of the assumptions used in the Holistic Approach to Offshore Transmission Planning Report to develop the conceptual network designs, the number of landing points for the Integrated solution is estimated to be 30 by 2050 and for the status quo 105.

Also taking into account the assumptions in the development of the conceptual network designs, the number of network assets in the Integrated option are 60 per cent lower in 2030, and around 70 per cent lower by 2050. This relates to onshore substations, export cables and offshore platforms.

For both sets of figures we feel this level of reduction is at the upper end of estimates as it is based on the assumption that full integration takes place before 2030. However, this may not be achievable, with changes more likely to happen in a phased way up to this date. We consider a 50 per cent reduction may be a more realistic estimate.

These figures are also caveated in that they represent a snapshot of the designs and are illustrative of the difference between the two approaches to offshore network designs we considered. More detailed planning, coordination and operational analysis would be required to progress the conceptual designs to implementable network designs, which may change these figures.

An additional benefit of the Integrated solution is that given its use of HVDC technology, which allows for greater lengths of sub-sea cable, is greater flexibility of where landing points can be located and therefore offer greater potential to be located at less environmentally sensitive sites. Such flexibility would of course have to be weighed against the additional costs of additional cable lengths in any project assessment.

Offshore Coordination Project / Summary of findings 33

Community and Social

Based on the assessment of the estimated number of assets and landing points required, there is likely to be a materially significant reduction in the local, social impact with the Integrated option compared to the status quo.

To assess the social impact, we invited feedback on specific questions from a range of councils around Great Britain, targeting both those experiencing high levels of offshore development currently and those which are likely to see it in future. We received responses from councils in the east of England and would welcome views from councils in other parts of the country too as our work progresses.

The east of England council officials supported offshore wind as an important part of the future Great Britain's energy system, as a means to reduce the effect of climate change and achieve net zero greenhouse gas emissions by 2050.

The respondents saw offshore wind as a possible economic catalyst for Great Britain as a whole, including on technology development, industry growth, higher employment and energy independence.

They believe that offshore wind has potential as an economic stimulus for their local area and community, including infrastructure development, uplift in property value, industry growth and higher employment. However, they feel that the benefits are for Great Britain more widely than for the local community.

The biggest impacts on a local community are seen to be:

- The disruption during the construction phase of the cable route (including construction of sub-stations and booster stations); the long-term impact associated with the permanent / semi-permanent, large structure/s (i.e. landscape and visual impact);
- Lack of coordination between infrastructure projects; and
- Inadequate mitigation and compensation for local communities.
- The respondents recognised that it was not realistic to wholly avoid new connections in their areas when connecting offshore wind into the electricity transmission system. However, they believe that network connections should be more strategic and coordinated to minimise onshore impacts.

Offshore Coordination Project / Summary of findings 34

Where the cost-benefit analysis could go beyond phase 1

This is the first phase of work and further analysis is required to go into more detail in certain areas. We feel it would be beneficial to consider some factors further, after the completion of this version of the cost-benefit analysis. We do not anticipate the messages from the analysis will change significantly, but the additional analysis will help bring further confidence in the assessment. The areas where there could be benefit in considering further are set out below. During the consultation we will assess whether any can be addressed in that period or whether we would propose they are progressed in a potential second phase.

- The development and assessment of further approaches to coordination, beyond the single Integrated option considered to date, taking different dates as the starting point for integration and considering deliverability and the tipping point between the economics of the Integrated and status quo approaches;
- The assessment of a wider variety of potential generation and demand scenarios beyond Leading the Way;
- More detailed analysis of the relative requirements and costs of the onshore network in the different options; and
- More assessment of landing point information (comparative size/location impacts).

Feedback Questions:

Do you agree with our assessment of the costs and benefits?

Do you have any other evidence to support or challenge the assessment made?

What do you see as the potential impact on the environment of these proposals, particularly the reduction in the number of assets and landing points?

Do you have any further evidence on the potential social and community impacts of these proposals? We would particularly welcome responses from local authorities on this question.

Where do you see value for further work to build on and test these findings? Either from the proposed list or beyond?

How to respond

Offshore Coordination Project / Summary of findings 35

Key recommendations from the connections report

We recommend the following actions are taken forward to improve the connections process in the timescales set out below. Work is already underway to progress the immediate to short-term opportunity. Alongside this we will assess our capacity to progress the other recommendations alongside other resource commitments and discussions on the scope for a potential second phase of the project. The timeframes referred to in this section are:

Timeframe	Expected connection date
Immediate-term	Early 2020s
Short-term	Mid to late 2020s
Medium-term	Mid to late 2020s and early 2030s
Long-term	Early to Mid-2030s and beyond

Table 6 Timeframes referred to in the Offshore Connections Review Report

Offshore Coordination Project / Summary of findings 36

Immediate to Short Term Opportunities

1. Review the Connections and Infrastructure Options Note (CION) to implement improvements that drive and encourage coordination

The CION[18] process evaluates a range of transmission options to lead to the identification and development of the overall efficient, coordinated and economical connection point for offshore connections, onshore connection design and, where applicable, offshore transmission system / interconnector design to develop and maintain an efficient, coordinated and economical system of the electricity transmission network.

This review includes considering:

- The value of exercising the existing option to reopen the CION and encourage coordination of projects;
- The development of the concept of regional CIONs, where a group of connections in a similar geographical area are assessed through the CION process; and
- The mechanisms for how key stakeholders could be more involved in relevant points in the process.

This should allow us to facilitate coordination in a clear, transparent and defined way, allow easier access to connection sites for project developers, and enhance the capacity to connect more customers in the future.

This recommendation will help address some of the current issues with the CION that stakeholders have fed back, which include:

- The time taken to complete the CION process and a lack of consistency in the average times for offers;
- The level of communication and collaboration between the ESO, the project developer and key stakeholders such as local councils and environmental organisations;
- The current process is iterative and the outcome of one CION analysis must be known before another CION can be completed with any certainty;
- Generation background assumptions are not applied consistently across CION projects and changes are too frequent, which results in the process taking a long time, re-work taking place and unexpected changes for the connectee; and
- Coordination across projects is challenging as a result of the CION being a standalone project by project assessment rather than taking a coordinated approach with a multi-developer CION considering numerous projects at the same time.

In collaboration with the relevant stakeholders we will agree the timescales in which we can implement this option.

18 www.nationalgrideso.com/document/45791/download

Offshore Coordination Project / Summary of findings 37

Medium to Long Term Opportunities

1. Package or coordinate connection offers

In this activity, we would investigate in conjunction with The Crown Estate and Crown Estate Scotland whether it would be possible to package a connection offer with the seabed lease agreement to encourage greater coordination. This would focus connection applications on a specific time window as far as possible and would therefore also potentially facilitate the management of applications as a group.

This would help address the issue that the connections process can be long with key milestones for progress often separated by multiple years. It will help with the timing of decision making and the availability of information throughout the process and help prioritise the projects with higher certainty of progressing. Considering connection applications together as part of the zone would also allow more coordination with interested parties onshore.

2. Review where the risk sits for financial liabilities for offshore connections and ensure that this is optimal for encouraging coordination

In an integrated approach, where multiple developers are connecting to an offshore network, there needs to be clear agreement on how the project liabilities will be managed and ensure that this is done in a way that balances the needs of projects to gain appropriate funding with ensuring that one party does not penalise another and also ensuring that incentives are in place to drive coordination. Project liabilities are the risks of costs that are incurred (generally by the TOs) between an application being accepted and the connection being completed and generation starting. This review may involve refinement of the current liabilities for broader system and generator-driven investment.

In addition, developers will need a clear route to market and certainty on delivery of their connection assets. Where this goes beyond the remit of the ESO we anticipate that this will be considered as part of the BEIS-led Offshore Transmission Review.

3. Consider formalising developers' roles in the System Operator-Transmission Owner Code (STC) to improve the efficiency and customer focus of the CION decision making process

This would enable developers to be formally involved in the CION process especially with the proposed grouped studies and help further with some of the challenges highlighted on the previous page.

This would also potentially give developers more direct control over the works that they are reliant on and therefore allow them and others up to coordinate more when the certainty is increased.

4. Codification of the CION into the Connection Use of System Code (CUSC)[19] to define timescales and provide clarity and consistency

Although not coordination-specific, this would be beneficial in streamlining CION offers and ensuring consistency for all connections. Codification of the CION would have the benefit of greater transparency for customers, with potentially greater certainty and more information earlier in the process.

19 CUSC www.nationalgrideso.com/industry-information/codes/connection-and-use-system-code-cusc

Offshore Coordination Project / Summary of findings 38

Next steps for the recommendations

Immediate to short term opportunities

Review Connection and Infrastructure Options Note (CION) to implement improvements that drive and encourage coordination.

Work has commenced in scoping the review of the CION, the most effective way to take this forward and the timescales in which it will deliver. There will be further direct engagement with stakeholders as we refine and then implement these changes.

Medium to long term opportunities

Following publication of this consultation we will be refining our thoughts on what a potential Phase 2 of the Offshore Coordination project may look like. We will engage further with stakeholders on the prioritisation of these potential improvements and how best to progress them.
The proposed second phase of the ESO's work on Offshore Coordination will take these proposed areas of improvement and fully plan out a roadmap for their implementation.

Feedback Questions:

Do you think that if the areas we are highlighting were improved, that the ability to coordinate projects would be significantly increased?

Do you think we have missed anything in our offshore connections review that would add value and increase coordination?

How to respond

Offshore Coordination Project / Summary of findings 39

Continuing the conversation

Email us with your views on Offshore coordination or any of our future of energy documents at box.OffshoreCoord@nationalgridESO.com and one of our team member will get in touch.

For further information on the project and current and past events please visit: www.nationalgrideso.com/future-energy/projects/offshore-coordination-project

Write to us at:

Offshore Coordination Team
Faraday House
Warwick Technology Park
Gallows Hill Warwick
CV34 6DA

Glossary

Alternating current AC
Electric power transmission in which the voltage varies in a sinusoidal fashion, resulting in a current flow that periodically reverses direction. In Great Britain the direction is reversed 50 times each second.

Ancillary services
Services procured by a system operator to balance demand and supply and to ensure the security and quality of electricity supply across the transmission system. These services include reserve, frequency control and voltage control. In Great Britain these are known as balancing services and each service has different parameters that a provider must meet.

Bipole HVDC Configuration
The combination of two converter poles with a common low voltage return path, which if available will only carry a small unbalance current during normal operation.

Bootstrap
Subsea high voltage direct current (HVDC) link providing undersea connections between two points on the National Electricity Transmission System.

Boundary
The transmission system is split by boundaries that cross important power-flow paths where there are limitations in capability or where we expect additional bulk power transfer capability will be needed.

Cable corridor
The route taken by cables, either undersea or onshore.

Capacity
The maximum rated power output of an electricity generation technology - usually measured in Watts (or kilowatts (kW), megawatts (MW), gigawatts (GW) or terawatts (TW)).

Capital Expenditure Capex
Funds used by a company to acquire, upgrade and create assets such as IS systems, property, or equipment.

Carbon dioxide CO_2
The main greenhouse gas. The vast majority of CO_2 emissions come from the burning of fossil fuels.

Carbon intensity
A way of examining how CO_2 is emitted in different processes. Usually expressed as the amount of CO_2 emiitted per km travelled, per unit of heat created or per kWh of electricity produced.

Circuit breaker
A switch that connects or disconnects a circuit, generator, load or piece of transmission equipment and automatically shuts off the power when required to prevent damage.

Connection and Infrastructure Options Note CION
This is the document where the output of the CION optioneering process is recorded. It provides a joint record of the rationale for the selection of the overall preferred connection option from the assessment of technical, commercial, regulatory, environmental, planning and deliverability aspects.

Connection Use of System Code CUSC
The Connection and Use of System Code is the contractual framework for connecting to and using the National Electricity Transmission System (NETS).

Contingency
Is the loss or failure of a part of the power system (e.g. a transmission line), or the loss/failure of individual equipment such as a generator or transformer. This is also called an unplanned “outage”.

Constraint costs
The costs incurred through paying generators to vary their power output when the electricity transmission system is unable to transmit power to the location of demand, due to congestion at one or more parts of the transmission network.

Contract for Difference CfD
A contract between the Low Carbon Contracts Company (LCCC) and a low carbon electricity generator, designed to reduce its exposure to volatile wholesale prices.

Cost-Benefit Analysis CBA
A method of assessing the benefits of a given project in comparison to the costs. This tool can help to provide a comparative base for all projects to be considered.

Decarbonisation
The process of removing carbon emissions (e.g. generated by burning fossil fuels) from our economic and social activities.

Department for Business, Energy and Industrial Strategy BEIS
A UK Government department with responsibilities for business, industrial strategy, science, innovation, energy, and climate change.

Direct Current DC
Electrical current that moves in one direction only.

Direct Current Circuit Breakers DCCBs
A DC switch that connects or disconnects a circuit, generator, load or piece of transmission equipment and automatically shuts off the power when required to prevent damage.

Dynamic performance
Fast response to changes in frequency, voltage and current on the transmission network to maintain stable network operation.

Meshed connections
Is a network design, where the exact flow of power on any particular line of the network depends on the combination of loads and generation at different locations, and the characteristics of the lines.

National Grid Electricity System Operator (ESO) ESO
National Grid Electricity System Operator (ESO) moves electricity to where it is needed on the transmission system, balancing supply and demand on a second by second basis in Great Britain. The ESO does not own any transmission assets, the electricity transmission system is owned by National Grid Electricity Transmission, Scottish Hydro Electricity Transmission and SP Transmission. Since April 2019 the ESO has been a legally separate company within the National Grid Group and has its own regulation, incentive scheme and company board.

Forward Plan
Published each financial year between 2018/19 and 2020/21, our Forward Plan describes what the ESO is planning to do to deliver benefits for our customers and stakeholders. It includes a set of criteria for our performance to be measured against.

Future Energy Scenarios *FES*
The *FES* is a range of credible pathways for the future of energy out to 2050. They form the starting point for our transmission network and investment planning, and are used to identify future operability challenges and potential solutions.

Gigawatt GW
A unit of power. 1 GW = 1,000,000,000 watts.

Gigawatt Hour GWh
1,000,000,000 watt hours, a unit of energy.

Great Britain GB
A geographical, social and economic grouping of countries that contains England, Scotland and Wales.

Greenhouse gas
A gas in the atmosphere that absorbs and emits radiation within the thermal infrared range.

Grid Code
Specifies the technical requirements for connection to, and use of, the National Electricity Transmission System.

Grid curtailment
This is when the output from a generation unit connected to the electricity system is reduced due to operational balancing.

Grid Losses (transmission losses)
Power lost through the energisation and transmission of energy through the transmission network.

High Voltage Alternating Current HVAC
AC power transmission at voltages above 110 kilovolts (kV).

High Voltage Direct Current HVDC
DC power transmission at voltages above 110 kilovolts (kV).

Infeed
The provision of power from generators onto the National Electricity Transmission System.

Interconnector
Transmission assets that connect the GB market to Europe and allow suppliers to trade electricity or gas between markets.

Key Performance Indicator KPI
A measure of performance

Landing Point
The location where a submarine or other underwater cable makes landfall.

Leading the Way Scenario LW
One of the 2020 Future Energy Scenarios (*FES*) in which it is assumed that GB decarbonises rapidly with high levels of investment in world-leading decarbonisation technologies. Our assumptions in different areas of decarbonisation are pushed to the earliest credible dates. Consumers are highly engaged in acting to reduce and manage their own energy consumption. This scenario includes the highest and fastest improvements in energy efficiency to drive down energy demand, with homes retrofitted with insulation such as triple glazing and external wall insulation, and a steep increase in consumer participation in smart energy services. Hydrogen is used to decarbonise some of the most challenging areas of society such as some industrial processes, with this Hydrogen produced solely from electrolysis powered by renewable electricity. Leading the way achieves 40 GW of offshore wind by 2030 and meets the UK target for net zero greenhouse gas emissions in 2050.

Load factor
An indication of how much a generation plant or technology type has output across the year, expressed as a percentage of maximum possible generation. These are calculated by dividing the total electricity output across the year by the maximum possible generation for each plant or technology type.

Loss of Load Expectation LOLE
Used to describe electricity security of supply. It is an approach based on probability and is measured in hours per year. It measures the risk, across the whole winter, of demand exceeding supply under normal operation. In Great Britain the standard is 3 hours per year but this does not mean there will be loss of supply for 3 hours per year. It gives an indication of the amount of time, across the whole winter, which the Electricity System Operator (ESO) will need to call on balancing tools such as voltage reduction, maximum generation or emergency assistance from interconnectors. In most cases, loss of load would be managed without significant impact on end consumers.

LVDC return cable
Low voltage direct current return cable. During normal operation the LVDC cable carries only a small unbalance current. Upon a single HVDC cable fault, the LVDC return cable path takes over the full current in the healthy circuit and the faulty circuit can be isolated.

Mega tonnes of CO_2 equivalent $MtCO_2e$
The equivalent of 1,000,000 tonnes of carbon dioxide; the standard unit for measuring national and international greenhouse gas emissions.

Megawatt MW
A unit of power. 1 MW = 1,000,000 watts.

Megawatt hour MWh
A unit of energy. 1MWh = 1,000,000 watt hours,

Net zero greenhouse gas emmissions
When the total of all greenhouse gasses emitted in a year reaches zero, after all emissions and all carbon sequestration has been accounted for. This is the current UK target for 2050.

National Electricity Transmission System NETS
The network and assets infrastructure that supports the electricity transmission system in England, Scotland and Wales.

Office of gas and electricity markets Ofgem
The UK's independent National Regulatory Authority, a non-ministerial government department. Their principal objective is to protect the interests of existing and future electricity and gas consumers.

Offshore
This term means wholly or partly in offshore waters.

Offshore HVDC switching platforms
The offshore high voltage direct current switching platforms that interconnects two or more direct current circuits using circuit breakers or disconnectors to form a multi-terminal HVDC network.

Offshore HVDC Converter Platform
The offshore (in the sea) high voltage direct current converter platform converts alternating current (power that flows in alternating directions) into direct current (power that can only flow in one direction).

Onshore converter station
Onshore infrastructure on the National Electricity Transmission System that converts between HVDC and HVAC.

Onshore
This term refers to assets that are wholly on land.

Operating expenditure Opex
Operational expenditure which is an ongoing cost for running a product, business, or system.

Power System Analysis
A group of studies used to analyse a power system's response to events over different time periods.

Power transfer
The transport of power from one point to another.

Radial
Direct single connection of an offshore wind farm to the onshore transmission network without connection to other points.

Reinforcements
Additional grid infrastructure implemented to ensure the National Electricity Transmission System can accommodate existing and future generation and demand.

Revenue = Incentives + Innovation + Outputs RIIO
Ofgem's regulatory framework that sets price controls to determine the amount network companies can earn from the services they provide.

Security and Quality of Supply Standard SQSS
A set of standards used in the planning and operation of GB's National Electricity Transmission System, including both onshore and offshore.

System Operator-Transmission Owner Code STC
The System Operator Transmission Owner Code defines the relationship between the transmission system owners and the system operator.

Terawatt hour TWh
1,000,000,000,000 watt hours, a unit of energy

Technology Readiness Level TRL
This is a scale for measuring the maturity of technology, from basic research through test, launch and operations. It indicates where a system is on development lifecycle and its readiness for operational use.

The Crown Estate
Is an independent commercial business, created by an Act of Parliament, with a diverse portfolio of UK buildings, shoreline, seabed, forestry, agriculture and common land. They are responsible for the leasing of seabed offshore in England and Wales.

The Crown Estate Scotland
Manages land and property owned by the Monarch in right of the Crown in Scotland. The business was set up following the Scotland Act 2016 and pays all revenue profit to the Scottish Consolidated Fund. They are responsible for the leasing of seabed offshore in Scotland.

Transmission Owner TO
A collective term used to describe the three electricity transmission asset owners within Great Britain, namely National Grid Electricity Transmission, Scottish Hydro Electric Transmission Limited and SP Transmission plc.

United Kingdom of Great Britain and Northern Ireland UK
A geographical, social and economic grouping of countries that contains England, Scotland, Wales and Northern Ireland. The 2050 Net Zero Emissions Target is on a UK basis (i.e. includes Northern Ireland as well).

Voltage control
The regulation of connection point voltage to within statutory limits.