Disclaimer

This Statement, dated September 2010, is produced by National Grid Electricity Transmission plc ("NGET") acting in its role as National Electricity Transmission Operator (NETSO). It is produced pursuant to Special Condition C4 ("Role in respect of the National Electricity Transmission System Operator area located in offshore water") of the licence to participate in the transmission of electricity granted to NGET pursuant to Section 6(1) (b) of the Electricity Act 1989 (as amended by the Utilities Act 2000, the Energy Act 2004 and the Energy Act 2008).

The form of this Statement has been approved by the Authority.

The Statement and this web site ("the Site"), which must be used in accordance with the following Terms and Conditions, are governed by the law of and subject to the jurisdiction of England and Wales and of Scotland.

The information required to be included in this Statement is set out in Special Condition C4 of NGET’s licence. This Statement is not intended to imply any legal obligations as regards the future development of the National Electricity Transmission System. This Statement should not be regarded as an indicator of the performance and prospects of National Grid or any other party.

Whilst reasonable care has been taken in the preparation of this Statement, no representation, express or implied, is made as to the accuracy or completeness of such information. NGET and members of the National Grid Group do not accept any liability for the accuracy of the information contained herein and in particular neither NGET nor the Group, nor the directors nor the employees of NGET nor the Group shall be under any liability for any error or misstatement or opinion on which the recipient of this Statement relies or seeks to rely other than fraudulent statements or fraudulent misrepresentation.

Copyright

Any and all copyright and all other intellectual property rights contained in the Statement and in any other Site content (including PDF documentation) belong or have been licensed to National Grid. If you modify or adapt the Statement, the Site content or any such documentation, you acknowledge and accept full responsibility for the accuracy of the modified or adapted Statement, Site content and/or documentation. To the extent that you re-use the Statement, any Site content or documentation in its original form and without making any modifications or adaptations thereto, you must reproduce, clearly and prominently, the following copyright statement in your own documentation: © 2010 National Grid plc, all rights reserved.

The trade marks, logos and service marks displayed on the document and on the Site are owned and registered (where applicable) by National Grid or another member of the Group. No rights or licence are granted or may be implied by their display on the Site.

Cover Photograph: Gunfleet Sands Offshore Windfarm in the Northern Thames Estuary, Great Britain
© DONG Energy
Foreword

The 2010 Offshore Development Information Statement (Statement) has been published by National Grid Electricity Transmission plc (NGET) acting in its role as National Electricity Transmission System Operator (NETSO). National Grid Electricity Transmission plc is a member of the National Grid plc (National Grid) group of companies. The Statement is produced in accordance with the obligations placed on NGET under Special Licence Condition C4 of its electricity transmission licence. Amongst other things, this condition requires that NGET publishes this Statement on an annual basis.

The Statement provides a wide range of information relating to the possible development of both the offshore and onshore electricity transmission systems and provides a high-level desktop analysis of the various ways in which:

- the offshore transmission network can be developed to interconnect offshore generation with the onshore transmission network; and

- the onshore transmission network can be reinforced to provide the necessary connection and transfer capability to support the connection of offshore transmission networks.

The aim is to identify potential economic and co-ordinated options from this desktop analysis. It is envisaged that the Statement will provide a platform for more detailed analysis and evaluation to be performed regarding the optimisation of offshore transmission development.

The detailed evaluation and design of offshore infrastructure, including any environmental impact assessment, remains the responsibility of the Offshore Transmission Owner (OFTO) or developer (dependent on the approach applicable to the individual project). Therefore the actual development of the offshore and onshore transmission systems can and may differ from that illustrated in the Statement.

The Statement includes a number of conceptual design strategies which demonstrate how different technology and topology assumptions can impact the optimisation of offshore transmission development. Given a better understanding of the technologies available since the publication of the 2009 Statement, NGET has undertaken a conceptual design study into the development of an integrated offshore transmission network. The resulting design is one that is based on the installation of high voltage multi-user assets that interconnect the offshore platforms to form an offshore network. This conceptual design highlights how the overall volume of assets installed offshore could be reduced, whilst network security and operational flexibility is improved. This is based on onshore/offshore optimisation, the latest technology and a degree of anticipatory investment offshore.

As with all designs included within this Statement, this approach represents one of many ways in which efficient offshore connection could be facilitated. The mechanism by which it could be delivered is not discussed in this Statement.

The inclusion of the different design strategies may facilitate the evaluation of the potential options in terms of capital costs, planning implications, risks, environmental assessment and the supply chain for individual offshore generation projects.
Comments

I hope you find the 2010 Statement both interesting and informative. Given the challenges facing the electricity industry in facilitating offshore generation and contributing to the UK’s environmental targets, I would particularly welcome any comments you may have on both the style and content of the Statement so we can fully consider any improvements for the 2011 Statement. An Online Survey Form has been made for this very purpose. I look forward to receiving your views on the Statement, including suggestions on how it may be further improved.

Nick Winser, Executive Director, Transmission
National Grid
September 2010
# Contents

**Executive Summary**

<table>
<thead>
<tr>
<th>1. Offshore Electricity Transmission Overview</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 Background</td>
</tr>
<tr>
<td>1.2 Offshore Generation Development</td>
</tr>
<tr>
<td>1.3 Offshore Electricity Transmission</td>
</tr>
<tr>
<td>1.4 Previous and Parallel Initiatives</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Offshore Development Information Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 Aim and Purpose</td>
</tr>
<tr>
<td>2.2 Statement Development</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Current Offshore Generation and Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1 Offshore Wind Generation: Development to Date</td>
</tr>
<tr>
<td>3.2 Offshore Marine Generation: Development to Date</td>
</tr>
<tr>
<td>3.3 Offshore Wind Development Map</td>
</tr>
<tr>
<td>3.4 Offshore Generation: Grid Connections</td>
</tr>
<tr>
<td>3.5 East Coast</td>
</tr>
<tr>
<td>3.6 North West</td>
</tr>
<tr>
<td>3.7 Thames Estuary</td>
</tr>
<tr>
<td>3.8 Bristol Channel</td>
</tr>
<tr>
<td>3.9 Scotland</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4. Future Generation and Demand Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1 Overview</td>
</tr>
<tr>
<td>4.2 Industry Consultation and Selection Process</td>
</tr>
<tr>
<td>4.3 Future Scenarios</td>
</tr>
<tr>
<td>4.4 Future Scenario: 2020 Renewable Assessment</td>
</tr>
<tr>
<td>4.5 Additional Sensitivities</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5. Offshore and Associated Onshore Connection Designs</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1 Overview</td>
</tr>
<tr>
<td>5.2 Onshore/Offshore Design</td>
</tr>
<tr>
<td>5.3 North West – Irish Sea</td>
</tr>
<tr>
<td>5.4 Bristol Channel – Atlantic Array</td>
</tr>
<tr>
<td>5.5 South Coast – Hastings and West of Isle of Wight</td>
</tr>
<tr>
<td>5.6 East Anglia - Norfolk</td>
</tr>
<tr>
<td>5.7 East Coast – Dogger Bank and Hornsea</td>
</tr>
<tr>
<td>5.8 Scotland</td>
</tr>
</tbody>
</table>
6. Main Interconnected Transmission System
6.1 Background and Assessment Methodology 118
6.2 Boundary Map 120
6.3 MITS Reinforcement Options 121
6.4 Boundary Considered 124

7. Way Forward
7.1 Feedback on 2010 Statement 134
7.2 Consultation on 2010 Statement 134
7.3 Proposed Consultation Timetable and Key Milestone Dates 135
7.4 Continuous Development of Statement 135

Glossary 136

Appendices
1. Future Scenarios Details A-1
2. Maps A-7
3. Offshore Network Design Methodology A-9
Executive Summary

Introduction

The 2010 Offshore Development Information Statement (Statement) is the second to be published by National Grid Electricity Transmission plc (NGET) acting in its role as National Electricity Transmission System Operator (NETSO).

The aim of this annual Statement is to facilitate the development, in offshore waters, of an efficient co-ordinated and economical system of electricity transmission. The Statement includes a wide range of information relating to the possible development of the National Electricity Transmission System (NETS) in offshore waters including applicable technology, potential offshore transmission design and onshore transmission co-ordination. It is also supported by technical and economic analysis which sets out options for reinforcing both the offshore and onshore transmission networks. It has not, however, looked at project specific engineering routes or the availability of routes to shore.

Scope, Responsibility and Deliverability Considerations

When reading the Statement, it is important to consider that all future scenarios contained within and the illustrative electricity transmission system connection works shown, have been developed purely for analysis purposes, via a desktop study and included for illustrative purposes only. These designs are based on a fixed point in time and may change as the offshore network evolves.

The designs should not be considered as implying actual connection dates or future connection routes for new infrastructure and are not intended to reflect the Transmission Owners (TOs) investment decisions regarding the development of their transmission area. The Statement does not cover sub-transmission connections other than showing the nearest affected Grid Entry Point.

The detailed evaluation and design of offshore infrastructure, including any environmental impact assessment, remains the responsibility of the Offshore Transmission Owner (OFTO) or developer (dependent on the approach applicable to the individual project). All diagrams represent the shortest route to shore given an electrically efficient onshore connection point.

The actual development of the offshore and onshore transmission systems can and may differ from that illustrated in the Statement.

Offshore Generation: Developments

Offshore generation has a critical role to play in delivering the UK’s renewable energy targets and security of supply needs; and in decarbonising the energy sector. Changes to the UK energy markets and regulatory framework have been made to encourage the development of renewable energy in the UK. The introduction of the Renewables Obligation (RO) scheme has provided a considerable incentive for the development of renewable generation. Recent changes to the scheme’s operational timeline (extended to 2037) and the introduction of the banding system, with some technology types receiving additional Renewable Obligation Certificates, will continue to provide financial support to the development of renewable energy.

In addition to the market stimulus provided by the RO, offshore generation has been supported by The Crown Estate’s leasing programme for offshore generation sites. To date there have been five offshore wind development leasing rounds and one marine generation leasing round which represents a potential offshore generation capacity of 55 GW (approx maximum). There have also been significant developments in the delivery of offshore generation since the publication of the 2009 Statement. The total amount of installed capacity from offshore generation is now in excess of 1 GW.

In addition to the market stimulus provided by the RO, offshore generation has been supported by The Crown Estate’s leasing programme for offshore generation sites. To date there have been five offshore wind development leasing rounds and one marine generation leasing round which represents a potential offshore generation capacity of 55 GW (approx maximum). There have also been significant developments in the delivery of offshore generation since the publication of the 2009 Statement. The total amount of installed capacity from offshore generation is now in excess of 1 GW.

The first tender round for transitional offshore wind projects nears completion. The announcement of the preferred bidders, selected to own and operate the first £700m worth of transmission links to seven of the offshore wind farms was made in August 2010. The commencement of the first enduring tender round is subject to the outcome of the enduring regime consultation process. In addition to the existing ‘OFTO
build’ approach, DECC/Ofgem are consulting on providing the option which will enable generator developers to design and construct the transmission infrastructure which will eventually be transferred to the appointed OFTO (‘Generator Build’ option). The consultation also outlined the implementation challenges that have been identified in delivering the ‘Generator Build’ option and considered how the regime can facilitate the development of a co-ordinated electricity transmission system.

Future Scenarios

To assess the need for future transmission system development, it is necessary to make assumptions regarding the future generation and demand background that the electricity transmission system will need to accommodate. Four future generation and demand background scenarios: Slow Progression, Gone Green, Accelerated Growth and Sustainable Growth are used to assess the range of potential investment options. The future scenarios cover the period from 2010 to 2025 and consider the anticipated range of potential offshore developments from nearly 17 GW of offshore generation capacity in 2025 in the Slow Progression scenario to over 47 GW of offshore generation capacity in 2025 in Sustainable Growth. The future scenarios, presented in this Statement, are different from the contracted position for the future use of the NETS as presented in the Seven Year Statement (SYS).

Figure 1 details the amount of offshore generation (wind and marine) capacity for each of the four future scenarios (inclusive of offshore generation connecting to the onshore distributed electricity network).

Figure 1 - Future Scenarios Comparison: Offshore Generation (Accumulative Capacity)

The dates (and the associated build-up rates) depicted in the future scenarios study period are for analysis purposes only and are intended to illustrate how the electricity transmission system would need to be developed to enable that level of generation to connect to the electricity network. The actual transmission connection dates of the offshore generation projects are subject to the current governance framework, planning process, supply chain, technology and financial considerations all of which will be reflected in the connection date provided to and agreed by the developer. Furthermore the actual development of the offshore and onshore transmission systems can and may differ from that illustrated by the future generation and demand scenarios (and sensitivities) included within the Statement.

In addition to the four main scenarios, sensitivities on Interconnectors and Additional Regional Capacity (ARC) have been analysed and the results included in the Statement.
Offshore and Associated Onshore Connection Designs

Key factors in the design of the offshore electricity transmission network are the technologies available and the application of the National Electricity Transmission System Security and Quality of Supply Standard (NETS SQSS). After reviewing the existing technology available and that expected in the near future, a set of possible standard designs for offshore electricity transmission has been formulated and subsequently presented in the Statement.

The Statement also includes a number of conceptual desktop design strategies which demonstrate how different technology and topology assumptions can impact the optimisation of offshore transmission development. The different design strategies presented in the Statement are:

- **Radial**: point-to-point connections from the offshore generation to suitable onshore Main Interconnected Transmission System (MITS) collector substations using current generation technology.

- **Radial Plus**: similar to radial in the use of point to point connections for connecting the offshore generation to the onshore MITS but utilising anticipated future transmission technology capability within the strategy (e.g. 2 GW capacity converter stations and high capacity offshore cables) in line with delivery forecasts for the next five years. Radial Plus also differs from the Radial Strategy in that multiple groups of offshore generation are connected to the radial point-to-point connections as opposed to a single group being connected radially.

- **Integrated**: an interconnected offshore design using AC cable and HVDC interconnection between offshore platforms and development areas, using the same advanced technology as with the Radial Plus Strategy. Multiple offshore platforms will be interconnected, providing fewer cables and reduced asset volumes.

The 2010 Statement includes a conceptual integrated network design solution. As the transition through the various offshore wind farm development leasing rounds e.g. Round 1, 2, 3, Scottish Territorial Waters (STW), etc occurs, the expected growth rate, location and size of offshore wind projects has led NGET to consider different ways in which offshore connections might be optimised. Given a better understanding of the technologies available since the publication of the 2009 Statement, NGET has undertaken a conceptual design study into the development of an integrated offshore transmission network.

The study has been premised on the principle that any design solution should:

- maximise the potential deliverability of offshore wind;
- co-ordinate onshore and offshore investment requirements to minimise environmental impacts;

The different design strategies are illustrated in Figure 2.

![Figure 2 - Strategy Design Configurations for Large Offshore Wind Farms](image-url)
maximise security of supply and network resilience, increasing the level of resilience to offshore connections; and

minimise the overall cost to consumers.

The resulting design is one that is based on the installation of high voltage multi-user assets that interconnect the offshore platforms to form an offshore network. This conceptual design highlights how the overall volume of assets installed offshore could be reduced, whilst network security and operational flexibility is improved. This is based on onshore/offshore optimisation, the latest technology and a degree of anticipatory investment offshore.

It should be recognised however that in order to attain the benefits associated to the integrated solution, it will be necessary to commence development of this solution within a suitable timeframe. Early common technical and functional specifications will be needed to ensure a smooth transition to an integrated design.

As with all designs included within this Statement, this approach represents one of many ways in which efficient offshore connection could be facilitated. The mechanism by which it could be delivered is not discussed in this Statement.

The inclusion of the different design strategies may facilitate the evaluation of the potential options in terms of capital costs, planning implications, risks, environmental assessment and the supply chain for individual offshore generation projects.

All design strategies included herein reflect the aim and intention of the Statement in facilitating the development of an efficient, co-ordinated and economical system of electricity transmission. This Statement does not discuss the potential regulatory mechanisms/frameworks for the enduring offshore regime that could incentivise particular design solutions.

Main Interconnected Transmission System (MITS)

The accumulative effect of all the possible new generation (both onshore and offshore) has a marked effect on the nature of the power flows across the MITS. A large proportion of new generation lies to the north of the electricity network; while demand remains in the south which leads to electricity transmission reinforcements being needed for a number of northern boundaries.

To accommodate the changing power flows across the transmission network a number of reinforcements have been proposed as strategic developments. For this Statement, the NETS SQSS required boundary transfers have been plotted against a number of key system boundaries for each future scenario. Against each boundary, a set of MITS reinforcements has been identified which satisfies the requirements for the majority of the future scenarios. The graphs shown in Chapter 6 show both the required transfers for each boundary, (for the selected boundaries under the given future scenario), superimposed with the present and future capabilities under the given reinforcements. The results from the analysis are intended to illustrate the continuous change of the MITS boundaries over time and how the timing of MITS reinforcements may vary under the different future scenarios.

Practical Challenges

Amongst the many challenges for development of the offshore transmission network, the availability of the following limited resources is likely to be key. Asset production capacity, installation equipment, offshore routes free of underwater restrictions such as existing gas pipes, feasible and acceptable landing points on the coastal foreshore, overland routes to interface points and limited options for onshore substations will present significant challenges. The designs includes in this Statement have not considered these issues in any detail. The outcome of any such analysis may result in a different connection design to that presented in this Statement. Suitable consents must be obtained and legislation met for all developments by the responsible party; this is of particular significance for any onshore infrastructure work.
Way Forward

The Statement is the subject of an annual review process, facilitated by NGET with industry participation. NGET will commence a formal review of the 2010 Statement, in December 2010. The review will be conducted with the industry and will take the form of a formal consultation document (which will be available on National Grid’s website). The review exercise will incorporate an industry workshop which is scheduled for January 2011. The aim of the workshop will be to review the 2010 Statement (and the associated consultation document) and to identify how the Statement may be continually developed in line with the latest offshore developments and licence provisions.

Any proposed amendments to the structure/layout and the future scenarios which may be incorporated within future editions of the Statement, are the subject of this annual review process with a subsequent formal submission to the Authority (outlining the proposed amendments to structure/layout and future scenarios).
Chapter One

Offshore Electricity Transmission Overview

1.1 Background

The UK has two key environmental targets relating to renewable energy and greenhouse gas emissions (GHGs). The first of these targets is part of the European Union’s (EU) integrated energy/climate change proposal that addresses the issues of energy supply and climate change and in doing so sets a target of 20% of European energy (including electricity, heat & transport) to come from renewable sources by 2020.

The UK’s contribution to this target is 15% which is lower than the European wide average due to the UK’s low starting point (2% compared to EU average of 9%). However, the UK has the largest increase of any country which was due to its low starting point, economic strength and its high potential for renewable generation i.e. significant wind, wave and tidal resources.

The Renewable Energy Strategy (published in July 2009) identified that in order to meet this target approximately 30% of UK’s electricity will have to come from renewable sources by 2020, with a corresponding 12% from heat and 10% from transport.

The second target, which also follows the principles of the overall EU 20/20/20 vision (20% of energy from renewable sources along with a 20% reduction in GHG emissions and 20% improvement in energy efficiency by 2020) but goes even further, has been incorporated in the Climate Change Act and sets a target of 80% reduction in GHGs from the 1990 levels by 2050. This equates to a 34% reduction in GHGs emissions by 2020 as specified by the Climate Change Committee.

This section details the changes that have happened to the UK energy markets and the electricity regulatory framework to encourage the development of renewable energy in this country.

1.1.1 Renewables Obligation

The Renewables Obligation (RO) scheme obligates electricity suppliers to source an increasing proportion of their power from renewable generation. Accredited renewable generators are issued with Renewable Obligation Certificates (ROCs) for each megawatt hour (MWh) of eligible energy generated, multiplied by a factor that is dependant on the type of generation technology.

The Renewables Obligation, the Renewables Obligation Scotland and the Northern Ireland Renewables Obligation have been designed to incentivise renewable generation into the electricity generation market. Renewable generators can sell ROCs that they have acquired to electricity suppliers. Each year, the Office of Gas and Electricity Markets (Ofgem) sets the percentage of electrical energy for which suppliers must obtain ROCs for and the buy-out price that suppliers must pay for any deficit (with the proceeds recycled to suppliers based on their proportion of the total number ROCs obtained).

The RO was introduced in 2002 with an original end date of 2027. However, in light of the 2020 targets and the need to encourage investment in renewable energy up to 2020, the operational timeline of the RO


Renewable Obligation (Scotland) Order came into effect in April 2002
Renewable Obligation (Northern Ireland) Order came into effect in April 2005
has been recently extended to 2037\(^9\). A limit of 20 years support for accredited generating stations was also introduced in parallel (subject to the 2037 end date) to avoid overcompensation.

The Department of Energy and Climate Change (DECC) are currently consulting on whether to allow operators of large offshore wind generating stations to register for their ROCs in phases of operational capacity to account for long construction periods. The 20 years of support would apply to up to five phases starting from the date of full RO accreditation and then once a year for a maximum of five years\(^{10}\).

Historically one ROC was issued for each MWh of eligible renewable output generated. However April 2009 introduced the concept of a banding system. The banding system used onshore wind power as a reference technology (reference band), with any technology which needed more support (post demonstration and emerging technologies band) being granted additional ROCs and similarly more commercially viable technologies (established bands) being granted less ROCs.

**TABLE 1.1 – Renewable Obligation Certificates Allocation (England, Wales & Scotland)\(^{11}\)**

<table>
<thead>
<tr>
<th>Developmental Category for Renewable Obligation Banding</th>
<th>Technologies</th>
<th>Level of Support ROCs per MWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most Established</td>
<td>Landfill Gas</td>
<td>0.25</td>
</tr>
<tr>
<td>Established</td>
<td>Co-firing of Biomass</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Sewage Gas</td>
<td></td>
</tr>
<tr>
<td>Reference</td>
<td>Co-firing of Biomass with CHP</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>Co-firing of Energy Crops</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Energy from Waste with CHP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Geopressure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hydro-electric</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Onshore Wind</td>
<td></td>
</tr>
<tr>
<td>Post Demonstration</td>
<td>Co-firing of Energy Crops with CHP</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>Dedicated Biomass</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Offshore Wind</td>
<td></td>
</tr>
<tr>
<td>Emerging Technologies</td>
<td>Anaerobic Digestion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dedicated Biomass with CHP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dedicated Energy Crops</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dedicated Energy Crops with CHP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gasification</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Geothermal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pyrolysis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Solar Photovoltaic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tidal Impoundment – Tidal Barrage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tidal Impoundment – Tidal Lagoon</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tidal Stream</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wave</td>
<td></td>
</tr>
<tr>
<td>Enhanced Wave &amp; Tidal Bands (Scotland Only)(^{12})</td>
<td>Wave and tidal projects located in Scottish waters and not receiving Government grant support.</td>
<td>Tidal 3.0</td>
</tr>
<tr>
<td></td>
<td>Wave</td>
<td>Wave 5.0</td>
</tr>
</tbody>
</table>


Under the banding scheme, offshore wind projects attracts 1.5 ROCs with tidal/wave projects attracting 2 ROCs for each MWh of eligible renewable output generated. To further stimulate the market, additional ROCs were to be made available to offshore wind projects which met a number of preconditions. It has subsequently been announced that this additional support for offshore wind projects would be extended, with projects which have been fully accredited between 1st April 2010 and 31st March 2014 attracting 2 ROCs for each MWh of eligible renewable output generated.

Offshore power generation will play an important part in the meeting of the renewable energy and carbon emission targets for 2020 and afterwards towards 2050. In addition to the market stimulus provided by the RO, offshore generation has been supported by The Crown Estate’s leasing programmes for offshore generation sites. The development of these programmes and the regulatory framework for offshore generation is detailed in the following sections.

1.2 Offshore Generation Development

Great Britain has the potential to generate renewable electricity energy by utilising the vast natural resources readily and freely available in the waters surrounding the country. This ‘green energy’ can be captured by offshore wind farms and marine technology (tidal and wave) located in the UK’s offshore waters.

1.2.1 Offshore Wind Development

Offshore wind farm developers lease the seabed on which their infrastructure is to be constructed from The Crown Estate. To facilitate this, The Crown Estate has held a number of allocation rounds, allocating defined areas of the seabed to potential wind farm developers.

The Crown Estate launched the first round of offshore wind farm site allocations, in the UK’s territorial waters, in 2000. Round 1 was intended to act as a demonstration round allowing potential developers to gain an understanding of the technology, environmental and economic issues associated with developing and operating an offshore wind farm. The Round 1 allocation permitted a seabed area of 10 km² to be developed with a maximum number of 30 turbines to generate a minimum installed capacity of 20 MW.

The Round 1 locations were put forward by potential developers based on a range of relevant factors including water depth, wind resource and grid connection. Areas of high nature conservation value were avoided as were areas of seabed where existing activities and uses were potentially incompatible with offshore wind farm development. As a result, all the proposed Round 1 offshore wind farm sites are located in water depths of less than 20 m and no further than 12 km (7.5 miles) offshore.

Following the success of Round 1, The Crown Estate conducted a second round (Round 2) in 2003 for sites at least 8-13 km (5-8 miles) offshore. Leases were awarded to 15 projects. The combined generation capacity of Round 1 and Round 2 is approximately 8 GW.

In May 2010, The Crown Estate announced awards for the Round 1 and Round 2 project extensions. Three Round 1 and Round 2 offshore wind farm operators were selected to extend five sites, creating an additional 1.7 GW generation capacity. In addition, two other projects were offered increased capacity within their existing Round 1 and 2 site areas.

---

13 Offshore wind projects which have government consent and have placed order for wind turbines in financial year 2009/10 will be eligible for 2 ROCs with 1.75 ROCs available in 2010/11.
15 http://www.bwea.com/offshore/how.html
16 http://www.bwea.com/marine/devices.html
17 http://www.bwea.com/marine/devices2.html
18 http://www.thecrownestate.co.uk/marine_all_activity_map.pdf
20 http://www.thecrownestate.co.uk/our_portfolio/marine/offshore_wind_energy/rounds-one-two.htm
21 http://www.thecrownestate.co.uk/our_portfolio/marine/offshore_wind_energy/1-2-lease-area-extensions.htm
http://www.thecrownestate.co.uk/rounds_1_2_site_extension_awards.pdf
In January 2010, The Crown Estate announced the development partners for Round 3 offshore wind development zones. The aim of Round 3 offshore wind energy generation was to deliver a quarter of the UK electricity needs by 2020. Each of the development partners has been assigned to one of the nine development zones. The combined generation capacity of Round 3 could amount to 32 GW by 2020 and is sufficient to ensure that the 25 GW that has been enabled by the Strategic Environment Assessment (SEA) for offshore renewable energy can be achieved.

Exclusivity agreements have also been granted by The Crown Estate for up to 6.4 GW of generation capacity in Scottish Territorial Waters (STW). The combined generation capacity for Rounds 1, 2 and 3 projects along with STW projects could amount to over 47 GW by 2020.

### 1.2.2 Offshore Marine Technology

The geography of the UK lends itself to the utilisation of other offshore renewable power generation technologies, including wave and tidal generation. Wave energy is the extraction of energy that is transferred from air to sea as the wind blows over the water’s surface. Tidal energy is the extraction of energy that is transferred to the sea, in the form of tides, through the combination of moon/sea gravitational pull and the rotation of the earth. There are two types of tidal energy:

- **Tidal Range**
  
  Tidal ranges harnesses energy from the rise and fall of the tides. Collecting high tide waters behind barriers or barrages and extracting energy by passing it through turbines as the tide falls (e.g. the Severn Estuary).

- **Tidal Stream**
  
  Tidal streams utilises the kinetic energy from tidal currents to turn underwater turbines which are similar to those of wind turbines.

Full scale marine generation is actively being developed within the UK but with limited wave and tidal generation capacity installed to date (all of which have been small in generation capacity and not directly connected to the National Electricity Transmission System (NETS)).

In March 2010, The Crown Estate announced that they had entered into Agreements for Lease for projects with a potential generation capacity of 1,200 MW in the Pentland Firth and Orkney Waters. The Pentland Firth and Orkney Waters is the first area to be made available for commercial-scale development of wave and tidal energy in Scotland (and the whole of the UK). The projects are believed to represent the largest planned development of wave and tidal energy worldwide.

### 1.3 Offshore Electricity Transmission Regulatory Regime

#### 1.3.1 Regime Overview

Ofgem, in collaboration with DECC, has established a regulatory regime for offshore transmission networks to ensure that new offshore renewable generation projects are connected to the electricity grid economically and efficiently. The offshore transmission regime was activated on 24th June 2009 (‘Go-
Active’) at which date DECC extended the scope of NGET’s system operator role to offshore waters. Therefore, NGET is responsible for the day-to-day management of the flow of electricity onto and over the National Electricity Transmission System.

NGET (in its role of National Electricity Transmission System Operator (NETSO)) will have a relationship with each of the OFTOs in accordance with the System Operator - Transmission Owner Code\(^{31}\) (STC). In addition, NGET’s existing responsibility of operating and co-ordinating onshore applications for transmission grid connections has been extended to include the processing of applications for offshore connections. NGET offers terms of connection to and/or use of the transmission system to offshore generators in respect of a transmission system connection point at an offshore location. The extension of NGET’s system operator role has extended the scope of NGET’s work in respect of the development of an efficient, co-ordinated and economical system of electricity transmission to include offshore transmission connections.

Offshore transmission that operates at 132 kV or above will be a licensed activity\(^{32}\), regulated by Ofgem\(^{33}\) and assigned through an annual competitive tender process. Qualifying companies will bid to become the Offshore Transmission Owner (OFTO) for a particular offshore network. The OFTOs revenue will be predominately made up of the 20 year revenue stream determined by its bid during the tender process, which is based on its submission of costs of financing, designing/con structing (if applicable), operating, maintaining and decommissioning of the transmission assets. OFTOs will receive their regulated revenue stream payments via NGET (acting in their role of NETSO). NGET will calculate and levy the charges payable by the offshore generator for the transmission service, according to its published Use of System Charging Methodology\(^{34}\).

1.3.2 Transitional Arrangements and Enduring Regime

The process to introduce this offshore transmission regime has been divided into two discrete categories:

- **Transitional**

  Transitional projects are those in which the offshore transmission assets have been or are being constructed by the offshore generator.

  These, subject to meeting the criteria of the applicable Tender Regulations, will be able to participate in the Transitional Tender Rounds. The first transitional tender round commenced in June 2009\(^{35}\) with the second transitional tender round expected to commence in 2010\(^{36}\).

  Offshore transmission licences will be granted upon transfer of the transmission assets from the developer to the OFTO.

- **Enduring**

  Based on Ofgem’s December 2009 consultation\(^{37}\), subsequent tenders will be completed under the enduring regime, for projects that meet certain preconditions set by Ofgem. Enduring projects can currently be run on the basis of securing a transmission licence, via an Ofgem run competition, to design, build, finance, operate and maintain the transmission assets (‘OFTO Build’ option).

  However, following the responses received to the December 2009 consultation, Ofgem and DECC have engaged extensively with the stakeholder community and carefully considered the arguments raised by respondents. As a result, a further consultation on extending the flexibility of the enduring regime to include the option for generators to build offshore transmission assets, before transferring them to an OFTO appointed through a competitive tender process (‘Generator Build’ option), was

\(^{31}\) http://www.nationalgrid.com/uk/Electricity/Codes/sotocode/

\(^{32}\) http://www.opsi.gov.uk/acts/acts2004/ukpga_20040020_en_1

\(^{33}\) http://www.opsi.gov.uk/acts/acts2008/ukpga_20080032_en_1

\(^{34}\) Facilitated by Ofgem’s E-Serve Division: http://www.ofgem.gov.uk/E-Serve/Pages/e-serve.aspx

\(^{35}\) http://www.ofgem.gov.uk/Electricity/Charges/chargingstatementsapproval

\(^{36}\) http://www.ofgem.gov.uk/Networks/offtrans/rott/Pages/rott.aspx


issued in August 2010. The consultation also outlined the implementation challenges that have been identified in delivering this further option and considered how the regime can facilitate the development of a co-ordinated electricity transmission system.

**Transitional Projects**

Ofgem commenced the first round of tenders to appoint new offshore transmission owners in June 2009. This first transitional tender round included a total of nine projects which represented over 2 GW of generation capacity and £1 billion of transmission links.

Table 1.2 lists the offshore wind farm projects which were included in the first transitional tender round.

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Size (MW)</th>
<th>Expected Completion Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrow</td>
<td>90</td>
<td>Operational</td>
</tr>
<tr>
<td>Greater Gabbard</td>
<td>504</td>
<td>Q4 2010</td>
</tr>
<tr>
<td>Gunfleet Sands I &amp; II</td>
<td>164</td>
<td>Operational</td>
</tr>
<tr>
<td>Ormonde</td>
<td>150</td>
<td>Q1 2011</td>
</tr>
<tr>
<td>Robin Rigg (East &amp; West)</td>
<td>180</td>
<td>Operational</td>
</tr>
<tr>
<td>Sheringham Shoal</td>
<td>315</td>
<td>Q2 2011</td>
</tr>
<tr>
<td>Thanet</td>
<td>300</td>
<td>Operational</td>
</tr>
<tr>
<td>Walney 1</td>
<td>183.6</td>
<td>2011</td>
</tr>
<tr>
<td>Walney 2</td>
<td>183.6</td>
<td>2012</td>
</tr>
</tbody>
</table>

The shortlist of potential OFTOs bidding to own and operate the transmission connections for the first tranche of transitional projects was announced by Ofgem in December 2009, with six potential companies in the running to become the OFTO for the nine offshore wind farm projects.

The preferred bidders selected to own and operate the first £700m worth of transmission links to seven of the offshore wind farms were announced by Ofgem in August 2010 with the Secretary of State commencing the remaining statutory provisions for the offshore transmission transitional regime, in July 2010.

The process for arranging the transfer of the transmission assets (from generator developer/operator to appointed OFTO) and the formal issuing of transmission licences to the appointed OFTOs is currently being communicated and facilitated by Ofgem with further announcements expected in due course.

For the Ormonde project, three bidders have been selected to submit Best and Final Offers (BaFO). The Invitation to Tender (ITT) stage is to be re-run for the Greater Gabbard project.

Table 1.3 lists the preferred bidders to become the OFTO for the seven offshore wind farms and the status of the remaining two offshore wind farm projects included in the first transition tender round.

---

40 http://www.ofgem.gov.uk/Networks/offtrans/rott/Pages/rott.aspx
41 http://www.ofgem.gov.uk/Media/PressRel/Documents1/Offshore%20Electricity%20Transmission%20Tender%20Rules.pdf
42 http://www.opsi.gov.uk/si/si2010/uksi_20101888_en_1
TABLE 1.3 – Transitional Round 1 Offshore Wind Farm Projects: Preferred & Reserve Bidders

<table>
<thead>
<tr>
<th>Project Name/Size</th>
<th>Forecast Transfer Value (£m)</th>
<th>Preferred Bidders</th>
<th>Reserve Bidders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrow (90 MW)</td>
<td>36.5</td>
<td>Transmission Capital Partners</td>
<td>Macquarie Capital Group</td>
</tr>
<tr>
<td>Gunfleet Sands I &amp; II (164 MW)</td>
<td>48.2</td>
<td>Transmission Capital Partners</td>
<td>Macquarie Capital Group</td>
</tr>
<tr>
<td>Robin Rigg (East &amp; West) (180 MW)</td>
<td>57.3</td>
<td>Transmission Capital Partners</td>
<td>Macquarie Capital Group</td>
</tr>
<tr>
<td>Sheringham Shoal (315 MW)</td>
<td>182.2</td>
<td>Macquarie Capital Group</td>
<td>Balfour Beatty Capital</td>
</tr>
<tr>
<td>Thanet (300 MW)</td>
<td>163.1</td>
<td>Balfour Beatty Capital</td>
<td>Macquarie Capital Group</td>
</tr>
<tr>
<td>Walney 1 (183.6 MW)</td>
<td>101.8</td>
<td>Macquarie Capital Group</td>
<td>Transmission Capital Partners</td>
</tr>
<tr>
<td>Walney 2 (183.6 MW)</td>
<td>105</td>
<td>Macquarie Capital Group</td>
<td>Transmission Capital Partners</td>
</tr>
<tr>
<td>Ormonde (150 MW)</td>
<td>101.1</td>
<td>BaFO process to be run with Balfour Beatty Capital, Macquarie Capital Group and Transmission Capital Partners</td>
<td></td>
</tr>
<tr>
<td>Greater Gabbard (504 MW)</td>
<td>316.6</td>
<td>ITT to be rerun with shortlisted firms</td>
<td></td>
</tr>
</tbody>
</table>

The second transitional tender round is expected to commence in 2010. The projects that have qualified for the second tender round have yet to be announced although the qualifying project requirements was published by Ofgem in August 2010.

Enduring Projects

The commencement of the first enduring tender round is subject to the outcome of the enduring regime consultation process. As previously noted in December 2009, Ofgem issued a consultation on the enduring regulatory regime for offshore electricity transmission which focused on a limited number of aspects of the enduring regime, within the framework put in place by DECC at ‘Go-Active’. The consultation stressed the key principles of providing flexibility and facilitating the delivery of significant volumes of offshore generation. It also set out minded-to positions in respect of key elements of the enduring regime. Among other things, it reviews the different stages at which Ofgem considered it was appropriate that a generator could request the appointment of an OFTO.

Under the enduring framework, outlined by DECC in June 2009, the OFTO would assume responsibility for the procurement, construction, operation and maintenance of the transmission assets. However, the December 2009 consultation outlined a minded-to position that provided flexibility over when the generator could request a tender (as long as it had met the tender entry conditions). The spectrum of options ranged from the OFTO undertaking all the pre-construction activity (‘Early OFTO Appointment’) to this being taken forward by the generator (‘Late OFTO Appointment’).

Subsequently DECC/Ofgem announced their intention to consult further on the enduring regulatory regime for offshore electricity transmission. In addition to the existing ‘OFTO build’ approach, DECC/Ofgem have consulted on providing the option of enabling generator developers to design and construct the

---

transmission infrastructure which would then be transferred to the appointed OFTO (‘Generator Build’ option).

The consultation also outlined the implementation challenges that have been identified in delivery of this further option and considered how the regime can facilitate the development of a co-ordinated electricity transmission system.  

**Offshore Transmission Connection Application Process**

The transmission grid connection application process shown in Figure 1.1 is initiated by the generator developer submitting a Connection Application to NGET, which will include a statement as to which offshore tender round the developer wishes to submit the project into.

**FIGURE 1.1 – Overall Connection Application Process**

When a competent application is confirmed, NGET will have 3 months to issues a “Stage 1” offer to the generator developer. The generator developer will also have three months to consider the offer, accept or reject the offer or refer the offer (to the Authority). The construction programme in the offer will be based on the date of entry into the tender process identified by the generator developer in their application and the assumed date of appointment of an OFTO deriving from this.

In the period up to the commencement of the tender process, the generator developer is free to progress as much of the design work, e.g. onshore/offshore routing studies, consenting progression, etc, as they wish, strictly at their own risk (Ofgem have indicated a minded-to position regarding recovery of certain efficiently incurred pre-construction costs, following the grant of the licence to a successful OFTO). Indeed, the developer is entitled to commence this in advance of submission of a connection application, and produce the results of studies and surveys to NGET in support of their application.

NGET will take ‘due cognisance’ of such additional data provided by a generator developer, although there is no obligation on NGET to adopt any routes etc, identified in such supporting documentation. Ultimately NGET’s role, as defined by its transmission licence, is to design and operate an economic efficient and co-ordinated transmission system while facilitating entry to the market without undue

discrimination between users or classes of users. As such, NGET will undertake desktop studies to derive an offshore route from the Connection Site to the Onshore Transmission Interface, having due consideration of the overall system development and issues associated with the scheme.

When Ofgem has appointed an OFTO, NGET will submit an application to the OFTO for a Construction Offer (TOCO) in respect of the offshore works associated with the successful bid. NGET will then incorporate the terms of these works into a “Stage 2” offer to the generator, who again will have three months to consider and accept the offer, reject the offer or refer the offer (to the Authority).

This process is designed to enable that the works in the revised offer will be progressed, both onshore and offshore, through to commissioning, completion and operation of the plant.

It should be noted that the process as outlined above is the subject of further consultation. Confirmation of the transmission grid connection application and the OFTO tender processes will be clearer when the arrangements for enduring regime has been finalised following the completion of the consultation process.

1.4 Previous and Parallel Initiatives

1.4.1 Enhanced Transmission Investment Incentives

The Transmission Access Review (TAR) Final Report published in June 2008 sets out a package of measures that were targeted at helping to facilitate the UK’s 2020 targets, by reducing or removing grid related access barriers to connecting new generation. These measures include steps to create the appropriate regulatory and commercial framework and rules to enhance the speed with which new generation (renewable and conventional) could connect to the transmission system. Two parallel activities have followed on from the TAR Final Report:

i. 2020 Transmission System Study ("ENSG Study") – The three electricity onshore Transmission Owners (TOs) have undertaken system studies to look at investment scenarios that would be capable of supporting the UK’s 2020 targets.

ii. Enhanced transmission investment incentives ("TO incentives") – this work focused on the development of appropriate funding arrangements, as enhancements to the arrangements under the current transmission price control (TPCR4). It also considered the merits of introducing incentives to encourage the transmission companies to anticipate future investment requirements.

Published by the Electricity Networks Strategy Group (ENSG) in July 2009, the ENSG study (‘Our Electricity Transmission Network: A Vision for 2020’ report) identified a large number of major transmission system projects designed to support the connection of new generation. The report highlighted reinforcements which the TOs considered were most likely to commence in the near future and also set out areas where further reinforcements have been identified for potential future consideration.

In order to take forward their work on TO incentives, Ofgem asked the transmission companies to identify and provide further information on those projects which the TOs considered required additional or earlier funding during the current transmission price control period (TPCR4). The final proposals for the Enhanced Transmission Investment Incentives were published by Ofgem in January 2010. The proposals confirmed the funding framework which would be adopted to fund costs up to the end of 2011/12 and outlined how Ofgem would phase their decisions on funding the investment proposed by the TOs, on which an additional expenditure of around £1 billion is currently planned over this period. Ofgem assessed the initial tranche of investments and announced their intention to allow £78 million of

pre-construction funding and £241 million of construction funding on projects planned to commence construction before 1st April 2011:

i. Beauty-Blackhillock-Kintore, (SHETL);
ii. Beauty-Dounreay, (SHETL);
iii. Knocknagael, (SHETL);
iv. Deeside substation component of the Western HVDC link, (NGET);
v. East Anglia, (NGET) and;
vi. Preparatory work on the SPTL-NGET interconnection (SPTL).

The transmission companies have provided further information to support their case for funding for the remaining projects due to start construction by April 2012. Ofgem will make assessments and reach a decision regarding the funding arrangement in due course. Ofgem intends to address future funding arrangements as part of the next transmission price control review process.

1.4.2 Improving Grid Access

Following its consultation on the options for grid access reform, DECC announced the Government decision to implement a Connect and Manage (C&M) approach to transmission access. This new approach commenced on 11th August 2010, the date at which the necessary industry code and licence modifications became effective.

The new arrangements continue the principle introduced under Interim Connect and Manage (ICM), where generation projects are allowed to connect to the transmission system in advance of the completion of the wider reinforcement works. C&M introduces the concept of ‘Enabling Works’, which are those transmission reinforcement works required to be completed prior to a generator connecting, the criteria for identifying “enabling works” is set out within a new section (Section 13 – Enabling Works) of the Connection and Use of System Code (CUSC). In accordance with the CUSC, offers made by the NGET shall be on the basis of the Connect and Management Arrangements (as outlined in Section 1.4 of the CUSC).

Under C&M derogations against the National Electricity Transmission System Security and Quality of Supply Standard (NETS SQSS), required to facilitate connections ahead of the completion of the wider onshore transmission reinforcement works, in some circumstances can be self managed by the relevant TO.

1.4.3 National Electricity Transmission System Security & Quality of Supply Standard

The National Electricity Transmission System Security and Quality of Supply Standard (NETS SQSS) version 2.0 was issued in June 2009. This is the first version of the NETS SQSS to contain criteria for the planning and operation of offshore transmission networks.

The criteria are organised along similar lines as those used for the planning and operation of the onshore transmission system. They are divided into sections as follows:

i. Generation Connection Criteria;
ii. Demand Connection Criteria;

53 [http://www.ofgem.gov.uk/Networks/Trans/PriceControls/TPCR5/Pages/TPCR5.aspx](http://www.ofgem.gov.uk/Networks/Trans/PriceControls/TPCR5/Pages/TPCR5.aspx)
56 [http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20mix/renewable%20energy/policy/access_review/file46774.pdf](http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20mix/renewable%20energy/policy/access_review/file46774.pdf)
57 [http://www.ofgem.gov.uk/Networks/Trans/ElecTrans/Policy/tabPages/Traccrw.aspx](http://www.ofgem.gov.uk/Networks/Trans/ElecTrans/Policy/tabPages/Traccrw.aspx)
60 [http://www.nationalgrid.com/uk/Electricity/Codes/gbsqsscode/](http://www.nationalgrid.com/uk/Electricity/Codes/gbsqsscode/)
iii. Operation of an Offshore Transmission System;

iv. Voltage limits in planning and operating an offshore transmission system.

In 2008, the NETS SQSS Review Group commenced a ‘Fundamental Review’ of the NETS SQSS criteria in view of the anticipated changes in generation and transmission technologies. This review has recently consulted on a number of proposals ranging from removing regional inconsistencies to introducing criteria to determine the appropriate level of capability for a transmission system with a large capacity of renewable generation. Amendment Reports will be submitted to the Authority in autumn 2010 recommending changes to the NETS SQSS. The Review Group included in its consultation documents an update to the status of those issues being reviewed for which proposals are not yet developed. Work is ongoing in these areas and the Review Group has arranged an industry workshop in October 2010 to discuss the priorities and timetable for the ongoing review.

The ongoing review includes the development of criteria for the Round 3 offshore wind farms. The existing criteria has been developed based on a cost benefit analysis of projects up to 100 km offshore and up to 1500 MW in size and are designed to be consistent with the onshore criteria. This was adequate for Round 1 and Round 2 offshore wind farms but is not sufficient for all of the Round 3 offshore wind farm projects. This is because the Round 3 offshore wind farms will significantly extend the design limits considered to date, both in term of their distance from the shore and the generation capacity of the projects. The NETS SQSS criteria will be reviewed to take into account the cost benefit analysis of the Round 3 offshore wind farms projects. In summary, the cost benefit analysis considers, for different network design options, the relative capital costs and cost of losses against the expected costs of energy curtailed during planned and unplanned component outages. As a result of this assessment, the existing criteria may be extended or additional criteria may be added to reflect the expected cost of constructing and operating these systems.

61 http://www.nationalgrid.com/uk/Electricity/Codes/gbsqsscode/Fundamental+SQSS+Review/
Chapter Two

Offshore Development Information Statement

2.1 Aim and Purpose

The aim of this annual Statement is to facilitate the development, in offshore waters, of an efficient co-ordinated and economical system of electricity transmission. The Statement seeks to do this by providing a wide range of information relating to the possible development of both the offshore and onshore electricity transmission systems and provides a high-level analysis of the various ways in which:

- the offshore transmission networks can be developed to interconnect offshore generation with the onshore transmission network; and
- the onshore transmission network can be reinforced to provide the necessary connection and transfer capability to support the connection of offshore transmission networks.

The aim is to identify the most economic and co-ordinated options from this desktop analysis. It is envisaged that the Statement will provide a platform for more detailed analysis and evaluation to be performed regarding the optimisation of offshore transmission development.

2.1.1 Scope, Responsibility and Deliverability Considerations

When reading the Statement, it is important to consider that the illustrative transmission system connection works shown in this Statement have been identified purely for analysis purposes via a desktop study and included for illustrative purposes only. These designs are based on a fixed point in time and may change as the offshore network evolves. They should not be considered as implying actual future connection routes for new infrastructure and do not intend to reflect the TOs investment decisions regarding the development of their transmission area. The Statement does not cover sub-transmission connections other than showing the nearest affected Grid Entry Point.

The detailed evaluation and design of offshore infrastructure, including any environmental impact assessment, will be the responsibility of the OFTO or developer (dependent on the approach applicable to the individual project). All diagrams represent the shortest route to shore given an electrically efficient onshore connection point.

The actual development of the offshore and onshore transmission systems can and may differ from that illustrated in the Statement. Given the purpose and illustrative nature of this Statement, it should not be used as the basis for any financial, commercial or engineering decisions.

2.2 Statement Development

It is envisaged that the Statement will evolve from year to year in response to developments in offshore generation and as ongoing network studies and engineering feasibility assessments progress. These developments will be reflected in the structure and content of the Statement in the future.

2.2.1 Structure

The 2010 Statement describes the latest developments in offshore generation and the offshore electricity transmission regime. The Statement outlines the development and selection process for the future scenarios, with these scenarios reflecting the differing ways in which offshore generation may develop in forthcoming years. The offshore transmission network designs which could potentially cater for these future scenarios have been developed along with the corresponding onshore transmission reinforcements needed to provide the necessary local connection capability. The process used to develop the

---

62 Chapter 1 (Background) and 3 (Current Offshore Generation and Development)
63 Chapter 4 (Future Generation and Demand Background Scenarios)
transmission system designs, details of the illustrative designs, including an overview of the technology utilised (current and future), and a comparison of the different options is also provided in the Statement. The implications of offshore generation on the Main Interconnected Transmission System (MITS) have also been assessed and presented in the Statement along with an evaluation of the consequential onshore transmission reinforcements which will facilitate the transfer of offshore transmission generation (as depicted by the future scenarios) onto the MITS.

2.2.2 Design Strategies

The Statement includes a number of conceptual desktop design strategies which demonstrate how different technology and topology assumptions can impact the optimisation of offshore transmission development. The different design strategies presented in the Statement are:

- Radial: point-to-point connections from the offshore generation to suitable onshore MITS collector substations using current generation technology.
- Radial Plus: similar to radial in the use of point to point connections for connecting the offshore generation to the onshore MITS but utilising anticipated future transmission technology capability within the strategy (e.g. 2 GW capacity converter stations and high capacity offshore cables) in line with delivery forecasts for the next five years. Radial Plus also differs from the Radial Strategy in that multiple groups of offshore generation are connected to the radial point-to-point connections as opposed to a single group being connected radially.
- Integrated: an interconnected offshore design using AC cable and HVDC interconnection between offshore platforms and development areas, using the same advanced technology as with the Radial Plus Strategy. Multiple offshore platforms will be interconnected, providing fewer cables and reduced asset volumes.

The 2010 Statement includes a conceptual integrated network design solution. As the transition through the various offshore wind farm development leasing rounds e.g. Round 1, 2, 3, STW, etc occurs, the expected growth rate, location and size of offshore wind projects has led NGET to consider different ways in which offshore connections might be optimised. Given a better understanding of the technologies available since the publication of the 2009 Statement, NGET has undertaken a conceptual design study into the development of an integrated offshore transmission network.

The study has been premised on the principle that any design solution should:
- maximise the potential deliverability of offshore wind;
- co-ordinate onshore and offshore investment requirements to minimise environmental impacts;
- maximise security of supply and network resilience, increasing the level of resilience to offshore connections; and
- minimise the overall cost to consumers.

The resulting design is one that is based on the installation of high voltage multi-user assets that interconnect the offshore platforms to form an offshore network. This conceptual design highlights how the overall volume of assets installed offshore could be reduced, whilst network security and operational flexibility is improved. This is based on onshore/offshore optimisation, the latest technology and a degree of strategic investment offshore.

It should be recognised however that in order to attain the benefits associated to the integrated solution, it will be necessary to commence development of this solution within a suitable timeframe. Early common technical and functional specifications will be needed to ensure a smooth transition to an integrated design.

---

64 Chapter 5 (Offshore and Local Onshore Connection Designs) and supporting Appendices 3 (Offshore Network Design Methodology) & 4 (Review of Offshore Transmission Technologies)
65 Chapter 6 (Main Interconnected Transmission System (MITS) Considerations)
As with all designs included within this Statement, this approach represents one of many ways in which efficient offshore connection could be facilitated. The mechanism by which it could be delivered is not discussed in this Statement.

The inclusion of the different design strategies may facilitate the evaluation of the potential options in terms of capital costs, planning implications, risks, environmental assessment and the supply chain for individual offshore generation projects. It will also facilitate an assessment of the potential for any ‘future proofing’ of the transmission network to enable further evolution and European integration.

All design strategies included herein reflect the aim and intention of the Statement in facilitating the development of an efficient, co-ordinated and economical system of electricity transmission. This Statement does not discuss the potential regulatory mechanisms/frameworks for the enduring offshore regime that could incentivise particular design solutions.

2.2.3 Continuous Development

The Statement will be the subject of an annual review facilitated by NGET with industry participants prior to its publication. Interested parties are encouraged to provide feedback on all aspects of the 2010 Statement via an Online Survey Form. The feedback received will be incorporated into the formal review of the 2010 Statement which will commence in December 2010.

Any proposed amendments to the structure/layout and the future scenarios included in this Statement, which may be incorporated within future editions of the Statement, are the subject of this review process with a subsequent formal submission to the Authority. In addition, the content of the Statement will remain within the remit set by the special licence condition C4.
Chapter Three

Current Offshore Generation and Development

3.1 Offshore Wind Generation: Development to Date

According to RenewableUK’s (previously known as the BWEA) website\(^\text{67}\), as of 23rd September 2010, there were:

- 13 offshore wind farms in operation representing 1,341 MW of generation capacity;
- 4 offshore wind farm projects under construction representing 1,153 MW of generation capacity;
- 7 offshore wind farm projects have been granted consent representing 2,620 MW of generation capacity and;
- 5 offshore wind farm projects in planning representing 2,260 MW of generation capacity.

In total there are currently 29 offshore wind farms (representing 7,374 MW of generation capacity) currently in operation or under development.

The Crown Estate have facilitated a series of leasing rounds under which areas of seabed have been made available for the development of offshore wind farms via a competitive tender process.

3.1.1 Offshore Wind Farm Development: Round 1

The Crown Estate announced the first round (Round 1) of UK offshore wind farm development sites in 2000. This allocated 18 sites each within 12 nautical miles of the UK coastline\(^\text{68}\). Eleven Round 1 sites are now complete and generating power. Of the remaining sites, one is under construction\(^\text{69}\) and another has consent awaiting construction\(^\text{70}\). The remaining sites (Shell Flats (I-III), Scarweather Sands and Cromer) have been withdrawn due to difficulties with consenting, resource and ground conditions respectively. A further demonstration site at Blyth was developed prior to Round 1 and consists of two 2 MW turbines.

3.1.2 Offshore Wind Farm Development: Round 2

In 2002 the Department of Trade and Industry’s (DTI) consultation paper “Future Offshore”\(^\text{71}\) set out the Government’s policy direction and commitment to take a more strategic approach to offshore wind farm development. It set out the intention to restrict further development to strategic areas and undertake a Strategic Environmental Assessment (SEA)\(^\text{72}\). Three strategic areas were identified; the Greater Wash, the Thames Estuary and the north west (Liverpool Bay). The DTI commissioned an SEA covering these three areas. The SEA was completed in May 2003 and following consultation the DTI requested that The Crown Estate make available seabed areas in these strategic regions for the purposes of further wind farm development. Based on the conclusion of the SEA, the DTI issued guidance including a precautionary coastal exclusion zone of between 8-13 km (5-8 miles) from the coast to reduce the visual impact of development and avoid sensitive, shallow water feeding areas for certain species of sea bird. The SEA set out development scenarios limiting the total development possible within these three areas to between 4 and 7.5 GW (including the contribution from Round 1).

In July 2003 a competitive tender process began for the second round of offshore wind farm site allocations (Round 2). The fifteen successful projects were awarded Crown Estate agreements for lease.

\(^{69}\) [http://www.thecrownestate.co.uk/our_portfolio/marine/offshore_wind_energy/rounds-one-two.htm](http://www.thecrownestate.co.uk/our_portfolio/marine/offshore_wind_energy/rounds-one-two.htm)
amounting to 7.2 GW of generation capacity and included sites within and beyond territorial waters. Subsequently, some Round 2 sites faced unavoidable difficulties in developing their projects and were given the opportunity to relocate.

Of the fifteen sites allocated under Round 2, the first (Gunfleet 2 and Thanet) are either fully or partial operational. A further three (Greater Gabbard, Sheringham Shoal and Walney 1) are now under construction with Greater Gabbard scheduled to produce power during 201073.

3.1.3 Offshore Wind Farm Development: Round 1 & Round 2 Extensions

In May 2010, The Crown Estate announced awards for the Round 1 and Round 2 project extensions. It is presently envisaged that construction of the Round 1 and 2 extensions will commence in 2014, subject to consents, with completion of all projects by the end of 2016 in advance of Round 3.

In making the awards, The Crown Estate placed emphasis on the timely delivery of the additional offshore wind capacity. Successful applications have demonstrated that the extensions can be consented, constructed and operational within agreed timescales. The extensions will benefit from synergies with the original projects, with in some cases the potential for the sharing of construction crews and vessels, as well as electrical systems, construction bases, ports and onshore facilities.

3.1.4 Offshore Wind Farm Development: Scottish Territorial Waters (Round 1)

In January 2009, the Scottish Government indicated their intention of carrying out a Strategic Environment Assessment (SEA) for offshore wind in STW. The SEA report was released for consultation in May 201074.

In February 2009 exclusivity agreements were granted by The Crown Estate to ten companies and consortia for the development of commercial scale wind farms within STW. The agreements will enable the companies/consortia exclusive development rights over their chosen sites, allowing the project developers to commence with further site surveys and investigations prior to submitting consent applications, while awaiting the outcome of the SEA. If all of these sites were to be constructed in full, they could provide a potential installed capacity of over 6 GW of offshore wind energy.

3.1.5 Offshore Wind Farm Development: Round 3

The Round 3 development partners were announced by The Crown Estate in 2010. The aim of Round 3 offshore wind energy generation was to deliver a quarter of the UK electricity needs by 2020. Each of the development partners was assigned to one of the nine development zones. The combined generation capacity of Round 3 is sufficient to ensure that the 25 GW that has been enabled by the SEA for offshore renewable energy can be achieved.

3.1.6 Offshore Wind Farm Development: Demonstration Sites

The Crown Estate is also facilitating the ongoing development of wind turbine technology by awarding offshore wind demonstration sites to four companies75. The demonstration projects will play a key part in addressing both technical and cost challenges to facilitate construction further from shore and in increasing water depths.

An agreement for lease has been awarded to two sites in England and Wales: Gunfleet Sands extension (which will enable testing for up to two next generation offshore wind turbines) and Blyth Offshore Wind Demonstration site (National Renewable Energy Centre Ltd (NaREC76)) for a 100 MW grid connected site to test and demonstrate up to 20 next generation offshore wind turbines and associated infrastructure.

Exclusively agreements have been awarded for two sites in Scotland: Methil Offshore Wind Farm (to demonstrate 2B-Energy’s two offshore wind turbines77) and European Offshore Wind Deployment

73 http://www.bwea.com/ukwed/offshore.asp
74 http://www.scotland.gov.uk/Publications/2010/05/14155353/0
75 http://www.thecrownestate.co.uk/newscontent/92-offshore-wind-demonstration-sites.htm
76 http://www.narec.co.uk/media/news/n/narec_offshore_wind_demonstration_site_awarded_the_crown_estate_lease/
77 http://2-benergy.co/index.htm
Centre78 (to test and demonstrate up to 11 next generation offshore wind turbines and other technology in Aberdeen Bay).

3.2 Offshore Marine Generation: Development to Date

Full scale marine generation is currently being actively developed in UK offshore waters but as yet there is limited wave and tidal generational capacity installed (all of which have been small in generation capacity and not directly installed to the transmission system)79.

The marine energy testing facilities at the European Marine Energy Centre80 (EMEC) in Orkney (marine testing of full scale wave and tidal devices), the National Renewable Energy Centre81 (NaREC) in the north east of England (onshore testing of device components) and the Wave Hub82 in Cornwall (testing and demonstration of commercial full scale wave energy devices) have and will continue to enable developers to successfully tank test scale model prototype devices prior to deploying the first full scale devices at sea. Furthermore, additional funding has recently been made available to specific projects to encourage the development of wave and tidal technology within the UK83.

In March 2010, The Crown Estate announced that they had entered into agreements for lease for projects with a potential generation capacity of 1,200 MW in the Pentland Firth and Orkney Waters84. The Crown Estate subsequently announced that they will be inviting expressions of interest for a project in the Inner Sound (which lies between the Scottish mainland and the Isle of Stroma)85. The tidal project has been assigned a maximum generation capacity of 200 MW. In June 2010, The Crown Estate announced that it had invited four companies to tender for the tidal energy project at the Inner Sound location. In event of a successful bidder emerging from the process, The Crown Estate is currently planning to award an agreement for lease in Q4 2010.

The Scottish Government launched the Saltire Prize86 in 2008 which is intended to stimulate development of wave and tidal energy. A prize of £10 million will be awarded to the team that can demonstrate in Scottish waters, a commercially viable wave or tidal stream energy technology that achieves the greatest volume of electrical output over the set minimum hurdle of 100 GWh over a continuous two year period using only the power of the sea.

In March 2010, the Scottish Government published the Further Scottish Leasing Round (Saltire Prize Projects) document87 which identified potential further offshore areas88 being made available for wave and tidal energy projects. Following a discussion on the proposed areas, the Scottish Government and The Crown Estate intend to finalise areas for lease, which will be announced in a further Scottish leasing round for wave and tidal energy projects later in 201089.

---

78 http://www.aberdeenrenewables.com/
80 http://www.emec.org.uk/
81 http://www.narec.co.uk/
82 http://www.southwestrda.org.uk/working_for_the_region/key_kw_projects/cornwall_the_isles_of_scilly/wave_hub.aspx
84 http://nds.co.gov.uk/content/detail.aspx?NewsAreaId=2&ReleaseID=414752&SubjectId=2
85 http://www.thecrownestate.co.uk/our_portfolio/marine/wave-tidal/pentland-firth-orkney-waters.htm
86 http://www.scotland.gov.uk/Topics/Business-Industry/Action/leading/saltire-prize
87 http://www.scotland.gov.uk/Publications/2010/03/23084106/1
88 http://www.thecrownestate.co.uk/pfow_development_sites_map.pdf
89 http://www.thecrownestate.co.uk/pfow_development_sites_map.Inner_sound.pdf
91 http://www.scotland.gov.uk/Publications/2010/03/23084106/1
3.3 Offshore Wind Development Map

FIGURE 3.1 – Offshore Wind Development Map (also available in Appendix 2)
3.4 Offshore Generation: Transmission Grid Connections

The Transmission Entry Capacity (TEC) is the amount of generation a generator is contacted to export onto the National Electricity Transmission System (NETS) and is stated in megawatts (MW). The TEC Register\(^9\) provides a publicly available record of the existing allocation of TEC, the business it is allocated to and the site details. Only generators that are directly connected to the NETS or have rights to export to it will be listed in the TEC Register. This will be generators with a Bilateral Connection Agreement (BCA) or a Bilateral Embedded Generation Agreement (BEGA) with NGET (acting in its role as National Grid Electricity System Operator (NETSO)).

The offshore generation projects which have currently have a TEC allocation are a combination of all the different offshore wind farm leasing rounds which has been facilitated by The Crown Estate over recent years. Figure 3.2 illustrates the accumulative TEC of all the offshore generation projects and how much the TEC has been allocated in each year (as at 31st August 2010).

![TEC for Offshore Generation Projects](image)

The offshore generation projects have accumulative TEC allocation of nearly 10,000 MW by 2015 and over 15,000 MW by 2020 (which represents over a quarter of the maximum generation capacity leased by The Crown Estate through the various leasing rounds). There are currently no offshore developer generators who are contracted to connect to the NETS beyond 2020.

The different phasing of the offshore generation developments is illustrated in Figure 3.3 and provides an indication of which projects (within the particular leasing rounds) have agreed an electricity transmission grid connection with NGET (acting in its role as NETSO).

The majority of the TEC, (as at 31st August 2010), has been allocated to Round 2 offshore wind farm projects (with all developer generators entering into a Bilateral Agreement with NGET (acting in its role as NETSO) and therefore being allocated a TEC) and illustrates the advanced stage of development for these projects which will continue to be commissioned until 2020 (based on their transmission grid connection commissioning dates).

The recent timing of the Round 3 and Round 1 and 2 extensions announcements may account for the limited number of generator developers having formally agreed and signed their Bilateral Agreement with NGET (acting in its role as NETSO) and therefore being assigned a TEC.

---

To date, there are no formal transmission grid connections in place for any of the marine generation projects in Pentland Firth and Orkney Waters area (as announced by The Crown Estate); again this may be due to the timing of the official announcement regarding these developments.

Figures 3.2 and 3.3 do not included any offshore projects which are not directly connected to the NETS or do not have rights to export to it. Given their connection arrangements, the following Round 1 sites do not have a TEC and are therefore categorised as embedded generation within the NETS: Blyth\textsuperscript{91}, Burbo Bank\textsuperscript{92}, Kentish Flats\textsuperscript{93}, Lynn and Inner Dowsing\textsuperscript{94}, North Hoyle\textsuperscript{95}, Rhyl Flats\textsuperscript{96}, Scroby Sands\textsuperscript{97} and Teesside. These nine projects represent nearly 680 MW of generation capacity.

The following sections summarise the offshore generation projects (which currently have a Bilateral Agreement with NGET (acting in its role as NETSO)) that have been allocated a TEC (as of 31st August 2010). Therefore not all announced offshore generation sites will be included in the following sections. The sections will not cover sub-transmission connections other than showing the nearest affected Grid Entry Point.

\textsuperscript{91} http://www.eon-uk.com/generation/blyth.aspx
\textsuperscript{92} http://www.dongenergyny.com/Burbo/Pages/index.aspx
\textsuperscript{93} http://www.kentishflats.co.uk/
\textsuperscript{94} http://www.centricaenergy.com/index.asp?pageid=282&area=lynn
\textsuperscript{97} http://www.eon-uk.com/generation/scrobysands.aspx
3.5 East Coast

The east coast region will encompass several Round 1, Round 2 and Round 3 offshore wind farm sites with embedded and NETS connection. The TEC associated with each site in this region is shown in the figure below with additional information regarding the project status provided in the following sections (3.5.1 and 3.5.2).

3.5.1 Round 2 Sites

Docking Shoal – Centrica (DSW) Ltd

Docking Shoal in the Greater Wash region is located approximately 14 km (9 miles) off Wells-next-the-Sea on the north Norfolk coast and approximately 19.5 km (12 miles) off Skegness on the Lincolnshire coast. It was granted the agreement for lease of the seabed by The Crown Estate in 2004. It is currently in the process of obtaining consent and is contracted to be commissioned in October 2011. The project is allocated 500 MW of capacity at the Docking Shoal Offshore Connection Point from which it is expected to connect to its Onshore Transmission Interface at Walpole.

Dudgeon – Dudgeon Offshore Wind Limited

Dudgeon in the Greater Wash region is located on relatively flat, uniform seabed between the Cromer Knoll and Inner Cromer Knoll sandbanks, over 32 km (19.9 miles) north of the town of Cromer in north Norfolk. It is currently in the process of obtaining consent. The implementation will be split into two phases is contracted to be commissioned October 2015 and October 2016. The project is allocated 1320 MW of capacity to an Onshore Transmission Interface at Little Dunham.

99 http://www.warwickenergy.com/dudgeon.htm
Humber Gateway - E.ON Climate & Renewables UK Humber Wind Limited

Humber Gateway is located in the Greater Wash region, 8 km (5 miles) off the Holderness coast, East Riding of Yorkshire. It was granted the agreement for lease of seabed from The Crown Estate in 2003. A scoping report was produced in 2004 and more detailed surveys and consultation were carried out in 2005/06. Planning applications were submitted in 2009 and are yet to be approved. The project is presently contracted to be commissioned in April 2013. The project is allocated 220 MW of capacity at the Humber Gateway Offshore Connection Point to its Onshore Transmission Interface near Hedon.

Lincs – Centrica (Lincs) Limited

Lincs is located in the Greater Wash region approximately 8 km (5 miles) from Skegness and immediately to the east of the Lynn and Inner Dowsing offshore wind farms. It was granted the agreement for lease of the seabed from The Crown Estate in 2003. An application for consent was submitted in 2007 and was approved in 2008. It is currently under construction and is contracted to be commissioned in July 2011. The project has been allocated 250 MW of capacity at the Lincs Offshore Connection Point from which it is expected to connect to its Onshore Transmission Interface at Walpole.

Race Bank – Centrica (RBW) Ltd

Race Bank is located in the Greater Wash region approximately 27 km (16.8 miles) from Blakeney Point on the north Norfolk coast (outside the UK’s territorial waters). It was granted the lease of the seabed from The Crown Estate in 2004. It is currently in the process of obtaining consent and is contracted to be commissioned in June 2013. The project is allocated 500 MW of capacity at the Race Bank Offshore Connection Point from which it is expected to connect to its Onshore Transmission Interface at Walpole.

Sheringham Shoal - Scira Offshore Energy Ltd

Sheringham Shoal is located in the Greater Wash region between 17 km (10.5 miles) and 23 km (14.3 miles) off the coast of north Norfolk. The project is now in its construction phase and will be operational by the end of 2011. The project is allocated 315 MW of capacity at the Sheringham Shoal Offshore Connection Point from which it is expected to connect to its Onshore Transmission Interface at Norwich Main.

Triton Knoll – Triton Knoll Offshore Windfarm Limited

Triton Knoll in the Greater Wash region is located 33 km (20.5 miles) off the coast of Lincolnshire. The project is currently in the scoping and design stage. Implementation will be split into three phases and is contracted to be commissioned between 2018 and 2020. The project is allocated 1200 MW of capacity at the Triton Knoll Offshore Connection Point from which it is expected to connect to its Onshore Transmission Interface in east Lincolnshire.

Westermost Rough - Westermost Rough Limited

Westermost Rough is located in the Greater Wash region, 8 km (5 miles) from the Yorkshire coast. It was granted the agreement for lease of the seabed from The Crown Estate in 2007. It is currently in the process of obtaining consent and is contracted to be commissioned in April 2014. The project is allocated 175 MW of capacity at the Westermost Rough Offshore Connection Point from which it is expected to connect to its Onshore Transmission Interface near Hedon.
3.5.2 Round 3 Sites

**Dogger Bank – Forewind Limited**[^106]

The Dogger Bank zone is in the North Sea, located between 125 km (78 miles) and 290 km (180 miles) off the east coast of Yorkshire. The project is currently in the scoping stage. Implementation will be split into multiple phases with the first two stages contracted to be commissioned between 2016 and 2017. The project is currently allocated 1,000 MW of capacity.

3.6 North West

The east coast region will encompass several Round 1, Round 2, Round 1 & 2 Extensions and Round 3 offshore wind farm sites, with embedded and NETS connections. The TEC associated with each site in this region is shown in the figure below with additional information regarding the project status provided in the following sections (3.6.1 and 3.6.2).

![FIGURE 3.5 – North West Coast](image-url)

### FIGURE 3.5 – North West Coast

3.6.1 Round 1 Sites

**Barrow – Barrow Offshore Windfarm Limited**[^107]

Barrow Offshore Wind Farm is located approximately 7 km (4.3 miles) south west of Walney Island in the east Irish Sea near Barrow-in-Furness with a capacity of 90 MW at the offshore connection points. The 30 wind turbine development was commissioned in 2006 with one offshore substation, with interconnecting cables and a single 145 kV transmission cable extending from the offshore wind farm site to shore.

[^106]: http://www.forewind.co.uk/dogger-bank/
[^107]: http://www.bowind.co.uk/
Ormonde – Ormonde Energy Limited\textsuperscript{108}

The Ormonde offshore wind farm is currently being built in the Irish Sea, 10 km (6.2 miles) off Barrow-In-Furness. The project is now in the construction phase with onshore works having commenced in autumn 2009. The development work is due for completion during 2011 and first power is expected later that year. The project is allocated 150 MW of capacity at the Ormonde Offshore Connection Point from which it is expected to connect to its Onshore Transmission Interface at Heysham.

Robin Rigg (East and West) – E.ON UK Renewable Limited\textsuperscript{109}

The Robin Rigg Offshore Wind Farms (East and West) are located in the Solway Firth with a combined capacity at the offshore connection points of 180 MW. The site was commissioned in 2009 and is located near the ports of Workington and Maryport, with the Offshore Connection Points approximately 12 km (7.5 miles) from the shoreline.

3.6.2 Round 2 Sites

Gwynt Y Môr – Gwynt Y Môr Offshore Windfarm Limited\textsuperscript{110}

The Gwynt y Môr site is located 13 km (8 miles) off the north Wales coast at the nearest point to shore, 16 km (10 miles) from Llandudno and 18 km (11 miles) from the Wirral. DECC granted consent for the offshore works in December 2008. In 2009, permissions for onshore substation works and the (approx) 11 km cable route were granted by Denbighshire County Council and Conwy County Borough Council. Offshore foundations installation works are planned to commence by the end of 2011. The wind turbine installation will commence in Q2 2013 and the wind farm is expected to be operational in 2014. The project is allocated 574 MW at the Gwynt Y Môr Offshore Connection Point from which it is expected to connect to its Onshore Transmission Interface at St Asaph.

Walney I & II – Walney (UK) Offshore Windfarms Limited \textsuperscript{111}

Walney in the north west region is located 20 km (12.4 miles) offshore from Barrow-In-Furness, consists of two phases. Phase I has an allocated capacity of 182 MW at the Walney 1 Offshore Connection Point with its Onshore Transmission Interface at Heysham. Walney I is due to commission in 2011. Phase II with 182 MW of capacity has an Offshore Connection Point at Walney 2 and its Onshore Transmission Interface at Stanah and is due to commission in 2012.

West of Duddon Sands – ScottishPower Renewables (UK) Limited\textsuperscript{112}

West of Duddon Sands is located 14 km (8.7 miles) southwest of the Barrow-In-Furness coastline. The project currently has its consents approved and is contracted to be commissioned in October 2013. The project is allocated 333 MW of capacity at the West Dudden Sands Offshore Connection Point from which it is expected to connect to its Onshore Transmission Interface at Heysham.

\textsuperscript{108} http://www.vattenfall.co.uk/en/ormonde.htm
\textsuperscript{109} http://www.eon-uk.com/generation/robinrigg.aspx
\textsuperscript{111} http://www.dongenergy.com/Walney/Pages/index.aspx
\textsuperscript{112} http://www.scottishpowerrenewables.com/pages/west_of_duddon_sands.asp
3.7 Thames Estuary

The Thames Estuary will encompass several Round 1, Round 2 and Round 1 & 2 Extensions offshore wind farm sites, with embedded and NETS connections. The TEC associated with each site in this region is shown in the figure below with additional information regarding the project status provided in the following sections (3.7.1, 3.7.2 and 3.7.3).

FIGURE 3.6 – Thames Estuary

3.7.1 Round 1 and 2 Sites

**Gunfleet Sands I & II – Gunfleet Sands Limited**

Gunfleet Sands, lying within the Thames Estuary region some 7 km (4.3 miles) off the coast from Clacton on Sea was built in two phases. The construction phase for the total project comprising Gunfleet Sands 1 and 2 commenced in September 2008. Commissioning started in 2009 with the wind farm reaching full production during the spring of 2010. The project has 99.9 MW of capacity at the Gunfleet Sands 1 Offshore Connection Point for Phase I and 64 MW of capacity at a second Gunfleet Sands 2 Offshore Connection Point for Phase II, giving a combined total of 163.9 MW of capacity, to its Onshore Transmission Interface at Bramford.

3.7.2 Round 2 Sites

**Greater Gabbard – Greater Gabbard Offshore Winds Limited**

Greater Gabbard in the Thames Estuary is currently under construction. All 140 foundation monopiles and 30 turbines have now been installed offshore, as have both transformer platforms. Commissioning of the onshore substation is well-advanced. Installation of the first export cable is complete and installation

---

113 [http://www.dongenergy.com/gunfleetsands/Pages/index.aspx](http://www.dongenergy.com/gunfleetsands/Pages/index.aspx)

114 [http://www.scottish-southern.co.uk/SSEInternet/index.aspx?rightColHeader=30&id=15836](http://www.scottish-southern.co.uk/SSEInternet/index.aspx?rightColHeader=30&id=15836)
of the inter-array cables is well under way. The first turbines are expected to be commissioned in late summer and early autumn of 2010 and the first export of electricity expected in Q4 of 2010. The entire wind farm remains scheduled to be completed in 2012. The project has a capacity allocation of 500 MW at the Greater Gabbard Offshore Connection Point, from which it is expected to connect to its Onshore Transmission Interface at Leiston near Sizewell.

**London Array – London Array Limited**

London Array in the Thames Estuary consists of two phases. Phase I is contracted for commission in 2012 with a capacity of 486 MW. The additional capacity of 514 MW, for Phase II, is contracted for commission in April 2014, bringing the scheme’s total allocated capacity to 1,000 MW. Connection from the London Array Offshore Point is expected to its Onshore Transmission Interface at Cleve Hill.

**Thanet – Thanet Offshore Wind Ltd**

The Thanet project is located approximately 12 km (7.5 miles) off Foreness Point, the most eastern part of Kent. The development work is due for completion during 2010. The project has 300 MW of capacity at the Thanet Offshore Connection Point from which it is expected to connect to its Onshore Transmission Interface at Canterbury North.

### 3.7.3 Round 1 & 2 Extension Sites

**Galloper Wind Farm – Airtricity Developments (UK) Ltd**

The Galloper Wind Farm in the Thames Estuary is an extension to the existing Greater Gabbard project. A planning application is expected to be submitted during 2010 with a decision expected in 2012. The project is contracted to be commissioned in October 2015. The project has been allocated 500 MW of capacity at its Offshore Connection Point from which it is expected to connect to its Onshore Transmission Interface at Leiston near Sizewell.

### 3.8 Bristol Channel

The Bristol Channel has one Round 3 site. The TEC associated with this site is shown in the figure below with additional information regarding the project status provided in the following section.

FIGURE 3.7 – Bristol Channel

---


117 [http://www.sse.com/SSEInternet/index.aspx?rightColHeader=30&id=22148&TierSlicer1_TSMenuTargetID=324&TierSlicer1_TSMenuTargetType=4&TierSlicer1_TSMenuID=6](http://www.sse.com/SSEInternet/index.aspx?rightColHeader=30&id=22148&TierSlicer1_TSMenuTargetID=324&TierSlicer1_TSMenuTargetType=4&TierSlicer1_TSMenuID=6)
3.8.1 Round 3 Sites

Atlantic Array - Channel Energy Limited\textsuperscript{118}

Atlantic Array offshore wind farm will be located within the Bristol Channel Zone, between south Wales and north Devon. The project is currently in the scoping stage. Implementation will be split into multiple phases and is contracted to be commissioned between 2014 and 2017. The project is currently allocated 1515 MW of capacity.

3.9 Scotland

Scotland will encompass several Scottish Territorial Waters project sites, Round 3 offshore wind farm sites plus several marine generation sites. The TEC associated with each site in this region is shown in the figure below with additional information regarding the project status provided in the following sections (3.9.1 and 3.9.2).

FIGURE 3.8 – Scotland

3.9.1 Scottish Territorial Waters

Beatrice – SSE Generation Limited\textsuperscript{119}

The Beatrice offshore wind farm will be located approximately 13.5 km (8.4 miles) off the Caithness coast, in the Outer Moray Firth, to the north of the two existing Beatrice demonstrator turbines. The project is currently under development with the scoping report submitted in March 2010. Implementation will be split into multiple phases and is contracted to be commissioned between 2014 and 2016. The project is currently allocated 1,000 MW of capacity at its Beatrice Offshore Connection Point from which it is expected to connect to its Onshore Transmission Interface at Blackhillock.


\textsuperscript{119} http://www.scottish-southern.co.uk/SSEInternet/index.aspx?rightColHeader=30&id=17204
Neart na Gaoithe - Neart Na Gaoithe Offshore Wind Farm Limited\textsuperscript{120}

The proposed Neart na Gaoithe offshore wind farm will be located some 15 km (9.3 miles) off the Fife coast and covers an area of approximately 100 km\textsuperscript{2}. The project is currently under development. The project is contracted to be commissioned in December 2014. The project has been allocated 450 MW of capacity at its Offshore Connection Point and is expected to connect to its Onshore Transmission Interface at Crystal Rigg II.

3.9.2 Round 3 Sites

Firth of Forth – Seagreen Wind Energy Ltd\textsuperscript{121}

Firth of Forth offshore wind farm will be located approximately 25 km (15.5 miles) from Fife, off the east cost of Scotland. Phase 1 of the project is currently in the scoping stage and is contracted to be commissioned in June 2015. The current project capacity allocation is 1,075 MW.

Moray Firth - Moray Offshore Renewables Limited\textsuperscript{122}

Moray Firth offshore wind farm will be located on the Smith Bank in the Moray Firth approximately 22 km (13.8 miles) off the north east coast of Scotland. The project is currently in the scoping stage. Implementation will be split into multiple phases and is contracted to be commissioned between 2016 and 2020. The project is currently allocated 1500 MW of capacity.

\textsuperscript{120} \url{http://www.neartnagaoithe.com/}
\textsuperscript{121} \url{http://www.seagreenwindenergy.com/}
\textsuperscript{122} \url{http://www.morayoffshorerenewables.com/}
Chapter Four

Future Generation and Demand Background Scenarios

4.1 Overview

To assess the need for future transmission system development, it is necessary to make assumptions regarding the future generation and demand background that the electricity transmission system will need to accommodate. This chapter describes the four future generation and demand background scenarios: Slow Progression, Gone Green, Accelerated Growth and Sustainable Growth which have been developed and selected to assess the range of potential investment options.

The future scenarios cover the period from 2010 to 2025 and consider the anticipated range of potential offshore developments from nearly 17 GW of offshore generation capacity in 2025 in the Slow Progression scenario to over 47 GW of offshore generation capacity in 2025 in Sustainable Growth.

Each scenario illustrates the potential future development of the electricity network and will be evaluated with a view to facilitating the development, in offshore waters, of an efficient, co-ordinated and economical system of electricity transmission. The future scenarios also enable an assessment of the specific challenges which arise from that particular generation and demand background e.g. meeting the renewable energy targets, supply chain issues, etc.

All the future scenarios have been developed by utilising information received from the Transporting Britain’s Energy (TBE)\(^{123}\) and the Offshore Development Information Statement Future Scenario consultations, customer enquires, journals, press releases and other sources e.g. external consultants.

The future scenarios incorporate and reflect a number of factors including an assessment of the current supply chain, capital costs, a forecast of carbon prices and current subsidies available to certain types of power generation (which given the relative economics of power generation are an important contributor to the development of generation in offshore waters).

The future scenarios utilised in the Statement do not represent the contracted position of users of the NETS (as presented in Seven Year Statement\(^{124}\)) nor the investment planning programme(s) of the Transmission Owner(s). Given the uncertainties in predicting how the electricity network will be developed in the future, the future scenarios represents a range of credible generation and demand backgrounds against which the potential future development of the electricity network may be assessed and evaluated.

4.1.1 Sensitivity Analysis

In addition to the four main scenarios, sensitivities on Interconnectors and Additional Regional Capacity (ARC) have been analysed and the results included in the Statement.

The interconnectivity sensitivity considers the potential increase in interconnector capacity over the study period and how this may impact the development of the National Electricity Transmission System (NETS) in offshore waters.

The ARC sensitivity is based on the offshore development announcements by The Crown Estate, DECC and the Scottish Government regarding seabed allocations for wind and marine generation. This equates to approximately 55 GW of offshore generation capacity (excluding projects which have been officially cancelled by developers).

The ARC enables an examination of the potential local investment that may be required in the different geographic regions, if all the offshore generation capacity in that area connects to the electricity network. Identifying the different levels of potential capacity that could be developed in each of the regions enables


\(^{124}\) [http://www.nationalgrid.com/uk/Electricity/SYS/](http://www.nationalgrid.com/uk/Electricity/SYS/)
NGET to assess a number of different investment options that may not be covered directly by the four future scenarios. This should also assist developers in identifying the maximum capabilities and requirements in different geographic regions.

4.1.2 Future Scenarios Scope

The future scenarios and sensitivities represent a range of credible generation and demand backgrounds which have been submitted to the Authority, following consultation with the industry. The future scenarios and sensitivities make no assumptions regarding any future announcement by The Crown Estate and/or DECC/Scottish Government regarding future leasing allocation rounds for wind and marine generation. Subsequent editions of the Statement will review any (additional) future leasing allocations.

It is noted, however, that the Scottish Government has issued a consultation identifying a further 25 potential zones which may result in further leasing rounds being announced and facilitated by The Crown Estate in due course. In addition no assumptions have been made regarding the longer term (i.e. 2050) development of the generation in offshore waters in terms of potential additional capacity and the associated generation technology advancement which would have to be made to facilitate the associated level of offshore generation capacity.

4.1.3 Future Scenarios Deliverability

The (yearly) dates (and the associated build-up rates) depicted in the future scenarios study period are for analytical purposes only and are intended to illustrate how the electricity transmission system would need to be developed to enable that level of generation to connect to the electricity network.

The actual delivery of the build-up rates as illustrated by some of the future scenarios may be difficult given the time available and the challenges it could pose to all aspects of the connection process e.g. financing of the projects, ability of the supply chain to fulfil the orders, obtaining the necessary planning consent and the necessary grid development.

The actual transmission connection dates of the offshore generation projects are subject to the current governance framework, planning process, supply chain, technology and financial considerations all of which will be reflected in the connection date provided to and agreed by the developer.

Furthermore the actual development of the offshore and onshore transmission systems can and may differ from that illustrated by the future generation and demand scenarios (and sensitivities) included within the Statement.

4.2 Industry Consultation and Selection Process

The future scenarios and sensitivities which are being utilised to assess the need for future transmission system development were developed and selected based on comments received from industry participants following an extensive consultation period. The consultation paper was issued on 22nd March 2010 (for a period of 8 weeks) and outlined a number of potential future scenarios for inclusion in the Statement. The consultation document invited views on:

- the preferred number of future scenarios to be included in the Statement;
- which future scenarios should be included in the Statement;
- alternative/additional future scenarios which should form part of the Statement; and
- which sensitivities (if any) should be included in the Statement; and

125 http://www.scotland.gov.uk/Publications/2010/05/14155137/0
if sufficient information had been provided and what (if any) additional information should be included.

The consultation period closed on 14th May 2010 by which date 11 responses had been received from industry participants (1 from Onshore Transmission Owner, 1 from energy trade body and 9 from developers/generators).

Based on the responses received, NGET submitted its future scenario selection to the Authority (1st June 2010). The Authority confirmed (28th June 2010) that they did not intend to direct any changes to the future scenarios submitted by NGET.

4.2.1 Future Scenario Consultation Responses

The responses received from the consultation process can be summarised as follows.

Number of Future Scenarios

There was agreement that between three to five scenarios would be an appropriate number for inclusion in the Statement. It was noted that the inclusion of an odd number of scenarios could potentially result in users of the Statement focusing on the 'central scenario' which may undermine the purpose of a scenario-based approach.

Future Scenarios Selection

There was agreement that there should be a set of credible scenarios which provided a range of different outcomes. There was support for the inclusion of low, medium and high case scenarios as this, in the view of the respondents, would best illustrate the potential development of the electricity network in offshore waters.

The inclusion of a low case scenario which does not meet the UK’s European Union 2020 renewable targets still provided a divergence of views from industry participants. The majority of respondents acknowledged the benefit of including a low case scenario within the Statement as it could be utilised as a base case against which the other scenarios could be compared and assessed against. However, concern still remains that the inclusion of such a scenario would send out the wrong message to the industry as it assumes that the true potential of electricity generation in offshore waters is not achievable.

There were also mixed views as to what constituted a credible high case scenario within the study period. Respondents queried whether the Offshore Announcements scenario (46 GW of offshore generation capacity by 2020) was a credible scenario due to concerns on deployment costs and financial constraints. Alternatively it was viewed that the Offshore Announcements scenarios should be included as it was a key indicator of the amount of offshore wind generation there could be by 2020.

Some respondents indicated that the Gone Green scenario (19 GW of offshore generation capacity by 2020) should constitute the high case within the Statement whilst other respondents queried the benefit of including a scenario which was based on a NGET assessment of the amount of offshore wind which would be necessary for the UK to meet its 2020 renewable energy targets.

There was agreement that the data which formed part of the proposed Grid Connection scenario (i.e. the contracted position for the future use of NETS) would be best used as background information (rather than an actual scenario) and could be utilised as a measure of how things were progressing.

In addition, there was an acknowledgement of the benefit of having/agreeing a standard set of scenarios across the industry which could be utilised when assessing the various issues associated with the electricity grid e.g. infrastructure planning, security standards etc.

Based on comments received, the Grid Connections Scenario (as published in the Future Scenario consultation document) was not selected for inclusion in the 2010 Statement, as the data which forms the basis would not reflect the potential growth in offshore generation over the study period. The basis of this scenario will be included in the Statement (please refer to Chapter 3) as it will inform an assessment of what developers have actually proposed in terms of electricity network development.
In addition, the Offshore Announcement Scenario (as published in the Future Scenario consultation document) was also not selected for inclusion in the 2010 Statement, as this scenario will form the basis of the Additional Regional Capability (ARC) sensitivity (please refer to section 4.5).

The SEA Plus (SEA +) future scenario which formed part of the 2009 Statement has not been selected for inclusion in the 2010 Statement as key principles of this scenario are incorporated within the Accelerated Growth scenario.

Alternative/Additional Future Scenarios

There were a total of six additional/alternative future scenarios put forward by respondents:

- Amendments to the Offshore Announcement Scenario
  - A proposed increase in the amount of generation located in the north of Scotland (by 2020).
  - A proposed extension to the scenario timeline (through to 2030/2035) to allow for the realistic delivery of the Round 3 projects.
- Merger of Slow Progression & Grid Connection Future Scenarios
- Replace Slow Progression with (Ofgem’s) Project Discovery’s Slow Growth Scenario
- Inclusion of an additional future scenario which mimics (Ofgem’s) Project Discovery’s Green Transition Scenario.
- Inclusion of a new central scenario
  - 14 GW of offshore generation by 2020, increasing to 24 GW by 2025 (broadly in line with the Renewable Energy Strategy).
- Inclusion of an alternative/additional future scenario
  - 24 GW of offshore generation by 2020, increasing to 47 GW by 2025.

Sensitivities

Given the potential for significant offshore generation capacity, the benefit of incorporating sensitivities on a number of factors within the Statement was highlighted by respondents. The suggestions provided by respondents focused on the delivery of projects e.g. supply chain, availability of resources, attrition rate and electricity distribution (i.e. the potential of generation being exported to other countries through interconnectors). It was also recognised that there was continued benefit in analysing the network development required, in different geographical regions, if all anticipated capacity in that area connected to the electricity network.

Additional Information

The majority of respondents felt that sufficient information had been provided in the consultation document however it was proposed that additional detail on the assumptions made regarding the generation and demand background which supported each scenario e.g. supply chain, demand side management, build-up rates would be beneficial.

In addition information regarding the location of the onshore generation which supported each scenario was also requested. Given the focus of the Statement (i.e. potential development of the NETS in offshore waters), the probability of the electricity network being developed as depicted by the future scenarios and the commercial sensitivities/assumptions regarding the data utilised in the scenarios, providing this additional level of data may misinform users regarding the exact generation background which will be in operation at a future date. Therefore this information is not included in the Statement.
4.2.2 Future Scenario Selection: Representation of Industry Views

Future Scenario Selection: Representation of Industry Views

- Number of Future Scenarios
  - between 3 and 5.

- Preferred Future Scenario Selection
  - the inclusion of a Low (Slow Progression), Medium (Gone Green) and High Case (Accelerated Growth & Sustainable Growth);
  - no centralised scenario;
  - the inclusion of a scenario (Sustainable Growth) which is based on the submission by RenewableUK (which had support from a number of respondents to the Future Scenario consultation).

- Inclusion of Sensitivities Analysis
  - Interconnectors and Regional Development (Additional Regional Capacity).

- Utilisation of a Standard Set of Scenarios
  - The Slow Progress, Gone Green and Accelerated Growth scenarios have been used by the onshore Transmission Owners in preparing their most recent submission to Ofgem regarding the Enhanced Transmission Investment Incentives.

- Alternative Future Scenarios
  Alternative future scenarios were proposed for inclusion in the Statement (as part of the consultation exercise). A number of these future scenarios were not selected due to the following reasons:
  - insufficient divergences between the alternative scenarios proposed and those presented in the Future Scenario Consultation Document;
  - the inclusion of the suggested future scenarios would not illustrate the potential of the offshore electricity network;
  - the suggested future scenario would represent an unlikely generation background e.g. combining Slow Progression and Grid Connection scenarios.

4.3 Future Scenarios

4.3.1 Demand and Generation Backgrounds

Different investment requirements will be driven not just by the timing, volume and location of offshore developments but also by onshore generation patterns. Each view therefore has an onshore generation background that is consistent with the inherent underlying premise of that particular scenario.

Additional data for the generation (onshore and offshore) and demand backgrounds, which support each of the future scenarios, is provided in Appendix 1. For each future scenario, the generation background will illustrate the type and amount of generation which will be required to meet the annual peak demand for that particular year within the study period.

The data included in each of the future scenarios will reflect the latest information available to NGET as at the data freeze date i.e. March 2010 (subsequently adjusted for the development and inclusion of the Sustainable Growth scenario). The utilisation of a data freeze date may result in minor differences between what the future scenarios depict and what is actually (physically) available (in term of generation capacity of a particular generation type) for the first year of the study period.
Demand

In each of the scenarios, demand is included at its anticipated annual peak day level. Assessment of the electricity network adequacy tends to focus on system peak demand as this is often the most onerous demand condition that the network needs to be able to accommodate and will drive many of the required reinforcements. The demand level is multi-faceted and will reflect a number of key input variables e.g. economy, fuel prices, energy efficiencies, embedded generation, transmission losses and new demand sectors such as electric cars and heat pumps.

Generation

Generation that contributes to the meeting of this annual peak demand level (inclusive of plant margin) is built up into a generation background. The intermittency issues associated with some types of renewable generation, results in an increase in the likelihood of plant being unavailable to meet peak demand. This results in a higher plant margin. Therefore a significant amount of installed wind capacity will result in a higher overall required plant margin to meet demand, notwithstanding the increased potential for demand-side management.

The main difference between the generation backgrounds is the type of generation used to meet the demand and the timing and scale of future generation projects.

4.3.2 Scenario Summary

Slow Progression (SP): In this scenario, developed by NGET, the transmission offshore wind development builds up at a slower rate than in the other assessments. The Slow Progression scenario is similar to that developed and presented by National Grid in other documents such as the Ten Year Statement\(^\text{128}\) and the Development of Investment Scenarios\(^\text{129}\) and as such it has been the subject of challenge and scrutiny by the industry via the TBE consultation process and has been benchmarked against external consultants' analysis.

This future scenario has been used by the onshore Transmission Owners in preparing their most recent submission to Ofgem regarding the Enhanced Transmission Investment Incentives.

The generation background for this scenario is developed based on known and potential station closures and the connection of new generation capacity to replace this plant. The timing of these openings and closures is important when assessing how the power generation market will look over future years with the plant margin, fuel mix, suppliers generation portfolios, government and environmental legislation all taken into account when developing the scenario.

Amongst the key factors affecting the development of the generation background are the Large Combustion Plant Directive\(^\text{130}\) (LCPD) and further environmental legislation such as the Industrial Emissions Directive (IED), the European Union Emission Trading Scheme (EU ETS), the rate of development of renewable energy sources and the future of nuclear generation in Great Britain (GB).

The scenario does currently depict that the renewable electricity contribution (of 30%) is not reached by 2020. However, this scenario should become more closely aligned with the Gone Green scenario over the next decade, as the Renewable Obligation (RO), Climate Change Levy\(^\text{132}\) (CCL) and the EU ETS continue to incentivise the development of renewable generation. These incentives have been further enhanced by recent announcements to strengthen the RO and the proposed accelerating access to the grid\(^\text{133}\) which are important for the development and delivery of the offshore generation projects.

This steady onward progression towards alignment with the Gone Green scenario has been proven by previous versions of the Slow Progression scenario (which have depicted a lower amount of renewable generation when compared to this version). If this trend continues the deviation between the two


\(^{130}\) [http://www.defra.gov.uk/environment/quality/air/airquality/eu-int/eu-directives/lcpd/](http://www.defra.gov.uk/environment/quality/air/airquality/eu-int/eu-directives/lcpd/)


scenarios (Slow Progression and Gone Green) will become less clear until such time that one scenario will be required to depict that particular generation and demand background.

**Gone Green (GG):** This scenario, developed by NGET, represents a potential generation and demand background which meets the environmental targets and the unilateral GHG emissions target (34% reduction by 2020). It takes a holistic approach to the meeting of the targets i.e. assumes that heat and transport will contribute towards the environmental target of 15% of UK’s energy to come from renewable sources by 2020. It therefore reflects the approach taken by the Renewable Energy Strategy\(^\text{134}\) which identified that in order to meet this target, approximately 30% of UK’s electricity will have to come from renewable sources by 2020, with a corresponding 12% from heat and 10% from transport.

A previous scenario was utilised by the Electricity Network Strategy Group\(^\text{135}\) (ENSG) to underpin their ‘Our Electricity Transmission Network: A Vision for 2020’ report\(^\text{136}\). The Gone Green scenario was updated in November 2009. The updated scenario includes a different phasing of offshore wind development and although ultimately reaching the same capacity, there is less renewable generation required in 2020. This is due to a combination of lower forecast demands and a re-evaluation of how the aviation sector will be assessed against the target.

This future scenario has been used by the onshore Transmission Owners in preparing their most recent submission to Ofgem regarding the Enhanced Transmission Investment Incentives.

It is important to remember that the ultimate aim of this scenario is the achievement of the 2020 environmental targets. The generation and demand background supporting this scenario is one approach in achieving this aim. There are multiple alternative views which can be developed and reach the same objective and in reality the exact combination will be determined by government policy and the free market.

**Accelerated Growth:** This scenario, developed by NGET, depicts a significant amount of wind generation connecting to the electricity transmission network by 2020/2025. Other changes to the generation background are detailed in section 4.3.5.

In this scenario the UK exceeds its European Union 2020 renewable targets. The scenario has a considerable build-up rate between the years 2010 and 2020, which may be viewed as challenging and would necessitate the rapid progression of the connection process e.g. transmission grid connection dates, planning permission, commissioning process, etc, plus the establishment of a robust supply chain.

However, depending on the contribution made by the heat and transport sectors (in reaching the 2020 environment targets), it is conceivable that greater emphasis may be placed on the electricity sector (i.e. contribution will be in excess of the current allocation of 30%) with an associated emphasis on renewable electricity generation. This would potentially require an increase in the build-up rate between the years 2010 and 2020 as illustrated by this scenario (the issues regarding connection dates, planning permission and the supply chain notwithstanding).

This scenario assumes that the UK wind industry is sustained into the future through developments both in the UK and Europe. This future scenario utilises some elements of both the DECC Low Carbon Transition Plan\(^\text{137}\) and the Strategic Environmental Assessment\(^\text{138}\) Plus (SEA +) future scenario (which was utilised in the 2009 Statement). This future scenario has been used by the onshore Transmission Owners in preparing their most recent submission to Ofgem regarding the Enhanced Transmission Investment Incentives.

**Sustainable Growth:** This future scenario is based on the response by RenewableUK to the Offshore Development Information Statement Future Scenario consultation document. The scenario takes the Gone Green generation and demand background and replaces the offshore wind generation with one

---


\(^{135}\) [http://www.ensg.gov.uk/](http://www.ensg.gov.uk/)


which has an increased build-up rate between 2015 and 2025 that will encourage the establishment of a long-term manufacturing industry within the UK.

This scenario is similar in scope to that of the Accelerated Growth scenario as it depicts a significant amount of offshore generation connected to the electricity grid by 2025. However, the assumed build-up rates under this scenario differ from that depicted in the Accelerated Growth scenario.

Figure 4.1(a) details the total amount of offshore generation capacity, by milestone year, for the four scenarios.

FIGURE 4.1(a) – Future Scenarios Comparison (By Year): Offshore Generation (Accumulative Installed Capacity)

Figure 4.1(b) details the total amount of offshore generation capacity, by future scenario, for each milestone year.

FIGURE 4.1(b) – Future Scenarios Comparison (By Scenario): Offshore Generation (Installed Capacity)

The graphs serve to highlight the differences between the future scenarios regarding the potential offshore generation development, enabling a full range of investment analysis to be undertaken.
4.3.3 Slow Progression Scenario

Offshore Summary

The first Round 2 transmission connected offshore wind farm started to commercially generate in early 2010 (Gunfleet Sands II\(^{113}\)). Other Round 2 offshore wind farms are scheduled for (full or partial) operation capability throughout 2010 (Thanet\(^{116}\) and Greater Gabbard\(^{114}\)) and 2011 (Ormonde\(^{108}\), Sheringham Shoal\(^{139}\), Walney\(^{140}\)).

In order to stimulate the development of offshore generation, additional incentives have been introduced. Previously offshore wind projects that had government consents and had placed orders for wind turbines in financial year 2009/10 would have been eligible for two Renewable Obligation Certificates (ROCs) per MWh (rather than 1.5 ROCs which would normally apply for this type of generation). This additional support has been extended to offshore wind projects which have received full accreditation between 1\(^{st}\) April 2010 and 31\(^{st}\) March 2014. The projects that qualify will be entitled to 2 ROCs for each MWh of eligible renewable output generated\(^{14}\).

Furthermore, the Government has announced additional financial funding (grants totalling £10m) for the development of the next generation of offshore wind technologies\(^{141}\) e.g. 6 MW offshore wind turbines which will be important for the delivery of the Round 3 offshore wind projects. This funding is one in a series of initiatives e.g. establishment of £2 billion Green Investment Bank which has the aim of continuing to stimulate the growth in offshore generation\(^{142}\).

This scenario includes Round 3 offshore wind development towards the end of the decade with these developments beginning to connect after the completion of the Round 2 offshore wind projects. Some incremental wave and tidal projects have also been included towards the end of the study period. This includes the build up of capacity in the Pentland Firth in the far north of Great Britain.

In this scenario, there is over 10.5 GW of offshore (wind and marine) generation capacity (inclusive of generation connecting to the onshore electricity distribution system) included by 2020 with nearly 17 GW by 2025.

The build-up of offshore developments in this scenario is shown in Figure 4.2 with over 7 GW of Round 1 and 2 offshore wind capacities being included by 2020. An additional 2.6 GW of Round 3 offshore wind is included in 2020 (with a further 3.6 GW of Round 3 development by the end of study period).

FIGURE 4.2 - Slow Progression Scenario: Offshore Developments (Installed Capacity)

\(^{113}\) http://www.scira.co.uk/offshore/offshore.html
\(^{114}\) http://www.dongenergy.com/Walney/About_Walney/About_the_project/Pages/About_the_project.aspx
\(^{116}\) http://www.decc.gov.uk/en/content/cms/news/pn10_76/pn10_76.aspx
\(^{139}\) http://www.direct.gov.uk/en/Nl1/Newsroom/Budget/Budget2010/DG_186643
\(^{140}\) http://www.hm-treasury.gov.uk/junebudget_speech.htm
The accumulative build-up of offshore transmission wind capacity for this scenario is shown in Figure 4.3 in which there is nearly 10 GW of wind generation capacity being included by 2020 (with a further 4.9 GW connecting by 2025).

**FIGURE 4.3 - Slow Progression Scenario: Offshore Transmission Wind (Accumulative Installed Capacity)**

The annual offshore transmission wind capacity for this scenario is shown in Figure 4.4. The yearly rates range between 300 MW in 2017 (towards the end of the Round 2 connections but prior to the commencement of the Round 3 connections) to nearly 1800 MW (Round 3 connections) in 2020.

**FIGURE 4.4 - Slow Progression Scenario: Offshore Transmission Wind (Yearly Installed Capacity)**

This build-up rate assumes a steady increase in the current supply chain capability with an average yearly build-up rate of 900 MW (approximately 180 turbines connected each year, based on the utilisation of 5 MW turbines). The expansion and sustained development of the supply chain may be limited when compared to the opportunity represented by the other scenarios.

The accumulative build-up of offshore transmission renewable capacity for this scenario is shown in Figure 4.5. There is nearly 10 GW of wind and marine transmission generation capacity being included by 2020 (with a further 4.9 GW of wind and 1 GW of marine connecting by 2025).
This relatively low level of renewable energy (against the assessment of the contribution to be made by the electricity sector in meeting the 2020 renewable targets i.e. 21% against the 30% goal) is based upon a number of factors including an assessment of the current supply chain, capital costs, a forecast of carbon prices and current subsidies available.

However as illustrated by Figure 4.6, there is still a marked rise in the amount of installed renewable transmission generation capacity over the study period, with the predominant increase in offshore transmission wind.

**Demand Background**

The key drivers to transmission peak electricity demand are the historical demand patterns, the economy, fuel prices, energy efficiencies (non domestic and domestic e.g. CFL (compacted fluorescent lighting), household appliances and insulation) and embedded generation.
Demand is depicted to slowly recover from the impact of the economic recession which started in 2008/09 and resulted in a 2 GW reduction in peak demand. The depicted peak demand does not reach pre-recession levels until the very end of the study period. Increased exports at the time of system peak and economic growth are offset by increasing energy efficiency driven by high fuel prices and legislation such as Carbon Emission Reduction Target (CERT)\textsuperscript{143} and CRC Energy Efficiency Scheme\textsuperscript{144}, demand management (smart metering, smart grid) and growth in embedded generation. Potential areas of growth such as electric vehicles should have little or no impact on the system peak as any 'charging' would be likely to occur off-peak e.g. overnight supported by smart metering, the technology of which will become more prevalent towards the end of the decade.

**Generation Background**

The overall generation mix for this scenario is detailed in Figure 4.7. Generation is shown at full installed capacity with the total rising to account for the intermittent nature of wind generation and thus the need for back-up plant.

This scenario envisages the closure of 11.5 GW of oil and coal fired-plant under the Large Combustion Plant Directive by 2015 and the closure of 7.2 GW of nuclear capacity by 2020 (assuming a 5 year life extension to the existing AGR (advanced gas-cooled reactor) nuclear fleet unless an extension has already been granted). The market may ‘fill the gap’ with some renewable energy however the dominant energy source will be from new gas-fired generation.

\textsuperscript{143} http://www.decc.gov.uk/en/content/cms/what_we_do/consumers/saving_energy/cert/cert.aspx

\textsuperscript{144} http://www.decc.gov.uk/en/content/cms/what_we_do/lc_uk/crc/crc.aspx
Plant Closures:
- 11.5 GW of oil and coal fired plant under the Large Combustion Plant Directive by 2015.
- 7.2 GW of nuclear generation capacity by 2020 (assumes 5 year life extension to AGRs).
- 5.6 GW of gas generation capacity by 2020 (with a further 1.5 GW by 2025 due to age and the Industrial Emissions Directive).
- 12.7 GW of coal generation capacity by 2025 due to age profile and the Industrial Emissions Directive.

New Renewable build:
- 9.5 GW of transmission offshore wind generation capacity by 2020 (with a further 5 GW connecting by 2025).
- 6.4 GW of transmission onshore wind generation capacity by 2020 (with a further 0.3 GW connecting by 2025).
- 1.2 GW of transmission marine generation capacity by 2025.

Significant New Non Renewable Build:
- 13.0 GW of new gas generation capacity by 2020 (with a further 1.5 GW connecting by 2025).
- 1.0 GW of gas CCS generation capacity by 2025.
- 3.2 GW of coal CCS generation capacity by 2020 (with a further 4.2 GW connecting by 2025).
- 1.6 GW of new nuclear generation capacity by 2020 (with a further 5.7 GW connecting by 2025).

This scenario depicts a significant increase in the amount of renewable electricity generated but it falls short of the 2020 renewable target.

Table 4.1 compares the renewable share of generation energy, as depicted by the Slow Progression scenario, against the assumed 2020 renewable electricity contribution (as identified by Renewable Energy Strategy) for 2020 and 2025.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>20.7 GW</td>
<td>30%</td>
<td>21%</td>
<td>Below Target</td>
</tr>
<tr>
<td>2025</td>
<td>26.9 GW</td>
<td>28.8%</td>
<td>28%</td>
<td>Below Target</td>
</tr>
</tbody>
</table>

4.3.4 Gone Green Scenario

This scenario uses the Slow Progression scenario as a basis but in order to meet the European Union 2020 environmental targets and the unilateral GHG emissions target (34% reduction by 2020) a significant amount of additional renewable generation is required as well as a slightly lower fossil fuel capacity. The key differences between the Gone Green and Slow Progression scenarios are the amount of renewable energy connected to the electricity grid and the 10 year life extensions assumed for the existing nuclear generation capacity.

Offshore Summary

In this scenario, renewable wind plays a much larger role along with other types of renewable energy e.g. wave and tidal energy. The Round 2 offshore wind developments are similar to those included in the Slow Progression scenario, with some projects included at slightly earlier dates. The major difference is with the timing and scale of the Round 3 offshore developments.

There is over 19 GW of offshore (wind and marine) generation capacity (inclusive of generation connecting to the onshore electricity distribution system) included in 2020 with over 25 GW by 2025. The build-up of offshore developments in this scenario is shown in Figure 4.8 with over 7 GW of Round 1 and

---

The total renewable energy contribution for electricity will include embedded generation

52
Round 2 offshore wind capacities being included by 2020 and over 8 GW of Round 3 offshore wind generation included in 2020. The Round 3 figure increases to nearly 12 GW by 2025. There is over 1 GW of offshore generation capacity in Scottish Territorial Waters by 2020 (rising to nearly 3 GW by 2025).

The accumulative build-up of offshore transmission wind in this scenario is shown in Figure 4.9 in which there is over 16 GW of wind generation capacity being included by 2020 (with a further 5 GW connecting by 2025).

The annual offshore transmission wind capacity for this scenario is shown in Figure 4.10. The yearly rates range between 480 MW in 2010 to nearly 2,600 MW in 2019 (Round 3 and Scottish Territorial Waters connections).
This build-up rate assumes a significant increase in the current supply chain capability after 2014 with an average yearly build-up rate of 1,300 MW (approximately 260 turbines connected each year, based on the utilisation of 5 MW turbines). The build-up rates reduce after 2019 as the amount of installed capacity has reached the proposed level required to meet the 2020 environmental targets.

The accumulative build-up of offshore transmission renewable capacity for this scenario is shown in Figure 4.11. There is 16 GW of wind and 1.4 GW of marine transmission generation capacity being included by 2020 (with a further 5 GW of wind and 0.5 GW of marine connecting by 2025).

This scenario represents a potential generation and demand background for 2020 which meets the UK’s climate change targets with the emphasis on renewable electricity generation. Figure 4.12 demonstrates the increase in the amount of installed renewable transmission generation capacity over the study period.
Demand Background

The Gone Green demand background has been developed by calculating the energy requirement from three key sectors e.g. residential, service/commercial and industry. Energy efficiencies in the service and industry sector are counteracted by a rise in residential demand which is due to a combination of factors e.g. increased usage of heat pumps, the decarbonisation of heat etc.

Overall, the economic outlook is for the economy to recover slowly from the recession, with any future demand growth due to an improving economic background being offset by higher end-user prices, increasing energy efficiency and growth in embedded generation. This scenario does include a greater build-up of electric vehicles (towards the end of the study period) and there is also greater demand through heat pumps, only the latter of which will have any impact on peak electricity demand.

Generation Background

The overall generation mix for this scenario is detailed in Figure 4.13. The total amount of generation in this scenario is higher than in Slow Progression to account for the intermittent nature of wind although increasing levels of demand-side response towards the end of the period will also provide back-up for intermittent wind generation. In this scenario, renewable wind plays a much larger role along with other types of renewable energy e.g. wave and tidal energy. Some nuclear capacity will still close (however a 10 year life extension is assumed) but the construction of new plant brings the total nuclear capacity to 11 GW by 2020. Similarly, new coal plant with Carbon Capture and Storage (CCS) will replace some of the coal capacity closed under the Large Combustion Plant Directive (LCPD), leaving a total of nearly 18 GW of coal by 2020.
FIGURE 4.13 – Gone Green Scenario: Generation & Demand Background

Plant Closures:
- 11.5 GW of oil and coal fired plant under the Large Combustion Plant Directive by 2015.
- 2.5 GW of nuclear generation capacity by 2020 (assumes 10 year life extension to AGRs) (with a further 4.7 GW by 2025).
- 5.0 GW of gas generation capacity by 2020 (with a further 2.3 GW by 2025 due to age profile and Industrial Emissions Directive).
- 15.0 GW of coal generation capacity by 2025 due to age profile and the Industrial Emissions Directive.

Significant New Renewable:
- 16.2 GW of transmission offshore wind generation capacity by 2020 (with a further 5 GW connecting by 2025).
- 6.9 GW of transmission onshore wind generation capacity by 2020 (with a further 0.7 GW connecting by 2025).
- 1.4 GW of transmission marine generation capacity by 2020 (with a further 0.5 GW connecting by 2025).

Significant New Non Renewable Build:
- 9.3 GW of new gas generation capacity by 2020 (with a further 1.3 GW connecting by 2025).
- 2.0 GW of new gas CCS generation capacity by 2025.
- 3.2 GW of coal CCS generation capacity by 2020 (with a further 6.2 GW connecting by 2025).
- 2.9 GW of new nuclear generation capacity by 2020 (with a further 6.1 GW connecting by 2025).

This scenario illustrates a potential generation mix which will facilitate the achievement of the 2020 environmental targets (both renewable and greenhouse gases) and remain on the ‘path-way’ to the 2050 carbon emissions reduction target while maintaining security of supply.

Table 4.2 compares the renewable share of generation energy, as depicted by the Gone Green scenario, against the assumed 2020 renewable electricity contribution (as identified by Renewable Energy Strategy) for 2020 and 2025.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>29.6 GW</td>
<td>31.0%</td>
<td>30%</td>
<td>32%</td>
<td>On Target</td>
</tr>
<tr>
<td>2025</td>
<td>36.3 GW</td>
<td>35.8%</td>
<td>30%</td>
<td>37%</td>
<td>Above Target</td>
</tr>
</tbody>
</table>
4.3.5 Accelerated Growth

This scenario depicts a significant amount of wind generation connecting to the transmission electricity network by 2020/2025. This scenario starts by taking the Gone Green generation background and replaces the offshore wind generation with an aggressive build-up rate between 2010 and 2025. It also depicts less new coal plant with CCS connecting to the grid by 2025. It assumes only a 5 year life extension for existing nuclear generation.

Offshore Summary

The Round 2 offshore wind developments are similar to those included in the Gone Green scenario. The major difference is with the timing and scale of the Round 3 offshore developments which is earlier and has a more advanced delivery programme compared to the previous scenarios.

In this scenario, there is over 35 GW of offshore (wind and marine) generation capacity (inclusive of generation connecting to the onshore electricity distribution system) included in 2020 with over 44 GW by 2025. The build-up of offshore developments in this scenario is shown in Figure 4.14 with over 7 GW of Round 1 and Round 2 offshore wind capacities being included by 2020 and just over 20 GW of Round 3 offshore wind included in 2020. The Round 3 figure increases to over 27 GW by 2025. There is over 5 GW of offshore generation capacity in Scottish Territorial Waters by 2020 (rising to over 6 GW by 2025).

FIGURE 4.14 – Accelerated Growth Scenario: Offshore Developments (Installed Capacity)

The build-up of offshore transmission wind in this scenario is shown in Figure 4.15 in which there is over 32 GW of wind generation capacity being included by 2020 (with a further 8 GW connecting by 2025).

FIGURE 4.15 – Accelerated Growth Scenario: Offshore Transmission Wind (Accumulative Installed Capacity)
The annual offshore transmission wind capacity for this scenario is shown in Figure 4.16. The yearly rates range between 470 MW in 2010 (prior to the development of the majority of the Round 2 connections) and 6700 MW in 2015 (first tranche of Round 3 projects).

This build-up rate assumes a significant increase in the current supply chain capability between 2012 and 2015 before reducing prior to a second increase commencing in 2018. The average yearly build-up rate is 2,500 MW over the study period (approximately 500 turbines connected each year, based on the utilisation of 5 MW turbines).

The Accelerated Growth scenario depicts the rapid deployment of offshore generation capacity and would necessitate significant investment into the supply chain. The supply chain would need to begin building now to be ready to deliver this scenario. This scenario may also necessitate further growth of the UK domestic and European export market to sustain the supply chain that would have to be developed in the UK.

The accumulative build-up of offshore transmission renewable capacity for this scenario is shown in Figure 4.17. There is 32 GW of wind and 1.4 GW of marine transmission generation capacity being included by 2020 (with a further 8 GW of wind and 0.5 GW of marine connecting by 2025).
In this scenario, the UK exceeds its European Union 2020 renewable targets. The scenario has a considerable build-up rate between the years 2010 and 2020, which may be viewed as challenging by users of the Statement and would necessitate the rapid establishment of a robust supply chain. This scenario assumes that the UK offshore industry is sustained into the future through developments both in the UK and Europe.

Figure 4.18 demonstrates the increase in the amount of installed renewable transmission generation capacity over the study period, which is significantly higher than the previous scenarios.
Demand Background
The electricity demand in this scenario is the same as that used in the Gone Green scenario.

Generation Background
This scenario takes the Gone Green generation background and replaces the offshore wind generation with an aggressive build-up rate between 2010 and 2020. It depicts less new coal plant with CCS connecting to the grid by 2025 and assumes a 5 year life extension for the existing nuclear generation fleet (as in the Slow Progression Scenario). The overall generation mix for this scenario is detailed in Figure 4.19. The total amount of generation in this scenario is higher than in Gone Green to account for the intermittent nature of wind.

Plant Closures:
- 11.5 GW of oil and coal fired plant under the Large Combustion Plant Directive by 2015.
- 7.2 GW of nuclear generation capacity by 2020 (assumes 5 year life extension to AGRs).
- 5.0 GW of gas generation capacity by 2020 (with a further 2.3 GW by 2025 due to age profile and Industrial Emissions Directive).
- 15.0 GW of coal generation capacity by 2025 due to age profile and the Industrial Emissions Directive.

Significant New Renewable:
- 32.0 GW of transmission offshore wind generation capacity by 2020 (with a further 8.1 GW connecting by 2025).
- 7.9 GW of transmission onshore wind generation capacity by 2020 (with a further 0.7 GW connecting by 2025).
- 1.4 GW of transmission marine generation capacity by 2020 (with a further 0.5 GW connecting by 2025).

Significant New Non Renewable Build:
- 9.3 GW of new gas generation capacity (with a further 1.8 GW connecting by 2025).
- 1.5 GW of new gas CCS generation capacity by 2025.
- 3.2 GW of coal CCS generation capacity (with a further 4.3 GW connecting by 2025).
- 2.9 GW of new nuclear generation capacity (with a further 6.1 GW connecting by 2025).

In this scenario the UK exceeds its European Union 2020 renewable targets. This scenario assumes that the UK wind industry is sustained into the future through developments both in the UK and Europe.

The scenario has a considerable build-up rate between the years 2010 and 2020 which may be viewed as challenging. It will require an immediate and significant acceleration of the environment impact assessment and consenting process with compelling project economics to stimulate rapid financial close following consent.

However, depending on the contribution made by the heat and transport sectors (in reaching the 2020 environment targets), it is conceivable that greater emphasis may be placed on the electricity sector (i.e.
contribution will be in excess of the current allocation of 30%) with an associated emphasis on renewable electricity generation. This would require an increase in the build-up rate between the years 2010 and 2020 as illustrated by this scenario.

Table 4.3 compares the renewable share of generation energy, as depicted by the Accelerated Growth scenario, against the assumed 2020 renewable electricity contribution (as identified by Renewable Energy Strategy) for 2020 and 2025.

**TABLE 4.3 – Future Scenarios: Accelerated Growth: Renewable Assessment**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>46.5 GW</td>
<td>43.9%</td>
<td>30%</td>
<td>43%</td>
<td>Above Target</td>
</tr>
<tr>
<td>2025</td>
<td>57.3 GW</td>
<td>47.9%</td>
<td></td>
<td>50%</td>
<td>Above Target</td>
</tr>
</tbody>
</table>

**4.3.6 Sustainable Growth**

**Offshore Summary**

This scenario is similar in scope to that of the Accelerated Growth scenario as it depicts a significant amount of offshore generation connected to the electricity grid by 2025. However the assumed build-up rates under this scenario differ from that depicted in the Accelerated Growth scenario.

In this scenario, there is over 25 GW of offshore (wind and marine) generation capacity (inclusive of generation connecting to the onshore electricity distribution system) included in 2020 with over 47 GW by 2025. The build up of offshore developments in this scenario is shown in Figure 4.20 with over 6 GW of Round 1 and Round 2 offshore wind capacities being included by 2020 and nearly 12 GW of Round 3 offshore wind generation included in 2020. The Round 3 figure increases to nearly 30 GW by 2025. There is nearly 3 GW of offshore generation capacity in Scottish Territorial Waters by 2020 (rising to over 5 GW by 2025).

**FIGURE 4.20 – Sustainable Growth Scenario: Offshore Developments (Installed Capacity)**

The build-up of offshore transmission wind in this scenario is shown in Figure 4.21 in which there is over 22 GW of wind generation capacity being included by 2020 (with a further 20 GW connecting by 2025).
The annual offshore transmission wind capacity for this scenario is shown in Figure 4.22. The yearly rates range between 480 MW in 2010 (prior to the development of the majority of the Round 2 connections) and 4,000 MW from 2021 onwards (for the completion of Round 3 projects).

This build-up rate assumes a substantial and sustained increase in the current supply chain capability after 2014 with an average yearly build-up rate of 2,650 MW over the study period (approximately 530 turbines connected each year, based on the utilisation of 5 MW turbines). The slower growth rate than that depicted in the Accelerated Growth scenario may make the ramping up of the supply chain capacity more achievable. In addition, the longer and more sustained period of production may provide confidence to the development of a long-term market which will be of consideration to manufacturers and other supply chain companies considering setting-up or expanding in the UK.

The accumulative build-up of offshore transmission renewable capacity for this scenario is shown in Figure 4.23. There is 22 GW of wind and nearly 1.2 GW of marine transmission generation capacity being included by 2020 (with a further 20 GW of wind and 0.75 GW of marine connecting by 2025).
In this scenario, the UK exceeds its European Union 2020 renewable targets. This scenario will inform users regarding what grid development will be required in order to facilitate a significant amount of offshore generation.

Figure 4.24 demonstrates the increase in the amount of installed renewable transmission generation capacity over the study period, which is slightly higher than that depicted in the Accelerated Growth Scenario.

**Demand Background**

The electricity demand in this scenario is the same as that used in the Gone Green scenario.
Generation Background

The onshore generation in this scenario is the same as that used in the Gone Green scenario. The overall generation mix in this scenario is detailed in Figure 4.25 below.

**FIGURE 4.25 – Sustainable Growth Scenario: Generation & Demand Background**

**Plant Closures:**
- 11.5 GW of oil and coal fired plant under the Large Combustion Plant Directive by 2015.
- 2.5 GW of nuclear generation capacity by 2020 (assumes 10 year life extension to AGRs) (with a further 4.7 GW by 2025).
- 5.0 GW of gas generation capacity by 2020 (with a further 2.3 GW by 2025 due to age profile and Industrial Emissions Directive).
- 15.0 GW of coal generation capacity by 2025 due to age profile and the Industrial Emissions Directive.

**Significant New Renewable:**
- 22.2 GW of transmission offshore wind generation capacity by 2020 (with a further 22.0 GW connecting by 2025).
- 6.9 GW of transmission onshore wind generation capacity by 2020 (with a further 0.7 GW connecting by 2025).
- 1.2 GW of transmission marine generation capacity by 2020 (with a further 0.75 GW connecting by 2022).

**Significant New Non Renewable Build:**
- 9.3 GW of new gas generation capacity by 2020 (with a further 1.8 GW connecting by 2025).
- 2.0 GW of new gas CCS generation capacity by 2025.
- 3.2 GW of Coal CCS generation capacity by 2020 (with a further 4.3 GW connecting by 2025).
- 2.9 GW of new nuclear generation capacity by 2020 (with a further 6.1 GW connecting by 2025).

In this scenario, the UK exceeds its European Union 2020 renewable targets. The scenario takes the Gone Green generation and demand background and replaces the offshore wind generation with increased build-up rates between 2015 and 2025 which will encourage the establishment of a long-term manufacturing industry within the UK.

Table 4.4 compares the renewable share of generation energy, as depicted by the Sustainable Growth scenario, against the assumed 2020 renewable electricity contribution (as identified by Renewable Energy Strategy) for 2020 and 2025.
TABLE 4.4 – Future Scenarios: Sustainable Growth: Renewable Assessment

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>35.3 GW</td>
<td>34.9%</td>
<td>30%</td>
<td>36%</td>
<td>Above Target</td>
</tr>
<tr>
<td>2025</td>
<td>56.3 GW</td>
<td>46.8%</td>
<td></td>
<td>52%</td>
<td>Above Target</td>
</tr>
</tbody>
</table>

4.3.7 Comparison of Scenarios

Figure 4.26 shows the annual (accumulative) build-up for offshore transmission wind in all four future scenarios.

**FIGURE 4.26 – Future Scenarios Comparison: Offshore Transmission Wind (Installed Capacity)**

Figure 4.27 shows the annual (yearly) build-up for offshore transmission wind in all four future scenarios.

Each of the future scenarios depicts a different build rate for offshore generation which enable a comparison as to how differing build rates impact the development of the offshore electricity network.

Some of the scenarios have a considerable build-up rate which may be viewed as challenging. However, depending on the contribution made by the heat and transport sectors (in reaching the 2020 environmental targets), it is conceivable that greater emphasis may be placed on the electricity sector (i.e. target will be in excess of the current 30%) with an associated emphasis on renewable electricity generation. This would require an increase in build-up between the years 2010 and 2020 as illustrated by the Accelerated Growth scenario.
FIGURE 4.27 – Future Scenarios Comparison: Offshore Transmission Wind (Annual Build-Up Rates)

4.4 Future Scenarios: 2020 Renewable Assessment

The European Union’s integrated energy/climate change proposal set a target of 20% of European energy to come from renewable sources by 2020. The UK’s contribution to this target is 15%. The Renewable Energy Strategy identified that in order to meet this target; approximately 30% of UK’s electricity will have to come from renewable sources by 2020, with a corresponding 12% from heat and 10% from transport. In 2009, 6.7% of electricity was derived from renewable sources. This represented an increase from the previous year (5.6%).

For each of the four future scenarios, the following tables compare the renewable share of generation energy against the assumed 2020 renewable electricity contribution (as identified by Renewable Energy Strategy) for 2020 (Table 4.5) and 2025 (Table 4.6).

As depicted by Table 4.5, by 2020 three out of the four future scenarios meet or exceed the 2020 renewable electricity target.

**TABLE 4.5 – Future Scenarios: Renewable Assessment at 2020**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow Progression</td>
<td>20.7 GW</td>
<td>23%</td>
<td></td>
<td>21%</td>
<td>Below Target</td>
</tr>
<tr>
<td>Gone Green</td>
<td>29.6 GW</td>
<td>31.0%</td>
<td></td>
<td>32%</td>
<td>On Target</td>
</tr>
<tr>
<td>Accelerated Growth</td>
<td>46.5 GW</td>
<td>43.9%</td>
<td>30%</td>
<td>43%</td>
<td>Above Target</td>
</tr>
<tr>
<td>Sustainable Growth</td>
<td>35.3 GW</td>
<td>34.9%</td>
<td></td>
<td>36%</td>
<td>Above Target</td>
</tr>
</tbody>
</table>

146 Table 7 from The Digest of United Kingdom Energy Statistics 2010
Offshore Development Information Statement 2010

Table 4.6 illustrates that by 2025, there continues to be an increase in amount of renewable generation energy produced in each of the future scenarios with Slow Progression nearly reaching the 2020 renewable electricity contribution target.

**TABLE 4.6 – Future Scenarios: Renewable Assessment at 2025**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow Progression</td>
<td>26.9 GW</td>
<td>28.8%</td>
<td>28%</td>
<td>30%</td>
<td>Below Target</td>
</tr>
<tr>
<td>Gone Green</td>
<td>36.3 GW</td>
<td>35.8%</td>
<td>37%</td>
<td>50%</td>
<td>Above Target</td>
</tr>
<tr>
<td>Accelerated Growth</td>
<td>57.3 GW</td>
<td>47.9%</td>
<td></td>
<td>52%</td>
<td>Above Target</td>
</tr>
<tr>
<td>Sustainable Growth</td>
<td>56.3 GW</td>
<td>46.8%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.5 Additional Sensitivities

4.5.1 Additional Regional Capacity Sensitivity

This sensitivity has been developed using the offshore development announcements by The Crown Estate, DECC and the Scottish Government regarding seabed allocations for wind and marine generation. This equates to approximately 55 GW of offshore generation capacity with all the projects included at their total potential generation capacity e.g. Dogger Bank will be analysed at its full potential capacity of 12,800MW.

The sensitivity will exclude projects which have been officially cancelled by the developer e.g. offshore wind farm Round 1 Projects: Cromer, Scarweather Sands, Shell Flats. The ARC sensitivity makes no assumptions regarding any future announcement by The Crown Estate and/or DECC/Scottish Government regarding future leasing allocation rounds for wind and marine generation. It is noted that the Scottish Government has issued a consultation identifying a further 25 potential zones which may result in further leasing rounds being announced and facilitated by The Crown Estate in due course 125.

The ARC will enable an examination of the potential local investment that may be required in the different geographic regions, if all the offshore generation capacity in that area connected to the electricity network. Identifying the different levels of potential capacity that could be developed in each of the regions enables NGET to assess a number of different scenarios and investment options that may not be covered directly by the four future scenarios detailed in this document. This should also assist developers in identifying the maximum capabilities and requirements in different geographic regions.

Unlike the four main future scenarios, the ARC does not have a corresponding generation and demand background. In addition, no assumptions have been made regarding the associated connection dates, planning permission, supply chain and technology requirements etc which may impact the completion and connection of the installed generation capacity identified and analysed.

Chapter 5 contains the illustrative offshore network designs and local onshore transmission reinforcements that are adequate to cater for the ARC of offshore generation in the geographic regions.
4.5.2 Interconnectivity Sensitivity

There is the potential for additional interconnectivity capacity between Great Britain and its European neighbours and the potential for (electricity) imports and exports which could materialise over the study period. Table 4.7 indicates the specific projects that were included in the analysis.

### TABLE 4.7 – Additional Sensitivity: Interconnectivity

<table>
<thead>
<tr>
<th>Name</th>
<th>Capacity</th>
<th>Status</th>
<th>Treatment (Energy Flow)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IFA (GB to France)</td>
<td>2,000 MW</td>
<td>Existing (In Operation)</td>
<td>France to GB (Import)</td>
</tr>
<tr>
<td>Moyle (GB to Northern Ireland)</td>
<td>450 MW to Northern Ireland &amp; 80 MW to GB</td>
<td>Existing (In Operation)</td>
<td>GB to Northern Ireland (Export)</td>
</tr>
<tr>
<td>BritNed (GB to The Netherlands)</td>
<td>1,000 MW</td>
<td>Under Construction</td>
<td>Import/Export</td>
</tr>
<tr>
<td>East West Interconnector (GB to Ireland)</td>
<td>500 MW</td>
<td>Under Construction</td>
<td>GB to Ireland (Export)</td>
</tr>
</tbody>
</table>

**Other Potential Interconnectors**

- French Interconnector 2: 1,000 MW, Under Consideration, Import/Export
- Belgium/Netherlands Interconnector: 2,000 MW, Under Consideration, Import/Export
- Norwegian Interconnector: 2,000 MW, Under Consideration, Import/Export
- Irish Interconnector: 1,000 MW, Under Consideration, Import/Export

For the purposes of the future scenarios, 2,000 MW of interconnector import capacity has been assumed to be required at the time of annual peak demand on the electricity transmission system. This additional generation, available to the National Electricity Transmission System (NETS) via the interconnectors, will be utilising in meeting peak demand whilst maintaining adequate plant margin.

Increased interconnectivity will play an essential role in facilitating: i) competition by developing the European internal electricity market and ii) the transition to low carbon energy sector by efficiently integrating various renewables.

The interconnector capacity could be utilised as a trading mechanism by electricity industry participants providing additional flexibility within the electricity market which could be utilised to address the intermittency issues relating to certain renewable generation. Furthermore, it could also facilitate the development of the UK as a net electricity exporter which may be viewed as a plausible outcome in the Accelerated Growth and Sustainable Growth scenarios, given the significant amount of offshore wind and will provide additional emphasis to the development of an integrated offshore North Sea grid.

The development of the offshore North Sea grid is supported by European Network of Transmission System Operators for Electricity (ENTSO-E)\(^\text{147}\) and aligns itself with the target signed by the European Council in Barcelona 2002\(^\text{148}\) (electricity interconnection equivalent to 10% of installed production capacity by 2025 for each EU member state).

\(^{147}\) [https://www.entsoe.eu/](https://www.entsoe.eu/)
Chapter Five

5 Offshore and Associated Onshore Connection Design

5.1 Overview

Chapter 1 has given a brief insight on how legislation, government incentives and connection processes work together in simulating the connection of offshore generators. This chapter presents options for the connection of offshore generation to the Main Interconnected Transmission System (MITS) giving due consideration to the information presented in the previous chapters, particularly the various future scenarios described in Chapter 4.

This chapter will provide an insight into the potential offshore transmission infrastructure required to securely and reliably connect offshore generators to the MITS together with the necessary onshore reinforcements required to maintain network security and quality of supply compliance. The chapter does not cover sub-transmission connections other than showing the nearest affected Grid Entry Point.

As already established in previous chapters, the offshore regime includes Rounds 1, 2, 3 and Scottish Territorial Waters projects. Many of the early projects in Round 1 and 2 are already well developed in terms of design, with many of the sites under construction or in operation and therefore fall outside the scope of this chapter. There are a number of potential connection options for each project and this greatly influences the onshore network design, with a range of viable options discussed in this document.

The contracted background of all generation connection agreements with NGET can be found in the Transmission Entry Capacity Register (TEC)\(^{149}\).

5.1.1 Figures and Illustrative Diagrams

The indicative system connection works shown in this document have been identified, via a desktop study process, purely for analysis and have been included for illustrative purposes only. They should not be considered as implying actual future connection routes for new infrastructure. Detailed studies and consultations are required to establish the most appropriate type and location of system connection.

5.1.2 Planning Act 2008

The Planning Act 2008\(^{150}\) was granted Royal Assent on 26 November 2008 and established a new decision-making body, the Infrastructure Planning Commission (IPC)\(^{151}\) and a new consenting process for nationally significant infrastructure projects (NSIPs) in England and Wales.

The new Government has confirmed its commitment to an efficient and democratically accountable process for major infrastructure projects. It aims to bring forward legislation in 2011 to replace the IPC, whilst retaining its expertise and processes within a new Major Infrastructure Planning Unit (MIPU) within the Planning Inspectorate\(^{152}\). The MIPU will consider and make recommendations on NSIP proposals, with the relevant Secretaries of State responsible for deciding whether consent should be granted.

The new requirements apply to major energy generation, energy infrastructure in the form of overhead lines and pipelines over certain thresholds, as well as railways, ports, major roads, airports and water and waste infrastructure. National policy will be set out by Ministers in a series of National Policy Statements (NPS’s). The Act also imposes requirements on project promoters to consult affected parties and local communities prior to submitting an application and promoters are encouraged to do so early when developing proposals so as to allow projects to be shaped and influenced by consultation feedback.

\(^{149}\) [http://www.nationalgrid.com/uk/Electricity/GettingConnected/ContractedGenerationInformation/TransmissionEntryCapacityRegister/]


\(^{151}\) [http://infrastructure.independent.gov.uk/]

The Act sets out mandatory pre-application procedures which includes notification, consultation and publicity requirements. NGET is committed to meeting and if appropriate exceeding the requirements of the Planning Act 2008 and will engage and consult affected parties in the development of its projects, demonstrating how local communities’ and other stakeholders’ views have been taken into consideration. Our commitments in this regard are described in more detail in our Stakeholder Community & Amenity Policy, which also outlines how we seek to meet our statutory responsibilities under Schedule 9 of the Electricity Act 1989: to have regard to the preservation of amenity in the local area.

5.1.3 Technology

For more detailed explanations of offshore network design methodology and offshore transmission technologies please refer to appendix 3 and 4 respectively.

The ongoing development of high voltage equipment technologies, such as subsea cables and converter stations, means that energy transfer capability is continuously improving. For example, it is now feasible to develop an offshore converter station with a capacity in the region of 1000 MW. Within the next few years it is anticipated that the technology will have progressed to the extent that 2000 MW capacity is achievable.

As part of this Statement, the relevant offshore transmission technologies have been further reviewed from the previous statement and the indicative offshore transmission network designs updated. The findings of the technology review are included in Appendix 4. This includes data on the background capabilities, cost and dependencies, etc of various offshore transmission technologies.

In principle, there are no anticipated technical barriers to deploying the proposed connection designs. Although voltage/power ratings are in excess of those presently installed, these are achievable through incremental development rather than requiring an innovation step change. Detail on potential connection design types is included within Appendix 3.

5.2 Onshore/Offshore Design

This section considers the offshore and associated onshore connection works required to provide licence compliant connection to the MITS. The indicative offshore and onshore designs have been developed with sufficient capability to accept the full generation capacity whilst ensuring compliance with the National Electricity Transmission System Security and Quality of Supply Standard (NETS SQSS). Wider onshore transmission system requirements are discussed in Chapter 6.

As an expansion of the previous statement, three different development strategies have been prepared to demonstrate how different technology and topology assumptions can have an impact upon the optimum offshore transmission network. The three different design strategies presented are:

Radial Strategy – Point-to-point connections from the offshore generation to suitable onshore MITS collector substations using current transmission technology.

Radial Plus Strategy – Similar to radial in the use of point to point connections for connecting the offshore generation to the onshore MITS but utilising anticipated future transmission technology capability within the strategy (e.g. 2 GW capacity converter stations and high capacity offshore cables) in line with delivery forecasts for the next five years. Radial Plus also differs from the Radial Strategy in that multiple groups of offshore generation are connected to the radial point-to-point connections as opposed to a single group being connected radially.

Integrated Strategy – An interconnected offshore design using AC cable and HVDC interconnection between offshore platforms and development areas, using the same advanced technology as with the Radial Plus Strategy. Multiple offshore platforms will be interconnected, providing fewer cables and reduced asset volumes. The first HVDC cables laid would be of 2 GW size in preparation for the
subsequent stages saving on laying multiple cables of different sizes. More efficient coordination between onshore and offshore networks is also made possible.

Figure 5.1 shows how the different design strategies affect the design of an example 4 GW offshore wind farm development. The staging shows how each strategy may develop as each gigawatt of the project connects.

It can be seen from the integrated strategy that from the second stage, there is interconnection between the offshore platforms so for the loss of any single cable there is still a path back to shore. While there may not be sufficient transmission capacity to accommodate the full generation output following an outage, there should be enough to cover the majority given the reduced load factors of wind generation.

In addition to local offshore interconnection, the larger offshore generation areas within reasonable distance from each other may offer interconnection opportunities and share onshore collector substation capacity.

Where areas are interconnected, there will be power flow interaction and with the use of HVDC technology, there may be the opportunity to control and manage those power flows. With the management of an integrated offshore transmission system, the power injections into the onshore transmission system may also be controlled and possibly alleviate the need for some onshore reinforcements.

In order to illustrate the possible offshore connection options, the country has been split into a number of regions so each region can be shown in more detail. The developments along the east coast are very interactive and it should be noted that the transmission works extend from one region to the next.

Figure 5.2a and 5.2b show how the regions have been assigned and show an overview geographical map for the Radial and Integrated strategies.
FIGURE 5.2a - Radial Strategy Overview

Accelerated Growth Scenario
Radial Network

Note: Onshore reinforcements not shown on diagram.
FIGURE 5.2b - Integrated Strategy Overview

Accelerated Growth Scenario
Integrated Network

Scotland
North West
Bristol Channel
South Coast
East Coast
East Anglia

Note: Onshore reinforcements not shown on diagram.

This area has been identified has having significant constraints surrounding the offshore corridor and onshore landing points. Detailed analysis will be required to determine viable connection routes.
5.3 North West – Irish Sea

The North West region covers an area including North Wales, Lancashire, Merseyside and Clwyd. Currently North West has a number of existing onshore connection points for Round 1 and 2 offshore wind farms located in the Irish Sea. At the time of writing, there is a potential for the further connection of 4.2 GW of Round 3 proposed wind farms by early 2013/14. The planned Round 3 zone is located between Anglesey and the Isle of Man.

Figure 5.3 shows, for the four scenario backgrounds, the North West region potential incremental total generation capacity up to 2025.

FIGURE 5.3 - North West: Installed Offshore Generation Capacity

It can be seen from Figure 5.3 that the Accelerated Growth scenario dominates the other generation/demand scenarios.

5.3.1 North West: Radial Strategy Offshore Design

As the majority of the North West offshore wind farms lie within the south zone and are in close proximity to the shore (less than 50 km), the use of AC technology would be applicable and financially feasible. The northern part of the Irish Sea zone is more than 70 km from shore and would most likely require an HVDC connection.

The offshore Radial network design shown in Table 5.1a indicates the Radial design for a maximum zonal capacity of 4.2 GW from the Round 3 Irish Sea wind farm. The 4.2 GW is divided into five 0.6 GW and one 1 GW wind farm capacities.

All of the AC connection cables are expected to be connected to Wylfa 400 kV substation. Wylfa substation was selected due to its strategic location for connection and its close proximity to the shore, resulting in short offshore cable lengths and near negligible onshore cable lengths. The standard AC600 arrangement has been used here. However the short distances may allow for a larger number of smaller 132 kV platforms. A single HVDC link may be all that is required to connect a large proportion of the available development area to the north of the Irish Sea zone, connecting into an existing substation at either Stannah or Heysham.
TABLE 5.1a – North West: Radial Strategy Offshore Design

<table>
<thead>
<tr>
<th>Zone</th>
<th>Wind Farm¹⁵⁵</th>
<th>Capacity (MW)</th>
<th>TO Interface Point</th>
<th>Straight Line Connection Distance¹⁵⁶ (km)</th>
<th>Design Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Offshore</td>
<td>Onshore</td>
</tr>
<tr>
<td>Irish Sea</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JA1</td>
<td></td>
<td></td>
<td>Wyfia</td>
<td>35</td>
<td>1</td>
</tr>
<tr>
<td>JA2</td>
<td></td>
<td></td>
<td>Wyfia</td>
<td>37</td>
<td>1</td>
</tr>
<tr>
<td>IA1</td>
<td>4,200</td>
<td></td>
<td>Wyfia</td>
<td>28</td>
<td>1</td>
</tr>
<tr>
<td>NA1</td>
<td></td>
<td></td>
<td>Stanah</td>
<td>78</td>
<td>4</td>
</tr>
<tr>
<td>IA3</td>
<td></td>
<td></td>
<td>Wyfia</td>
<td>28</td>
<td>1</td>
</tr>
<tr>
<td>KA1</td>
<td></td>
<td></td>
<td>Wyfia</td>
<td>37</td>
<td>1</td>
</tr>
</tbody>
</table>

Note the radial strategy is limited to using the AC600, AC900 and HVDC1000 design blocks

¹⁵⁵ These are only indicative locations within the nominated area that may be developed.
¹⁵⁶ This is the straight line distance and the actual cable corridor length can be much longer.
FIGURE 5.4a - North West: Radial Strategy Offshore Design

Legend:
- AC cable
- HVDC cable
- AC connection point
- HVDC connection point
- Round 3 windfarm area
- Round 2 windfarm area
- Round 1 windfarm area
- Windfarm Array
- Region for Onshore Reinforcement Development

Possible Interface Substation Configuration

Shoreline

AC Platforms

Possible Interface Substation Configuration

Legend:
- AC cable
- HVDC cable
- AC connection point
- HVDC connection point
- Round 3 windfarm area
- Round 2 windfarm area
- Round 1 windfarm area
- Windfarm Array
- Region for Onshore Reinforcement Development
5.3.2 North West: Radial Plus Strategy Offshore Design

The Radial Plus strategy offers some advantage over the Radial strategy by using fewer high capacity AC cables thereby reducing the overall expected capital expenditure. The Radial Plus design does however require an additional offshore platform and puts more capacity at risk from the loss of any one cable.

Table 5.1b shows the Radial Plus design which is very similar to that of the Radial Strategy. In this design Wylfa also acts as the onshore connection point for the whole 4.2 GW of capacity to be transferred onshore. From Wylfa, significant reinforcement including an HVDC interconnection to South Wales will be required to accommodate the full generation capacity that could connect.

TABLE 5.1b – North West: Radial Plus Strategy Offshore Design

<table>
<thead>
<tr>
<th>Zone</th>
<th>Wind Farm\textsuperscript{157}</th>
<th>Capacity (MW)</th>
<th>TO Interface Point</th>
<th>Straight Line Connection Distance\textsuperscript{158} (km)</th>
<th>Design Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irish Sea</td>
<td>JA1</td>
<td>35</td>
<td>Wylfa</td>
<td>1</td>
<td>1 x AC500</td>
</tr>
<tr>
<td></td>
<td>JA2</td>
<td>37</td>
<td>Wylfa</td>
<td>1</td>
<td>1 x AC500</td>
</tr>
<tr>
<td></td>
<td>IA1</td>
<td>28</td>
<td>Wylfa</td>
<td>1</td>
<td>1 x AC500</td>
</tr>
<tr>
<td></td>
<td>NA1</td>
<td>78</td>
<td>Stanah</td>
<td>4</td>
<td>1 x HVDC1000</td>
</tr>
<tr>
<td></td>
<td>IA3</td>
<td>28</td>
<td>Wylfa</td>
<td>1</td>
<td>1 x AC500</td>
</tr>
<tr>
<td></td>
<td>KA1</td>
<td>37</td>
<td>Wylfa</td>
<td>1</td>
<td>2 x AC600</td>
</tr>
</tbody>
</table>

Note the Radial Plus and Integrated strategies assume the future availability of larger capacity cables and HVDC converters allowing the use of AC500 and HVDC2000 design blocks.

\textsuperscript{157} These are only indicative locations within the nominated area that may be developed.
\textsuperscript{158} This is the straight line distant and the actual cable corridor length can be much longer.
FIGURE 5.4b - North West: Radial Plus Offshore Design

Legend:
- AC cable
- HVDC cable
- AC connection point
- HVDC connection point
- Round 3 windfarm area
- Round 2 windfarm area
- Round 1 windfarm area
- Windfarm Array
- Region for Onshore Reinforcement Development

Legend:
- AC cable
- HVDC cable
- AC connection point
- HVDC connection point
- Round 3 windfarm area
- Round 2 windfarm area
- Round 1 windfarm area
- Windfarm Array
- Region for Onshore Reinforcement Development

Possible Interface Substation Configuration

Shoreline

AC Platforms

Possible Interface Substation Configuration
5.3.3 North West: Integrated Strategy Offshore Design

The integrated design, through the interconnection of platforms, provides a more secure offshore network design than the Radial and Radial Plus strategies, as its design allows power transfer diversion to occur for the fault of any single cable.

The proposed integrated design is different to the radial design as it does not consider individual single point connections to wind farms. The maximum connection distance increases to 300 km and uses a hybrid of AC and HVDC technologies to connect 4.2 GW of offshore generation. As the Integrated solution involves a complex offshore network, a number of onshore connections must be identified to transfer power from offshore to onshore. This includes the already identified substations at Wylfa and Pembroke as well as the proposed HVDC link which interconnects both substations.

It can be seen from Table 5.1c that more of the AC500 platform design is used than any other, with a combination of HVDC1000 and 2000 technology providing a high level of integration and connection between all the offshore wind farms.

**TABLE 5.1c – North West: Integrated Strategy Offshore Design**

<table>
<thead>
<tr>
<th>Zone</th>
<th>Wind Farm(^{159})</th>
<th>Capacity (MW)</th>
<th>TO Interface Point</th>
<th>Straight Line Connection Distance(^{160}) (km)</th>
<th>Design Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irish Sea</td>
<td>JA1</td>
<td>4,200</td>
<td>Wylfa</td>
<td>37</td>
<td>1 x AC500</td>
</tr>
<tr>
<td></td>
<td>JA2</td>
<td></td>
<td></td>
<td></td>
<td>1 x AC500</td>
</tr>
<tr>
<td></td>
<td>IA1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NA1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IA3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>KA1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note the Radial Plus and Integrated strategies assume the future availability of larger capacity cables and HVDC converters allowing the use of AC500 and HVDC2000 design blocks.

\(^{159}\) These are only indicative locations within the nominated area that may be developed.

\(^{160}\) This is the straight line distant and the actual cable corridor length can be much longer.
5.3.4 North West: Onshore Transmission Design

The 2010 primary network found in the North West currently consists of a number of 400 kV circuits: double circuit from Deeside to Wylfa via Pentir and a single circuit from Pentir to Trawsfynydd with a Tee point to Legacy. The majority of the loading of these circuits is principally due to the nuclear power station at Wylfa and the pumped storage stations at Dinorwig and Ffestiniog. It is expected that an additional 3.6 GW of power could flow through these circuits due to the replacement of the nuclear generator at Wylfa. Due to the large increase in power export from north Wales, reinforcements will be required which could in part consist of a second double circuit from Wylfa to Pentir along with an additional new circuit from Pentir to Trawsfynydd. These two reinforcements will help cater for the new nuclear generator at Wylfa as well as the offshore wind farms.

Deeside has also been considered as a possible connection site for further offshore generation. However existing planned developments at Deeside already include HVDC links to Ireland and the Scottish West Coast which may limit the site of any further development.

All the strategies call for the use of a 2 GW HVDC link from the North West region to Pembroke. The integrated strategy suggests that the HVDC link be directly fed from the Irish Sea Round 3 offshore wind farm to Pembroke. The Radial and Radial Plus strategies suggest a 2 GW HVDC link from Wylfa to Pembroke as a solution. The major difference between the Radial and Integrated strategies is that the radial strategy would need additional HVDC converters on Anglesey to receive the power from the wind farm and then resend much of it out again to Pembroke. Having the HVDC link terminating offshore within the wind farm would allow some of the power to bypass Anglesey and the North Wales transmission system, significantly reducing volume of assets and increasing resilience of offshore wind generation points.

Table 5.1d shows the reinforcements likely to develop up to 2030, enabling the network to cater for the onshore and offshore generation in North West.
<table>
<thead>
<tr>
<th>Ref.</th>
<th>Description</th>
<th>Approximate Date(^{161})</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>SP</td>
</tr>
<tr>
<td>R1.1</td>
<td>- Reconductor Trawsfynydd – Treuddyn with 2 x 85 km of GZTACSR conductor</td>
<td>2021/22</td>
</tr>
</tbody>
</table>
| R1.2 | - Mid Wales 400 kV substation and OHL  
- Establish new 400 kV substation in mid-Wales for the connection of multiple TAN8 wind generation sites  
- 80 km, double circuit overhead line (exact length to be determined via routing studies)  
| R1.3 | - Establish second Pentir – Trawsfynydd 400 kV circuit  
- Rationalise existing SP Manweb owned 132 kV circuit, strung between Trawsfynydd and tower 4ZC70, for operation at 400 kV by reconductoring the circuit using 2 x 700 mm\(^2\) conductor  
- Establishing a GSP at Bryncir to secure the demand at Four Crosses following SP Manweb route rationalised to 400 kV  
- Reconfiguration and extension of Pentir 400 kV substation by 3 bays  
- At Trawsfynydd 400 kV connect the circuit by utilising the spare line disconnector bay on Mesh corner 3  
- Installation of approximately 6 km of 2 x 2500 mm\(^2\), 400 kV XLPE cable to cross the Glaslyn Estuary | 2014/15 | 2014/15 | 2013/14\(^{162}\) | 162 2015/16\(^{162}\) | 2013/14\(^{162}\) | 162 2015/16\(^{163}\) |
| R1.4 | - Deeside – Trawsfynydd 120 Mvar series compensation | 2020 | 2016 | 2014 | 2014 |
| R1.6 | - New 400 kV, Pentir – Wylfa OHL  
- 40 km, 3 x 700 mm\(^2\) double circuit overhead line  
- Extension of Pentir 400 kV substation  
- Modifications to Wylfa substation | 2021/22 | 2017/18 | 2015/16\(^{162}\) | 162 2017/18\(^{163}\) | 163 2015/16\(^{162}\) | 162 2017/18\(^{163}\) |
| R1.7 (Radial Only) | - Wylfa to Pembroke 2GW HVDC link  
- 115 km HVDC cable link  
- Extension of Wylfa and Pembroke substations | 2023 | 2022 | 2022 | 2022 |
| R1.8 (Integrated Only) | - Irish Sea OWF to Pembroke 2 GW HVDC LINK  
- 120 km HVDC cable link  
- Substation extension at Pembroke | 2023 | 2022 | 2020 | 2020 |

---

161 The dates provided here are driven by the scenarios considered and should not be compared against contracted dates.  
162 Reinforcement is required to accommodate system capacity.  
163 A 7-year project lead time for the planning, building and commissioning of a new OHL of this magnitude is considered reasonable considering the planning process required by the IPC.
5.4 Bristol Channel – Atlantic Array

A number of new generation projects have been proposed within the Bristol Channel region, including new Round 3 wind farm connections and some Wave and Tidal renewable projects located in the South Wales and South West areas, as well as the proposed Severn Tidal Barrage. Figure 5.5 shows how the total offshore generation in the region is expected to rise in the future for the four different scenarios.

The onshore transmission network within the area consists of a number of circuits which covers both the South Wales and South West coasts. The existing South Wales circuits are generally 275 kV circuits therefore providing very little support for additional generation without replacing or upgrading to 400 kV. The South West onshore transmission network consists mostly of 400 kV circuits connecting the existing generation at Langage, Marchwood and Hinkley Point. Traditionally, the existing generation in the area matches the local demand closely, resulting in low transfers and the limiting case for exports to the demand centres in the east occurs under summer light load conditions. The allocated Round 3 zone within the Bristol Channel is located around 50 km offshore of Alverdiscott. The potential capacity from the Round 3 zone is around 1.5 GW.

5.4.1 Bristol Channel: Radial Strategy Offshore Design

For the Bristol Channel region, the proximity of the Round 3 wind farm area to the most suitable point of connection has been identified as being Alverdiscott, taking into account connection distance and reinforcement requirements. As the generation is around 50 km from the onshore connection points an AC solution has been considered. However, the actual cable distance may be considerably longer than 50 km, and therefore points towards a HVDC solution.

The additional regional capacity of 1500 MW has been divided up into three 500 MW wind farms and the AC600 design is deployed. This is because of technological limitations on cable ratings that are assumed in the Radial Strategy case.

Table 5.2a summarises the design for Bristol Channel Round 3 wind farm connection for the Radial connection strategy and Figure 5.6a shows the expected regional connection.
TABLE 5.2a – Bristol Channel: Radial Strategy Offshore Design

<table>
<thead>
<tr>
<th>Zone</th>
<th>Wind Farm(^{164})</th>
<th>Capacity (MW)</th>
<th>TO Interface Point</th>
<th>Straight Line Connection Distance(^{165}) (km)</th>
<th>Design Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bristol Channel</td>
<td>HA1</td>
<td>500</td>
<td>Alverdiscott</td>
<td>42</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>HA2</td>
<td>500</td>
<td>Alverdiscott</td>
<td>34</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>HA3</td>
<td>500</td>
<td>Alverdiscott</td>
<td>39</td>
<td>6</td>
</tr>
</tbody>
</table>

Note the radial strategy is limited to using the AC600, AC900 and HVDC1000 design blocks.

---

\(^{164}\) These are only indicative locations within the nominated area that may be developed.

\(^{165}\) This is the straight line distant and the actual cable corridor length can be much longer.
Offshore Development Information Statement 2010

FIGURE 5.6a – Bristol Channel: Radial Strategy Offshore Design

Legend
- AC cable
- HVDC cable
- AC connection point
- HVDC connection point
- Round 3 windfarm area
- Round 2 windfarm area
- Round 1 windfarm area
- Windfarm Array
- Region for Onshore Reinforcement Development

To Cliffrondd
Possible Interface Substation Configuration

To Wylfa

To Taunton

AC 400KV

HA3
HA2
HA1

AC 220KV

AC Platforms

Possible Interface Substation Configuration

To Indian Queens

AC 400KV

To Walham

AC 400KV

VSC HVDC 500KV

FIGURE 5.6b – Bristol Channel: HVDC Strategy Offshore Design
5.4.2 Bristol Channel: Radial Plus and Integrated Strategy Offshore Design

The Radial Plus and Integrated strategy design varies only slightly from the Radial Strategy design with the only change being in the use of the larger cables allowing the use of the AC500 standard design blocks (please refer to Figure 5.6b). More details of the design are provided below.

TABLE 5.2b – Bristol Channel: Radial Plus Strategy Offshore Design

<table>
<thead>
<tr>
<th>Zone</th>
<th>Wind Farm&lt;sup&gt;166&lt;/sup&gt;</th>
<th>Capacity (MW)</th>
<th>TO Interface Point</th>
<th>Straight Line Connection Distance&lt;sup&gt;167&lt;/sup&gt; (km)</th>
<th>Design Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bristol Channel</td>
<td>HA1</td>
<td>500</td>
<td>Alverdiscott</td>
<td>42</td>
<td>1 x AC500</td>
</tr>
<tr>
<td></td>
<td>HA2</td>
<td>500</td>
<td>Alverdiscott</td>
<td>34</td>
<td>1 x AC500</td>
</tr>
<tr>
<td></td>
<td>HA3</td>
<td>500</td>
<td>Alverdiscott</td>
<td>39</td>
<td>1 x AC500</td>
</tr>
</tbody>
</table>

Note the Radial Plus and Integrated strategies assume the future availability of larger capacity cables and HVDC converters allowing the use of AC500 and HVDC2000 design blocks.

<sup>166</sup> These are only indicative locations within the nominated area that may be developed.

<sup>167</sup> This is the straight line distant and the actual cable corridor length can be much longer.
FIGURE 5.6b – Bristol Channel: Integrated and Radial Plus Strategy Offshore Design

Legend
AC cable
HVDC cable
AC connection point
HVDC connection point
Round 3 windfarm area
Round 2 windfarm area
Round 1 windfarm area
Windfarm Array
Region for Onshore Reinforcement Development

Possible Interface Substation Configuration
5.4.4 Bristol Channel: Onshore Transmission Design

All of the 1.5 GW Round 3 zone offshore generation capacity is expected to connect to the Alverdiscott substation in all three network strategies. The existing substation at Alverdiscott does not have sufficient switching capability and therefore will need to be expanded.

With increasing generation in the South West area, the transfers from the region are expected to increase and strain the existing system, especially during summer light load conditions which are the constraining factor for this region, as mentioned earlier. The imminent connection of an additional 3.6 GW of new nuclear generation at Hinkley Point, combined with the possible 1.5 GW offshore connection, is expected to greatly increase the power flow across the boundary at such times, reinforcing the need for the proposed construction of an additional 50 km, 400 kV double circuit line from Hinkley Point to Seabank. This will also provide support for a possible further 1.2 GW of marine generation that may connect in the Severn Estuary area.

Table 5.2c shows the possible reinforcements which may be required for the Bristol Channel connections and indicative dates relative to the different generation scenarios.

**TABLE 5.2c – Bristol Channel: Onshore Transmission Reinforcements**

<table>
<thead>
<tr>
<th>Ref.</th>
<th>Description</th>
<th>Approximate Date</th>
</tr>
</thead>
</table>
| R2.1 | - New 400 kV, 18 bay substation at Hinkley Circuit Changes to connect to new 400 kV Hinkley substation  
- New 400 kV overhead line to Seabank circa 60 km, cutting into existing Hinkley- Melksham route to create Hinkley - Seabank, plus Melksham – Bridgewater- Hinkley.  
- Uprate section Hinkley to Melksham to 2 x 620mm² Gap or Equivalent Reconfigure the Melksham 400 kV substation line entry by swapping one of the Hinkley Point - Melksham circuits and one of the Bramley - Melksham circuits line entries at Melksham 400 kV substation  
- Extend Seabank substation by 2 bays  
- Modify Bridgewater substation, install two 400/132 kv SGTs to up-rate to 400 kV operation | SP: 2023  
GG: 2019  
AG: 2019  
SG: 2021 |
| R2.2 | - Extension of Alverdiscott substation | SP: 2019  
GG: 2019  
AG: 2014  
SG: 2016 |

---

168 This table takes account of new nuclear generation at Hinkley C and Oldbury B as well as possible offshore developments.
169 The dates provided here are driven by the scenarios considered and should not be compared against contracted dates.
5.5 South Coast – Hastings and West of Isle of Wight

The major large onshore power stations on the South Coast are Marchwood, Fawley and Dungeness. These onshore generators tend to balance the local demand such that power flows into and out of the region are limited. It is important to note that the Interconnector to France, located at Sellindge, can cause additional demand or provide additional generation support in this region. The existing onshore electricity transmission system in this region is characterised by a double circuit running from Mannington substation in the west through Bolney, Ninfield, Dungeness substations to Kemsley substation in the east, where it splits into further routes.

Figure 5.7 shows the possible increase in offshore generation capacity connecting to the South Coast region, for the different future scenarios. The potential level of generation connecting to the region is a maximum of 1.5 GW in the ARC scenario and around 1.3 GW in the Accelerated Growth scenario. The offshore generation expected in the area is from two Round 3 connections at Hastings offshore wind farm and West Isle of Wight Offshore wind farm. The limited level of expected generation means that connection to the existing onshore electricity transmission system in this region is predicted to be less problematic than elsewhere. Moreover, in this region, the Radial, Radial Plus and Integrated strategies are similar hence the discussion only expands on the Radial strategy.

**FIGURE 5.7 – South Channel: Installed Offshore Generation Capacity**

![South Coast - Offshore Generation Capacity](image)

5.5.1 South Coast: Offshore Design

**Hasting Offshore Transmission Design**

The Round 3 Hastings offshore wind farm is located directly south of Bolney and has a potential generation capacity of up to 600 MW. Due to its location and the small number of potential connection substations in the area, the most practical solution would be to connect Hastings to the existing substation at Bolney. The total onshore and offshore route length is expected to be 36 km. The most cost effective solution would therefore be a Radial Strategy point to point AC solution. The maximum zonal capacity is 600 MW in the ARC background and around 530 MW in the Accelerated Growth background. This power could be transmitted to the shore using two 220 kV 3-core submarine cables. The AC600 standard arrangement could be used for transferring 600 MW of power.
An alternative location for the onshore connection was also considered at Ninfield substation but was discarded on the basis that it is further away from the source of wind generation compared with Bolney, leading to an increase in transmission asset costs. Table 5.3a shows a general overview and requirements for the connection of Hastings offshore wind farm.

### TABLE 5.3a – Hasting Zone: Possible Offshore Transmission Design

<table>
<thead>
<tr>
<th>Zone</th>
<th>Wind Farm</th>
<th>Capacity (MW)</th>
<th>TO Interface Point</th>
<th>Straight Line Connection Distance (km)</th>
<th>Design Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hastings</td>
<td>AA1</td>
<td>600</td>
<td>Bolney</td>
<td>15</td>
<td>21</td>
</tr>
</tbody>
</table>

**West of Isle of Wight Offshore Transmission Design**

Another possible Round 3 offshore wind farm in the South Coast area is the West of Isle of Wight offshore wind farm. The capacity of the wind farm is expected to be 900 MW and it will be located about 40 km south of the proposed onshore connection at Chickerell substation. Alternative connection points were considered, namely the existing onshore substation at Mannington and a new substation between Chickerell and Mannington on an existing overhead line route.

These alternative connection locations were found to be less attractive, both financially and environmentally, due to longer cable route lengths coupled with extra costs associated with a new substation as well as possible disturbances to the coastline between Weymouth and Bournemouth. The existing robust onshore transmission infrastructure may accommodate the new infeed without further reinforcements, beyond additional substation bays at the point of connection.

A total connection length of 40 km (36 km offshore and 4 km onshore cables) is anticipated such that a Radial Strategy point to point AC solution would be the more cost effective technology.

The AC900 standard arrangement could be used, with three 220 kV 3-core submarine cables to transfer the maximum expected zone capacity of 900 MW to shore. Table 5.3b shows a general overview and requirements for the connection of West Isle of Wight offshore wind farm.

### TABLE 5.3b – West of Isle of Wight: Possible Offshore Transmission Design

<table>
<thead>
<tr>
<th>Zone</th>
<th>Wind Farm</th>
<th>Capacity (MW)</th>
<th>TO Interface Point</th>
<th>Straight Line Connection Distances (km)</th>
<th>Design Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Isle of Wight</td>
<td>DA1 &amp; DA2</td>
<td>900</td>
<td>Chickerell</td>
<td>36</td>
<td>4</td>
</tr>
</tbody>
</table>

---

170 These are only indicative locations within the nominated area that may be developed.
171 This is the straight line distant and the actual cable corridor length can be much longer.
172 These are only indicative locations within the nominated area that may be developed.
173 This is the straight line distant and the actual cable corridor length can be much longer.
5.5.2 South Coast: Onshore Design

It can be seen from Figure 5.8 that the onshore transmission system in the region consists of a double circuit at 400 kV running from Chickerell substation through Mannington, Lovedean, Bolney, Ninfield, Dungeness substations to Kemsley substation where it splits into further routes. The low level of generation already existing in the region coupled with local demand and low load flows result in an already robust system. This will allow connection of the possible wind farms without the need for future system reinforcements, other than the associated works for additional substation bays at the point of connection.

FIGURE 5.8 – South Coast: Round 3 Zone Locations
5.6 East Anglia – Norfolk

The East Anglia region encompasses several Round 1 and Round 2 wind farms including Greater Gabbard, London Array and Thanet. These are located around Norfolk, in the Thames Estuary area and in The Wash.

The Wash is a heavily protected area of the UK coastline and any proposals for connections in this area would need to undergo full consultation with the Government, its statutory advisors and local and national environmental bodies. There are many designated features within the Wash estuary including its status as a Special Area of Conservation (SAC), a Special Protection Area (SPA), a Ramsar site, and National Nature Reserve (NNR) and a Site of Special Scientific Interest (SSSI).

The area has been identified as having significant environmental and engineering constraints surrounding the offshore corridor and onshore landing points. The studies conducted in this analysis have not considered these aspects in any depth. This remains the responsibility of the Offshore Transmission Owner (OFTO) or developer.

To the east of Norfolk and Suffolk lies the Round 3 Norfolk development area with a potential wind farm capacity of 7.2 GW. Figure 5.9 shows the possible increase of wind generation capacity in the East Anglia region for the five different scenarios.

FIGURE 5.9 – East Anglia: Installed Offshore Generation Capacity

5.6.1 East Anglia: Radial Strategy Offshore Design

As stated earlier, the Round 3 Norfolk development area has a potential generation capacity of up to 7.2 GW. In the Radial Strategy case, AC600 and HVDC1000 designs are used, to indicate a slight advancement in future technology capability, yet meeting the proposed generation levels at the minimum cost. Multiple connection points and a number of offshore and onshore circuit route lengths (ranging between 28 km to 172 km in total) have been considered, which has led to a design that includes both HVDC and AC solutions. The six 1 GW wind farms, connected to Norwich Main and Bramford substations, each have a minimum combined onshore and offshore route length of over 87 km, hence a HVDC solution, comprising two offshore AC600 platforms linked to the shore by a single 1 GW HVDC link,
is considered most appropriate. This avoids the cost and complexity of having to provide intermediate AC platform substations along the cable route. An AC design was considered the best solution for the two 600MW wind farms, connected to a new substation at Lowestoft, due to much shorter route lengths.

Table 5.4a shows the capacity split, route lengths and standard design blocks considered for the Round 3 Norfolk wind farm development in the Radial Network strategy while illustrating the connection in the area.

**TABLE 5.4a – East Anglia: Radial Strategy Offshore Design**

<table>
<thead>
<tr>
<th>Zone</th>
<th>Wind Farm&lt;sup&gt;174&lt;/sup&gt;</th>
<th>Capacity (MW)</th>
<th>TO Interface Point</th>
<th>Straight Line Connection Distance&lt;sup&gt;175&lt;/sup&gt; (km)</th>
<th>Design Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Offshore</td>
<td>Onshore</td>
<td></td>
</tr>
<tr>
<td>Norfolk</td>
<td>V1</td>
<td>1000</td>
<td>Norwich Main</td>
<td>67</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>V2</td>
<td>1000</td>
<td>Norwich Main</td>
<td>62</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>U1</td>
<td>1000</td>
<td>Norwich Main</td>
<td>48</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>T1</td>
<td>600</td>
<td>Lowestoft</td>
<td>26</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>T2</td>
<td>600</td>
<td>Lowestoft</td>
<td>28</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Z1</td>
<td>1000</td>
<td>Bramford</td>
<td>128</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>Z2</td>
<td>1000</td>
<td>Bramford</td>
<td>142</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>Z3</td>
<td>1000</td>
<td>Bramford</td>
<td>145</td>
<td>27</td>
</tr>
</tbody>
</table>

Note the radial strategy is limited to using the AC600, AC900 and HVDC1000 design blocks.

<sup>174</sup> These are only indicative locations within the nominated area that may be developed.
<sup>175</sup> This is the straight line distant and the actual cable corridor length can be much longer.
FIGURE 5.10a – East Anglia: Radial Strategy Offshore Design

Legend
- AC cable
- HVDC cable
- AC connection point
- HVDC connection point
- Round 3 windfarm area
- Round 2 windfarm area
- Round 1 windfarm area
- Windfarm Array
- Region for Onshore Reinforcement Development

Possible Interface Substation Configuration

OFTO
Possible Interface Substation Configuration

Shoreline

Legend
- AC cable
- HVDC cable
- AC connection point
- HVDC connection point
- Round 3 windfarm area
- Round 2 windfarm area
- Round 1 windfarm area
- Windfarm Array
- Region for Onshore Reinforcement Development
5.6.2 East Anglia: Radial Plus Strategy Offshore Design

The Radial Plus network strategy shows few changes from the Radial Strategy, the main difference being in the use of AC500 design blocks. This design, developed for the Radial Plus and Integrated strategies and reliant on technological advances in the near future, uses one large cable instead of the two small cables used in the AC600 design. In addition, this enables HVDC2000 design blocks to be used, combining two HVDC1000 design blocks used in the Radial Network Strategy. Table 5.4b and Figure 5.10b shows more details on the possible designs under the Radial Plus strategy.

As can be seen from the Table 5.4b, 2 GW of the 3 GW offshore East Anglia capacity connected to Norwich Main substation is now delivered using a HVDC2000 link and the remaining 1GW uses a HVDC1000 link. A similar design is proposed for the 3 GW capacity connected to Bramford. Connection of the 1.2 GW wind generation at Lowestoft is the same as that in the Radial Strategy.

### Table 5.4b – East Anglia: Radial Plus Strategy Offshore Design

<table>
<thead>
<tr>
<th>Zone</th>
<th>Wind Farm</th>
<th>Capacity (MW)</th>
<th>TO Interface Point</th>
<th>Straight Line Connection Distance (km)</th>
<th>Design Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Offshore</td>
<td>Onshore</td>
</tr>
<tr>
<td>Norfolk</td>
<td>V1</td>
<td>1000</td>
<td>Norwich Main</td>
<td>67</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>U1</td>
<td>1000</td>
<td>Norwich Main</td>
<td>48</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>V2</td>
<td>1000</td>
<td>Norwich Main</td>
<td>62</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>T1</td>
<td>600</td>
<td>Lowestoft</td>
<td>26</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>T2</td>
<td>600</td>
<td>Lowestoft</td>
<td>28</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Z1</td>
<td>1000</td>
<td>Bramford</td>
<td>128</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>Z2</td>
<td>1000</td>
<td>Bramford</td>
<td>142</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>Z3</td>
<td>1000</td>
<td>Bramford</td>
<td>145</td>
<td>27</td>
</tr>
</tbody>
</table>

Note the Radial Plus and Integrated strategies assume the future availability of larger capacity cables and HVDC converters allowing the use of AC500 and HVDC2000 design blocks.

---

176 These are only indicative locations within the nominated area that may be developed.
177 This is the straight line distant and the actual cable corridor length can be much longer.
FIGURE 5.10b – East Anglia: Radial Plus Strategy Offshore Design

Legend:
- AC cable
- HVDC cable
- AC connection point
- HVDC connection point
- Round 3 windfarm area
- Round 2 windfarm area
- Round 1 windfarm area
- Windfarm Array
- Region for Onshore Reinforcement Development

Possible Interface Substation Configuration

OFTO

Shoreline

Possible Interface Substation Configuration

Legend:
- AC cable
- HVDC cable
- AC connection point
- HVDC connection point
- Round 3 windfarm area
- Round 2 windfarm area
- Round 1 windfarm area
- Windfarm Array
- Region for Onshore Reinforcement Development
5.6.3 East Anglia: Integrated Strategy Offshore Design

The Round 3 Norfolk development area has a potential capability of up to 7.2 GW. This maximum zonal capacity is divided into six 1000 MW and two 600 MW wind farms to enable the use of the standard, AC500, AC600, HVDC1000 and HVDC2000 designs. The Integrated strategy builds on the intentions of the Radial Plus strategy by fully utilising the HVDC2000 design and introducing interconnected links between Round 3 development sites. This saves on offshore HVDC and AC cable volumes, provides better security of supply through interconnection, and provides a large reduction in offshore platforms, reduces the sea-bed environmental impact and mitigates the risks imposed by offshore construction challenges. The interconnected nature of the network also leads to fewer onshore reinforcements as power flows could be more easily controlled. Table 5.4c and Figure 5.10c show the proposed connection designs in more detail.

The design constitutes a 6 GW link consisting of three HVDC2000 design blocks connecting 3 GW of Norfolk generation to Bramford substation. This is interconnected with Dogger Bank Round 3 offshore development using two HVDC1000 links; hence the requirement for additional capacity on the HVDC links to Bramford. Another 3 GW of Norfolk generation is connected to Norwich Main substation using two HVDC2000 links which are interconnected with Hornsea Round 3 wind farm developments using two HVDC1000 links. The design of the AC links to Lowestoft substation is the same as with Radial and Radial Plus network strategies and is explained in more details in the Radial Strategy.

The integrated design allows for the further expansion offshore including wider interconnection with possibly Belgium or the Netherlands.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Wind arm</th>
<th>Capacity (MW)</th>
<th>TO Interface Point</th>
<th>Straight Line Connection distance (Km)</th>
<th>Design Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norfolk</td>
<td>Z1</td>
<td>1000</td>
<td>Bramford Via HVDC link</td>
<td>180</td>
<td>2 x HVDC2000</td>
</tr>
<tr>
<td></td>
<td>Z2</td>
<td>1000</td>
<td></td>
<td></td>
<td>1 x HVDC2000</td>
</tr>
<tr>
<td></td>
<td>Z3</td>
<td>1000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>V1</td>
<td>1000</td>
<td>Norwich Main Via HVDC link</td>
<td>106</td>
<td>2 x HVDC2000</td>
</tr>
<tr>
<td></td>
<td>V2</td>
<td>1000</td>
<td></td>
<td>101</td>
<td></td>
</tr>
<tr>
<td></td>
<td>U1</td>
<td>1000</td>
<td></td>
<td>90</td>
<td></td>
</tr>
<tr>
<td></td>
<td>T1</td>
<td>600</td>
<td>Lowestoft</td>
<td>30</td>
<td>1 x AC600</td>
</tr>
<tr>
<td></td>
<td>T2</td>
<td>600</td>
<td></td>
<td>30</td>
<td>1 x AC600</td>
</tr>
</tbody>
</table>

Note the Radial Plus and Integrated strategies assume the future availability of larger capacity cables and HVDC converters allowing the use of AC500 and HVDC2000 design blocks.

---

178 These are only indicative locations within the nominated area that may be developed.
179 This is the straight line distance and the actual cable corridor length can be much longer.
180 Forms part of the wider integrated design incorporating Hornsea and Dogger Bank Projects.
FIGURE 5.10c – East Anglia: Integrated Strategy Offshore Design

This area has been identified as having significant environmental and engineering constraints surrounding the offshore corridor and onshore landing points. Detailed analysis will be required to determine viable connection routes.
5.6.4 East Anglia: Onshore Transmission Design

The transmission system in the East Anglia region is characterised by a 400 kV double circuit ring that links Walpole, Norwich Main, Bramford, Pelham and Burwell Main substations. Pelham substation provides interconnection between the East Anglia region and the main demand centres towards London. There are also four important circuits running towards Bramford substation from Sizewell, with two terminating at Bramford, one going through to Pelham and the fourth going through to Norwich, providing a transmission corridor for the existing nuclear generator located at Sizewell.

In addition to the many renewable generation projects contracted to connect in this region, significant CCGT generation development and new nuclear development at Sizewell is expected. The power flow through the East Anglia circuit ring is also affected heavily by generation connections in the east coast region where significant developments are expected, with potentially up to 12.8 GW and 4 GW of Round 3 offshore wind generation in the Dogger Bank and Hornsea Round 3 zones respectively. Other renewable sources of generation, such as wave, tidal power and biomass also add to the bulk of new generation connections.

In light of the significant generation expected to be connecting within and north of the region, a number of reinforcements have been developed.

Table 5.4d describes the reinforcements required to facilitate connection and their progression across the different future scenarios. These reinforcements are applicable to all three network strategies, as the amount of generation connecting to the region and the onshore landing points in all three network strategies are almost identical. The difference between them is the technology, volume of cables and construction material associated.

TABLE 5.4d – East Anglia: Onshore Transmission Reinforcements

<table>
<thead>
<tr>
<th>Ref.</th>
<th>Description</th>
<th>Approximate Dates181</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>SP</td>
</tr>
<tr>
<td>R3.1</td>
<td>- Reconductor the Norwich Main to Walpole Circuit</td>
<td>2017</td>
</tr>
<tr>
<td>R3.2</td>
<td>- Turn-in Norwich Main to Sizewell circuit at Bramford</td>
<td>2017</td>
</tr>
<tr>
<td></td>
<td>- Reconductor the Bramford to Norwich Main circuit</td>
<td></td>
</tr>
<tr>
<td>R3.3</td>
<td>- Install two Quadrature Boosters in Norwich to Walpole Circuit</td>
<td>Post 2025</td>
</tr>
<tr>
<td>R3.4</td>
<td>- Create a new Bramford to Twinstead 400kV overhead line circuit</td>
<td>2021</td>
</tr>
<tr>
<td>R3.5</td>
<td>- Extend and Reconfigure Bramford substation</td>
<td>2021</td>
</tr>
<tr>
<td>R3.6</td>
<td>- New Transmission Capacity near Lowestoft</td>
<td></td>
</tr>
</tbody>
</table>

This is the date when the reinforcement may be needed however it is not expected that the works will be achievable by this date due to construction, consents and planning issues.

181 The dates provided here are driven by the scenarios considered and should not be compared against contracted dates.
5.7 East Coast – Dogger Bank and Hornsea

There are significant developments planned in this region with the Round 3 offshore zones of Dogger Bank and Hornsea having the potential to connect up to 17 GW of wind capacity to the east coast of England, in addition to the Round 1 and 2 generation projects.

Figure 5.11 shows the total offshore generation capacity that may wish to connect to the coastlines of East Riding, Humberside and Lincolnshire. With the large areas of possible offshore wind generation made available there is noticeable variation apparent between the scenarios. The Gone Green and Slow Progression follow a similar pattern of generation build-up, whereas the other scenarios, Accelerated Growth and Sustainable Growth, exhibit much greater generation capacity and faster growth, particularly in the later part of the study period. Hence, the level of investment decisions would be equally varied, particularly when considering offshore transmission connection strategies.

Existing transmission substations closest to the east coast are located along the north and south banks of the Humber Estuary and south of The Wash. These substations are already heavily utilised providing connections to thermal generation. To accommodate the new offshore generation significant reinforcement will be required including the establishment of multiple new substations and new circuit routes.

FIGURE 5.11– East Coast: Installed Offshore Generation

East Coast - Offshore Generation Capacity

East Riding of Yorkshire

The Humber area is close to the Round 3 zones of Dogger Bank and Hornsea making it a convenient part of the system for the offshore connections to minimise the offshore cable distances. The north side of the Humber Estuary has CCGT generation at Saltend connected to Creyke Beck by means of a 275 kV network. The 275 kV network connecting Saltend offers negligible redundant capacity for additional connections.

The primary transmission circuit north of East Riding is located some distance from the coast before splitting off at Thornton towards the Humber estuary. However, the estuary is a barrier to new transmission routes heading south. Therefore, for offshore generation to connect to the coast north of the estuary the new circuits require either to be brought further inland or to cross the estuary through a tunnel.
**Humberside**

There is a cluster of large CCGT generators located south of the Humber Estuary, with Killingholme, South Humber Bank, Immingham and Keadby power stations connected in a double circuit 400kV ring. The local transmission system has been developed to accommodate the existing generation and provides very little spare transmission capability.

New generation capacity may be released if any of the existing generators close but these power stations are relatively new and there is no immediate indication of them closing. Therefore additional substations and circuits may be required to provide the capacity to accommodate any additional generation connecting to this region.

**Lincolnshire**

The transmission system in this area is characterised by a double circuit that predominantly carries north-south transfers with intake from the power stations around the Humber area linking to the circuits supplying the south and West Midlands load centres. Walpole is a significant substation situated directly in the main transmission route south to London in addition to accommodating heavy GSP demand, a new CCGT generator and new connections for Round 2 projects. Future expansion beyond what is already planned is not feasible with the existing substation limits due to circuit loading and the lack of adjacent land.

**The Wash**

The Wash is a heavily protected area of the UK coastline and any proposals for connections in this area would need to undergo full consultation with the Government, its statutory advisors and local and national environmental bodies. There are many designated features within the Wash estuary including its status as a Special Area of Conservation (SAC), a Special Protection Area (SPA), a Ramsar site, and National Nature Reserve (NNR) and a Site of Special Scientific Interest (SSSI).

The area has been identified as having significant environmental and engineering constraints surrounding the offshore corridor and onshore landing points. The studies conducted in this analysis have not considered these aspects in any depth. This remains the responsibility of the Offshore Transmission Owner (OFTO) or developer.

**5.7.1 East Coast: Radial Strategy Offshore Design**

The Dogger Bank wind farm generation project is located off the east coast of Yorkshire. This is the largest zone (Zone 3) in Round 3, with four sub-zones with the capacity to accommodate several wind farm arrays with the potential to generate up to 13 GW. The capacity of both the Hornsea and Dogger Bank offshore wind farms and their distance from the possible onshore connection points dictate that a conventional HVAC solution will be impractical and uneconomic and hence an HVDC solution has been applied in each case.

Table 5.5a and Table 5.5b show the feasible Offshore Transmission units for Dogger Bank and Hornsea respectively. Note the indicative offshore cable routes are designed to avoid areas allocated for mineral extraction, other offshore wind farms, and concentrations of oil and gas pipelines, however some pipeline and cable crossings are inevitable, and for some routes numerous.

The power from the offshore converter is routed through two HVDC cables (forming a bipole) to an onshore converter located in a compound adjacent to the NGET connection substation where it is converted back from HVDC to AC for input to the onshore transmission network.
TABLE 5.5a – East Coast Dogger Bank Zone: Possible Offshore Transmission Design

<table>
<thead>
<tr>
<th>Zone</th>
<th>Wind Farm(^{182})</th>
<th>Capacity (MW)</th>
<th>TO Interface Point</th>
<th>HVDC Straight Line Connection Distances(^{183}) (km)</th>
<th>Design Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Offshore</td>
<td>Onshore</td>
</tr>
<tr>
<td>H1</td>
<td></td>
<td>1000</td>
<td>Creyke Beck East</td>
<td>152</td>
<td>14</td>
</tr>
<tr>
<td>H2</td>
<td></td>
<td>1000</td>
<td>Creyke Beck East</td>
<td>168</td>
<td>14</td>
</tr>
<tr>
<td>H3</td>
<td></td>
<td>1000</td>
<td>Killingholme South</td>
<td>209</td>
<td>4</td>
</tr>
<tr>
<td>H4</td>
<td></td>
<td>1000</td>
<td>Creyke Beck East</td>
<td>179</td>
<td>14</td>
</tr>
<tr>
<td>H5</td>
<td></td>
<td>1000</td>
<td>Killingholme South</td>
<td>222</td>
<td>4</td>
</tr>
<tr>
<td>H6</td>
<td></td>
<td>1000</td>
<td>Killingholme South</td>
<td>236</td>
<td>4</td>
</tr>
<tr>
<td>I1</td>
<td></td>
<td>1000</td>
<td>Grimsby South</td>
<td>240</td>
<td>16</td>
</tr>
<tr>
<td>I2</td>
<td></td>
<td>1000</td>
<td>Grimsby South</td>
<td>257</td>
<td>16</td>
</tr>
<tr>
<td>I3</td>
<td>800</td>
<td></td>
<td>East Lincolnshire North</td>
<td>265</td>
<td>9</td>
</tr>
<tr>
<td>J1</td>
<td></td>
<td>1000</td>
<td>Hornsey</td>
<td>187</td>
<td>2</td>
</tr>
<tr>
<td>J2</td>
<td></td>
<td>1000</td>
<td>Hornsey</td>
<td>202</td>
<td>2</td>
</tr>
<tr>
<td>J3</td>
<td></td>
<td>1000</td>
<td>Hornsey</td>
<td>219</td>
<td>2</td>
</tr>
<tr>
<td>K1</td>
<td></td>
<td>1000</td>
<td>Creyke Beck East</td>
<td>239</td>
<td>27</td>
</tr>
</tbody>
</table>

Note the radial strategy is limited to using the AC600, AC900 and HVDC1000 design blocks.

---

\(^{182}\) These are only indicative locations within the nominated area that may be developed.

\(^{183}\) This is the straight line distance and the actual cable corridor length can be much longer.
TABLE 5.5b – East Coast Hornsea Bank Zone: Possible Offshore Transmission Design

<table>
<thead>
<tr>
<th>Zone</th>
<th>Wind Farm&lt;sup&gt;184&lt;/sup&gt;</th>
<th>Capacity (MW)</th>
<th>TO Interface Point</th>
<th>HVDC Straight Line Connection Distances&lt;sup&gt;185&lt;/sup&gt; (km)</th>
<th>Design Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Offshore</td>
<td>Onshore</td>
</tr>
<tr>
<td>Hornsea</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L1</td>
<td>1000</td>
<td>Grimsby South</td>
<td>85</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>L2</td>
<td>1000</td>
<td>East Lincolnshire North</td>
<td>111</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>M1</td>
<td>1000</td>
<td>East Lincolnshire South</td>
<td>82</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>M2</td>
<td>1000</td>
<td>East Lincolnshire South</td>
<td>95</td>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

Note the radial strategy is limited to using the AC600, AC900 and HVDC1000 design blocks.

---

<sup>184</sup> These are only indicative locations within the nominated area that may be developed
<sup>185</sup> This is the straight line distance and the actual cable corridor length can be much longer
Offshore Development Information Statement 2010

FIGURE 5.12a – East Coast: Radial Strategy Offshore Design

Legend
- AC cable
- HVDC cable
- AC connection point
- HVDC connection point
- Round 3 windfarm area
- Round 2 windfarm area
- Round 1 windfarm area
- Windfarm Array
- Region for Onshore Reinforcement Development
### 5.7.2 East Coast: Radial Strategy Onshore Design

The Radial and Radial Plus design strategies effectively deliver similar reinforcements which stand to reason as the generation capacity is connected at the same onshore asset sites in the Humber region, as shown in Table 5.5c. A number of reinforcements are required for these Radial designs because

- Individual offshore generation plants are connected to their dedicated connection points sharing onshore transmission system capacity with conventional generation: and
- Round 2 wind project necessitate localised upgrading and new investments.

#### TABLE 5.5c – East Coast: Possible reinforcements for offshore connections

<table>
<thead>
<tr>
<th>Ref.</th>
<th>Description</th>
<th>Approximate Date</th>
<th>SP</th>
<th>GG</th>
<th>AG</th>
<th>SG</th>
</tr>
</thead>
<tbody>
<tr>
<td>R4.1</td>
<td>- Extend the 400 kV substation at Creyke Beck.</td>
<td>2018</td>
<td>2018</td>
<td>2018</td>
<td>2018</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Establish a new 400 kV double busbar collector substation East Lincolnshire 400 kV.</td>
<td>2018</td>
<td>2018</td>
<td>2018</td>
<td>2018</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- New 400 kV, 48 km double circuit line from East Lincolnshire substation to Bicker Fenn.</td>
<td>2018</td>
<td>2018</td>
<td>2018</td>
<td>2018</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Substation at Walpole 400 kV double busbar.</td>
<td>2018</td>
<td>2018</td>
<td>2018</td>
<td>2018</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- New 400 kV, 34 km double-circuit line from the Spalding/Bicker Fen area to a new substation in the vicinity of Bainton, on the existing Cottam – Eaton Socon line.</td>
<td>2018</td>
<td>2018</td>
<td>2018</td>
<td>2018</td>
<td></td>
</tr>
<tr>
<td>R4.2a</td>
<td>- Establish a new 400 kV double busbar collector substation near East Lincolnshire 400 kV.</td>
<td>2021</td>
<td>2020</td>
<td>2017</td>
<td>2017</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- New 400 kV, 68 km double circuit line from East Lincolnshire substation to Walpole.</td>
<td>2021</td>
<td>2020</td>
<td>2017</td>
<td>2017</td>
<td></td>
</tr>
<tr>
<td>R4.3</td>
<td>- Establish a new 400 kV double busbar collector substation near Grimsby West 400 kV</td>
<td>2027</td>
<td>2027</td>
<td>2017</td>
<td>2017</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- New 400 kV, 46 km double circuit line from Grimsby West - East Lincolnshire 400 kV</td>
<td>2027</td>
<td>2027</td>
<td>2017</td>
<td>2017</td>
<td></td>
</tr>
<tr>
<td>R4.4</td>
<td>- Establish a new 400 kV double busbar collector substation south of Killingholme</td>
<td>2027</td>
<td>2027</td>
<td>2017</td>
<td>2017</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- New 400 kV, 12 km double circuit line from Killingholme south – Grimsby West</td>
<td>2027</td>
<td>2027</td>
<td>2017</td>
<td>2017</td>
<td></td>
</tr>
<tr>
<td>R4.4</td>
<td>- Establish a new 400 kV double busbar collector substation near Saltend</td>
<td>2026</td>
<td>2026</td>
<td>2019</td>
<td>2019</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Transfer the 400/275 kV interbus transformers from Creyke Beck to Saltend</td>
<td>2026</td>
<td>2026</td>
<td>2019</td>
<td>2019</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Uprate Saltend to Creyke Beck from 275 to 400 kV operation</td>
<td>2026</td>
<td>2026</td>
<td>2019</td>
<td>2019</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Combination of 400 kV, 6.5 km cable tunnel across the Humber estuary and 400 kV, 32 km double circuit overhead line from Grimsby West to Saltend</td>
<td>2026</td>
<td>2026</td>
<td>2019</td>
<td>2019</td>
<td></td>
</tr>
<tr>
<td>R4.6</td>
<td>- Establish a new 400 kV double busbar collector substation near Hornsea</td>
<td>N/A</td>
<td>2020</td>
<td>2017</td>
<td>2017</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- New 400 kV 41 km double circuit to Thornton</td>
<td>N/A</td>
<td>2020</td>
<td>2017</td>
<td>2017</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- New 400 kV 22 km double circuit to Saltend</td>
<td>N/A</td>
<td>2020</td>
<td>2017</td>
<td>2017</td>
<td></td>
</tr>
</tbody>
</table>

*This is the date when the reinforcement may be needed however it is not expected that the works will be achievable by this date due to construction, consents and planning issues.*

**196** The dates provided here are driven by the scenarios considered and should not be compared against contracted dates.
5.7.3 East Coast: Radial Strategy Design Approach

The radial configuration effectively connects the individual offshore AC/DC converters from each wind farm array to onshore converters via 1GW HVDC cables. In the case of Dogger Bank there are 13 radial connections considered at five onshore locations. A single dedicated HVDC cable link from each offshore converter is connected at one of five onshore substations: Creyke Beck, Grimsby West, South Humber Bank and two new connection points.

The shared volume of radial link cables entering the Humberside coastline will inevitably be beyond the present physical capacity of the current asset landing points, requiring additional land as well as increased network capability at various constrained circuit locations.

In light of Round 1 and 2 wind farms already connecting in this region, further multiple cables landing in The Wash would be problematic. There would also be difficulties in obtaining offshore routes and easements to the substations.

5.7.4 East Coast: Radial Plus Strategy Offshore Design

The Radial Plus follows a similar network configuration as the Radial design but uses advanced cable and substation technology. The concept of the Radial Plus Strategy is to form several groups of wind farm arrays, within a zone, with each group interlinked to a common point (an converter platform) providing a combined transmission capacity of 2 GW, this being the medium term limit of HVDC converters and cables. The individual group of wind farms arrays are then connected to their dedicated asset landing point onshore. Table 5.6a and Table 5.6b show the Radial Plus Strategy for the east coast: Dogger Bank and Hornsea respectively.

**TABLE 5.6a – East Coast Dogger Bank Zone: Radial Plus Strategy Offshore Design**

<table>
<thead>
<tr>
<th>Zone</th>
<th>Wind Farm</th>
<th>Capacity (MW)</th>
<th>TO Interface Point</th>
<th>HVDC Straight Line Connection Distances (km)</th>
<th>Design Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Offshore</td>
<td>Onshore</td>
</tr>
<tr>
<td>Dogger Bank</td>
<td>H1</td>
<td>1000</td>
<td>Creyke Beck East</td>
<td>152</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>H2</td>
<td>1000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>H3</td>
<td>1000</td>
<td>Killingholme South</td>
<td>209</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>H4</td>
<td>1000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>H5</td>
<td>1000</td>
<td>Killingholme South</td>
<td>236</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>H6</td>
<td>1000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>I1</td>
<td>1000</td>
<td>Grimsby South</td>
<td>239</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>I2</td>
<td>1000</td>
<td>East Lincolnshire North</td>
<td>265</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>I3</td>
<td>800</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>J1</td>
<td>1000</td>
<td>Hornsey</td>
<td>193</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>J2</td>
<td>1000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>J3</td>
<td>1000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>K1</td>
<td>1000</td>
<td>Hornsey</td>
<td>238</td>
<td>2</td>
</tr>
</tbody>
</table>

Note the Radial Plus and Integrated strategies assume the future availability of larger capacity cables and HVDC converters allowing the use of AC500 and HVDC2000 design blocks.

---

187 These are only indicative locations within the nominated are that may be developed.
188 This is the straight line distance. The actual cable corridor length can be longer.
TABLE 5.6b – East Coast Hornsea Zone: Radial Plus Strategy Offshore Design

Note the Radial Plus and Integrated strategies assume the future availability of larger capacity cables and HVDC converters allowing the use of AC500 and HVDC2000 design blocks.

The east coast Radial Plus strategy onshore proposed reinforcements are mostly the same as for the Radial strategy as shown in Table 5.5c.

5.7.5 East Coast: Radial Plus Strategy Design Approach

The application of Radial Plus strategy to the Dogger Bank zone would require six 2 GW rated cables and a single 1 GW of the existing technology cable to export power from this zone. Although this configuration effectively halves the cables needed compared to the Radial design, it would not reduce the onshore reinforcement required.

It would also fall short of fully capitalising on the benefits of advanced cable and substation technology. Similarly, Hornsea wind farm using a combination of 1 GW and 2 GW links would require a substantial amount of onshore reinforcement. This is because the characteristics of a radial design still exist with the power landing at specific existing or new connection points on the 400 kV transmission system with no alternative route to share the capacity. Any subsequent changes to these landing points would require consideration of the impact on offshore infrastructure in addition to onshore MITS alterations and therefore may hinder further offshore power generation development.

### Radial Plus Design - Hornsea

<table>
<thead>
<tr>
<th>Zone</th>
<th>Wind Farm(^{189})</th>
<th>Capacity (MW)</th>
<th>TO Interface Point</th>
<th>HVDC Straight Line Connection Distances(^{190}) (km)</th>
<th>Design Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hornsea</td>
<td>L1</td>
<td>1000</td>
<td>Grimsby South</td>
<td>110 16</td>
<td>1 x HVDC2000</td>
</tr>
<tr>
<td></td>
<td>L2</td>
<td>1000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>M1</td>
<td>1000</td>
<td>East Lincolnshire North</td>
<td>95 8</td>
<td>1 x HVDC2000</td>
</tr>
<tr>
<td></td>
<td>M2</td>
<td>1000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note 189 These are only indicative locations within the nominated area that may be developed.

Note 190 This is the straight line distance. The actual cable corridor length can be longer.
FIGURE 5.12b – East Coast: Radial Plus Strategy Offshore Design
5.7.6 East Coast: Integrated Strategy Design Approach

The anticipated advancement in electricity transmission technology, such as the more flexible (VSC) 2GW HVDC converters and larger offshore AC cables has made it possible to consider the Radial Plus strategy. However, technologies used by the Radial Plus strategy can be further considered for interlinking the neighbouring offshore wind farm arrays to form an offshore transmission circuit. The close proximity of the wind farm array blocks in Zone 3 make them ideal for interconnecting their substations together via AC cable, hence providing the ability to aggregate the local power generated before exporting it onshore and/or linking to neighbouring zones. This offers great flexibility in transmission options.

The Hornsea offshore wind farm in Zone 4 is relatively close to the Yorkshire coast, which has a number of sub-zones each capable of accommodating blocks of wind farm arrays. The configuration of the wind farm arrays enables the interconnection of the wind farm AC cables to form a local grid network. Furthermore, this network can be extended to link with other wind farm arrays within the neighbouring Dogger Bank and Norfolk zones. Table 5.7a and Table 5.7b and show the Integrated Strategy for the east coast: Dogger Bank and Hornsea respectively.

TABLE 5.7a – East Coast Dogger Bank Zone: Integrated Offshore Design

<table>
<thead>
<tr>
<th>Zone</th>
<th>Wind Farm</th>
<th>Capacity (MW)</th>
<th>TO Interface Point</th>
<th>HVDC Straight Line Connection Distance (km)</th>
<th>Design Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dogger Bank</td>
<td>H1</td>
<td>1000</td>
<td>South Humber via Z4 Hornsea; Walpole;</td>
<td>~250</td>
<td>1 x HVDC2000</td>
</tr>
<tr>
<td></td>
<td>H2</td>
<td>1000</td>
<td>Killingholme South; Saltend; Bramford Via Z5 Norfolk; Norway</td>
<td></td>
<td>1 x HVDC1000</td>
</tr>
<tr>
<td></td>
<td>H3</td>
<td>1000</td>
<td></td>
<td></td>
<td>2 x HVDC2000</td>
</tr>
<tr>
<td></td>
<td>H4</td>
<td>1000</td>
<td></td>
<td></td>
<td>1 x HVDC2000</td>
</tr>
<tr>
<td></td>
<td>H5</td>
<td>1000</td>
<td></td>
<td></td>
<td>1 x HVDC2000</td>
</tr>
<tr>
<td></td>
<td>H6</td>
<td>1000</td>
<td></td>
<td></td>
<td>2 x HVDC1000</td>
</tr>
<tr>
<td></td>
<td>I1</td>
<td>1000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>I2</td>
<td>1000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>I3</td>
<td>800</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>J1</td>
<td>1000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>J2</td>
<td>1000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>J3</td>
<td>1000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>K1</td>
<td>1000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note the Radial Plus and Integrated strategies assume the future availability of larger capacity cables and HVDC converters allowing the use of AC500 and HVDC2000 design blocks.

TABLE 5.7b – East Coast Hornsea Zone: Integrated Offshore Design

<table>
<thead>
<tr>
<th>Zone</th>
<th>Wind Farm</th>
<th>Capacity (MW)</th>
<th>TO Interface Point</th>
<th>HVDC Straight Line Connection Distance (km)</th>
<th>Design Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hornsea</td>
<td>L1</td>
<td>1000</td>
<td>South Humber Bank; Killingholme South;</td>
<td>~200</td>
<td>1 x HVDC1000</td>
</tr>
<tr>
<td></td>
<td>L2</td>
<td>1000</td>
<td>Norwich Main via Z5 Norfolk</td>
<td></td>
<td>1 x HVDC1000</td>
</tr>
<tr>
<td></td>
<td>M1</td>
<td>1000</td>
<td></td>
<td></td>
<td>1 x HVDC2000</td>
</tr>
<tr>
<td></td>
<td>M2</td>
<td>1000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note the Radial Plus and Integrated strategies assume the future availability of larger capacity cables and HVDC converters allowing the use of AC500 and HVDC2000 design blocks.

---

191 These are only indicative locations within the nominated area that may be developed.
192 This is the straight line distance. The actual cable corridor length can be longer.
193 These are only indicative locations within the nominated area that may be developed.
194 This is the straight line distance. The actual cable corridor length can be longer.
Possible Interface Substation Configuration

To Thornton & Hedon

Legend:
- AC cable
- HVDC cable
- AC connection point
- HVDC connection point
- Round 3 windfarm area
- Round 2 windfarm area
- Round 1 windfarm area
- Windfarm Array
- Region for Onshore Reinforcement Development

This area has been identified as having significant engineering and environmental constraints surrounding the offshore corridor and onshore landing points. Detailed analysis will be required to determine viable connection routes.
5.7.7 East Coast: Integrated Strategy Onshore Design

The onshore transmission system on the east coast of England spans from the predominantly 275 kV system around Teesside, down two 400 kV double circuits through Yorkshire to the Humber area where there is a concentration of mostly gas-fired generation. A significant amount of CCGT generation has been built around the Humber area due to ready access to the gas transmission system and the sharing of steam services with local heavy industry.

Transmission south from Keadby continues down through four 400 kV double circuits towards the major load centre of London. Before reaching London the most easterly of these four double circuits branches out into a further two 400 kV double circuits forming a ring around East Anglia.

In order to accommodate the scenario of connecting the maximum identified offshore capacity, the reinforcements shown in Table 5.8 have been identified. The reinforcement options, including substation locations and circuit routes, have only been developed by high level design and are therefore for indicative purposes only. The full development of each project will be subject to detailed survey and design, consenting, environmental assessment and funding. Note that there are fewer reinforcement projects compared with those required by Radial and Radial Plus strategies. This is predominantly due to the ability of an offshore integrated network to distribute the aggregated generation capacity across the strategic landing points.

**TABLE 5.8 – East Coast: Possible Onshore Reinforcements for Integrated Offshore Design**

<table>
<thead>
<tr>
<th>Ref.</th>
<th>Description</th>
<th>Approximate Date</th>
<th>SP</th>
<th>GG</th>
<th>AG</th>
<th>SG</th>
</tr>
</thead>
<tbody>
<tr>
<td>R4.1</td>
<td>- Extend the 400 kV substation at Creyke Beck</td>
<td>2018</td>
<td>2018</td>
<td>2018</td>
<td>2018</td>
<td></td>
</tr>
</tbody>
</table>
| R4.3 | - Establish a new 400 kV double busbar collector substation near Grimsby West 400 kV  
- New 400 kV, 110 km double circuit line from Grimsby West to Walpole 400 kV | 2027 | 2027 | 2017 | 2017 |
| R4.4 | - Establish a new 400 kV double busbar collector substation south of Killingholme  
- New 400 kV, 12 km double circuit line from Killingholme south – Grimsby West | 2027 | 2027 | 2017 | 2017 |
| R4.5 | - Establish a new 400 kV double busbar collector substation near Saltend  
- Transfer the 400/275 kV interbus transformers from Creyke Beck to Saltend  
- Up-rate Saltend to Creyke Beck from 275 to 400 kV operation  
- Combination of 400 kV, 6.5 km cable tunnel across the Humber estuary and 400 kV, 32 km double circuit overhead line from Grimsby West to Saltend | 2026 | 2026 | 2019 | 2019 |

This is the date when the reinforcement may be needed however it is not expected that the works will be achievable by this date due to construction, consents and planning issues.

The dates provided here are driven by the scenarios considered and should not be compared against contracted dates.
5.7.8 East Coast: Integrated Strategy Design Approach

Hornsea and Dogger Bank zones are in excess of 150 km from shore, making HVDC cables the only practical and economical connection option. Current thinking on offshore technology suggests that 2 GW is the medium term limit of HVDC converters and cables. This thinking is beyond last years statement assumptions of a 1 GW limit and while it would mean larger assets, less would be required.

This in turn would reduce construction activity to fewer seabed locations and thus assist the build and delivery process. Naturally, reduction in offshore substation assets would reduce the associated AC cables linking the platforms, as well as HVDC cables running across the seabed between offshore and onshore assets.

The potential connection of 13 GW of generation at Dogger Bank to the mainland could be achieved by a combination of direct onshore connections as well as linking to the neighbouring zones. In this context, the most northerly arrays at Dogger Bank could be integrated in such a way that there are two routes of 2 GW exporting cables; one being an interconnection with Norway and the other for direct connection to Creyke Beck 400 kV substation via a HVDC converter station. This would necessitate the extension of Creyke Beck substation and the reinforcement of its circuits going south.

Offshore interconnection of the Dogger Bank zone to the Norfolk zone, which is in-turn interconnected to the Bramford Zone and then onto the onshore network realises significant capacity benefits while reducing the total number of assets required to deliver the wind generation projects compared to the radial and radial plus strategies.

This configuration helps to spread the generation supply across the MITS as well as directing the power flow near the point-of-use, avoiding potential major onshore double circuit reinforcements.

The potential 4 GW of generation from the Hornsea zone also employs the integrated strategy in that it uses two directly connected 2 GW sea-to-shore cables, with the remaining generation linked with other arrays within the neighbouring zones. This combination of direct and integrated network reaps the benefits of transmission flexibility, minimising onshore reinforcement and environmental impact.

A co-ordinated strategy for integration of the onshore-offshore transmission network makes an effective use of the technologies and networking of the offshore zones, and in doing so has the potential of achieving an economic and efficient solution for transmitting offshore generation. This is evident from the reduced amount of onshore AC overhead line reinforcements, less land required for associated works compared to the Radial and to some extent the Radial Plus strategies.

There are added benefits in having larger platforms, substations and higher rated cables in the form of reduced maintenance due to fewer assets to maintain and the scope for standardisation. This strategy enables greater offshore network integration flexibility whilst minimising environmental disturbance and potentially stimulating the market for technological evolution.
5.8 Scotland

Scottish generation forms a large proportion of the total national electricity transmission system generation capacity, and with its natural resources it potentially contains a large proportion of the national electricity transmission system renewable generation base. Demand in Scotland is relatively low compared to its installed generation and forecasts indicate much more renewable generation to connect, both on and offshore. At times, this generation, excess gives rise to large power exports from Scotland into England which will increase as more generation is installed. Figure 5.13 shows the offshore generation capacity expected to connect to Scotland for each of the relevant scenarios.

Some of the major developments expected include the Moray Firth and Firth of Forth Round 3 wind zones, Scottish Territorial Waters projects and the Pentland Firth and Orkney strategic marine power development area. These projects and their potential connections are shown in Figure 5.14a. Also shown, as shaded lozenges, are the areas for reinforcement onshore in order to provide adequate transmission capability. All of the developments are subject to the appropriate agreements and permissions being established.

Figure 5.13 shows the offshore generation scenarios of Gone Green, Slow Progress, Accelerated Growth and Sustainable Growth for the Scotland region. From all the future scenarios it can be seen that the generation is forecast to increase into the future.

The strong likelihood of significant offshore and onshore renewable generation development in Scotland means that an extensive upgrade of the onshore transmission system (including offshore cable links) is likely to be required to facilitate the increased transmission of power into England. With the possibility of significant onshore transmission upgrades, the offshore transmission network could be interfaced with the onshore network at several different locations. Suggested locations have been shown in Figure 5.14a but it is quite possible that these will change in response to connection applications, OFTO appointments and more detailed surveys and analysis.
FIGURE 5.14a – Scotland: Reinforcement Areas and Offshore Development Areas
5.8.1 Scotland: Firth of Forth Offshore Transmission Design

The Crown Estate Round 3 Firth of Forth wind farm group is located 60 km from shore and is estimated to provide approximately 3.7 GW of offshore generation connection via a combination of AC or HVDC technologies.

Connection options on a predominantly radial basis include a 1 GW HVDC link to Tealing, and the remaining 2.7 GW to a new substation south of Torness with additional HVDC links and some 220 kV AC links to the closer generation in the territorial waters. This aligns with additional Round 2 generation which should connect to the same new substation. An outline of the connection works can be seen in Figure 5.14a and listed in Table 5.9a.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Wind farm196</th>
<th>Capacity (MW)</th>
<th>TO Connection Interface Point</th>
<th>Straight Line Connection Distances197 (km)</th>
<th>Design Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firth of Forth</td>
<td>F1</td>
<td>1000</td>
<td>Tealing</td>
<td>52</td>
<td>1 x HVDC1000</td>
</tr>
<tr>
<td></td>
<td>F2</td>
<td>1000</td>
<td>Torness South</td>
<td>55</td>
<td>1 x HVDC1000</td>
</tr>
<tr>
<td></td>
<td>G1</td>
<td>600</td>
<td>Torness South</td>
<td>31</td>
<td>1 x AC600</td>
</tr>
<tr>
<td></td>
<td>G2</td>
<td>600</td>
<td>Torness South</td>
<td>31</td>
<td>1 x AC600</td>
</tr>
<tr>
<td></td>
<td>G3</td>
<td>500</td>
<td>Torness South</td>
<td>43</td>
<td>1 x AC600</td>
</tr>
</tbody>
</table>

An integrated strategy design may reduce the number of cables to shore and onshore substation requirements by joining transmission circuits together offshore and directly transmitting the energy further south.

5.8.2 Scotland: Firth of Forth Onshore Transmission Design

The Scottish Territorial Waters and 3 offshore generation projects in the Firth of Forth could potentially see generation of up to 3.6 GW or higher connecting into the onshore transmission system in the south east of Scotland. There is a possibility of connecting limited generation capacity into the existing sites in this region but beyond 500 MW this will require the establishment of a new 400 kV substation in the Torness south area. As the generation volume increases there could be the requirement to increase the capacity on the 400 kV cables from Thornton Bridge – Torness and to increase the capacity on the proposed Strathaven – Wishaw - Smeaton 400 kV double circuit overhead line.

At this point the capacity utilising the existing transmission corridors has been exhausted. In order to provide the further capacity required to accommodate the potential generation, further transmission circuits will be required. This could take the form of a HVDC link to transfer power from Torness south to a point on the east coast of England via an offshore DC cable.

5.8.3 Scotland: Moray Firth Offshore Transmission Design

The Moray Firth has projects including a Crown Estate Round 3 lease area of up to 1.3 GW capacity and another possible 1.1 GW from Beatrice windfarm. Moray Firth is located approximately 50 km from the western shore allowing either AC or HVDC connections to be considered. To connect the developments HVDC links have been chosen connecting to Peterhead and Blackhillock as shown in Figure 5.14a.

Additional HVDC links are expected to pass through or in close proximity to Moray Firth. A 600 MW HVDC circuit is proposed from Mybster to Blackhillock to accommodate planned onshore renewable

196 These are only indicative locations within the nominated area that may be developed
197 This is the straight line distance. The actual cable corridor length can be longer.
developments and relieve Caithness. To connect the planned Viking windfarm on Shetland a 600 MW HVDC link is proposed, again connecting to Blackhillock.

**TABLE 5.9b – Scotland – Moray Firth: Radial Strategy Offshore Design**

<table>
<thead>
<tr>
<th>Zone</th>
<th>Wind farm</th>
<th>Capacity (MW)</th>
<th>TO Interface Point</th>
<th>Straight Line Connection Distances (km)</th>
<th>Design Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moray Firth</td>
<td>C1</td>
<td>300</td>
<td>Peterhead</td>
<td>130 Offshore 15 Onshore</td>
<td>1 x HVDC1000</td>
</tr>
<tr>
<td></td>
<td>D1</td>
<td>1000</td>
<td>Blackhillock</td>
<td>101 Offshore 28 Onshore</td>
<td>1 x HVDC1000</td>
</tr>
</tbody>
</table>

With the support of a European capital grant of €74.1m under the European Energy Programme for Recovery (EEPR) SHETL is progressing development work on the establishment of the first HVDC offshore hub and deployment of multi-terminal VSC HVDC technology to facilitate an integrated solution to the above, as illustrated in Figure 5.14b. This approach will reduce the number of circuits to shore, reduce the overall cost and provide greater flexibility to accommodate different permutations and timings of the generation projects.

**5.8.4 Scotland: West Coast Offshore Transmission Design**

Considerable additional offshore generation capacity is expected to develop off the Scottish West Coast and a number of projects in the Scottish Territorial Waters have already been identified (such as the Argyll Array, Islay and Kintyre). These pose some challenges to connect as they require navigation around or across many Western Islands and rough terrain before reaching any significant onshore transmission infrastructure.

The Argyll Array (potentially 1500 MW just south of Tiree) could be connected with a single HVDC link to Dalmally 275 kV substation. Some onshore reinforcements would also be required to support the Dalmally connection.

**5.8.5 Caithness and Northern Isles Transmission Design**

The Pentland Firth, Orkney and Shetland offer further potential for renewable generation development, not only for wind but also wave and tidal generation. While there is significant potential and interest along the North coast it is unclear at the moment how much of the resource will be exploited and when.

The onshore transmission in the far north of Scotland limits how much new generation capacity could be accommodated without major reinforcement. AC subsea cables and larger HVDC links options are being considered to connect new generation in this area. Subject to the predicted growth in wind and marine generation materialising in this area, it is likely that the longer term network solution will involve the use of further HVDC links that integrate into the current reinforcement strategies that are described above in 5.8.3.

**5.8.6 The Western Isles**

The design solution for the Western Isles is a single 450 MW HVDC link from Gravir on Lewis to Beauly on the Scottish mainland. It is being driven by proposed wind farms on the Isle of Lewis. Pre-construction development and consents for the HVDC link are substantially complete. There is substantial marine resource and further wind resource on and around the Western Isles. The proposed 450 MW link includes an option to double up on the 76 km onshore cable section between Dundolll and Beauly on the Scottish mainland at the time of construction. This would avoid the repeat environmental impact of extended undergrounding at a later date whilst still providing scope for accommodating further renewable generation in the future.

---

198 These are only indicative locations within the nominated area that may be developed.
199 This is the straight line distance. The actual cable corridor length can be longer.
5.8.7 Integrated Offshore Networks in Scotland

The preceding description and Figure 5.14b provides an indication of the scope for and benefits from an integrated approach to transmission solutions on and around Scotland. It is clear that as well as regional economies and flexibility (as illustrated in the Moray Firth); an integrated approach is important and potentially beneficial in respect of the wider bulk transmission solutions for the National Electricity Transmission System.

FIGURE 5.14b – Scotland: Reinforcement Areas and Integrated Offshore Development Areas

Legend
- AC cable
- HVDC cable
- AC connection point
- HVDC connection point
- Round 3 windfarm area
- Round 2 windfarm area
- Round 1 windfarm area
- Windfarm Array
- Region for Onshore Reinforcement Development
Chapter Six

Main Interconnected Transmission System Considerations

6.1 Background and Assessment Methodology

The Main Interconnected Transmission System (MITS) needs to evolve as the distribution and level of generation and demand changes across Scotland, England and Wales.

In order to quantify and analyse power flow capability entering or leaving a geographical region of interest at a given time, the term ‘boundary capability’ is often used. The boundaries are pre-defined borders which split the country into two adjacent regions. The boundaries are typically set so they cross critical transmission routes and are used as an important tool to study and discuss MITS capability. The advantage of using such a concept rather than a repetitive individual line analysis is the added information it provides about boundary constraints. Once the boundary constraints have been identified, appropriate reinforcement will aid in strengthening the network around the constraint region and thus reduce the constraint.

The areas either side of a boundary are considered to be either importing or exporting depending on the balance of generation and demand within the area. The greater the imbalance in the enclosed area the greater the boundary transfer across the transmission circuits. For the National Electricity Transmission System (NETS), the most onerous conditions are typically at winter peak when demand is highest and most generation is operating. This is the condition that most assessments study and the boundary analysis presented here reflects this condition.

In essence the ‘boundary capability’ must satisfy all the standards set out in the NETS SQSS and meet values of required transfer and voltage compliance under fault conditions, (N-1, N-D and N-2). The NETS SQSS defines a process by which the required transfer capability of each MITS boundary can be determined, based upon the balance of generation and demand on each side of the boundary this is the ‘planned transfer’ capability of the MITS boundary. The required transfer capability can then be compared with the planned transfer capability of the MITS boundary to assess whether it requires reinforcement.

The boundary capability and the future required transfer graphs shown in this chapter have all been calculated against the requirements of the NETS SQSS200.

Within the planned transfer calculation a ranking list of generation, based upon the future scenario (as described in Chapter 4), is used to identify the likeliest generation to be in operation during peak transmission system demand. From that, each generator’s MW output can be calculated. All the different future scenario generation ranking orders assume that as wind generation increases, the level of non-wind generation at the bottom of the ranking order falls out of merit, (i.e. new wind generation tends to displace existing conventional generation). As generation increases in one region, this will displace generation in other regions, keeping the total demand and generation in balance. The inverse is true for plant closures. These changes alter the planned transfers across a boundary as follows:

- **Unchanged** if new generation displaces existing generation on the same side of the boundary;
- **Increased** if new generation is added on the side of the boundary with a generation surplus, and displaces generation on the side of the boundary with a generation deficit;
- **Decreased** if new generation is added on the side of the boundary with a generation deficit, and displaces generation on the side of the boundary with a generation surplus.

This chapter shows the effect of the future scenarios on selected key boundaries. Graphs are presented for key boundaries showing the required transfers, boundary capabilities and reinforcement requirements.

---

It should be noted that the suitability of the existing NETS SQSS used for determining the required boundary transfer capability is presently under review, as a result of the expected increase in intermittent renewable generation and a corresponding increase in overall generation variability. If the NETS SQSS is found to be sub-optimal, the standard may be revised, altering the boundary capabilities deemed necessary. Any changes to the NETS SQSS arising from the current reviewers are not expected to alter the requirements of boundary capability by more than a few hundred MW.

The analysis undertaken for this chapter is based on the Radial strategic design. The integrated design strategy will produce different MITS boundary transfers as the offshore generation connects to different points, additional transmission routes are available offshore and with the use of HVDC technology, the power transfer is controllable. The latter would be achievable by extending and linking the MITS with the offshore integrated network resulting in an improved network design. There is scope for the conceptual integrated offshore network to be considered as part of the onshore MITS, as this will alleviate some of the constraints normally associated with bulk power transfers on the main onshore transmission system. The NETS SQSS will need to be extended to cover interconnected offshore networks as the current provisions for the MITS do not extend to cover such a network.
6.2 Boundary Map

FIGURE 6.1 - MITS Boundary Map (also available in Appendix 2)
6.3 MITS Reinforcement Options

The analysis of onshore MITS reinforcements is dominated by the requirements of the NETS SQSS. For a given background of generation and demand and for each MITS boundary on the transmission system, the NETS SQSS principally gives a 'rule-of-thumb', in the form of the required boundary capability. This is the amount of MW that can be securely transferred across the boundary at time of peak, without infringing either circuit ratings or voltage and stability limits.

Where the network is such that an actual boundary transmission capability is less than the NETS SQSS requirement, then new transmission works to reinforce that boundary are required. If a suitable reinforcement can not be delivered by the year required, then that system boundary would be non-compliant with the NETS SQSS under that scenario and a derogation may be required until suitable boundary capability can be provided. It is the responsibility of each TO to propose and deliver the most economic and efficient reinforcements without hindering the connection of any customer. Where reinforcement may only be needed for a short period it may be more efficient to not undertake the work and temporarily restrict the network power flows. This can avoid infrastructure investment but the cost and risk of constraining the MITS needs to be considered.

Following DECC's implementation of the 'Connect and Manage' regime in August 2010, the position on derogations is a little more complex than previously:

- Where the underlying cause of the derogation is not linked to any new generation, connecting under the 'Connect and Manage' regime, then NGET (acting in its role as NETSO) and the relevant TO have to seek endorsement of a derogation from Ofgem in the previous way, (this case will become the exception, going forwards).

- Where the underlying cause of the derogation is the connection of new generation under the 'Connect and Manage' regime, such that the timescales (often four years) of the new generation are in advance of the ability of the TO to deliver wider system reinforcements in time, then the TO self-derogates the non-compliance with the NETS SQSS. Such a self-derogation has to be accompanied by reports to Ofgem, which (at minimum) state:
  - the nature of the derogation;
  - the expected consequences, (which are likely to include costs of additional constraints, and may include benefits of new generation connected);
  - the long-term solution, which is normally a transmission reinforcement; and
  - the duration of the derogation – i.e. when the reinforcement is expected to remove the derogation.

For this Statement the NETS SQSS boundary power flow required transfer has been plotted for each boundary and scenario. Against each boundary a set of MITS reinforcements has been identified which satisfies the requirements for the majority of the future scenarios. The reinforcements may not cover the extremes of all of the requirements for all the scenarios as to do this would give rise to a high risk of over investment.

Many of the identified reinforcements for the MITS boundaries in this chapter have also been identified in the report: ENSG 'Our Electricity Transmission Network: A Vision for 2020'. Please note that the ENSG report also contained several reinforcements required to address local issues. These reinforcements have been considered in Chapter 5.

Table 6.1 below shows the table of reinforcements developed following the analysing of the MITS network and which are used in the following boundary discussion. Each reinforcement identified in the table has an associated year that it would be required against each future scenario and boundary. The time when the reinforcement could actually be physically delivered may be much later than the requirement date shown in the table. This can be due to many factors, particularly when the reinforcement project is large

---

as each project can represent significant work in terms of planning, surveying, obtaining consents, funding and construction. Where there is an expected difference between the requirement date and soonest possible delivery date the date has been highlighted.

<table>
<thead>
<tr>
<th>Ref.</th>
<th>Description</th>
<th>Year Required For Each Scenario</th>
<th>Boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td>WS1</td>
<td>Reconductor Harker – Hutton – Quernmore:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 2 x 116 km of GZTACSR conductor.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WS2</td>
<td>Series and Shunt Compensation:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Harker - Hutton circuits.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Harker - Stella circuits.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Stella - Spennymoor circuits.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WS3</td>
<td>West Coast HVDC Link:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- HVDC cable connection from Deeside to Hunterston, ~400 km, submarine and</td>
<td>B7</td>
<td>2014</td>
</tr>
<tr>
<td></td>
<td>land sections.</td>
<td></td>
<td>2011</td>
</tr>
<tr>
<td></td>
<td>- HVDC converter ~2 GW capacity installation at Deeside and Hunterston.</td>
<td></td>
<td>2011</td>
</tr>
<tr>
<td></td>
<td>- Deeside: New 400 kV 21 bay GIS substation together with line entry and</td>
<td></td>
<td>2011</td>
</tr>
<tr>
<td></td>
<td>generator connection rationalisation.</td>
<td></td>
<td>2011</td>
</tr>
<tr>
<td></td>
<td>- Substation extension at Hunterston.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WS4</td>
<td>East Coast HVDC Link:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Extend Norton 400 kV GIS by one bay for new Hawthorn Pit circuit.</td>
<td>B6</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>- Up-rate existing Hawthorn Pit to Norton 275 kV circuit to 400kV operation,</td>
<td></td>
<td>2018</td>
</tr>
<tr>
<td></td>
<td>transfer into 400 kV substations.</td>
<td></td>
<td>2018</td>
</tr>
<tr>
<td></td>
<td>- Hawthorn Pit: establish new 400 kV substation (9 bay) plus one additional</td>
<td>B7</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>400/275kV supergrid transformer connected to existing Hawthorn Pit 275 kV.</td>
<td></td>
<td>2020</td>
</tr>
<tr>
<td></td>
<td>Modify line entries.</td>
<td></td>
<td>2019</td>
</tr>
<tr>
<td></td>
<td>- HVDC cable connection from Hawthorn Pit to Peterhead, ~360 km, submarine</td>
<td>B11</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>and land sections.</td>
<td></td>
<td>2020</td>
</tr>
<tr>
<td></td>
<td>- HVDC converter ~2 GW capacity installation at Hawthorn Pit and Peterhead.</td>
<td>B32</td>
<td>2015</td>
</tr>
<tr>
<td></td>
<td>- Reconductoring from 275 to 400 kV from Rothienorman to Peterhead, and a</td>
<td></td>
<td>2018</td>
</tr>
<tr>
<td></td>
<td>new 400 kV substations at Rothienorman and Peterhead.</td>
<td></td>
<td>2016</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WS5</td>
<td>Torness to Lackenby HVDC Link:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 2 GW HVDC link from Torness to Lackenby.</td>
<td>B6</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2020</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2023</td>
</tr>
<tr>
<td>WS6</td>
<td>Penwortham Quad boosters:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Quad boosters at Penwortham.</td>
<td>B32</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2020</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2018</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2016</td>
</tr>
<tr>
<td>R1.7</td>
<td>Wylfa to Pembroke 2 GW HVDC link:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 115 km HVDC cable link.</td>
<td>B8</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2020</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2022</td>
</tr>
<tr>
<td>LN1</td>
<td>Up-rate Hackney - Tottenham - Waltham Cross circuit to 400 kV:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- New 400 kV substation at Waltham Cross and associated circuit changes.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Up-rate and reconductor Hackney – Tottenham - Waltham Cross circuit to 400</td>
<td>B14</td>
<td>2015</td>
</tr>
<tr>
<td></td>
<td>kV.</td>
<td></td>
<td>2015</td>
</tr>
<tr>
<td></td>
<td>- Modify Tottenham substation.</td>
<td></td>
<td>2015</td>
</tr>
<tr>
<td></td>
<td>- Install two 400/132 kV super grid transformers (SGTs) at Brimsdown substation.</td>
<td></td>
<td>2015</td>
</tr>
</tbody>
</table>

This is the date when the reinforcement may be needed however it is not expected that the works will be achievable by this date due to construction, consents and planning issues.
MITS reinforcements may increase the transfer capability across only a single boundary, or may benefit multiple boundaries, (depending on the nature of the reinforcement and the surrounding network). An example of this is the west coast HVDC link which provides approximately 2 GW of additional capability across the Anglo Scottish region B6 and B7. The boundaries that benefit from each reinforcement are indicated in Table 6.1.

The distribution of generation, demand and transmission infrastructure across a boundary will eventually dictate the reinforcement requirement and time when it may be needed. The timing may be set by whichever boundary requires the reinforcement first or when the total cost of constraints on all affected boundaries exceeds the threshold needed for the reinforcement to be cost-effective.

The graphs shown in this chapter show both the required transfers for each boundary, (for the selected boundaries under the given future scenario), superimposed with the present and future capabilities under the given reinforcements. The reinforcements are shown on the graph as step changes, indicating the possible benefit and capability of each reinforcement which could be achieved if the reinforcements are implemented. The positioning of the step reinforcement step changes on the graphs reflects dates that may be practically achieved and may not fully cover the boundary requirements.

In essence the results displayed are intended to illustrate the continuous change of the MITS boundaries over time and how the timing of MITS reinforcements may vary under the different future scenarios. It is important to state that the results are qualitative and not quantitative as it gives a general prediction of the trend throughout the study period. In reality, each boundary transfer can be effected in numerous ways and fluctuate over short and long timescales due to different patterns of generation and demand.

Some of the projects proposed to address local network congestion do also provide a benefit to the wider system boundaries. Please review Chapter 5 for the details of such projects.
6.4 Boundaries Considered

For the purpose of analysing the capability of the MITS and determine the need for onshore transmission reinforcement, it is useful to divide up the system and consider power transfers across certain critical boundaries. Nine of these critical boundaries which are directly impacted by offshore generation connections have been selected in this case. These are described and explained in each sub-section of this chapter, accompanied with a detailed explanation of the trends associated with the backgrounds and capabilities. It should be noted that this selection was also based on the size of boundaries, with the nine selected boundaries being wider system boundaries rather than local system boundaries (i.e. the generation within the boundary is greater than 1,500 MW).

The analysis was conducted assuming the Radial offshore design. This is because the Radial design requires the same MITS reinforcements as the Radial Plus design but much more reinforcements compared to the integrated design strategy and hence represents the most onerous conditions from an onshore reinforcement perspective. Moreover, developers are currently planning their work with respect to the Radial offshore design.

Seven boundaries were selected from the north; three in the Anglo Scottish region, (B6, B7 and B32), two in the Midlands regions, (B8 and B9), one in the north east and Yorkshire (B11) and one in north east, Trent and Yorkshire (B16). In addition to these two southern boundaries were selected, one being south west, (B12), and London (B14). It can be seen that chosen boundaries offer a wide representation of the capability across different regions of Great Britain.

The lines shown on the later graphs are assigned a particular colour to indicate the required transfer for each future scenario. Refer to Table 6.1 for step changes in capability which arises from the proposed reinforcements, identified by a WS prefix in the individual boundary reinforcement figures. The Slow Progression (SP) future scenario is assigned a blue colour, while the Gone Green (GG) future scenario is assigned a green colour, Accelerated Growth (AG) is represented as an orange line and Sustainable Growth (SG) is represented as a plum coloured line. A solid black line represents the capability of the boundary against the Gone Green scenario before and after reinforcement is applied. The improvement due to a particular reinforcement is shown as a step in the capability and the recommended reinforcement is identified on the graph using its reference number as specified in Table 6.1 above. In some cases where the Accelerated Growth scenario requirement is much higher than the Gone Green scenario, reinforcements have been identified for the Accelerated Growth scenario and these are shown as black dotted lines.

Although the discussion in this chapter frequently uses the expression that certain reinforcements ‘are required’ in certain years, this should be understood as: for a given future scenario the reinforcement implemented will achieve compliance for that given year within the study period. Discrepancies may occur between the future scenarios, due to differences in generation and demand which would result in the reinforcement to be applied in a different year within the study period.
6.4.1 Boundary B6: SPT – NGET

Boundary B6 is an Anglo Scottish boundary which acts as a primary interface between NGET and SPT. Presently the planned transfer across the boundary is around 3 GW. This is because the generation in Scotland exceeds its own demand therefore the excess power flow travels down into England. Due to Scotland’s geographical landscape, a large portion of future onshore generation and offshore wind farms (e.g. Round 3 offshore wind farm projects: Firth of Forth, Moray Firth) is expected to connect around Scotland, thus further increasing power flows. Coupled with a number of generation units falling out of merit south of the border, a much higher transfer capability is required for this boundary.

The existing network crossing B6 consists of four primary circuits and a number of smaller 132 kV circuits, giving a maximum thermal capability of 3.3 GW following works which are currently in construction known as the Transmission Investment for Renewable Generation (TIRG) works. If flows increase to around 6-8 GW as expected with the new renewable generation, the west and east coast HVDC links, (WS3 & WS4), must be implemented. Series and shunt compensation would also be required to aid in stability issues.

As stated above, the current capability of boundary B6 is 3.3 GW, incorporating the TIRG works to be completed in 2012/13. As illustrated by Figure 6.2, it can be seen that the required transfer is expected to increase throughout the coming years all the way up to 2025. The analysis carried out on this boundary showed that the series and shunt reactive compensation (WS2 - to alleviate voltage collapse and compliance issues) and the west coast HVDC link (WS3) are essential to meet the required transfers up to 2018.

The Gone Green, Accelerated Growth and Sustainable Growth required capabilities appear to be consistent between the years of 2014-18 with similar transfer capabilities. Beyond 2018, Gone Green and Sustainable Growth follow a similar trend up to 2025, while Accelerated Growth deviates dramatically with its required transfer capability increasing to a much higher level than in Gone Green and Sustainable Growth. This is due to greater output from Round 3 offshore wind farms (Moray Firth and Firth of Forth) as well as the offshore wind farm projects in Scottish Territorial Waters (e.g. Inch Cape, Beatrice and Argyll Array, etc). Due to this large increase in required transfer capability, further reinforcements would be required if the generation follows the Accelerated Growth trend. This can be achieved by implementing another east coast HVDC link between Torness and Lackenby (WS5) to further increase the boundary capability and minimise any thermal overloads on the existing B6 circuits.

Figure 6.2 - Boundary B6 Required and Proposed Capability
6.4.2 Boundary B7: SPT – NGET Upper North

Boundary B7 is another boundary found within the Anglo Scottish region and is located south of B6. B7 is characterised by six primary circuits all rated at 400 kV.

As illustrated by Figure 6.3, it can be seen that the trend traces are broadly similar to B6 (Figure 6.2) thus the reinforcements required for boundary B6 are also valid for B7. The two most essential reinforcements applied to this boundary are (i) the re-conductoring of Harker-Hutton from 1.37 GVA to 3.1 GVA per circuit (WS1) which will improve the thermal and voltage limits of the boundary and (ii) the west coast HVDC link (WS3) between Hunterston and Deeside which increases the capability of B7 significantly by providing an additional 2 GW across the boundary. These two identified reinforcements are sufficient to provide a boundary capability higher than the required transfer up to 2018-2019.

The Gone Green, Accelerated Growth and Sustainable Growth future scenarios require a higher capability in 2020, due to a higher planned and required transfer, (a consequence of a large proportion of potential LCPD closures in England and Wales, as well as a ‘net’ increase in generation from Scotland). In order to achieve the desired required transfer, both HVDC links (east & west) must be installed, providing a capability of 8.4 GW. The east coast HVDC link (WS4) provides approximately 1.3 GW of additional B7 capability. This particular reinforcement helps the power flow to be redistributed in the northern region of B7 thus alleviating any voltage compliance issues associated with this boundary, as in accordance to NETS SQSS standards. If Accelerated Growth is considered, then the Torness to Lackenby HVDC link (WS5) would be necessary.

Figure 6.3 - Boundary B7 Required and Proposed Capability
6.4.3 Boundary B11: NGET North East & Yorkshire

Boundary B11 is referred to as the north east and Yorkshire boundary as it begins roughly at the same location as B7 cutting across the Harker-Hutton 400 kV circuits but then travels south to include the Manchester and Leeds areas. The boundary then cuts east to encompass the north east coast including Killingholme and Grimsby.

This boundary is of great importance as it is characterised by the “bulk” flow travelling from the north to the south of England. It is also a key region of great interest as a large portion of Round 1 and 2 offshore wind farms lie to the north of the boundary, along with the Round 3 offshore wind farms (Dogger Bank and Hornsea). The circuits across this boundary must be capable of catering for any increased load flows that may result from growth in generation north of the boundary.

From Figure 6.4, it can be seen that the dominant backgrounds are Accelerated Growth and Sustainable Growth due to the higher volumes of northern generation. The existing capability of the boundary is in the region of 10 GW which is sufficient to handle the level of flows crossing the boundary for all the backgrounds up to 2017. By 2017, the first signs of generation increase are shown in Sustainable Growth where the existing capability is insufficient to meet the required transfer. As Accelerated Growth and Sustainable Growth follow an upward trend, both east and west coast HVDC links (WS3 and WS4) will provide the additional capacity to meet all the future scenarios, with sufficient capacity left for future growth in generation north of the boundary.

Figure 6.4 - Boundary B11 Required and Proposed Capability
6.4.4 Boundary B16: NGET North East, Trent & Yorkshire

Boundary 16 is the north east, Trent and Yorkshire boundary and follows a boundary path similar to that of B11 encompassing Manchester and Leeds. The biggest difference between B11 and B16 is that it includes the Trent area located south of the area referred to in Chapter 5 as ‘The Wash’. This area includes substations at Spalding North, Staythorpe, Cottam and West Burton. This boundary is affected by the numerous Round 1 and 2 offshore wind farms and the proposed Round 3 Dogger Bank and Hornsea offshore wind farms to be connected onshore just north of this boundary in the east coast region.

The required transfer for this boundary resembles that of B11 but is represented by a less stepped curve, as shown in Figure 6.5. This is predominately due to the increase of east coast generation being offset by numerous thermal power stations falling out of merit in Lincolnshire.

As boundary B16 begins roughly at the same location as B11 and B7, the west coast HVDC link (WS3) can be used to provide an additional 2 GW of capacity to the boundary. A need is shown for this reinforcement after 2016 as Accelerated Growth and Sustainable Growth exceed the existing boundary capability. However under the Gone Green and Slow Progression background the existing capability is sufficient to satisfy the required transfer in the later years.

Figure 6.5 - Boundary B16 Required and Proposed Capability
6.4.5 Boundary B32: Upper North & North Lancaster

Boundary B32 runs mostly in parallel with B7 but encompasses Heysham, Hutton and Penwortham. The boundary also cuts through four 400 kV circuits running from Norton and Lackenby in Teeside into north Yorkshire.

Figure 6.6 shows the required transfer capabilities, as well as the existing and proposed boundary capabilities with the application of suitable reinforcements. The dominating background for B32 is Sustainable Growth, which exceeds Accelerated Growth between 2013 and 2024. In all scenarios, the west coast HVDC Link (WS3) is required to achieve compliance in 2015. Beyond 2020 Accelerated Growth, Sustainable Growth and Gone Green all require the east coast HVDC Link (WS4) and the Penwortham Quadature Boosters (WS6) to be triggered in order to achieve the required level of compliance. It must be noted that WS1 was integrated in the base case of the analysis before studying B32 and its subsequent years.

Figure 6.6 - Boundary B32 Required and Proposed Capability

![Boundary B32 - NGET Upper North & North Lancashire](image-url)
6.4.6 Boundary B8: NGET North to Midlands

Boundary B8 crosses approximately through the centre of the MITS network, separating the north from the Midlands and the south. Several Round 1 and 2 offshore wind farms, the Irish Sea and much of the Dogger Bank and Hornsea Round 3 offshore wind farms are expected to connect to the onshore network just north of B8.

The required transfers across Boundary B8 tend to vary between 8-10 GW throughout 2010-2020 before a steep increase in required transfer in 2020 in the Accelerated Growth and Sustainable Growth scenarios. The rate of increase in required transfers of these two scenarios then levels off as the closure of older thermal and CCGT plant in the region counterbalances much of the new renewable generation connections.

The increase in transfers seen from 2019 can be attributed to a forecast closure of thermal plant in the south of the country and further increases in northern renewable generation. The addition of a HVDC link (R1.7) from Wylfa to Pembroke will provide the additional boundary capacity to satisfy the additional transfers beyond 2020.

Figure 6.7 - Boundary B8 Required and Proposed Capability
6.4.7 Boundary B9: NGET Midlands to South

Boundary B9 bisects England and separates the Midlands region from the south. Despite Birmingham being a large demand centre in the Midlands region. There is significant generation within the Midlands, (e.g. generating units at Rugeley, Cottam, Spalding North, etc.) that make this a critical boundary.

In addition, numerous Round 1 and 2 offshore wind farms are located in close proximity to The Wash region as well as some of the Dogger Bank and Hornsea Round 3 offshore wind farms expected to connect to the onshore network just north of B9.

Figure 6.8 shows that all the required capability in all scenarios increase up to 2017-18 due to a greater level of generation north of B9 which results in a non compliance in 2015 under Slow Progression. Beyond 2018, the power flow from the north tends to decrease under all future scenarios, suggesting that any new reinforcements would be short lived considering the timescales required for construction of such reinforcements.

Figure 6.8 - Boundary B9 Required and Proposed Capability
6.4.8 Boundary B12: NGET South & South West

B12 is an importing boundary which is located west of London and covers the region to the south and south-west of England. Several Round 1 and 2 offshore wind farms as well Hastings, West of Isle of Wight and Bristol Channel Round 3 offshore wind farm areas are expected to connect within this boundary.

This boundary is strongly affected by a number of generators located in and around the region to secure local demand. The required transfer can vary from 3.1 GW to 6 GW depending on the timing and location of generators falling out of merit, especially those subject to LCPD closures. The results for this boundary showed that the highest required transfer was close to 6 GW throughout the 15 years. Figure 6.9 shows that there is little variation between all the scenarios but Slow Progression produces the highest required transfer due to less new generation commissioning south of this boundary.

The studies have shown that there is a voltage limitation on the B12 boundary under the Gone Green future scenario. The required transfer boundary capability is 5 GW. This can be alleviated by installing an appropriate reactive compensation unit at Waltham which would increase the boundary capability beyond the required compliance level. Although the Slow Progression required transfer exceeds the boundary capability for a short period of time, any proposed reinforcements would be short-lived.

Figure 6.9 - Boundary B12 Required and Proposed Capability
6.4.9 Boundary B14: NGET London

Boundary B14 encircles London, the largest demand centre in the National Electricity Transmission System (NETS). With the exception of some small Combined Heat and Power and the concentration of oil, gas, and coal-fired plant in the lower Thames estuary, there is little generation in the London area. Outside the boundary lie the large nuclear units to the north (Sizewell) and to the south (Dungeness). There are also large coal and gas plants at Didcot and Marchwood to the west. Consequently, the demand in London is chiefly met by transmission connections from remote generation sources. The Sellindge and BritNed interconnectors have a large impact on the flow of power in and around London, with power imports helping support London demand or during export conditions, pulling power through London from the north.

From Figure 6.10, it can be seen that the predicted transfers across B14 increase almost linearly throughout the coming years, with few differences between the background scenarios up to 2022. This is due to expected London demand growth and no new generation connecting within the London boundary. The forecast required transfers across the four scenarios range from 9.6 to 10.6 GW. Between 2022 and 2025, the required transfer for Accelerated Growth and Sustainable Growth shoots up by 600 MW which is due to an increase in generation from East Anglia and changes in the generation background within the Thames estuary area (e.g. changes in the assumptions for the interconnector links). The capabilities on this boundary were shown to have dropped in comparison to the earlier analysis, thus requiring further reinforcement i.e. up-rating Hackney – Tottenham – Waltham Cross circuits to 400 kV (LN1).

Figure 6.10 - Boundary B14 Required and Proposed Capability
Chapter Seven

Way Forward

The Statement will be published on an annual basis by NGET. It is intended that this Statement will be used as the basis for future editions of the Statement subject to industry consultation. Industry feedback is therefore sought to inform the development of subsequent Statements to ensure that this Statement fulfils its objective of facilitating the development, in offshore waters, of an efficient, co-ordinated and economical system of electricity transmission.

7.1 Feedback on the 2010 Statement

Interested parties are encouraged to provide feedback on all aspects of the 2010 Statement via the Online Survey Form. Given the timeline for the development of the 2011 Statement, (as outlined in section 7.3), it would be appreciated if responses can be provided as soon as possible such that the replies can be used to develop and articulate the formal consultation exercise which will be published in December 2010.

Should you have any questions on the Offshore Development Information Statement, please do not hesitate to contact us: transmission.odis@uk.ngrid.com.

7.2 Consultation on 2010 Statement

The Statement will be the subject of an annual review process, facilitated by NGET with industry participants. Any proposed amendments to the structure/layout and the future scenarios which may be incorporated within future editions of the Statement, are the subject of this annual review process with a subsequent formal submission to the Authority (outlining the proposed amendments to structure/layout and future scenarios).

In December 2010, NGET will commence a formal review of the 2010 Statement. The review will seek to:

- assess whether the form of the Statement and the future scenarios presented in the Statement facilitate the development, in offshore waters, of an efficient, co-ordinated and economical system of electricity transmission; and
- identify any areas for potential further development which could be incorporated within future editions of the Statement (dependant on availability of information, commercial sensitivities etc).

The review will be conducted with the industry and will take the form of a formal consultation document (which will be available on National Grid’s website\(^2\)).

NGET welcomes the involvement of the industry in the continuous development of the Statement and therefore will be arranging an industry workshop for January 2011. The aim of the workshop will be to review the 2010 Statement (and the associated consultation document) and to identify how the Statement may be continually developed in line with the latest offshore developments and licence provisions. Further details regarding the timing and location of the industry workshop will be made public in due course. However if you have any suggestions on the format, agenda of the workshop please contact us: transmission.odis@uk.ngrid.com.

\(^2\) \(\text{http://www.nationalgrid.com/uk/Electricity/ODIS/}\)
7.3 Proposed Consultation Timetable and Key Milestone Dates

The proposed timetable for the publication of the 2011 Statement is as follows:

- Publication of 2010 Statement – by 30th September 2010;
- Feedback on 2010 Statement via the Online Survey Form;
- Publication of the ‘Annual Statement Review’ Consultation – December 2010;
- Statement Workshop – January 2011;
- Submission, (to the Authority), of proposed changes to the form of Statement – by 1st March 2011 (if required);
- Submission, (to the Authority), of proposed changes to the Future Scenarios included in the Statement – by 1st June 2011 (if required);

7.4 Continuous Statement Development

The Statement will continue to evolve as advised by feedback received from the industry and reflect the latest developments in the offshore electricity regime and offshore electricity generation. However the content of the Statement will remain within the remit set by the special licence condition C4.

It is intended that the annual review process will facilitate the continuous development of the Statement and encourage activity participation from interested parties with the view to enhancing future versions of the Statement in accordance with the licence provisions.
Glossary

Simplified definitions of many of the terms used in this statement are provided below to assist a diverse range of readers to understand this Statement. Please be aware that many of these terms are officially and precisely defined in various industry codes, standards, and licence conditions.

Air Insulated Substations/Switchgear (AIS)
Traditionally, substations at transmission voltages use atmospheric air as the principal insulating medium. The substation components energised at transmission voltages (such as circuit breakers, disconnectors, instrument transformers and the conductors that interconnect them) are supported on porcelain insulating columns and spaced with sufficient clearances that the surrounding air will provide adequate insulation.

Array
The electrical network, typically energised at 33 kV or 11 kV, used to collect the power generated by multiple generators and deliver it to a central substation where the power is aggregated and its voltage is stepped up for export to the electricity grid.

Authority
The Gas and Electricity Markets Authority established by section 1 of Utilities Act 2000. The Authority’s principal objective is to protect the interests of existing and future consumers in relation to gas conveyed through pipes and electricity conveyed by distribution or transmission systems.

Boundary
A border which divides the National Electricity Transmission System into two adjacent regions. Boundaries are used when assessing and discussing the future requirements and capabilities of the transmission system. Boundaries are defined such that they highlight the most constrained areas of the network where reinforcement is thought most likely.

Boundary Transfer Capability
The maximum pre-fault power that the transmission system can carry from the region on one side of a boundary to the region on the other side of a boundary while ensuring acceptable transmission system operating conditions will exist following one of a range of different faults.

Busbar
The common connection point of two or more transmission circuits.

Constraints
Limitations applied to the operation of the power system, to prevent it from operating in a state in which, following a fault, unacceptable operating conditions could be experienced. Constraint costs are incurred when it is necessary to alter the power output of generators in order to alleviate the constraint.

Current Source Converter (CSC)
A type of HVDC converter which uses electronic switches that can be controlled on, and naturally commutate off at the end of each cycle. Please refer to the corresponding technology sheet in Appendix 4 which describes the merits of CSC converters.

Gas Insulated Substations/Switchgear (GIS)
Substations in which the components that are energised at transmission voltages are enclosed in a metal vessel containing pressurised sulphur hexafluoride (SF₆) gas. The improved insulation properties of SF₆ over atmospheric air means that a GIS substation can be arranged more compactly than an equivalent AIS substation.
**Grid Supply Point (GSP)**

A point of supply from the national electricity transmission system to a distribution network or transmission connected load. Typically only large industrial loads are directly connected to the transmission system.

**High Voltage Alternating Current (HVAC or AC)**

Electric power transmission in which the voltage varies in a sinusoidal fashion, resulting in a current flow that periodically reverses direction. HVAC is presently the most common form of electricity transmission and distribution as it allows the voltage level to be raised or lowered using a transformer.

**High Voltage Direct Current (HVDC)**

Electric power transmission in which the voltage is held at a constant magnitude. HVDC is commonly used for point to point long-distance and/or subsea connections. HVDC offers various advantages over HVAC transmission but requires the use of costly power electronic converters at each end to change the voltage level and convert it to/from AC.

**Infeed Loss Risk**

The maximum amount of power injection into the electricity transmission system that can be lost for different types of power system contingencies, as defined by the NETS SQSS. The normal infeed loss risk, relating to relatively common contingencies, is presently 1000 MW. The infrequent infeed loss risk, relating to relatively uncommon/multiple contingencies, is presently 1320 MW. The power system is designed in such a way that it is not possible to lose generation infeed greater than these thresholds. As such, the infeed loss risk defines the maximum capacity of radial offshore transmission connections. Operationally, adequate frequency response is maintained to ensure that the power system can withstand the sudden loss of generation up to the infeed loss risk. There is an active proposal which, should it be approved by the Authority, will increase the infrequent loss risk from 1320 to 1800 MW.

**Main Interconnected Transmission System (MITS)**

The 400 kV and 275 kV elements of the transmission system, including in Scotland, the 132 kV elements operated in parallel with 400 kV or 275 kV elements, excluding radial connections to generators, transformer connections to lower voltage systems and interconnectors to other power systems.

**National Electricity Transmission System Security and Quality of Supply Standard (NETS SQSS)**

The National Electricity Transmission System Security and Quality of Supply Standards (NETS SQSS) sets out a co-ordinated set of criteria and methodologies that Transmission Licensees (both onshore and offshore) shall use in the planning and operation of the National Electricity Transmission System. The criterion presented in the NETS SQSS represents the minimum requirements for the planning and operation of the National Electricity Transmission System.

**Offshore Grid Entry Point (Offshore GEP)**

The point at which an offshore generator connects to the offshore transmission system, defined as the AC connection onto the low voltage busbar on the OFTO platform substation.

**Onshore Interface Point**

The point at which an offshore transmission system is directly connected to the onshore transmission system.

**Static VAR Compensators (SVC) and Static Compensators (STATCOM)**

Both are devices which are capable of producing variable inductive and capacitive reactive power and can be used to regulate the network voltage on the network and control the power factor at grid entry and interface points.
System Operator - Transmission Owner Code (STC)

The System Operator–Transmission Owner Code (STC) defines the high-level relationship between the National Electricity Transmission System Operator and the transmission network owners.

Transformer

An electro-magnetic device that can be used to change the voltage level in an AC network.

The Department of Energy and Climate Change (DECC)

The Department of Energy and Climate Change is the Government department responsible for all aspects of UK energy policy (previously with BERR, which is now the Department for Business, Innovation and Skills) and climate change mitigation policy (previously with the Department for Environment, Food and Rural Affairs (DEFRA)).

The Crown Estate

The Crown Estate is the owner of the seabed (out to the 12 nautical miles limit) around the coast line of UK. They also own around half of the foreshore, the area between mean high and mean low water (spring tides in Scotland) and approximately half of the beds of estuaries and tidal rivers in the United Kingdom. The Crown Estate also has the right to exploit natural energy resources, excluding fossil fuels on the UK continental shelf within the Renewable Energy Zone.

Units

Measures of Power – the rate at which energy is being generated, consumed, or transferred:

- Gigawatt (GW) = 1,000,000,000 Watts
- Megawatt (MW) = 1,000,000 Watts
- 1 Watt = 1 Joule/second

Measures of Energy – the amount of energy generated, consumed, or transferred. In electricity, energy is commonly expressed as a multiple of the energy that would be realised if a particular power level were maintained for an hour:

- Gigawatthour (GWh) = 1,000,000,000 Watts X 3600 seconds
- Megawatthour (MWh) = 1,000,000 Watts X 3600 seconds

Measures of Voltage – the electrical potential at which electrical conductors are energised:

- Kilovolts (kV) = 1,000 Volts
- 1 Volt = 1 Joule/coulomb of charge

Voltage Source Converters (VSC)

A type of HVDC converter which uses electronic switches which can be controlled on and off.