Transmission infrastructure associated with connecting offshore generation

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Prepared for The Crown Estate in April 2013 by

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Enhancing Society Together

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1 Introduction

1.1 Overview

At present, offshore wind accounts for around 1.5% of the UK's electricity supply[1] and this figure will need to increase significantly in order to achieve our 2020 renewable energy targets. The Government's Renewable Energy Roadmap, published in July 2011[2] and updated in December 2012[3], confirms its aspiration to install up to 18GW of offshore wind capacity by 2020. Against this backdrop, The Crown Estate has leased a number of areas of seabed for offshore wind development, and developers have registered their interest in deploying up to 46GW of capacity. Just over 4GW of this is in operation or construction with the remainder in various stages of development. The majority of the remainder will be delivered under The Crown Estate's Round 3 programme, which consists of 9 offshore wind zones in the UK waters covering areas as far north as Moray Firth in Scotland and as far south as the West Isle of Wight zone, off the Dorset and Hampshire coasts.

Given the scale of the expected development of offshore wind over the coming years, and following consultation with key stakeholders, The Crown Estate has identified an emerging need to provide high level technical and environmental information on the transmission infrastructure that may be required to connect offshore generation. This need will be particularly acute amongst planning and consenting regulators and stakeholders, who will be required over the coming years to consider planning applications and decisions on offshore wind projects and the associated transmission infrastructure. However, a wider audience could also benefit from access to this information.

The Crown Estate has commissioned Royal HaskoningDHV and GL Garrad Hassan to produce this document in response to this need. The purpose of this document is to provide a knowledge-based reference resource on the electricity transmission infrastructure associated with connecting offshore energy generation projects.

1.2 Aims and objectives

The aim of this document is to provide reference information on the technical and environmental aspects of the electrical transmission infrastructure associated with connecting offshore renewable energy generation projects to the national electricity transmission system. The document includes material on the potential nature, type and functions of infrastructure, provides a range of images of equipment, and outlines the key technical and environmental considerations associated with installation and operation. It also includes high level descriptions of the relevant planning and regulatory frameworks applicable to this sector. As part of this, the document summarises the roles and responsibilities of key parties, such as National Grid, Scottish Power Transmission, Scottish Hydro Electric Transmission, Offshore Transmission Owners (OFTOs) and Ofgem.

The objective of this document is to provide helpful reference material on transmission infrastructure associated with connecting offshore energy generation. As part of this, it includes a comprehensive list of further information on infrastructure and related issues, with links where appropriate.

This document is not intended to be a guide to developing grid connections or to be used as a form of checklist by readers as to what should or will be incorporated into a particular project. Each offshore generation project will have its own unique characteristics which will drive what the specific connection requirements are. The document does include a number of typical connection scenarios in order to illustrate potential differences between ways of connecting projects. In practice however, the connection requirement and infrastructure needs will vary based on project specifics.

A key objective of this document is to provide helpful reference material on transmission infrastructure associated with connecting offshore energy generation. As part of this, it includes a comprehensive list of further information on infrastructure and related issues, with links where appropriate.

1.3 Target audience

This document is primarily targeted at the planning and consenting community and is focussed accordingly. However, we hope and expect that it will be useful as reference material across a range of stakeholders.

Source: Royal HaskoningDHV

1 UK Energy Statistics. www.gov.uk/government/organisations/department-of-energy-climate-change/
2 DECC. Renewable Energy Roadmap July 2011. Available at: www.gov.uk/government
3 DECC. Renewable Energy Roadmap December 2012. Available at: www.gov.uk/government

1.4 How to use this document

This document is comprised of eight parts:

1. Background to UK offshore renewable energy generation;
2. An overview of the different connection scenarios used in this document;
3. Information on offshore transmission infrastructure components;
4. Information on onshore transmission infrastructure components;
5. An outline of relevant planning legislation and consenting framework;
6. An outline of relevant electricity regulation and connection process;
7. Glossary of terminology and abbreviations; and
8. Appendices containing further information (including FAQs and references to further information).

The bulk of information is contained within the sections on individual components of transmission infrastructure (parts 3 and 4).

For each component the following information is provided:

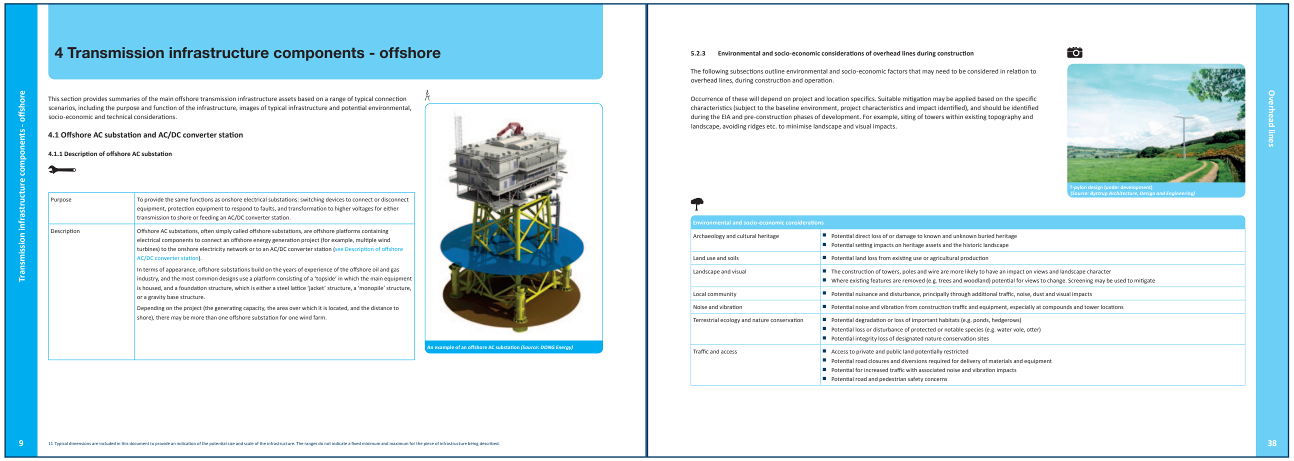
- A technical description;
- A range of typical images, including typical dimensions where appropriate;
- Environmental and socio-economic considerations during construction; and
- Environmental and socio-economic considerations during operation.

Each section uses colour-coding and symbols to aid navigation throughout the document. The navigation tools are shown in the following image:

Infrastructure components are uniquely coloured to aid navigation

Sketches of infrastructure components

Environmental considerations during construction



Technical descriptions of infrastructure components

Photographs of infrastructure

Environmental and socio-economic considerations during operation

2 UK offshore renewable energy generation

2.1 Offshore wind energy

The UK is well situated for producing offshore wind and potentially has the largest offshore wind resource in Europe, estimated to comprise over a third of the total European potential offshore wind resource[4].

The first major phase of offshore wind development in the UK, known as ‘Round 1’, established demonstration scale projects of up to 30 wind turbines, amounting to approximately 1GW of capacity in total. In 2003, The Crown Estate announced a second phase of development, known as ‘Round 2’, with fifteen project licences awarded, amounting to a total capacity of approximately 7GW.

As a result of The Crown Estate’s Round 1 and Round 2 programmes, the UK is currently the world leader in terms of operational offshore wind energy, with 18 operational projects representing over 2GW of installed capacity, and over 7GW of capacity within projects under construction or in the planning process (as of January 2013).

Current status of UK offshore wind farm projects (as of January 2013)

Offshore wind farm status	Number of projects
Operational & under construction	21*
Under development	30*
Consented	7**
Submitted for consent	10**

*Source: * The Crown Estate*
*** Renewable UK*[5]

These figures are included in the nearly 40GW of offshore wind capacity for which there are secured connection agreements in Great Britain as of December 2012. Whilst this is a success story in its own right, substantially more offshore wind energy generation is required to help the UK meet its binding national and international targets on renewable energy and CO_2 reduction. In 2008, The Crown Estate announced proposals for a third phase of development, known as ‘Round 3’, which has the potential to achieve more than 25GW of installed offshore wind energy generation capacity.

Round 3 plans were followed by an announcement in 2009 by The Crown Estate that they were to offer extensions to certain Round 1 and Round 2 projects. The extension projects were intended to directly contribute to the 2020 targets, help secure the offshore wind supply chain and increase investor confidence in the market. This announcement included the identification of 10 sites situated within Scottish territorial waters which the Scottish Government endorsed in their 2010 Draft Plan for Offshore Wind Energy in Scottish Territorial Waters[6].

Offshore wind projects in construction, operation or under development are shown in the figures on page 5.

2.2 Wave and tidal energy

2.2.1 Wave and tidal energy background

Over the last few decades, technologies to convert energy in ocean waves and tidal streams into electricity have been successfully developed, tested and have started to be commercialised. In parallel, a number of sites to deploy the technologies- either singly as prototypes or in multiples to create power stations - have been developed, with government consents and grid connection agreements being obtained. It is estimated that wave and tidal stream energy has the potential to meet up to 20%[7] of the UK’s current electricity demand and it, along with a number of other energy sources, will be utilised in the coming decades to help reduce the UK’s reliance on fossil fuels.

The UK wave and tidal resources are estimated to be follows[8]:

- Wave: 69 TWh/year (27 GW);
- Tidal stream: 95 TWh/year (32 GW);
- Tidal range (barrage schemes): 96 TWh/year (45 GW); and
- Tidal range (lagoon schemes): 25 TWh/year (14 GW).

In broad terms, wave resources are continuously distributed around the northwest of Scotland, southwest Wales and southwest England, whereas tidal resources occur at a set of discrete sites all around the UK.

The Crown Estate has been working on wave energy and tidal energy for several years, running the first commercial-scale wave and tidal stream leasing round in the Pentland Firth and Orkney waters, running a leasing round for tidal stream projects in the Rathlin Island and Torr Head area (Northern Ireland), and leasing a number of other sites all around the UK for technology development and demonstration purposes.

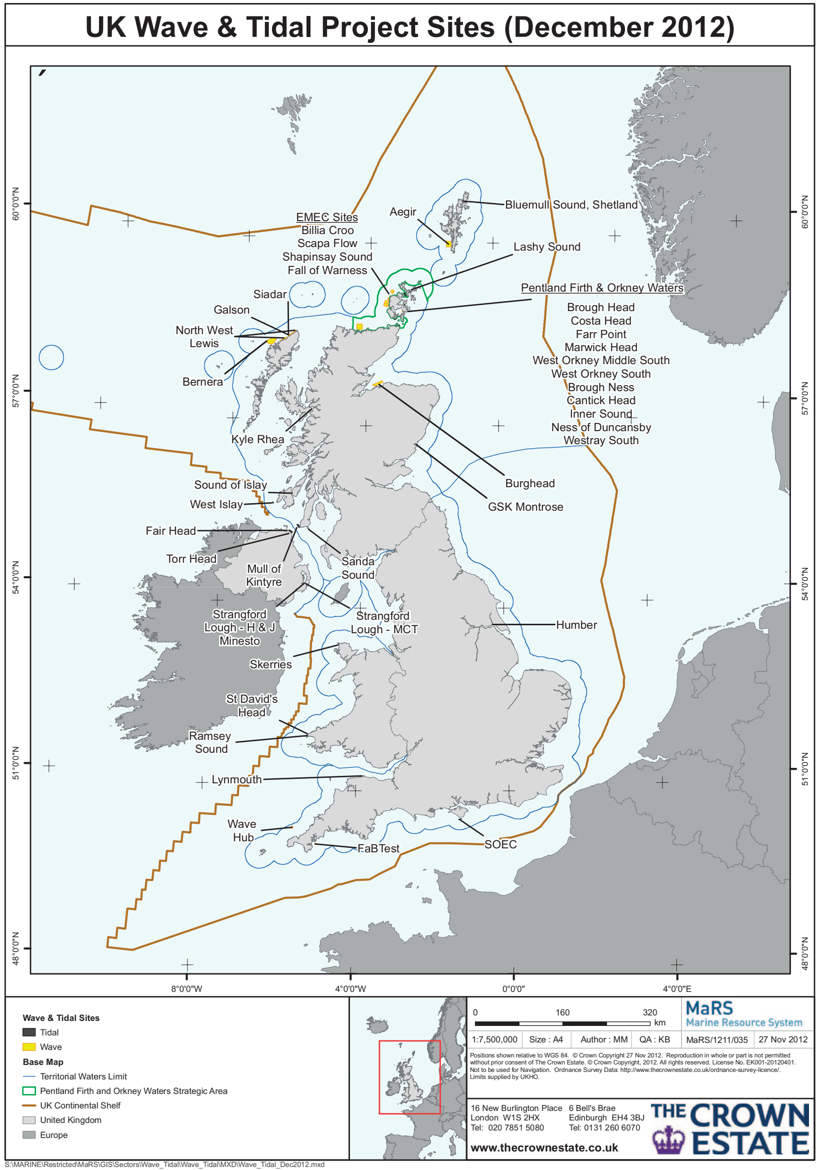
4 Renewable UK. Offshore Wind Farms. Available at: www.renewableuk.com
5 Renewable UK. Offshore Wind Farms. Available at: www.renewableuk.com
6 The Scottish Government, Marine Scotland. Draft Plan for Offshore Wind Energy in Scottish Territorial Waters. Available at: www.scotland.gov.uk
7 As estimated by The Carbon Trust in their report ‘Future Marine Energy’, 2006
8 ‘UK Wave & Tidal Key Resource Areas Project - Summary Report’, The Crown Estate (October 2012)

Further, the first full scale grid connected test centre - the European Marine Energy Centre (EMEC) - was established in Orkney in 2003. To date, 41 wave and tidal sites have been leased around the UK, with a total potential capacity of approximately 2GW, which is believed to be more than any other country. This development pipeline is helping the UK to build and maintain a global lead in wave and tidal energy.

2.2.2 Wave and tidal energy transmission infrastructure

Given the expected scale and location of currently identified wave and tidal sites, the grid infrastructure required to connect these to the onshore networks can be expected to be similar in nature to the AC transmission infrastructure described within this document for offshore wind (proximity to the coast suggests that HVDC solution will be unlikely in the UK). It should be noted that the scale of the devices and arrays which are currently grid connected is small (less than 5 MW) and the foreseeable planned arrays of 8 - 10MW will require smaller cable and substation infrastructure. Further information on potential grid infrastructure requirements in the Pentland Firth and Orkney Waters was published by The Crown Estate in 2012[9].

Wave and tidal sites that have been leased to date are shown in the following figure:



UK wave and tidal projects *(December 2012) (Source: The Crown Estate)*

9 'Pentland Firth and Orkney Waters Onshore Infrastructure Information Note', 2012

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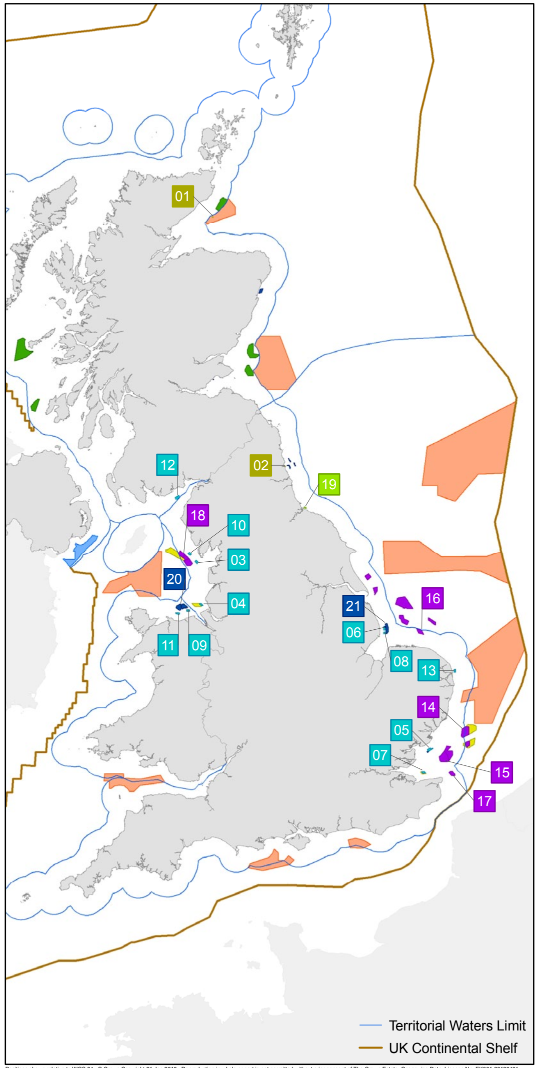
Offshore windfarms in construction or operation



No	Project name	Tenant name	Capacity (MW)
Operational demo sites			
01	Beatrice Demonstrator Site	Talisman Energy Ltd	10
02	Blyth	Blyth Offshore Wind Limited	4
Round 1 operating assets			
03	Barrow	Barrow Offshore Wind Ltd	90
04	Burbo Bank	Dong Energy Burbo (UK) Ltd	90
05	Gunfleet Sands I & II	Gunfleet Sands Limited	172
06	Inner Dowsing	Inner Dowsing Wind Farm Limited	97
07	Kentish Flats	Kentish Flats Ltd	90
08	Lynn	Lynn Wind Farm Limited	97
09	North Hoyle	NWP Offshore Ltd	60
10	Ormonde	Ormonde Energy Limited	150
11	Rhyl Flats	Rhyl Flats Wind Farm Limited	90
12	Robin Rigg (E &W)	E.ON Climate & Renewables UK Robin Rigg East / West Ltd	180
13	Scroby Sands	E.On Climate & Renewables UK Offshore Wind Ltd	60
Round 2 operating assets			
14	Greater Gabbard	Greater Gabbard Offshore Winds Limited	504
15	London Array 1	E.ON Climate & RenewablesUK London Array Ltd, Dong Energy London Array (1 & 2)Ltd, Masdar Energy UK Ltd	630
16	Sheringham Shoal	Scira Offshore Energy Limited	317
17	Thanet	Thanet Offshore Wind Limited	300
18	Walney 1 & 2	Walney (UK) Offshore Windfarms Limited	368
Round 1 assets under construction			
19	Teesside	Teesside Windfarm Ltd	62
Round 2 assets under construction			
20	Gwynt y Mor	Gwynt y Mor Offshore Wind Farm Limited	576
21	Lincs	Lincs Wind Farm Limited	270

Offshore wind farms in construction or operation ***(Source: The Crown Estate (January 2013))***

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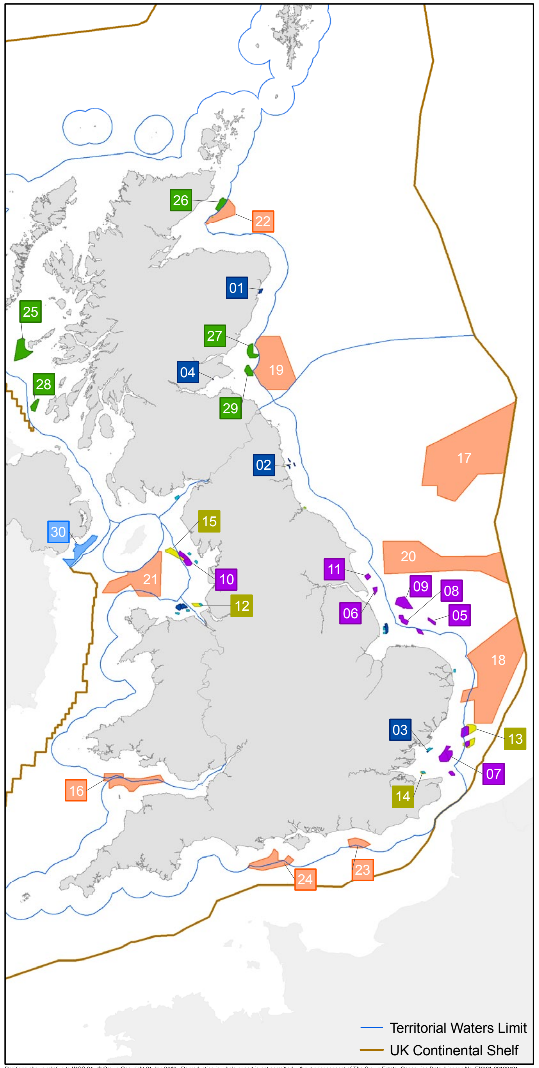
Offshore wind projects under development



No	Project name	Tenant name	Capacity (MW)
Demo sites			
01	Aberdeen Bay European Offshore Wind Deployment Centre	Aberdeen Offshore Wind Farm Ltd	77
02	Blyth Demonstrator Site	Narec (National Renewable Energy Centre)	Up to 100
03	Gunfleet Sands 3	Dong Energy Gunfleet Sands Demo (UK) Limited	12
04	Methil	2-B Energy	12
Round 2 sites			
05	Dudgeon	Dudgeon Offshore Wind Ltd	560
06	Humber Gateway	E.ON Climate & Renewables UK Humber Wind Limited	219
07	London Array 2	E.ON Climate & RenewablesUK London Array Ltd, Dong Energy London Array (1 & 2)Ltd, Masdar Energy UK Ltd	240
08	Race Bank	Centrica (RBW) Limited	580
09	Triton Knoll	Triton Knoll Offshore Wind Farm Limited	900-1200
10	West of Duddon Sands	ScottishPower Renewables (WODS) Ltd and Dong Energy West of Duddon Sands (UK) Ltd	389
11	Westermost Rough	Westermost Rough Limited	210
Round 1 and 2 extension sites			
12	Burbo Bank Extension	Dong Energy Burbo Extension (UK) Limited	258
13	Galloper Extension	SSE Renewables, RWE Npower Renewables	504
14	Kentish Flats Extension	Vattenfall Wind Power Limited	51
15	Walney Extension	Dong Energy Walney Extension (UK) Limited	750
Round 3 zones			
16	Bristol Channel Zone	Channel Energy Limited	1500
17	Dogger Bank	Forewind Ltd	9000-12800
18	East Anglia	East Anglia Offshore Wind Limited	7200
19	Firth of Forth	Seagreen Wind Energy Ltd	3465
20	Hornsea	SMart Wind Ltd	4000
21	Irish Sea	Celtic Array	4185
22	Moray Firth	Moray Offshore Renewables Limited	1300-1500
23	Southern Array	E.ON Climate and Renewables UK Southern Array Limited	665
24	West Isle of Wight	Eneco Round 3 Development Limited	900-1200
Scottish territorial waters sites			
25	Argyll Array	Scottishpower Renewables (UK) Limited	1800
26	Beatrice	Beatrice Offshore Windfarm Limited	920
27	Inch Cape	Seaenergy Renewables Inch Cape Limited	905
28	Islay	Islay Offshore Winds Limited	690
29	Neart na Gaoithe	Neart Na Gaoithe Offshore Wind Limited	450
Northern Ireland sites			
30	Northern Ireland Offshore Wind Resource Area	First Flight Wind	600

Offshore wind projects under development ***(Source: The Crown Estate (January 2013))***

3 Electrical connection scenarios

3.1 Overview of scenarios

It is clear from the overall policy framework, leasing opportunities and developer interest that offshore wind, wave and tidal electricity generation is set to expand significantly over the coming decades. Once generated offshore, the electricity needs to be transported by subsea cables to the coast and then across land by buried cables or overhead lines to the nearest connection point with the national electricity transmission system(s) and ultimately to end consumers. Therefore the electricity generated by offshore renewable energy projects contributes to the electrical supply of the whole country.

There is more than one way that a new connection can be made to the transmission or distribution system, depending on a variety of technical, financial and environmental factors. To aid the reader of this document in understanding the different potential connection options, a number of typical infrastructure design scenarios have been developed. They are by no means intended to be exhaustive, and the connection requirements and infrastructure needs will vary based on project specifics. However, these scenarios have been chosen to cover a range of possible circumstances.

The principal variables across the scenarios included in this document are:

- The location of the onshore substation for the offshore energy generation site (i.e. adjacent to a substation belonging to the Onshore Network Operator[10], or separate from it, most likely adjacent to the submarine cable landfall);
- The complexity of the onshore substation; and
- Whether alternating current (AC) or direct current (DC) is used for the transmission from offshore energy generation site to shore (please refer to Section 3.3.1 for a full explanation of these options).

The following seven scenarios are utilised in this document:

A	Connection directly to Onshore Network Operator Substation (AC)
B1	Connection to Onshore Network Operator substation, with a new neighbouring substation (AC)
B2	Connection to Onshore Network Operator substation, with a new neighbouring substation (DC)
C1	Connection to Onshore Network Operator substation, with a new separate substation (AC)
C2	Connection to Onshore Network Operator substation, with a new separate substation (DC)
D1	Tee-connection to existing Onshore Network Operator overhead line, with a new separate substation (AC)
D2	Tee-connection to existing Onshore Network Operator overhead line, with a new separate substation (DC)

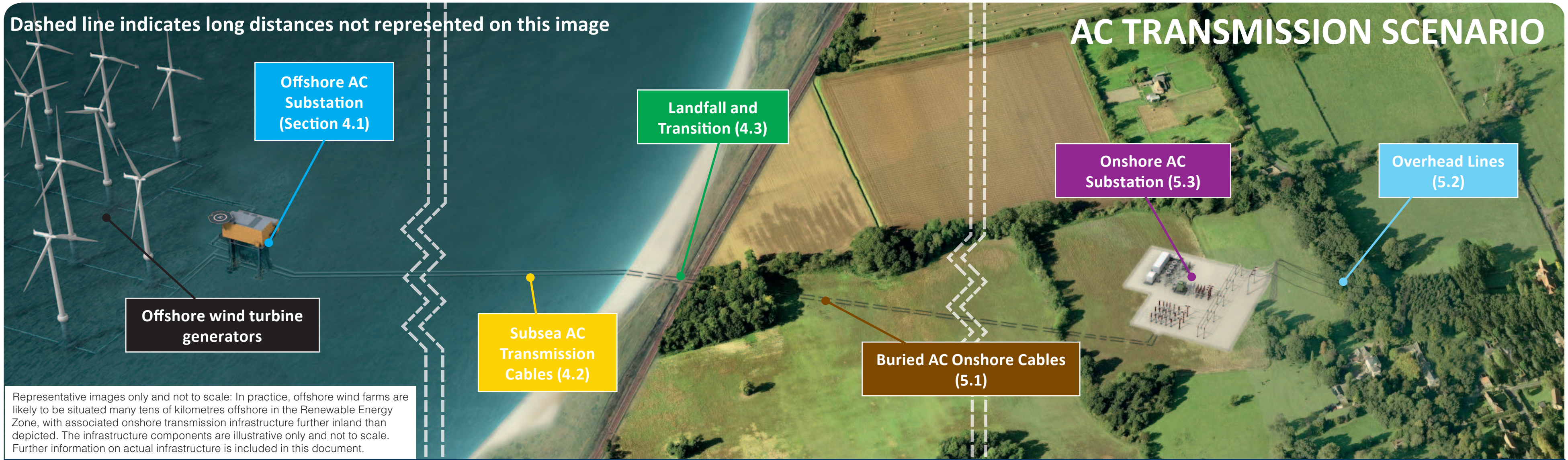
Each of these connection scenarios is described in further detail in Appendix VI. However, in order to provide a visual representation of how these could look, two scenarios (B1 and B2) are illustrated below. These show the connection of an offshore wind farm with an AC connection and with a DC connection. In both cases, connection is via a buried cable to a new inland substation adjoining a new / existing Onshore Network Operator's substation, which connects to the onshore transmission network.

The two scenarios illustrated on the following page should neither be seen as typical nor optimal. Other scenarios, including ones outside the seven identified, may be used in practice.

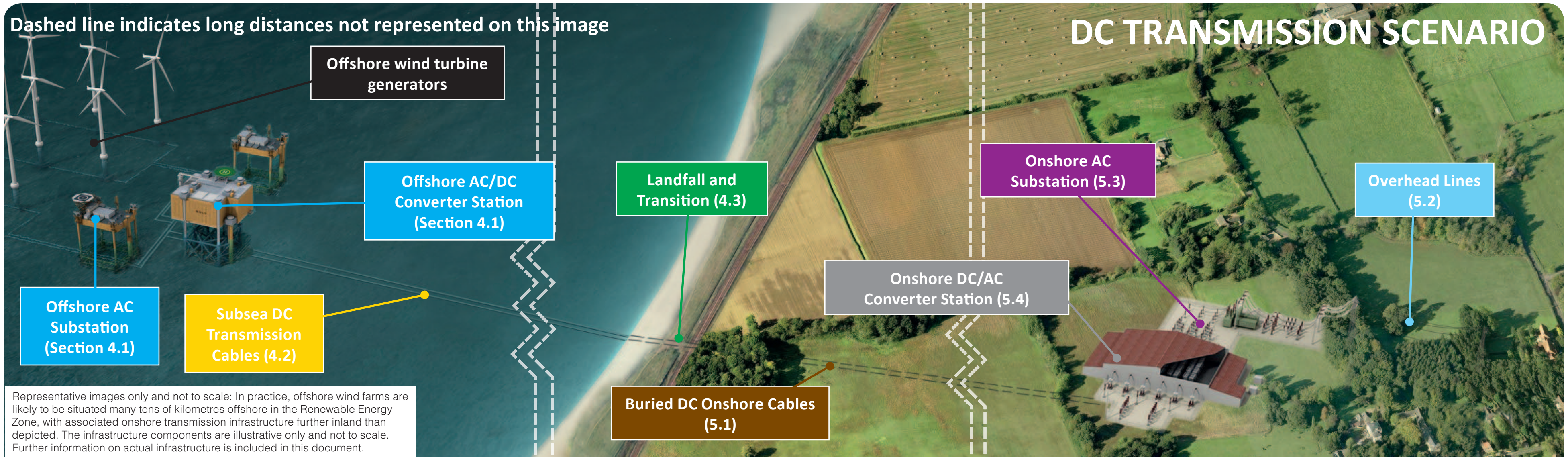
Source: Royal HaskoningDHV

10 Onshore Network Operators are responsible for the onshore transmission and distribution networks in Great Britain. The term is used here to avoid having to distinguish between transmission and distribution. Transmission networks operate at voltages of 275 and 400 kV, and also 132 kV in Scotland. Distribution networks operate at lower voltages. See section 7.2 for further details.

3.2 Example scenarios



Connection in AC to the onshore electricity system, with a new substation *(Source: Royal HaskoningDHV adapted from a Siemens image)*



Connection in DC to the onshore electricity system, with a new converter station *(Source: Royal HaskoningDHV adapted from a Siemens image)*

3.3 Factors affecting design

3.3.1 Alternating current (AC) and direct current (DC)

Traditionally, AC is used for transmission of electricity at high voltages onshore, and local distribution of electricity to consumers at lower voltages. High-voltage DC transmission (HVDC) has had relatively limited application, and has typically been limited to point-to-point transmission over long distances, to interconnect two electricity systems operating at different frequencies, or to build a transmission link through submarine environment.

For subsea AC cables, costs increase rapidly as distance increases, because longer AC cables need to have a wider cross-sectional area and other mitigation measures to deal with undesirable extra current[11]. AC cables also suffer from extra power losses due to the extra current.

HVDC transmission can be more expensive for shorter connections because it requires converter stations at each end of the cable, but for power transmission in the range relevant for large scale offshore wind (i.e. in the region of 1000MW+) HVDC may be cost competitive compared to AC transmission at longer distances. This builds in the cost of electrical losses as well as the costs of the offshore AC/DC converter stations, which are significantly larger than an AC offshore substation. The use of HVDC may also provide benefits in control of power flows and voltages, and better response to disturbances, which may be valuable to the electricity system operator.

Commercial HVDC technology is still for point-to-point transmission, i.e. a ‘two-terminal’ system. Technology to allow more than two points to be interconnected with DC is feasible but is still to be demonstrated commercially. Similarly, inter-operability of equipment from multiple suppliers is still to be demonstrated at commercial scale.

Developers will determine the most appropriate transmission technology type based on the specific characteristics of their projects.

3.3.2 Transmission designs, overhead lines and buried cables

Electricity transmission and distribution networks are designed to transfer electrical energy from generators to consumers. Reliability is a very strong ‘design driver’, because the costs and impacts of failing to provide energy on demand are very high. Therefore networks are designed to be able to continue to meet demand with one or more concurrent failures, or other ‘contingencies’, usually by providing multiple paths or redundant equipment: for example, two transformers in a substation, each capable of independently meeting most of the expected electricity demand on that substation.

Capital cost is also important. For a given amount of power expected to flow between points on the network, there will be an optimum voltage which balances the costs of insulation (which increases with voltage) and conductor size (which decreases with voltage). Network designers seek to choose optimum voltage levels, bearing in mind that transformation between voltage levels requires transformers and associated equipment in substations, also with considerable costs. However, some broad standardisation in voltage levels will be beneficial, for example in terms of economies of scale of production, sharing of spares and enhanced safety.

Choices between overhead lines and buried cables are an important issue in project design and are dependent on project specifics. To date, underground cables have typically been used for the short onshore section of an offshore electrical system.

Developers will take factors such as reliability and capital cost considerations into account when planning and developing their projects based on the specific characteristics of their projects.

Source: Royal HaskoningDHV

11 As AC cables carry not only the ‘desired’ current and also an independent and useless ‘capacitive current’ that increases with the length of the cable, the cable cross-sectional area must also increase with cable length to compensate for this additional current, while keeping electrical losses to an acceptable level. Increased cross-sectional area and other mitigation measures increase AC transmission costs.

4 Transmission infrastructure components - offshore

This section provides summaries of the main offshore transmission infrastructure assets based on a range of typical connection scenarios, including the purpose and function of the infrastructure, images of typical infrastructure and potential environmental, socio-economic and technical considerations.

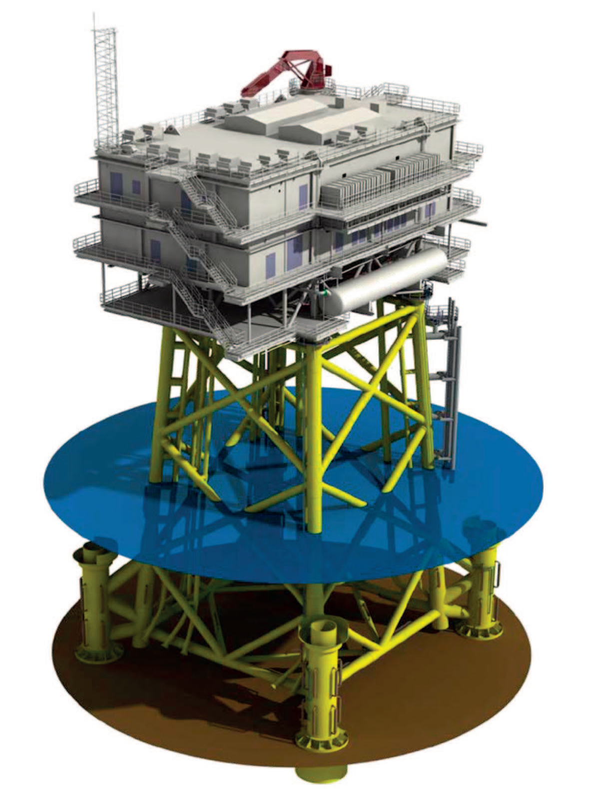
4.1 Offshore AC substation and AC/DC converter station

4.1.1 Description of offshore AC substation

Description of infrastructure	
Purpose	To provide the same functions as onshore electrical substations: switching devices to connect or disconnect equipment, protection equipment to respond to faults, and transformation to higher voltages for either transmission to shore or feeding an AC/DC converter station.
Description	Offshore AC substations, often simply called offshore substations, are offshore platforms containing electrical components to connect an offshore energy generation project (for example, multiple wind turbines) to the onshore electricity network or to an AC/DC converter station (see Description of offshore AC/DC converter station). In terms of appearance, offshore substations build on the years of experience of the offshore oil and gas industry, and the most common designs use a platform consisting of a 'topside' in which the main equipment is housed, and a foundation structure, which is either a steel lattice 'jacket' structure, a 'monopile' structure, or a gravity base structure. Depending on the project (the generating capacity, the area over which it is located, and the distance to shore), there may be more than one offshore substation for one wind farm.

An example offshore AC substation with monopole foundation (170MW) - Gunfleet Sands Offshore Wind Farm *(Source: Royal HaskoningDHV)*

Description of infrastructure	
Typical dimensions[12]	Offshore AC substations vary in size depending on the capacity of offshore wind farm to be connected. An example of a jacket and topside structure: **Thanet offshore AC substation (300 MW) (see image on page 11)** Topside Dimensions: approximately 30m x 30m x 15m (LxWxH); Total Weight = 1,250 tonnes *[Source: SLP Engineering Website]* See Images of offshore AC substation. This is typical of an offshore AC substation. Dimensions of other offshore AC substations are unlikely to fall outside the range of minus 25% or plus 50% of this size.
Specifications and technical considerations	The specifications of offshore AC substations are highly project-dependent. Typically they will be based on considerations such as: ■ Required on-board equipment for substation; ■ Water depth at substation location; ■ Personnel accommodation requirements (if applicable); ■ Access requirements (via air/sea) as applicable; ■ Structural guidelines imposed by authorities; and ■ Project-specific platform installation requirements.
Installation	Jacket support structures are installed by lifting, generally from a barge, using a heavy-lift crane vessel. This and the topsides lift are generally the heaviest lifts on an AC offshore wind project, which may decide the size of the crane vessels used. The jacket structure is then pinned to the seabed by piling. Monopile support structures are installed by driving a large-diameter pile to the required depth, using a piling rig installed on a jackup vessel, and then installing on top an intermediate fabricated steel structure or 'transition piece'. This is leveled and may be grouted in place. Gravity-base support structures are generally made of concrete, and installed by lifting as for jacket structures. The seabed needs to be leveled beforehand. Gravity-base structures may be transported to site by barge, or may be floated. For all support structure options, the topsides are installed from a barge by heavy-lift crane equipped on the barge or on a separate vessel.
Operation and maintenance	Operations will likely all be carried out remotely, most likely from shore. However, there may be scope in the future for permanently manning offshore for O&M purposes. Maintenance is likely to be carried out by vessel or helicopter but is likely to be less frequently than is required for wind turbines. Most maintenance will be limited to inspection, and minor actions such as taking oil samples of transformers. Replenishment of fuel for standby diesel generator may be required infrequently.



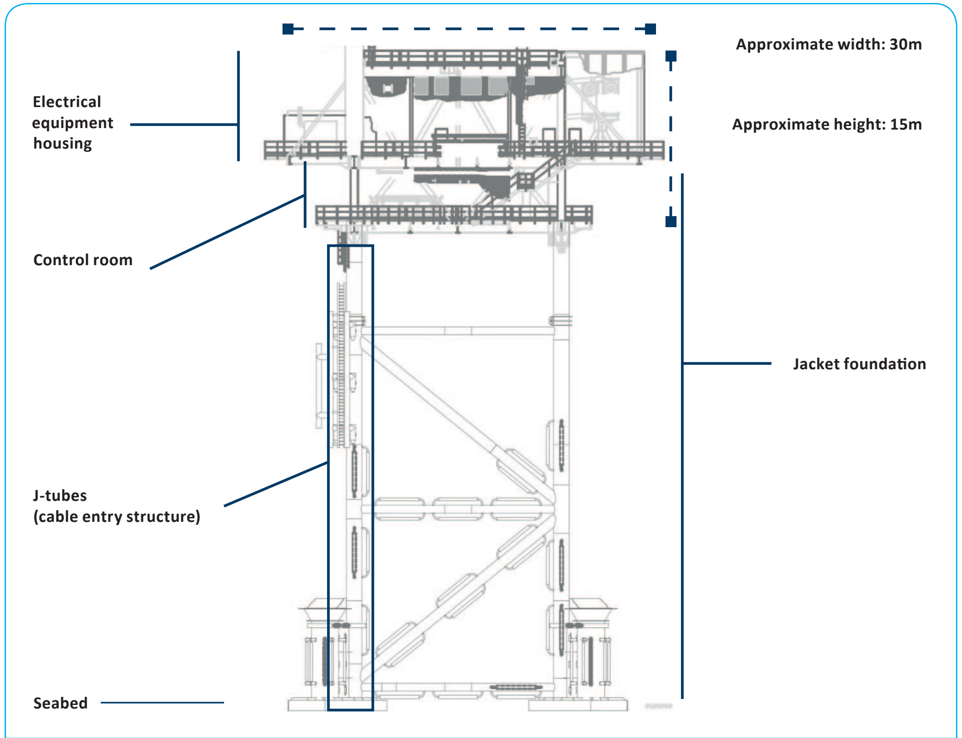
An example of an offshore AC substation *(Source: DONG Energy)*

12 Typical dimensions are included in this document to provide an indication of the potential size and scale of the infrastructure. The ranges do not indicate a fixed minimum and maximum for the piece of infrastructure being described.

4.1.2 Images of offshore AC substation

This subsection provides a range of images of offshore AC substation platforms.

An example offshore AC substation (300MW) with jacket foundation - Thanet Offshore Wind Farm *(Source: Royal HaskoningDHV)*



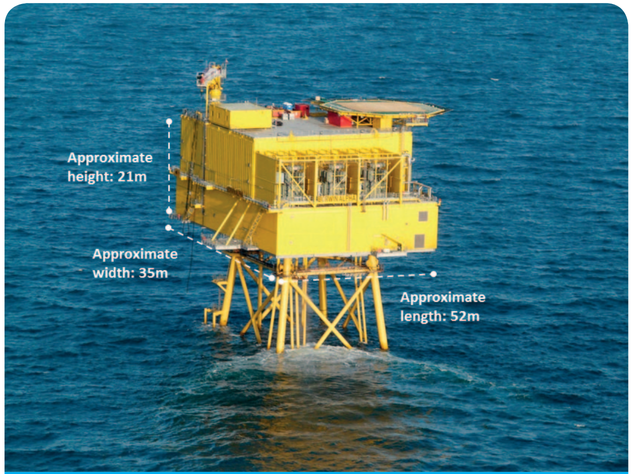
Offshore AC substation elevation *(Source: Royal HaskoningDHV)*

4.1.3 Description of offshore AC/DC converter station

Description of infrastructure	
Purpose	To convert power from AC to High Voltage DC (HVDC) for transmission to shore. They are only needed for projects which deploy HVDC assets.
Description	Offshore AC/DC converter stations are offshore platforms similar to offshore AC substations as discussed in the preceding subsection. They contain power-electronic converters to convert the power generated by the wind turbines in AC to DC, for transmission to shore. They are likely to be larger than offshore AC substations. In terms of appearance, offshore converter stations build on the years of experience of the offshore oil and gas industry and offshore AC substation projects. Offshore converter stations consist of a 'topside' in which the main equipment is housed, and a foundation structure, which is most likely a steel lattice 'jacket' structure. Monopiles or gravity base structures as discussed in the previous subsection for offshore AC substations are also possible, but less likely, because of the larger size of converter stations. Depending on the project generating capacity and design, there may be one offshore converter station, fed by one or more offshore AC substations nearby.
Typical dimensions[13]	Offshore AC/DC converter stations vary in size depending on the capacity of wind farms to be connected. An example of an offshore converter station: **HelWin2 HVDC offshore converter station (690 MW).** Topside Dimensions: 98m x 42m x 28 m (LxWxH); Total Weight = 10,000 ~ 10,500 tonnes, *[Source: Heerema Fabrication Group Website]* This is much larger than the example offshore AC substation given in the previous subsection, because it contains AC to DC conversion equipment. There are few offshore converter stations in service, and dimensions of others could be significantly different. HVDC technology is also developing rapidly, so size could change significantly in future.
Specifications and technical considerations	The specifications of offshore converter stations are highly project-dependent. Typically they will be based on considerations such as: ■ Required on-board equipment; ■ Water depth at location; ■ Accommodation requirements (if applicable); ■ Access requirements (air/sea) as applicable; ■ Structural design requirements imposed by regulatory and certification authorities; and ■ Project-specific platform installation requirements.

4.1.4 Images of offshore AC/DC converter station

Currently few examples exist as this is an emerging technology offshore. As such, plans and elevations are not typically available. However, given certain similarities to offshore AC substations, please refer to plans and elevations in Section 4.1.2 as a proxy.



An example offshore converter station (with jacket foundation) - Borwin Alpha Platform (400MW) ***(Source: TenneT)***

13 Typical dimensions are included in this document to provide an indication of the potential size and scale of the infrastructure. The ranges do not indicate a fixed minimum and maximum for the piece of infrastructure being described.

Description of infrastructure	
Installation	Jacket support structures are installed by lifting, generally from a barge, using a heavy-lift crane vessel. This and the topsides lift are generally the heaviest lifts on an offshore wind project. The jacket structure is then pinned to the seabed by piling. Monopile support structures are installed by driving a large-diameter pile to the required depth, using a piling rig installed on a jackup vessel, and then installing on top an intermediate fabricated steel structure or 'transition piece'. This is leveled and may be grouted in place. Gravity-base support structures are generally of concrete, and installed by lifting as for jacket structures. The seabed needs to be leveled beforehand. Gravity-base structures may be transported to site by barge, or may be floated. For all support structure options, the topsides are installed from a barge by a heavy-lift crane.
Operation and maintenance	Operations will likely all be carried out remotely, most likely from shore. However, there may be scope in the future for permanently manning offshore for O&M purposes. Maintenance is likely to be carried out by vessel or helicopter, but is likely to be less frequently than required for wind turbines. Most maintenance will be limited to inspection, and minor actions such as taking oil samples of transformers. Replenishment of fuel for standby diesel generator may be required infrequently. Replacement of some power electronics component of the converter may also take place during planned maintenance.

Offshore converter station (right) ***(Source: TenneT)***

Source: Royal HaskoningDHV

4.1.5 Environmental and socio-economic considerations during construction of offshore AC substations and AC/DC converter stations

The following subsections outline environmental and socio-economic factors that may need to be considered in relation to offshore AC substations and AC/DC converter stations, during construction and operation.

Occurrence of these will depend on project and location specifics. Suitable mitigation may be applied based on the specific characteristics (subject to the baseline environment, project characteristics and impact identified), and should be identified during the EIA and pre-construction phases of development. In relation to mitigation that may be applied to offshore substations, an example is undertaking a geophysical magnetometer survey to identify any unknown heritage assets. Should any assets be identified an exclusion zone will be established and piling will be located outside this area.

Where potential impacts are identified for a specific project, mitigation measures may be implemented to avoid or reduce the impact. An example of a mitigation measure for an offshore substation could be undertaking a geophysical magnetometer survey during the EIA to identify any previously unknown heritage assets that could be impacted by piling. If the survey findings are negative this would reduce the risk of encountering archaeology during the construction phase, whilst a positive result would allow the option of an exclusion zone to be established, with all piling activity located outside this area.

Environmental and socio-economic considerations	
Archaeology and heritage	■ Potential loss of or damage to known and unknown buried heritage
Commercial fisheries	■ Potential restricted access to fishing grounds as a result of safety exclusion areas during construction. ■ Potential displacement to other grounds to avoid gear interactions with structures ■ Collision risk with structure (safety aspects)
Fish and shellfish	■ Potential noise from piling - (e.g. behavioural response, lethal effects or physical injury) ■ Potential habitat loss or disturbance to especially bottom dwelling species such as sand eel which are important prey species for birds, marine mammals and fish ■ Potential increased suspended solids and sediment deposition affecting respiration in bottom dwelling and spawning species e.g. sand eel
Marine and physical processes	■ Scour from seabed foundations (piles) during operational phase have the potential to alter physical processes and sediment structure
Marine and water sediment quality	■ Potential re-suspension of sediments and associated hazardous substances ■ Potential for accidental spillage from construction vessels
Marine ecology and nature conservation	■ Potential habitat loss or disturbance to especially sensitive/designated habitats e.g. reefs and associated species which may take time to recover ■ Potential increased suspended solids and sediment deposition around the construction site may affect epibenthic species especially those which are filter feeders
Marine mammals	■ Potential noise from piling - behavioural response, displacement from natural habitat and possible feeding areas, physical injury to hearing organs ■ Collision risk
Ornithology	■ Potential displacement due to disturbance of construction from offshore feeding sites to other areas e.g. herring gull, great cormorant etc. ■ Potential loss of feeding grounds for on-passage (migrating) species e.g. dunlin, knot and others ■ Potential loss of prey species e.g. sand eel for migratory species such as Arctic Tern
Other marine users	■ Construction vessels and helicopter flights may cross other users transit routes e.g. dredging, oil and gas operations and freight

Environmental and socio-economic considerations	
Seascape and visual	■ Potential lighting of compounds ■ Potential for seascape to change
Shipping and navigation	■ Potential increased collision risk

4.1.6 Environmental and socio-economic considerations during operation of offshore AC substations and AC/DC converter stations

Environmental and socio-economic considerations	
Archaeology and heritage	■ Potential damage to unknown buried heritage from maintenance and repair activity e.g. anchoring
Commercial fisheries	■ Potential restricted access to fishing grounds due to structures permanently present ■ Potential collision risk with structure (safety aspects)
Fish and shellfish	■ Potential electromagnetic fields (as part of cable distribution) ■ Potential creation of artificial rocky habitat
Marine and physical processes	■ Scour from seabed foundations have the potential to alter physical processes (localised for one substation) and species associated with particular seabed habitats
Marine and water sediment quality	■ Potential for accidental spillage from structures during operation
Marine ecology and nature conservation	■ Potential habitat disturbance to seabed due to maintenance and repair activity ■ Scour and associated increases in suspended sediments if scour protection is absent may affect benthic and epibenthic communities especially suspension (filter) feeders and plankton (high turbidity)
Marine mammals	■ Potential collision risk ■ Potential electromagnetic fields (as part of cable distribution) - behavioural changes
Ornithology	■ Potential displacement of breeding and feeding birds or those on-passage (migrating) species due to structures present ■ Potential loss of feeding grounds especially species depending on fish species associated with specific substrates e.g. sand eels ■ Potential loss of prey species
Other marine users	■ Operational vessels and helicopter flights may cross other users transit routes such as dredgers, oil and gas operations and freight
Seascape and visual	■ Potential lighting of compounds ■ Potential for seascape to change
Shipping and navigation	■ Potential increased collision risk ■ Potential cable interference with radar ■ Potential re-routing required ■ Search and rescue (SAR)

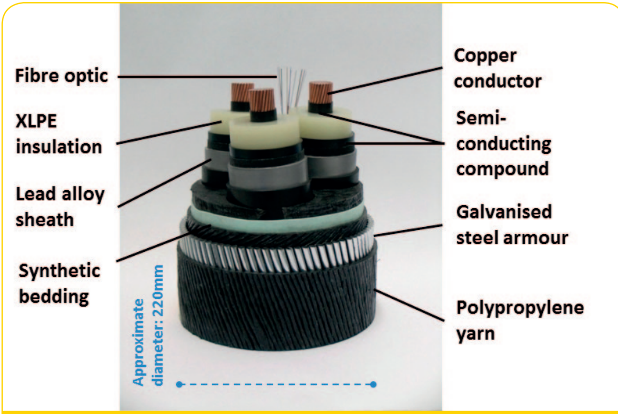
4.2 Subsea transmission cables

4.2.1 Description of subsea transmission cables

Description of infrastructure	
Purpose	To transfer the power from the offshore AC substation or the offshore AC/DC converter station to shore. Commonly called 'export cables', to distinguish from the smaller 'inter-array cables' which connect the wind turbines to each other and to the offshore substation(s). Depending on project design, there may also be a requirement for cables between substation platforms (if there are more than one). For the purposes of this document, any cables between substations are considered similar to export cables.
Description	Either AC or DC subsea transmission cables may be used for this purpose, depending on the project. For AC, 3-core cables are used, i.e. three separate conductors are enclosed in a single cable. For a DC connection, pairs of cables (a 'bipole' arrangement) are required, one with a positive polarity conductor, and another a negative polarity conductor[14]. The cables in this case are a single core construction. Depending on the project, there may be multiple cables (or multiple pairs of cables, for DC), from each offshore AC substation or AC/DC converter station. For both AC and DC, the voltage of the connection to shore will be chosen to optimise costs. Higher voltages which result in lower energy losses but are more expensive are justified by larger projects and greater distance from shore.
Typical dimensions[15]	Examples of cable sizes typically used are listed below. [Source: various cable manufacturers] 132 kV (AC) 3 core 800mm² Copper conductor cables: ■ Capacity: Approximately 175 MVA ■ Diameter: 214mm ■ Weight: 87 kg/m 220 kV (AC) 3 core 1000mm² Copper conductor cables: ■ Capacity: Approximately 330 MVA ■ Diameter: 258mm ■ Weight: 117 kg/m +/- 300 kV HVDC: 2 x single 2000mm² Copper conductor cables: ■ Capacity: Approximately 1030 MW ■ Diameter: 280 mm each ■ Weight: 106 kg/m each

4.2.2 Images of subsea transmission cables[16]

4.2.2.1 Cables



AC cable (220 kV) *(Source: Prysmian Group)*

HVDC cable (200 kV) *(Source: Prysmian Group)*

14 It is possible for HVDC transmission to be achieved with a single cable. This may cause greater electromagnetic fields. In this case, the return path is provided by current flowing through the sea or through the earth. This may be considered as a short-term measure when there is a failure of one cable or its associated equipment.
15 Typical dimensions are included in this document to provide an indication of the potential size and scale of the infrastructure.
16 Both AC and DC cables are illustrated

Description of infrastructure	
Specifications and technical considerations	The specifications of subsea export cables are project-dependent. Typically they will be based on considerations such as: ■ Transmission distance required; ■ Required capacity of link; ■ Required burial depth of cables; ■ Thermal resistivity of sea bed where cable will be installed; ■ Project-specific armouring requirements; and ■ Ducted sections en route, and impact on cable thermal capacity (see Description of landfall and transition). The heat released from electrical losses in operation is very small. However thermal issues are 'design-drivers' for buried cables: the size and cost of the cable required will depend on the heat dissipation that can reliably be achieved. This is particularly difficult in dry sandy soils (particularly landfalls on beaches and dunes), and in ducts (particularly vertical ducts or 'J-tubes' at the connections to the offshore substation). Depending on cable protection measures implemented, the cable may be exposed by movement of sand, and is then subject to current forces. The cable is vulnerable to damage from trawling and anchors. Protection is primarily achieved by burying the cable in the seabed beyond the penetration depth of fishing gear and anchors, but in some circumstances (including where burial to a suitable depth is not possible) protection can be provided by dumping rock on top of the cables or through plastic or concrete protection mats. Spacing between groups of cables from different phases of an offshore project, or from adjacent projects, may be affected by the current or possible future ownership of the cables. If there are multiple cables with potentially different owners, it is likely that larger spacing will be required between the cables to provide adequate separation of the cables for future maintenance and repair access.
Installation	Installation of cables is from a ship or barge, using an installation tool, to plough, jet or excavate a trench. Backfilling may be accomplished during cable installation, or in a second pass, or may occur naturally. Cables can be manufactured and transported in sufficient lengths to reach the shore without jointing, except for the most distant offshore projects. Joints may also be required close to the landfall, where a cable with a larger cross-section may be required for the beach section. Jointing is achieved on the cable-laying vessel or on a separate vessel or jackup barge. The joint is a few metres long and is slightly larger in diameter than the cable, but needs no additional support structure or protection, and is buried on the seabed in the same manner as the rest of the cable. After laying, inspection may be carried out by remotely-operated vehicles (ROVs) or divers.
Operation and maintenance	Limited to visual inspection to detect unsatisfactory burial or cable exposure at offshore substation or along route. Some online condition monitoring may be implemented. Cable failures require substantial mobilisation of vessels, equipment, space and staff.

Source: Royal HaskoningDHV

4.2.2.2 Cable-laying vessel

Cable-laying vessel *(Source: Prysmian Group)*

Cable-laying barge *(Source: Visser Smit Marine Contracting VSMC (Photographer Carel Kramer))*

4.2.2.3 Subsea cable plough[17]

Subsea cable plough ready to bury cables offshore *(Source: Royal HaskoningDHV)*

Cable plough and subsea cable *(Source: Hughes Sub-surface Engineering Ltd.)*

17 Cable ploughs are used to bury cables both offshore and onshore.

4.2.2.4 Cable burial - remotely operated vehicle[18]

Cable trenching ROV *(Source: Soil Machine Dynamics Ltd.)*

Cable trenching ROV prior to deployment *(Source: Soil Machine Dynamics Ltd.)*

18 ROVs are used to carry out inspections of cables once installed ROVs (trenching ROV in particular) may also be used during cable installation.

4.2.3 Environmental and socio-economic considerations during installation of subsea transmission cables

The following subsections outline environmental and socio-economic factors that may need to be considered in relation to subsea transmission cables, during construction and operation.

Occurrence of these will depend on project and location specifics. Suitable mitigation may be applied based on the specific characteristics (subject to the baseline environment, project characteristics and impact identified), and should be identified during the EIA and pre-construction phases of development. For example, to avoid collisions between cable laying vessels and other shipping, consultation will be undertaken through various means, including shipping and fishing publications. A 'notice to mariners' will subsequently be issued with the location and programme for installation; this will be updated as and when necessary.

Environmental and socio-economic considerations	
Archaeology and heritage	■ Potential loss of or damage to known and unknown buried heritage due to corridor excavation by ploughing or trenching
Commercial fisheries	■ Potential restricted access fishing grounds during excavation due to buffer zones around the cable corridor ■ Potential for temporary displacement of fishing vessels to other grounds thus putting pressure on other operators ■ Potential displacement of static gear fisheries (potting) inshore ■ Potential temporary disturbance or damage to commercially exploited shellfish beds
Fish and shellfish	■ Potential habitat loss or disruption to seabed communities ■ Potential increase in suspended solids and deposition. Can cause smothering of seabed communities
Marine and water sediment quality	■ Potential re-suspension of sediments and hazardous substances due to excavation ■ Potential for accidental spillage from construction vessels
Marine ecology and nature conservation	■ Potential habitat loss or disruption ■ Potential temporary increase in suspended solids and deposition may affect seabed communities
Marine mammals	■ Potential temporary displacement to other areas (construction activities) ■ Potential collision risk
Ornithology	■ Potential loss of prey species in offshore feeding grounds
Other marine users	■ Potential damage to other subsea cables ■ Potential cable and pipeline crossings
Shipping and navigation	■ Potential for increased collision risk ■ Potential anchor snagging on unburied cable

4.2.4 Environmental and socio-economic considerations during operational phase of subsea transmission cables

Environmental and socio-economic considerations	
Archaeology and heritage	■ Potential damage to unknown buried heritage from maintenance and repair activity e.g. anchoring
Commercial fisheries	■ Potential electro-magnetic fields (EMF) interference with navigation instruments ■ Potential unburied cables (snagging towed gear)
Fish and shellfish	■ Potential EMF (as part of cable distribution)
Marine and water sediment quality	■ Potential re-suspension of sediments and hazardous substances during major cable repair activities ■ Potential for accidental spillage from cable repair vessels
Marine ecology and nature conservation	■ Potential habitat disturbance due to maintenance and repair activity
Marine mammals	■ Potential EMF (as part of cable distribution) - behavioural changes especially migratory patterns
Other marine users	■ Potential damage to other subsea cables due to operational activities e.g. anchoring
Shipping and navigation	■ Potential increased collision risk with maintenance and repair vessels ■ Potential interference with communications due to EMF

4.3 Landfall and transition pit

4.3.1 Description of landfall and transition pit

Description of infrastructure	
Purpose	To bring the subsea cables to shore, and connect to buried onshore cables or overhead lines
Description	Landfall can be achieved through a variety of methods depending on the individual circumstances at the coast. For example the landfall works might consist of a Horizontal Directional Drilling (HDD) section, whereby directional boring is carried out from the onshore side (e.g. under a sea defence wall) to install cable ducts. A similar image of the HDD process is included in Subsection 5.1.2.7. Trenching is likely to be used for some of the route and may be feasible for the entire route. Where there is danger of physical damage to the cable, ducts may be installed in the trench. Above high water or high tide, precautions will be taken against accidental excavation of cables and ducts, for example by installing cable warning tape or possibly high-density plastic cable tiles installed directly above the cable. Cable landfall diamond signs will also be installed on posts at high water, to mark the landfall to vessels. As noted previously, adequate heat dissipation from the cables may be particularly difficult on dry soils at landfalls and in ducts. This may require use of a larger cable size for the landfall section, with a subsea joint to the main cable length, below low water mark. At the land end, a transition pit is typically constructed, consisting of a shallow chamber in which the submarine cables can be connected to the onshore cables. This is typically backfilled with sand and protected by a suitable cover. At the transition pit each 3-core AC cable from offshore is normally changed to 3 single core AC cable for continuation in land. It is feasible for the subsea cables to be connected directly to an overhead line, rather than to buried onshore cables in a transition pit. In this case the cables would be led up out of the ground onto a wood pole or lattice steel tower, terminated, and connected to the overhead line conductors. This arrangement is more likely to be found on high voltage interconnectors connecting directly to the transmission network, or for the connection of smaller wave and tidal devices connecting directly to an 11kV line for example.
Typical dimensions[19]	Length depends on the distance from High Water mark to Low Water mark. Cable burial depth is typically a few metres. Parallel cables may typically require spacing of 2m, though this is highly dependent on soil conditions. The transition pit may be 10m x 5m per cable, by 2m deep.

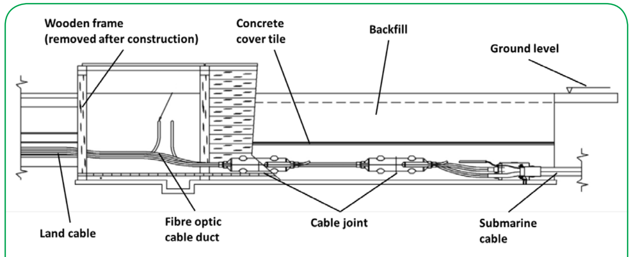
Cable barge and plough at landfall ***(Source: Visser Smit Marine Contracting VSMC (Photographer Carel Kramer)***

19 Typical dimensions are included in this document to provide an indication of the potential size and scale only. Actual sizes will depend on specifics of the project.

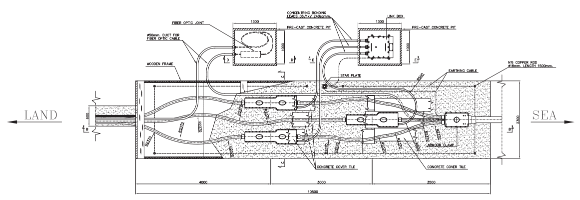
Description of infrastructure	
Specifications and technical considerations	Specifications are location-dependent. Choice of landfall site is heavily dependent on soil conditions, topography and other location-specific issues. Technical considerations are limited to respecting maximum bend radii[20] for the cables, and ensuring adequate passive cooling of the cables in operation. Where an offshore wind project is to be developed in phases, it may be preferable to build the landfall works to accommodate the intended final project size: for example, installing cable ducts adequate for all phases of the project, though only installing cables for the first phase. This may be preferable because the overall cost is lower if done as one activity, or to limit the disturbance to habitats and to traffic and local residents, or to prevent the need for future excavation close to live cables. Spacing between groups of cables from different phases of an offshore project, or from adjacent projects, may be affected by the current or possible future ownership of the cables (see Offshore Transmission Owners (OFTOs) in Subsection 7.1.5). If there are multiple owners, with separate legal agreements for the cable routes, it is likely that larger spacings will be required to facilitate future maintenance and inspection.
Installation	For trenching, standard excavation equipment will be used to dig a trench, typically to a minimum 1m depth, from below the low-water mark to well above the high-water mark. If no protective duct is required, the buried onshore cable(s) will be laid in the bottom of the trench and covered with a protective layer of sand or cement-bound sand, before the trench is re-filled with the remainder of the excavated material. If ducts are required, these will be installed with bedding and selected backfill material if necessary. There are often technical reasons why trenching is not recommended. Typical examples include existing sea defences, where dunes cannot be disturbed or due to coastal processes such as erosion. In these cases, HDD will typically be used. A pit will be dug well above the high-water mark, and a specialised drilling rig will be installed in the pit to drill at an oblique angle under the beach. The direction of the drill bit is controlled during drilling so that it emerges where required. Plastic ducting is then drawn back through the hole from the lower end (which may be from a barge at sea) to the drilling rig The construction compound for the HDD drilling equipment may extend to 40 m x 40 m unless restricted by site conditions Where ducts have been installed, by trenching or HDD, the cables are then drawn through the ducts by a winch. The transition pit is constructed of concrete using standard civil engineering equipment. Jointing of cables within the pit requires temporary weather protection.
Operation and maintenance	Limited to occasional inspection. Cable failures will require rapid fault finding and repair. Excavation will be required at the point of fault, and it is possible that some temporary weather protection and a compound may be required while the cable is repaired.

4.3.2 Images of landfall and transition pit.

Cable barge and plough at landfall ***(Source: Visser Smit Marine Contracting VSMC (Photographer Carel Kramer))***



Elevation of a transition pit during construction ***(Source: Prysmian Group)***



Plan view of a transition pit ***(Source: Prysmian Group)***

20 This is a measure of cable flexibility, as defined by the radius of the arc created by the cable once it is bent to its maximum.

4.3.3 Environmental and socio-economic considerations of landfall and transition during construction

The following subsections outline environmental and socio-economic factors that may need to be considered in relation to landfall and transition, during construction and operation.

Occurrence of these will depend on project and location specifics. Suitable mitigation may be applied based on the specific characteristics (subject to the baseline environment, project characteristics and impact identified), and should be identified during the EIA and pre-construction phases of development. For example, dependent of ground conditions, different installation methods can be considered at landfall to reduce the impact on marine and inter-tidal ecology. A faster installation method can be used to ensure installation is undertaken during the autumn/ winter to minimise the impact on breeding birds. A slower installation methodology may be more appropriate where the area of habitat disturbance must be minimised, for example salt marsh.

Environmental and socio-economic considerations	
Archaeology and heritage	■ Potential loss of or damage to known and unknown buried heritage due to corridor excavation by ploughing or trenching
Commercial fisheries	■ Temporary disturbance or damage to inshore shellfish species such as lobster
Fish and shellfish	■ Potential habitat loss or disruption to inshore seabed communities ■ Potential increase in suspended solids and deposition (smothering) can impact upon some inshore seabed communities
Marine and intertidal ecology and nature conservation	■ Potential disruption to intertidal habitats and benthic species ■ Potential increase in suspended solids and smothering (deposition)
Marine and water sediment quality	■ Potential re-suspension of sediments and release of hazardous substances due to excavation ■ Potential for accidental spillage from construction equipment
Ornithology	■ Landfall sites may be protected areas due to breeding bird species or those overwintering e.g. oyster catcher ■ Potential loss of prey species in feeding grounds
Shipping and navigation	■ Potential for collision with cable excavation vessels in transit
Other marine users	■ Proximity to other cable landfall routes ■ Cable and pipeline crossings ■ Potential disruption to marine recreation activities

4.3.4 Environmental and socio-economic considerations of landfall and transition elements during operational phase

Environmental and socio-economic considerations	
Archaeology and heritage	■ Potential damage to unknown buried heritage from maintenance and repair activity e.g. anchoring
Fish and shellfish	■ Potential EMF impacts on certain species of fish
Marine and intertidal ecology	■ Potential disturbance to seabed and intertidal areas due to maintenance and repair activity
Other marine users	■ Potential disruption to marine recreation activities during maintenance and repair

Source: Royal HaskoningDHV

5 Transmission infrastructure components - onshore

5.1 Buried onshore transmission cables

5.1.1 Description of buried onshore cables

Description of infrastructure	
Purpose	To transfer the power from the offshore wind farm and connect from landfall or transition pit to the onshore electricity network.
Description	Usually in the case of AC, 3 single core cables are used onshore, unlike 3-core cable used offshore. This is mainly for heat dissipation consideration. For DC, the DC cable types used onshore are very similar to their offshore counterparts. Horizontal Directional Drilling (HDD) works may be required for the crossing of roads, railways, rivers and canals. Jointing bays may be required where cables are jointed, similar to the transition pits described in Description of landfall and transition. See also Images of onshore trenching equipment.
Typical dimensions[21]	Similar to subsea transmission cables, though for AC, three smaller single-core cables are used. Each group of three cables (AC) or two cables (DC) will typically require a corridor of up to 1.5 m width, and further spacing between parallel groups of around 2m. These dimensions are dependent on design and soil conditions. The installation of the cable onshore generally takes place in trenches with a cover of 0.8m - 1.2m deep.

Cable ducting prior to trench infill (132kV) ***(Source: Royal HaskoningDHV)***

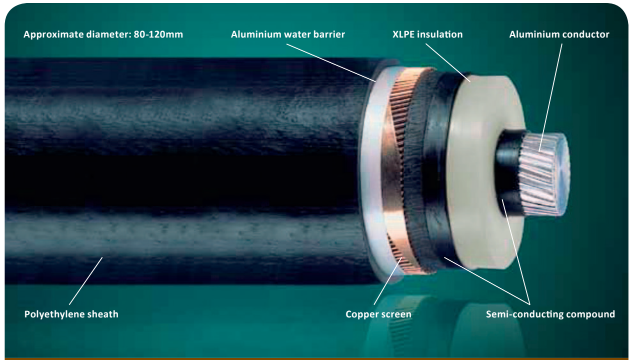
21 Typical dimensions are included in this document to provide an indication of the potential size and scale of the infrastructure. Actual sizes will depend on specifics of the project.

Description of infrastructure	
Specifications and technical considerations	The specifications of buried onshore cables are project-dependent. Typically they will be based on considerations such as: ■ Required capacity of link; ■ Required burial depth of cables; ■ Ambient temperature conditions at cable laying depth; ■ Thermal resistivity of ground where cable will be installed; ■ Project-specific armouring requirements; and, ■ Ducted sections on route, and impact on cable capacity. Technical considerations include heat dissipation and cable protection. ■ The heat released from electrical losses in operation is very small, but as noted previously, adequate heat dissipation from the cable is a design-driver; and ■ The cable is vulnerable to damage from agricultural activities such as ploughing. Ducts may be used. Spacing between groups of cables from different phases of an offshore project, or from adjacent projects, may be affected by the current or possible future ownership of the cables. If there are or may be different owners, with separate legal agreements for the cable routes, it is likely that larger spacings will be required.
Installation	Standard civil engineering equipment is used to excavate a trench, followed by installation of cable or ducts from cable drums, with fine bedding material or sand where necessary. The cables are then covered with more sand or selected excavated material. The trench is then backfilled with excavated material, and the surface reinstated. For sections along roads, traffic management will be required. Where extensive runs of ducts are used, cable will be installed by winch from stationary drums, through manholes at points where the ducts change direction. As indicated previously, Horizontal Directional Drilling (HDD) may be used for the crossing of roads, railways, rivers, canals and sensitive areas (e.g. designated sites).
Operation and maintenance	Limited to inspection where feasible, for example in joint bays or inspection chambers. Some online condition monitoring is possible. Cable failures will require rapid fault-finding and repair. Excavation will be required at the point of fault and possibly some temporary weather protection and compound while the cable is repaired.

Image of buried cable route (road crossing) 1-2 years after construction
(Source: Royal HaskoningDHV)

5.1.2 Images of onshore buried cable

5.1.2.1 Cables[22]



Buried AC cable (220kV)[23] *(Source: ABB Limited.)*

Cable ducting prior to trench infill (132kV) *(Source: Royal HaskoningDHV)*

5.1.2.2 Images of buried onshore cables in ducts

An example three-duct cable arrangement during trenching (132kV) *(Source: Royal HaskoningDHV)*

22 DC Cables are identical to their offshore counterparts. AC onshore cables use single core rather than three-core cables.
23 An aluminium conductor is shown in the picture as an example but a copper conductor can also be used.

5.1.2.3 Images of cable drums during transportation

Cable drums *(Photo at Sheringham Shoal taken by CHPV and supplied by Scira Offshore Energy)*

5.1.2.4 Landscape after cable trenching[24]

Image of buried cable route (agricultural land) 1-2 years after construction *(Source: Royal HaskoningDHV)*

24 The current state of the environment post-trenching can be observed in the images.

5.1.2.5 Images of onshore trenching equipment[25]

Onshore Trencher *(Source: Royal HaskoningDHV)*

Onshore trencher during operation *(Source: Royal HaskoningDHV)*

25 Trenchers excavate the trench prior to cable laying and burial.

5.1.2.6 Images of jointing bays[26]

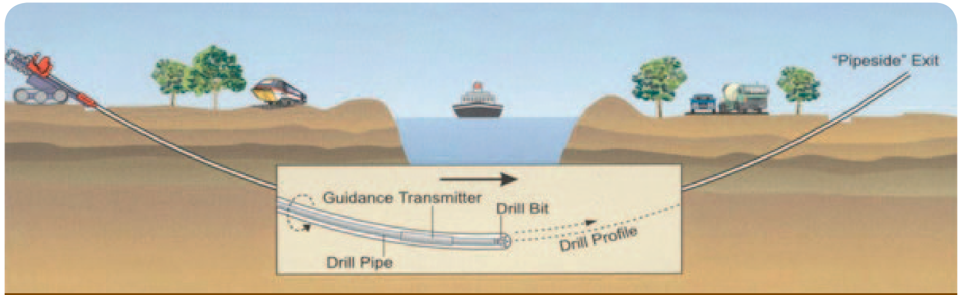
Jointing bay during construction showing temporary shuttering *(Source: Balfour Beatty PLC)*

Temporary jointing container *(Source: ABB Limited)*

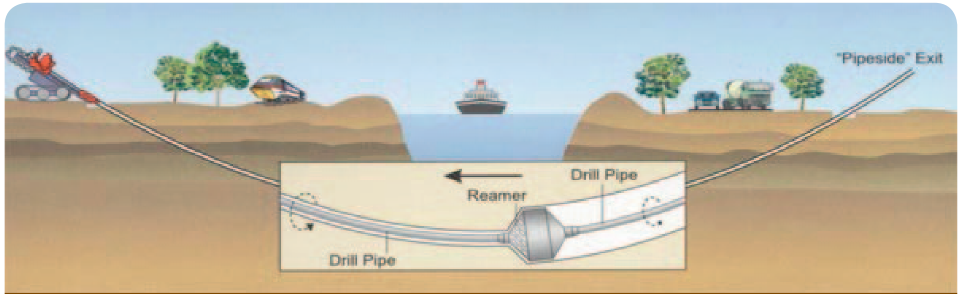
26 Jointing is the process of coupling two sections or lengths of cable together to create one continuous cable.

5.1.2.7 Images of horizontal directional drilling[27]

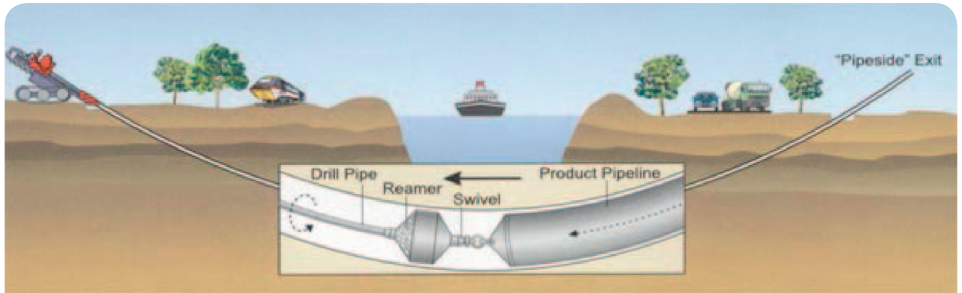
An example of HDD drilling rig *(Photo at Sheringham Shoal taken by CHPV and supplied by Scira Offshore Energy)*



Process diagram HDD drilling Phase 1 *(Source: Balfour Beatty PLC)*



Process diagram HDD drilling Phase 2 *(Source: Balfour Beatty PLC)*



Process diagram HDD drilling Phase 3 *(Source: Balfour Beatty PLC)*

27 Horizontal directional drilling (HDD) is a technique used to lay cables beneath surface obstacles.

5.1.3 Environmental and socio-economic considerations during installation of buried cable systems

The following subsections outline environmental and socio-economic factors that may need to be considered in relation to onshore buried cables, during construction and operation.

Occurrence of these will depend on project and location specifics. Suitable mitigation may be applied based on the specific characteristics (subject to the baseline environment, project characteristics and impact identified), and should be identified during the EIA and pre-construction phases of development. For example, water crossings can be achieved during cable installation through a number of different methods, each with different environmental advantages and disadvantages. Horizontal directional drilling may be employed to ensure no surface impact on the integrity of a river for example.

Environmental and socio-economic considerations	
Archaeology and cultural heritage	■ Potential direct loss of or damage to known and unknown buried heritage
Land quality	■ Potential disturbance of previously contaminated land, potential transportation of contaminates (by physical movement, water and air) and the impact on human health and ecology ■ Potential for land contamination from construction activities, in particular the storage and use of oil and the use of bentonite for drilling or filling ducts
Land use and soils	■ Potential for land to be temporarily lost from existing use or agricultural production ■ Potential degradation or loss of soil resource
Local community	■ Potential nuisance and disturbance principally through additional traffic, noise, dust and visual impacts ■ Potential for temporary closures or diversions of Public Rights of Way ■ Use of local contractors during construction
Noise and vibration	■ Potential noise and vibration from construction traffic and equipment, especially at compounds and drilling locations
Terrestrial ecology and nature conservation	■ Potential degradation or loss of important habitats (e.g. ponds, hedgerows, woodland, watercourses, grassland) ■ Potential loss or disturbance of protected or notable species (in particular: water vole, otter, badger, great crested newts, reptiles and breeding birds) ■ Potential adverse effects on designated (statutory and non-statutory) nature conservation sites
Traffic and access	■ Access to private and public land potentially restricted ■ Potential road closures and diversions ■ Potential for increased traffic with associated noise and vibration impacts
Water resources	■ Potential water contamination and associated risks to humans and riparian ecology from construction activities using oil, bentonite or other harmful substances ■ Potential sedimentation and increase in turbidity of watercourses during open cut cable installation or from adjacent soil storage and trench areas, particularly during wet periods

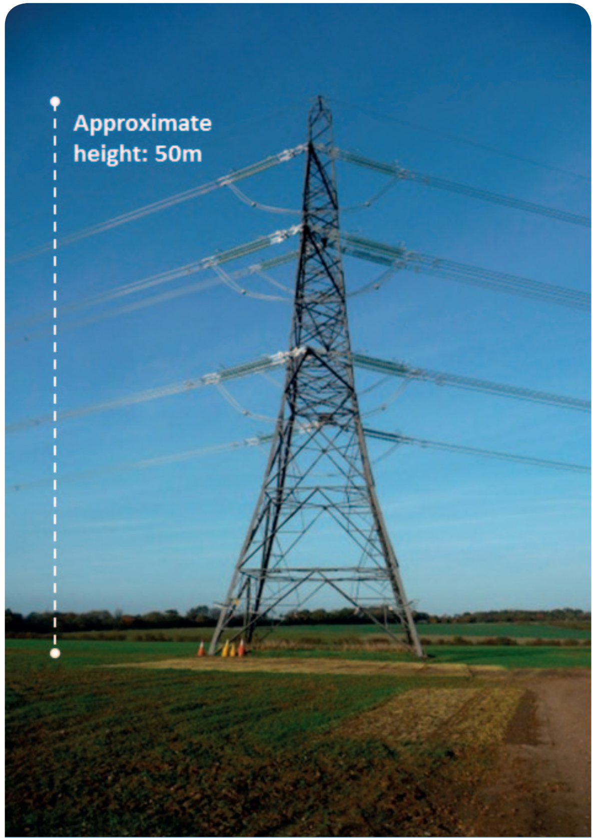
5.1.4 Environmental and socio-economic considerations during operational phase of buried cable systems

Environmental and socio-economic considerations	
Land use and soils	■ Potential soil heating from electrical cables at full rating, which may alter crop growth ■ Potential restricted crop growth through the physical presence of the cable in-situ ■ Reinstatement of land to previous condition - can include enhancement measures
Local community	■ Potential for community concern regarding electromagnetic fields ■ Potential health and safety concerns regarding electric current
Traffic and access	■ Where cables are buried beneath roads, surface may be uneven or require additional remediation works

5.2 Overhead lines

5.2.1 Description of tower-based overhead lines[28]

Description of infrastructure	
Purpose	To transmit electrical power on land.
Description	One or two sets of three bare conductors in the case of AC or two conductors in the case of DC[29] are supported by lattice steel towers ('pylons'), with steel cross arms carrying insulators. In all cases an earth wire is installed between the tops of the towers for lightning protection. A new 'T'-type tower design has recently been proposed as a result of a national design competition. This is tubular rather than lattice construction, with typically lower height and lower visual impact. However this has not yet completed the trial or demonstration stage, and is not expected to be in use in the near future.
Typical dimensions[30]	A typical 275 kV or 400 kV overhead line on National Grid's system will be approximately 40m to 50m in total height, depending on the ground clearance used. The total width of the tower at its widest point will be approximately 15-20m. The distance between towers will depend on the topography and climate, but on flat terrain will be of the order of 200-300m.
Specifications and technical considerations	Standard specifications have been developed by the electricity transmission and distribution industry. Design is affected by the terrain and environmental conditions, particularly wind and ice loads. Ground clearance in rough terrain is particularly important, and must be maintained when conductors stretch at higher temperatures. Stronger and larger towers are required at changes in direction. Towers on a straight section can be lighter ('tension towers'). Electromagnetic fields are much reduced by use of overhead lines rather than AC cables. In both cases, the installation's EMF levels can be designed to comply with the relevant exposure limits for the public.
Installation	Standard civil engineering equipment is used for excavation and construction of foundations (4 per tower, typically 2m x 2m x 2m, depending on ground conditions). Cranes are used for erection of the lattice towers, though in most cases it is feasible to use 'rising derricks' (i.e. lifting equipment attached to the partially-completed tower), rather than tall cranes, as the maximum component weight is not great. On rough or sensitive terrain, special vehicles may be used to reach the tower sites. In remote terrain, helicopters may be used for transport of heavy components. Insulators and other fittings may be installed by crane or rising derrick. Conductor is installed using winches and pulleys, from cable drums. Special equipment is required for installation over roads, railways and waterways.
Operation and maintenance	Regular visual inspection, for damage and tree growth. Tree cutting may be required periodically.



An example tension tower in profile (400 kV) *(Source: Paul Vertigen)*

28 It is very rare to use wood poles for transmission overhead lines above 33kV (although there may be some instances in the UK). For this reason, only tower based overhead lines are included in this document.
29 There are currently no DC overhead lines in use in the UK public electricity networks, but there are examples in other countries.
30 Typical dimensions are included in this document to provide an indication of the potential size and scale of the infrastructure. The ranges do not indicate a fixed minimum and maximum for the piece of infrastructure being described. Actual sizes will depend on specifics of the project.

5.2.2 Images of tower lines

An example tension tower (400kV) arrangement in a rural setting *(Source: National Grid)*

An example junction and corner tower (400kV) *(Source: National Grid)*

5.2.3 Environmental and socio-economic considerations of overhead lines during construction

The following subsections outline environmental and socio-economic factors that may need to be considered in relation to overhead lines, during construction and operation.

Occurrence of these will depend on project and location specifics. Suitable mitigation may be applied based on the specific characteristics (subject to the baseline environment, project characteristics and impact identified), and should be identified during the EIA and pre-construction phases of development. For example, siting of towers within existing topography and landscape, avoiding ridges etc. to minimise landscape and visual impacts.

T-pylon design (under development)
(Source: Bystrup Architecture, Design and Engineering)

Environmental and socio-economic considerations	
Archaeology and cultural heritage	■ Potential direct loss of or damage to known and unknown buried heritage ■ Potential setting impacts on heritage assets and the historic landscape
Land use and soils	■ Potential land loss from existing use or agricultural production
Landscape and visual	■ The construction of towers, poles and wire are more likely to have an impact on views and landscape character ■ Where existing features are removed (e.g. trees and woodland) potential for views to change. Screening may be used to mitigate
Local community	■ Potential nuisance and disturbance, principally through additional traffic, noise, dust and visual impacts
Noise and vibration	■ Potential noise and vibration from construction traffic and equipment, especially at compounds and tower locations
Terrestrial ecology and nature conservation	■ Potential degradation or loss of important habitats (e.g. ponds, hedgerows) ■ Potential loss or disturbance of protected or notable species (e.g. water vole, otter) ■ Potential integrity loss of designated nature conservation sites
Traffic and access	■ Access to private and public land potentially restricted ■ Potential road closures and diversions required for delivery of materials and equipment ■ Potential for increased traffic with associated noise and vibration impacts ■ Potential road and pedestrian safety concerns

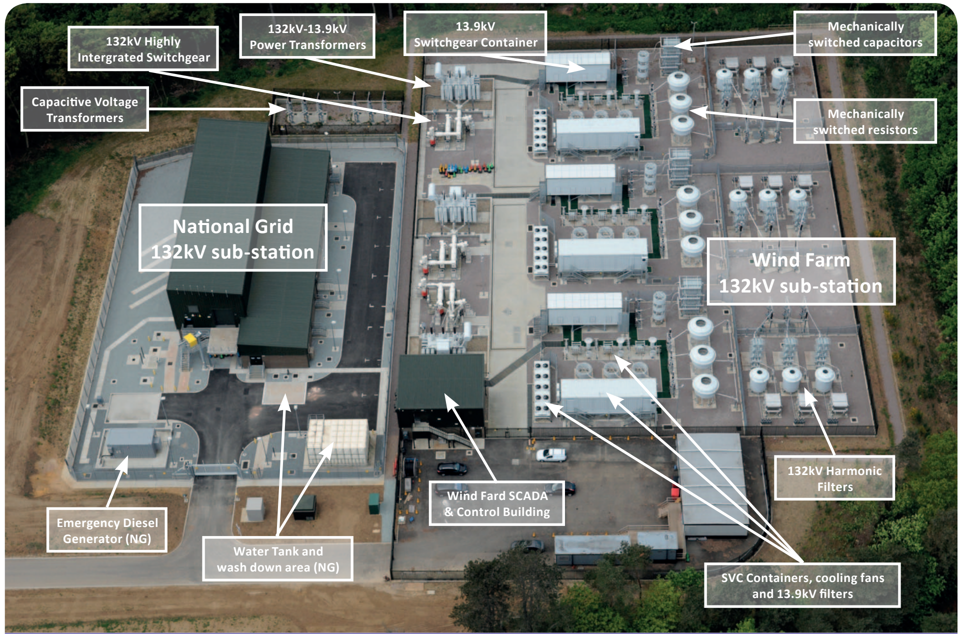
5.2.4 Environmental and socio-economic considerations of overhead lines during operation

Environmental and socio-economic considerations	
Archaeology and cultural heritage	■ Potential setting impacts on heritage assets and the historic landscape
Land use and soils	■ Potential land loss from existing use or agricultural production at tower bases ■ Potential problems with turning field machinery and existing agricultural practices, including ploughing and spraying, due to pylon obstruction
Landscape and visual	■ Potential alteration and disruption of existing views ■ Potential effects on the integrity of landscape designations (e.g. Areas of Outstanding Natural Beauty) ■ Potential alteration of character of area
Local community	■ Potential community concern regarding EMF ■ Radio and television reception may be disrupted locally in certain circumstances ■ Potential health and safety concerns in relation to physical and arced (air-transmission) contact with transmission lines ■ Lines, poles and towers may fall during high winds
Noise and vibration	■ Potential vibration or humming during operation of older lines
Terrestrial ecology and nature conservation	■ Potential adverse effect on the integrity of designated nature conservation sites ■ Potential collision risk of overhead lines to birds and bats, and disturbance during breeding from noise and light associated with maintenance activities

Source: Royal HaskoningDHV

5.3 Onshore AC substations

In this subsection and its subsections, the onshore AC substation and its typical components (as illustrated in the sketch on the following page) are discussed in the following order:

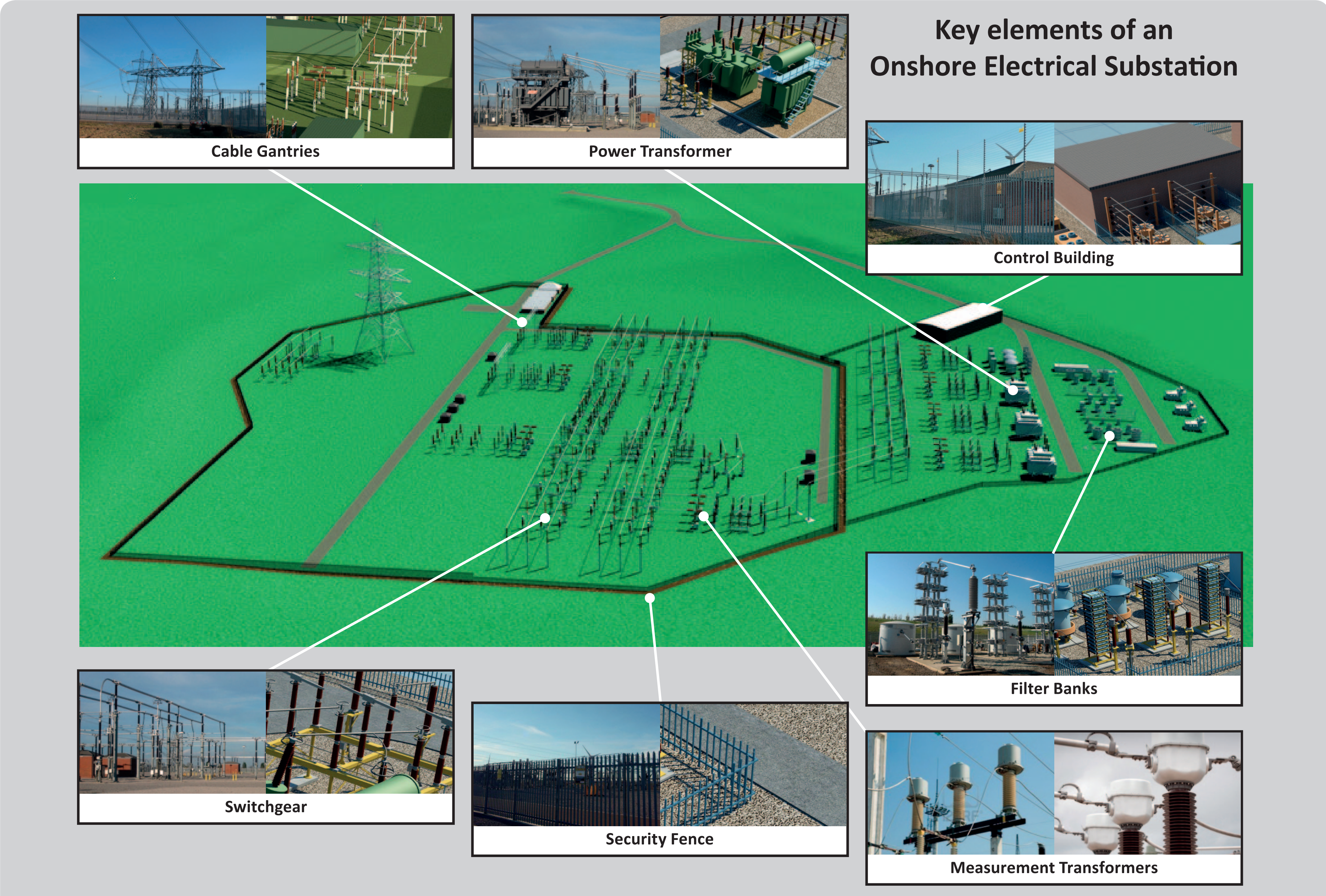


Onshore AC substation (132kV) *(Source: SSE)*

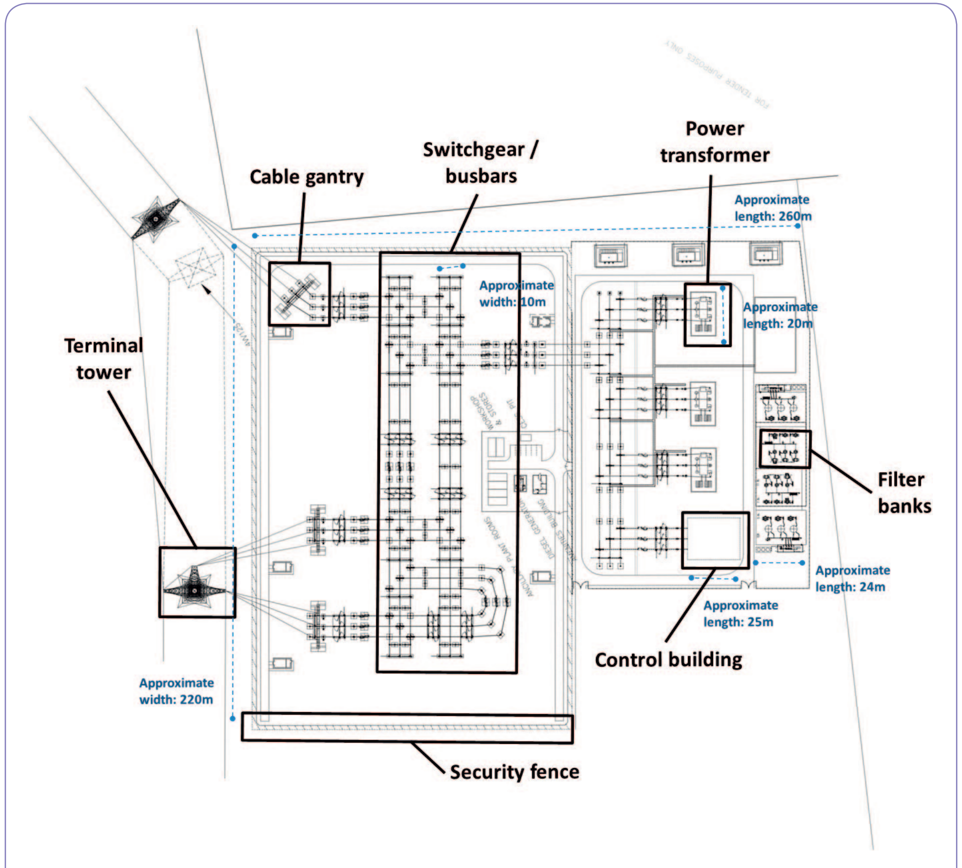
5.3.1 Overview of onshore AC substations

5.3.1.1 Description of onshore AC substations

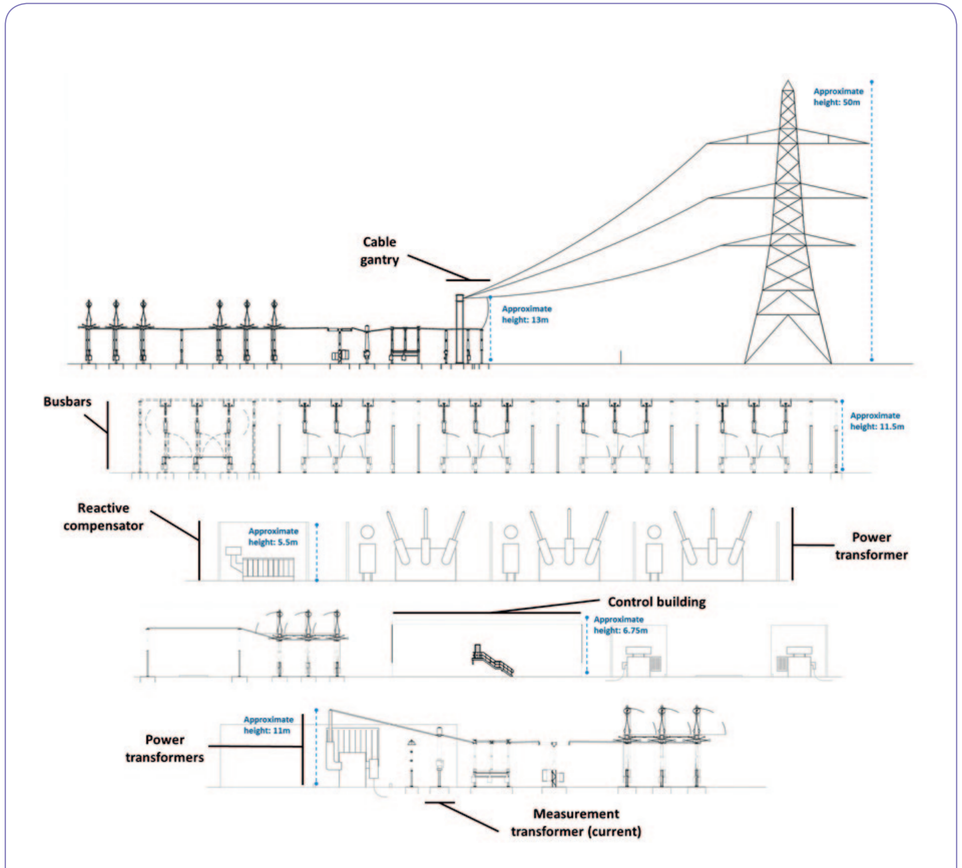
Description of infrastructure	
Purpose	To house electrical equipment for switching and protection of the electrical system. In most cases it also steps up electrical voltages to connect to the onshore electricity transmission system.
Description	Outdoor compound with ground-mounted components and busbar connections. See subsequent sections.
Typical dimensions	Varies greatly depending on applications: see illustrations. Some flexibility for trading height for footprint in restricted locations.
Specifications and technical considerations	Principal factors are voltage level and power rating. See subsequent sections for items contained within the substation.
Installation	Standard civil engineering practice for drainage, foundations, buildings, fences and other structures.
Operation and maintenance	Operation is largely automatic, and other operations can be carried out remotely. Regular visual inspection. Infrequent scheduled maintenance (yearly or less often).



Source: LDA Design on behalf of Dudgeon Offshore Wind Ltd



Example substation plans *(Source: Royal HaskoningDHV adapted from National Grid/ ABB Limited image)*



Cross-sections through an onshore substation *(Source: Royal HaskoningDHV adapted from National Grid image)*

5.3.2 Outdoor switchgear and busbars

This subsection is based on the use of outdoor air-insulated equipment. This is standard practice in the UK electricity industry. However if the site is particularly restricted, or if there is a risk of salt deposits on insulators for a site close to the coast, gas-insulated equipment may be more appropriate (see next subsection). Alternatively, air-insulated equipment as described here may be used inside a large shed.

5.3.2.1 Description of outdoor switchgear and busbars

Description of infrastructure	
Purpose	To interrupt current and to disconnect items of equipment. Busbars provide overhead electrical connections between items of equipment within a substation.
Description	The term ‘switchgear’ here refers to several different components such as disconnecting switches, circuit breakers and earthing switches, which combine to provide a system which provides the required functionality and can be safely operated and maintained. Outdoor switchgear as used in substations takes several forms, but fundamentally takes two forms: ■ Ground-mounted equipment; and, ■ Equipment mounted overhead on support structures. This equipment is interconnected by bare tubular metallic conductors called busbars. These provide the same function as the bare conductors on overhead lines, but as they are rigid, the height above ground can be reduced. The ground clearance is also reduced because access to the substation compound is restricted.
Typical dimensions[31]	The dimensions of the equipment used are highly dependent on the voltage of the equipment, due to vertical and horizontal clearance distance regulations which must be followed to ensure a safe system. Typically the highest components in an outdoor substation compound are the busbars and supporting gantries, at 5 to 15m height. Dimensions of ground-mounted switchgear equipment will typically be 2m wide x 2m long and 3m tall.
Specifications and technical considerations	Specifications vary significantly between different switchgear functions, depending principally on voltage, and the current to be interrupted. Technical considerations relevant to this document are limited to clearance distances required from bare conductors, which determine the heights and appearance of the substation.
Installation	All equipment in this category is installed onto prepared concrete foundations or onto lattice support structures, by relatively small cranes, direct from the delivery vehicle. Transport dimensions and access road dimensions do not exceed normal limits on the UK road network.
Operation and maintenance	Operation from control building or remotely, when required. Regular visual inspection. Infrequent scheduled maintenance (yearly or less often).

5.3.2.2 Images of outdoor switchgear and busbars

An example 400kV substation switchgear and busbars *(Source: Royal HaskoningDHV)*


400kV Air-insulated switchgear / busbars during construction *(Source: Siemens)*

31 Typical dimensions are included in this document to provide an indication of the potential size and scale of the infrastructure. The ranges do not indicate a fixed minimum and maximum for the piece of infrastructure being described. Actual sizes will depend on specifics of the project.

5.3.3 Gas-insulated switchgear

As noted above, gas-insulated equipment may be used if the site is particularly exposed to salt deposits or pollution, or if the site dimensions are very restricted. However it is substantially more expensive.

5.3.3.1 Description of gas-insulated switchgear

Description of infrastructure	
Purpose	To interrupt current and to disconnect items of equipment. Gas-insulated switchgear is more compact than air-insulated switchgear as discussed in the previous section, and is protected against pollution and salt deposits.
Description	The term ‘switchgear’ here refers to several different components such as disconnecting switches, circuit breakers and earthing switches, which combine to provide a system which provides the required functionality and can be safely operated and maintained. Gas-insulated equipment encloses the switching elements in a tank which is pressurised with an insulating gas, sulphur hexafluoride (SF_6). This equipment is interconnected by metallic conductors also insulated in the same way.
Typical dimensions[32]	The dimensions of the equipment used are dependent on the voltage level. For transmission voltages the equipment will typically be 4m tall or less. The footprint will be smaller than equivalent air-insulated equipment.
Specifications and technical considerations	Specifications vary significantly between different switchgear functions, depending principally on voltage, and the current to be interrupted.
Installation	All equipment in this category is installed onto prepared concrete foundations, by relatively small cranes, direct from the delivery vehicle. Transport dimensions and access road dimensions do not exceed normal limits on the UK road network.
Operation and maintenance	Operation from control building or remotely, when required. Regular visual inspection. Infrequent scheduled maintenance (every 10 years, or less frequently).

5.3.3.2 Images of gas-insulated switchgear

Housed gas-insulated switchgear *(Source: Siemens)*

Housed gas-insulated switchgear *(Source: ABB Limited)*

32 Typical dimensions are included in this document to provide an indication of the potential size and scale of the infrastructure. Actual sizes will depend on specifics of the project.

5.3.4 Power transformers

5.3.4.1 Description of power transformers

Description of infrastructure	
Purpose	To transfer AC electrical power from one voltage level to another. In this context, to step up the voltage of the wind farm connection to the voltage of the electricity system to which it is connected.
Description	A large steel tank contains windings made of electrical conductors wound around a steel core, with external electrical connections to overhead lines or cables. Transformers of this scale all use some form of oil as the insulating/cooling medium, and may also include air forced fans to increase the MVA rating (see Glossary) during times of maximum loading, possibly also with separate radiator banks. There may be a separate smaller tank mounted above the main tank, to allow the insulating oil to expand when warm.
Typical dimensions[33]	Example: 400/132/13 kV Auto transformer Cooling: Oil Natural Air Forced, i.e. with fans Weight: 200 tonnes (without oil) Typical dimensions 5m x 3m x 3m. Insulator connections to connect to overhead lines may add 3m to the height. For the highest voltages and power ratings, dimensions will be larger: 7m x 4m x 4m, with a further 4m height if bushings for connection to overhead lines are required.
Specifications and technical considerations	This is usually the heaviest and largest onshore component. Bend radii, gradients and ground clearance requirements may be critical for design of the access road. There is also a risk of failure leading to a fire, and substation design may include walls to prevent damage to neighbouring equipment. Given design requirements, the damage from this would be limited to the immediate area surrounding the transformer. A bund will be necessary around the transformer foundation, sufficient to contain all the oil, in the event of a spillage.
Installation	Access requirements are critical for access road design. Traffic management is likely to be necessary. The transformer is installed onto a concrete foundation, usually by skidding direct from the delivery vehicle. Additional equipment such as radiators, cable terminations and header tanks are then installed, and the transformer filled with oil. Electrical connections are then made. Commissioning can take several days.
Operation and maintenance	Operation is automatic. Regular visual inspection and oil sampling, in addition to online conditioning monitoring. Infrequent scheduled maintenance (yearly or less often).

5.3.4.2 Images of power transformers

An example power transformer tank during installation *(Source: Royal HaskoningDHV)*

An example power transformer *(Source: Royal HaskoningDHV)*

33 Typical dimensions are included in this document to provide an indication of the potential size and scale of the infrastructure. The ranges do not indicate a fixed minimum and maximum for the piece of infrastructure being described. Actual sizes will depend on specifics of the project.

5.3.5 Reactive compensation and filter banks

5.3.5.1 Description of reactive compensation and filter banks

Description of infrastructure	
Purpose	To provide controllable reactive power (see Appendix III: Frequently Asked Questions) to assist with voltage control. To filter out disturbances ('harmonics') on the electrical system before they can affect other users.
Description	Wound components ('reactors') in tanks, capacitor banks and other similar items connected by busbars. May also contain power-electronic equipment such as Static VAR Compensators (SVCs). A wind farm may require one or both of reactive power compensation and harmonic filtering. In some cases, it may be possible to provide both functions from one set of equipment.
Typical dimensions[34]	Varies greatly depending on application. Capacitor banks may be stacked on racks to 5m height or more. Reactors are typically 3m x 3m x 3m. Power-electronic devices are typically contained in prefabricated metallic enclosures similar in size and construction to shipping containers, or else within the control building. Note that the reactors and capacitor banks are typically installed as three identical configurations, one for each phase.
Installation	As for other substation components. No particular difficulties, as these components are generally smaller than other substation components.
Operation and maintenance	Operation from control building or remotely, when required. Regular visual inspection. Infrequent scheduled maintenance (yearly or less often).

5.3.5.2 Images of reactive compensation and filter banks

An example filter bank compound including reactors (in tanks) and capacitor banks (in racks) *(Source: ABB Limited)*

Static VAR compensation reactors providing reactive compensation (400kV) *(Source: National Grid)*

An example filter bank compound with static VAR compensation reactors *(Source: National Grid)*

34 Typical dimensions are included in this document to provide an indication of the potential size and scale of the infrastructure. The ranges do not indicate a fixed minimum and maximum for the piece of infrastructure being described. Actual sizes will depend on specifics of the project.

5.3.6 Measurement transformers

5.3.6.1 Description of measurement transformers

Description of infrastructure	
Purpose	To provide measurements of current and voltage within the substation, for control, protection and metering purposes.
Description	Measurement transformers consist of current transformers (CTs) and voltage transformers (VTs). They are wound components, often contained in an oil-filled tank. Insulating bushings allow connection to cables or overhead conductors.
Typical dimensions[35]	Dimensions vary depending on voltage level, purpose and location. For medium voltage equipment, such as 33kV switchgear, such equipment has a minimal footprint, with a VT panel typically the same size footprint as a normal switchgear panel (e.g. W1m, L1.5m, H2.2m) whilst CTs may be mounted on cables or within the switchgear panels. At higher voltages, the size of such equipment becomes significant and in the case of switchyard layout adds to the overall footprint. A typical 132 kV outdoor CT (single phase) would have dimensions as follows: WxLxH: 0.7 x 0.8 x 2.8m. A 132 kV single phase VT would be of similar dimensions. For both CTs and VTs, three of such components would be required at a standard substation yard (one per phase)
Installation	These components are relatively small compared to other items in the substation compound. Installation by small crane onto steel lattice structures or prepared concrete foundations.
Operation and maintenance	Regular visual inspection. Infrequent scheduled maintenance (yearly or less often).

Voltage measurement transformers *(Source: Royal HaskoningDHV)*

35 Typical dimensions are included in this document to provide an indication of the potential size and scale of the infrastructure. The ranges do not indicate a fixed minimum and maximum for the piece of infrastructure being described. Actual sizes will depend on specifics of the project.

5.3.6.2 Images of measurement transformers

Voltage measurement transformers *(Source: Siemens)*

Current measurement transformer *(Source: Siemens)*

5.3.7 Overhead line gantry

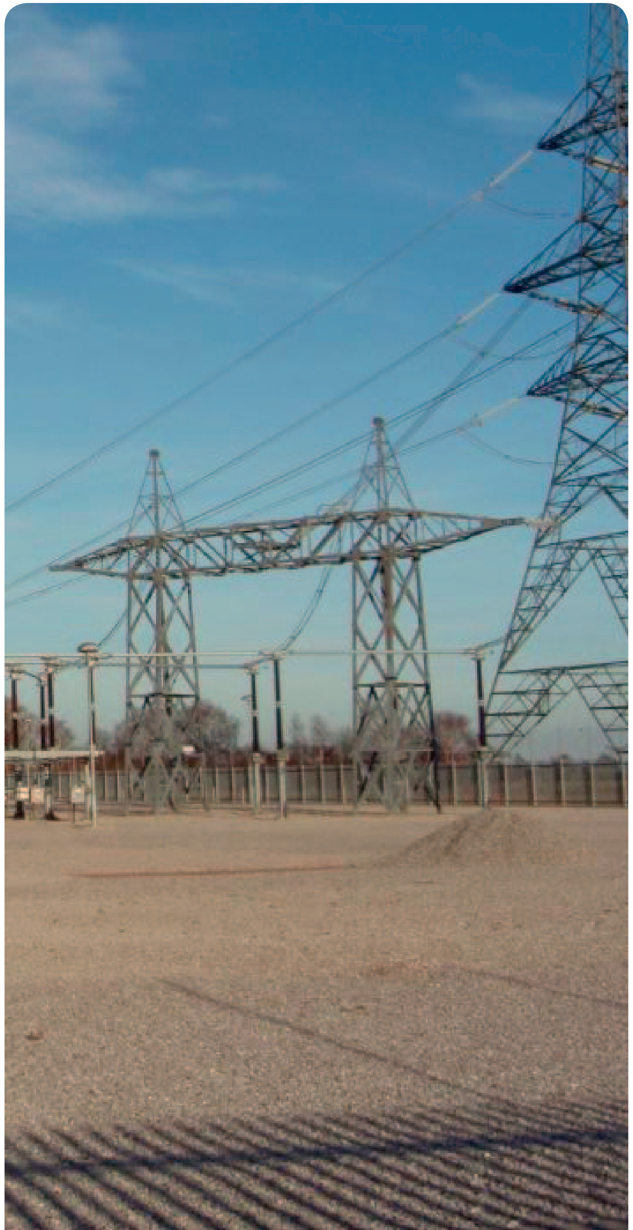
5.3.7.1 Description of overhead line gantry

Description of infrastructure	
Purpose	To carry overhead lines from towers to the substation, i.e. to receive bare overhead conductors from an overhead line and connect to equipment within the substation compound.
Description	Typically a lattice steel portal structure, supporting the overhead conductors via insulators.
Typical dimensions[36]	Depends on voltage level and therefore required clearances between conductors and to ground. Can be 10-15 m tall and 15 m wide. Likely to be the tallest structure within the substation compound, though significantly smaller than transmission towers outside the substation.
Specifications and technical considerations	Determined by structural loads imposed by the conductors, wind and ice.
Installation	Structural steelwork typically assembled on site, and installed prepared concrete foundations by small crane.
Operation and maintenance	Regular visual inspection. Infrequent scheduled maintenance (yearly or less often).

5.3.7.2 Images of overhead line gantry

An example overhead terminal tower (400kV) ***(Source: Royal HaskoningDHV)***

An example overhead line gantry (400kV) ***(Source: Royal HaskoningDHV)***



An example of overhead line gantry (400kV) ***(Source: Royal HaskoningDHV)***

36 Typical dimensions are included in this document to provide an indication of the potential size and scale of the infrastructure. The ranges do not indicate a fixed minimum and maximum for the piece of infrastructure being described. Actual sizes will depend on specifics of the project.

5.3.8 Cable terminations on overhead lines

5.3.8.1 Description of cable terminations on overhead lines

Description of infrastructure	
Purpose	To connect underground cables directly to overhead lines.
Description	Cable sealing ends (insulating bushes) mounted in a compound adjacent to the tower, or on the tower itself at low level, and connected to the overhead line conductors by vertical bare conductors.
Typical dimensions[37]	Cable sealing ends may be 3-4m in height, depending on voltage.
Specifications and technical considerations	None relevant.
Installation	Ground-mounted: Small compound and concrete foundations. Cable sealing ends mounted on concrete foundations using small crane. Tower-mounted: new steel lattice platform added to tower at low level. Cable sealing ends mounted on platform using a small crane. In both cases, the cables are terminated at the cable sealing ends. Bare flexible conductors are run vertically down from the overhead line to terminate on the cable sealing ends. An outage on the line will be needed to make the terminations.
Operation and maintenance	Regular visual inspection. Thermal imaging may be used to detect hot spots and early fault symptoms.

5.3.8.2 Images of cable terminations on overhead lines

Overhead line cable termination (400kV) ***(Source: Royal HaskoningDHV)***

37 Typical dimensions are included in this document to provide an indication of the potential size and scale of the infrastructure. Actual sizes will depend on specifics of the project.

5.3.9 Security and control buildings

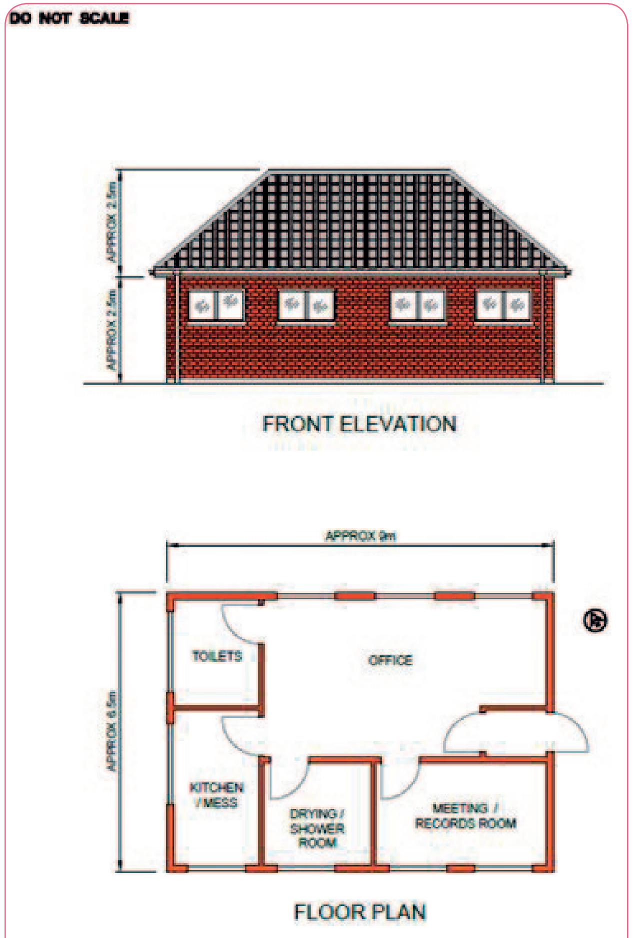
5.3.9.1 Description of security / control buildings

Description of infrastructure	
Purpose	To house relay protection and control cubicles, communications cubicles, indoor switchgear, auxiliary supplies & standby batteries, staff toilet and mess room, stores.
Description	Containing substation control and amenity facilities in a single or two-storey building, often constructed to meet local requirements for vernacular architecture.
Typical dimensions[38]	Single or two-storey, typically 8m x 20m.
Specifications and technical considerations	Standard building practice.
Installation	Standard building practice.
Operation and maintenance	Regular visual inspection. Infrequent scheduled maintenance (yearly or less often).

5.3.9.2 Images of security / control buildings

Typical security fence and control room *(Source: Royal HaskoningDHV)*

Substation control buildings during construction (Source: Royal HaskoningDHV)



Example amenities block *(Source: Warwick Energy)*

38 Typical dimensions are included in this document to provide an indication of the potential size and scale of the infrastructure. The ranges do not indicate a fixed minimum and maximum for the piece of infrastructure being described. Actual sizes will depend on specifics of the project.

5.3.10 Access roads and landscape proposals

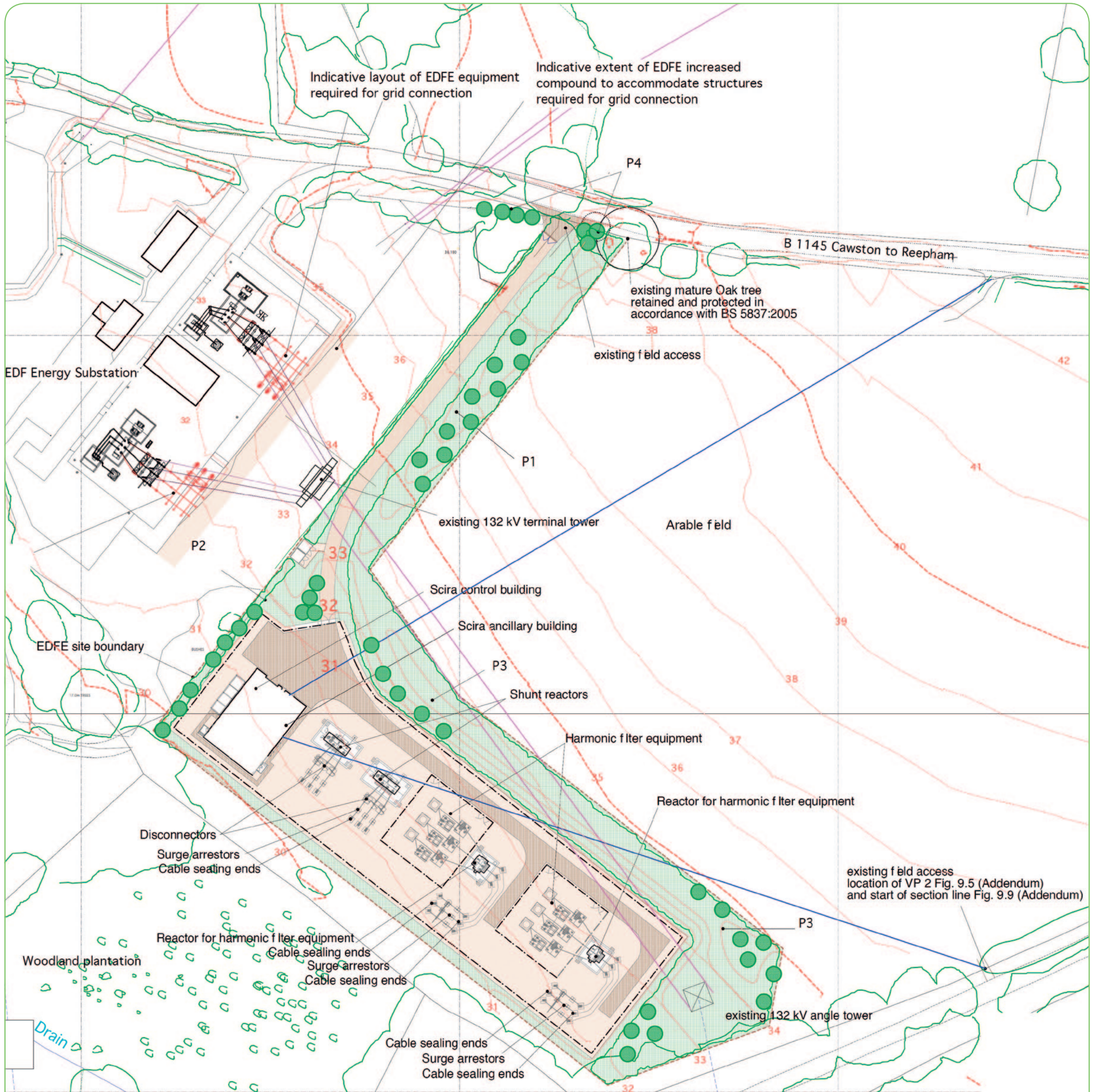
5.3.10.1 Description of access roads and landscape proposals

Description of infrastructure	
Purpose	Access Roads: to provide access, especially for the largest and heaviest equipment. Landscape proposals: to reduce visual and noise impacts.
Description	Road access, permanent, metalled. Landscape proposals: usually trees for screening.
Typical dimensions	The access road must be sized for the largest delivery, typically the power transformers. Single carriageway may be adequate, with passing places.
Specifications and technical considerations	None relevant.
Installation	Standard civil engineering practice.
Operation and maintenance	Regular visual inspection. Minor repairs when required. Planted areas will require attention several times a year. Trees may require pruning or thinning after several years' growth.

Screening measures simulation (after 5 years) ***(Source: LDA Design on behalf of Dudgeon Offshore Wind Ltd)***

Screening measures simulation (after 10 years) ***(Source: LDA Design on behalf of Dudgeon Offshore Wind Ltd)***

5.3.10.2 Images of access roads and landscape proposals



Landscape proposals plan ***(Source: Douglas Rule CMLI, Cambridge Landscape Architects and Scira Offshore Energy)***

5.3.11 Environmental and socio-economic considerations for AC substations during construction

The following subsections outline environmental and socio-economic factors that may need to be considered in relation to onshore AC substations during construction and operation.

Occurrence of these will depend on project and location specifics. Suitable mitigation may be applied based on the specific characteristics (subject to the baseline environment, project characteristics and impact identified), and should be identified during the EIA and pre-construction phases of development. For example, vehicle wheel washing can be established at site access points to avoid track-out of soils and debris on to public highways.

Environmental and socio-economic considerations	
Archaeology and cultural heritage	■ Potential direct loss of, or damage to, known and unknown buried archaeology ■ Potential direct loss of, or damage to, designated assets or areas ■ Provide opportunities for research and recording of previously unknown archaeology
Dust and air quality	■ Potential for dust arising from areas where vegetation has been removed, soils stored and vehicle tracks, particularly in dry or windy conditions, potential to cause impacts on human health especially where sensitive receptors exist (e.g. schools, hospitals) ■ Construction vehicle emissions have the potential to impact on air quality
Land quality	■ Potential disturbance of previously contaminated land, potential transportation of contaminants (by physical movement, water and air) and the impact on human health and ecology
Land use and soils	■ Potential land loss from existing use or agricultural production ■ Potential degradation or loss of soil resource
Landscape and visual	■ Potential change in the character of the landscape and on views (including from removal of existing ground features) ■ During construction areas will be needed for soil storage, site lay-down areas, equipment storage, internal access tracks and CDM demarcation ■ Potential impacts from lighting of compounds
Local community	■ Potential for nuisance and disturbance principally through the other impacts discussed in this table, but in particular additional traffic, noise, dust and visual impacts
Noise and vibration	■ Potential for noise and vibration from construction traffic and equipment, especially at compounds and pilling locations and during groundworks ■ Construction likely to take a significant amount of time in a single location
Terrestrial ecology and nature conservation	■ Potential degradation or loss of important habitats (in particular: ponds, hedgerows, woodland, watercourses, grassland) ■ Potential loss or disturbance of protected or notable species (in particular: water vole, otter, badger, great crested newts, reptiles and breeding birds) ■ Potential adverse effect on the integrity of designated (statutory and non-statutory) nature conservation sites
Traffic and access	■ Access to private and public land may be restricted ■ Potential for road closures and diversions ■ Potential increased traffic with associated noise and vibration impacts ■ Potential road and pedestrian safety concerns ■ Access routes may need widening and temporary control measures implemented, particularly where abnormal indivisible loads require delivery (of particular importance for transformers)

Environmental and socio-economic considerations	
Waste	■ If significant earth works are required a large quantity of material will likely need to be removed offsite with an associated increase in traffic movements or used in the earthworks onsite which may have additional landscape and visual impacts
Water resources	■ Potential water contamination and the associated risks to humans and riparian ecology from construction activities using oil or other harmful substances ■ Potential sedimentation and increase in turbidity of watercourses from areas where vegetation has been cleared ■ Requirement for significant excavation and potentially piling may impact on groundwater quality and regimes ■ Requirement for de-watering, and discharging of water, may have potential impacts on water resources (e.g. abstractions) and riparian ecology

5.3.12 Environmental and socio-economic considerations for AC substations during operation

Environmental and socio-economic considerations	
Flood risk	■ Potential increase in flood risk to facility itself and to others downstream from increased surface water run-off, especially from large areas of hardstanding, for example access tracks and buildings, where sustainable drainage systems are not employed
Landscape and visual	■ Potential for existing landscape character and views being altered, especially if situated within open countryside or residential areas ■ Potentially tall (e.g. overhead line gantries and switchgear) and bulky (e.g. transformers, buildings and converter sheds) equipment may effect landscape character and views of local area ■ Additional landscape works and screening may mitigate views of infrastructure
Local community	■ Use of local contractors during operation ■ Potential safety and security concerns over unmanned stations particularly in remote locations ■ Potential community concern regarding EMF
Noise and vibration	■ Potential for noise from the operation of the substation, in particular a ‘humming’ associated mainly with the operation of cooling equipment, particularly in relation to transformers and reactors ■ Potential noise and vibration from operation and maintenance activities
Terrestrial ecology and nature conservation	■ Additional landscape works and screening may provide habitats and opportunities for biodiversity enhancement
Traffic and access	■ Operation and maintenance access required, which may impact on local access routes

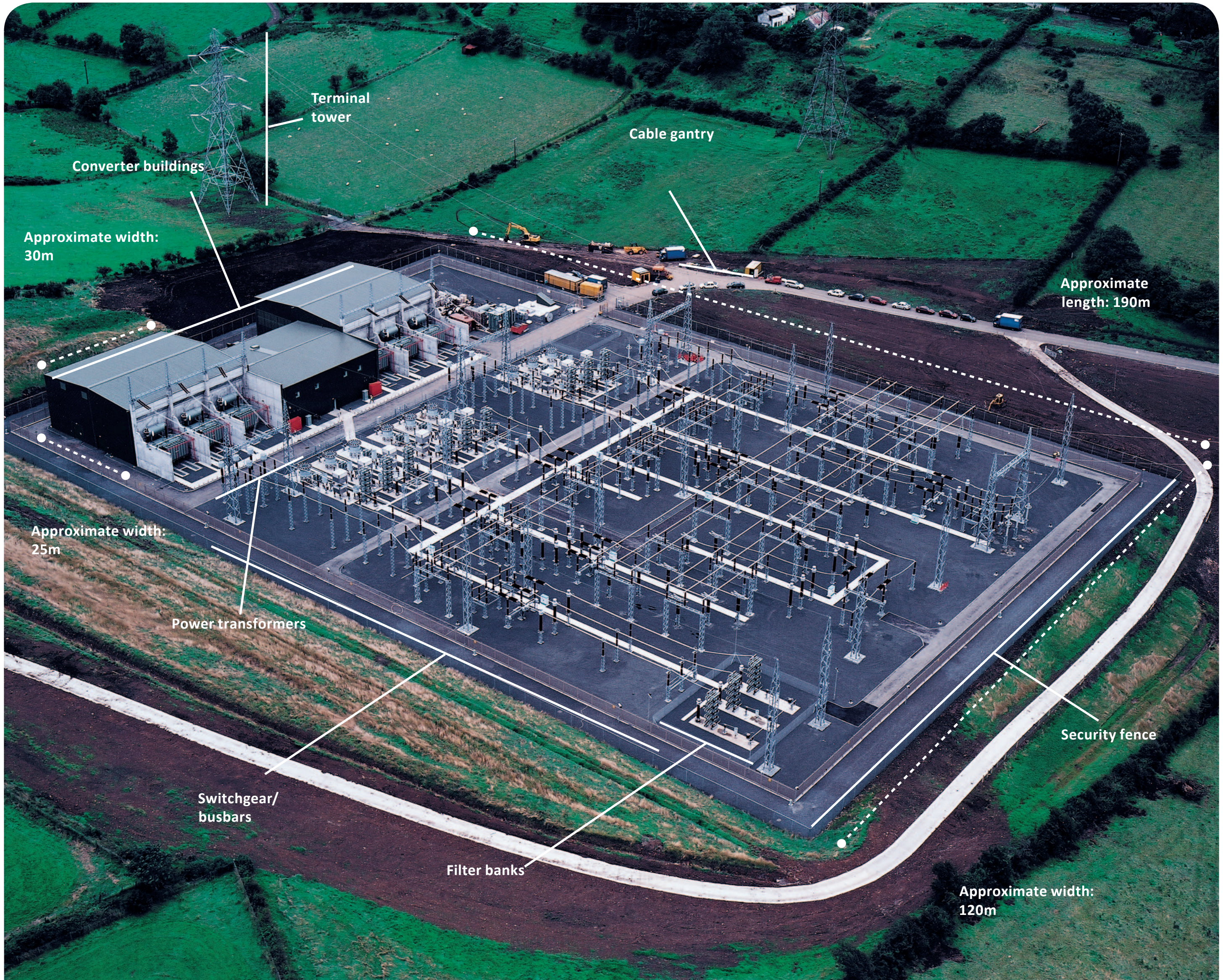
5.4 Onshore DC/AC converter stations

In this subsection, DC/AC converter stations are discussed. Converter stations may include certain major components (such as transformers, cable terminations on overhead lines, and access roads / landscape proposals, etc.) which are the same as those discussed in Subsection 5.3 (Onshore AC substation) so this subsection will focus on the unique part of converter stations.

5.4.1 Description of DC/AC converter stations

Description of infrastructure	
Purpose	To convert from HVDC connection from the offshore wind farm to AC for connection to the onshore electricity system. It should be noted that a converter station can be both for converting from AC to DC or vice versa.
Description	Outdoor compound with ground-mounted components and busbar connections, similar in appearance to conventional outdoor substations, but with larger buildings containing converter components. The converter components are principally power-electronic devices, insulated supports, cooling equipment, and control equipment.
Typical dimensions	Varies greatly depending on applications: see illustrations. Some flexibility for trading height for footprint in restricted locations.
Specifications and technical considerations	Principle factors are voltage level (both AC and DC), and power rating. As HVDC is a relatively new technology, particularly for offshore wind, there is little previous experience, and potentially a wide range of design solutions in any particular application. Unlike conventional outdoor substations, the dominant visual effect, especially at close range, may be the converter building, rather than equipment in the outdoor compound.
Installation	As for outdoor substations
Operation and maintenance	Operation is largely automatic. Control of power and reactive power flows, and other functions, can be carried out remotely. Regular visual inspection. Infrequent scheduled maintenance (yearly or less often).

5.4.2 Image of converter stations



Example HVDC converter station (500MW) *(Source: Siemens)*

5.4.3 Environmental and socio-economic considerations for DC/AC converter stations during construction

The following subsections outline environmental and socio-economic factors that may need to be considered in relation to DC/AC converter stations during construction and operation.

Occurrence of these will depend on project and location specifics. Suitable mitigation may be applied based on the specific characteristics (subject to the baseline environment, project characteristics and impact identified), and should be identified during the EIA and pre-construction phases of development. For example, landscape and screening proposals can be developed to reduce the landscape and visual impact of converter stations.

Environmental and socio-economic considerations	
Archaeology and cultural heritage	■ Potential direct loss of, or damage to, known and unknown buried heritage ■ Potential direct loss of, or damage to, designated assets or areas ■ Opportunities for research and recording of previously unknown heritage assets
Dust and air quality	■ Potential for dust arising from areas where vegetation has been removed, soils stored and vehicle tracks, particularly in dry or windy conditions, potential to cause impacts on human health especially where sensitive receptors exist (e.g. schools, hospitals) ■ Construction vehicle emissions have the potential to impact on air quality and subsequently human health and contribute to greenhouse emissions
Land quality	■ Potential disturbance of previously contaminated land ■ Potential transportation of contaminates (by physical movement, water and air) and the impact on human health and ecology
Land use and soils	■ Potential land loss from existing use or agricultural production ■ Potential degradation or loss of soil resource (of particular importance for the Best and Most Versatile Land)
Landscape and visual	■ Potential change in the character of the landscape and on views (including from removal of existing ground features) ■ During construction areas will be needed for soil storage, site lay-down areas, equipment storage, internal access tracks and CDM demarcation ■ Potential impacts from lighting of compounds
Local community	■ Potential for nuisance and disturbance principally through the other impacts discussed in this table, but in particular additional traffic, noise, dust and visual impacts
Noise and vibration	■ Potential for noise and vibration from construction traffic and equipment, especially at compounds and pilling locations and during groundworks ■ Construction likely to take a significant amount of time in a single location
Terrestrial ecology and nature conservation	■ Potential degradation or loss of important habitats (e.g. ponds and hedgerows) ■ Potential loss or disturbance of protected or notable species (e.g. water vole, otter) ■ Potential adverse effect on the integrity of designated (statutory and non-statutory) nature conservation sites
Traffic and access	■ Access to private and public land may be restricted ■ Potential for road closures and diversions ■ Potential increased traffic with associated noise and vibration impacts ■ Potential road and pedestrian safety concerns ■ Access routes may need widening and temporary control measures implemented, particularly where abnormal indivisible loads require delivery (of particular importance for transformers)

Environmental and socio-economic considerations	
Waste	■ If significant earth works are required, a large quantity of material will need to be removed offsite with an associated increase in traffic movements or used in the earthworks onsite which may have additional landscape and visual impacts
Water resources	■ Potential water contamination and associated risks to humans and riparian ecology from construction activities using oil or other harmful substances ■ Potential sedimentation and increase in turbidity of watercourses from areas where vegetation has been cleared ■ Requirement for significant excavation and potentially piling and the impact on groundwater quality and regimes ■ Requirement for de-watering, and discharging of water, potential impact on water resources (e.g. abstractions) and riparian ecology

5.4.4 Environmental and socio-economic considerations for DC/AC converter stations during operation

Environmental and socio-economic considerations	
Flood risk	■ Potential increase in flood risk to facility itself and to others downstream from increased surface water run-off, especially from large areas of hardstanding, for example access tracks and buildings, where sustainable drainage systems are not employed
Landscape and visual	■ Existing landscape character and views may be altered, especially if situated within open countryside or residential areas ■ Potentially tall (e.g. overhead line gantries and switchgear) and bulky (e.g. transformers, buildings and converter sheds) equipment may effect landscape character and views ■ Additional landscape works and screening may mitigate views of infrastructure
Local community	■ Use of local contractors during operation ■ Potential safety and security concerns over unmanned stations particularly in remote locations ■ Potential community concern regarding EMF
Noise and vibration	■ Potential noise associated with the operation of the substation, in particular a 'humming' associated mainly with the operation of cooling equipment, particularly in relation to transformers and reactors ■ Potential noise associated with the operation of switchgear ■ Potential noise and vibration from operation and maintenance activities
Terrestrial ecology and nature conservation	■ Additional landscape works and screening may provide habitats and opportunities for biodiversity enhancement
Traffic and access	■ Operation and maintenance access required which may impact on local access routes

6 Legislative, policy and planning framework

This section provides an overview of the legislative, policy and planning framework for consenting offshore and onshore transmission infrastructure that is associated with the delivery of offshore renewable energy generation. It includes current policy programmes and relevant Strategic Environmental Assessments (SEA), as well as energy and planning policy contexts. The arrangements in Scotland, Wales and Northern Ireland differ and are highlighted below where this is of relevance.

Appendix II contains further Information, and links to, documents described in this section.

6.1 The need for renewable energy

6.1.1 Current UK renewable energy objectives

The UK renewable energy policy centres on a number of key drivers:

- The need to reduce carbon dioxide emissions to tackle climate change caused by greenhouse gas emissions;
- The desire to secure national energy supply as part of a long term sustainable energy policy; and
- The desire to promote competitive markets in the UK and beyond, helping to raise the rate of sustainable economic growth and to improve our productivity.

There are a number of overarching UK environmental targets / goals that set the national policy framework for tackling climate change and renewable energy production.

Overarching UK environmental targets:

- The UK Government's agreed (legally binding) target under the Kyoto Protocol (signed in 1997) is to reduce greenhouse gas emissions (comprising six gases, including carbon dioxide) by 12.5% compared to 1990 levels, averaged over the period 2008 to 2012;
- A UK Government commitment (in 2009), under the European Union Renewable Energy Directive, for the UK to ensure that 15% of all its energy, including heat and transport, comes from a renewable source by 2020.
- In Scotland, a separate suite of renewable energy generation targets have been set. The goal for 31% renewable energy generation in Scotland by 2011 was exceeded by 4% and the Scottish Government announced a new target for Scotland's electricity generation to be the equivalent to 50% of Scotland's needs by 2015 and a target for renewable generation equivalent to 100% of Scotland's needs by 2020;
- The Northern Ireland Executive 2011 target of 12% electricity consumption from renewable sources was exceeded in 2012. The Executive have a 2015 target of 20% and a 2020 target of 40% of electricity consumption from renewable sources; and
- The Welsh Government set out their low carbon ambitions (including renewable energy generation) in their 2012 paper; Energy Wales: A Low Carbon Transition. It recognises that energy policy for Wales is the responsibility of UK Government, but wishes alignment with Welsh Government aims in order to deliver a low carbon economy.

6.1.2 Climate Change Act 2008

The Climate Change Act 2008 received Royal Assent on 26 November 2008, making the UK Government the first in the world to introduce legally binding long-term objectives to tackle climate change. The Act places a duty on the UK government to reduce emissions by at least 80% by 2050, compared to 1990 levels. Since two-thirds of UK emissions originate from the use of energy, this will act as a driver for large-scale adoption of low carbon energy sources, such as wind generation, over the next 40 years.

6.1.3 Energy Act 2004 and Energy Act 2008

The Energy Act 2004 enables The Crown Estate to award seabed leases for offshore wind farm development throughout the Renewable Energy Zone (REZ). The 2004 Act also introduced new provisions into the Electricity Act 1989 to enable a developer of an offshore generation project to obtain a declaration extinguishing public rights of navigation through the water column occupied by the wind turbines and other offshore structures. This is available within territorial waters only. It also makes provision for the establishment of Safety Zones around offshore renewable energy installations and specifically for offshore wind farms (a zone up to 500m around each structure from its outer edge as determined under the United Nations Convention on the Law of the Sea (UNCLOS)). The 2004 Act also introduced powers to enable offshore transmission owner (OFTO) licences to be granted on the basis of a competitive tender. Please refer to Section 7.1 for further details.

The Energy Act 2008 updated the legislation with respect to offshore renewable energy generation to ensure that the new and emerging technologies were acknowledged. It also strengthened the Renewables Obligation to drive greater and more rapid deployment of renewables in the UK. In addition, the 2008 Act refined provisions relating to the offshore transmission regulatory framework.

6.1.4 Renewables obligation and electricity market reform

The principal fiscal incentive for renewable electricity projects in the UK is the Renewables Obligation (RO) scheme. The scheme was introduced in January 2000 and it places an obligation on UK suppliers of electricity to source an increasing proportion of their electricity from renewable sources. The RO subsidy mechanism will be open to new generation until 31 March 2017.

The UK Government's 2012 Energy Bill, published in November 2012, outlined a series of proposals for overhauling the electricity market structure in a process termed 'Electricity Market Reform (EMR)'. One of the key provisions in the Bill is the replacing of the RO support mechanism with Contracts for Difference (CfD) which are intended to provide long-term stable returns through hedging revenue from the electricity market against contracted strike-prices. The two mechanisms, RO and CfD are intended to run in parallel from 2014 to 2017 following which the CfD will take over as the financial support mechanism for all commercialized low carbon generation.

6.1.5 Renewable Energy Directive 2009/28/EC

The Renewable Energy Directive outlines renewable energy production, greenhouse gas reduction and energy efficiency targets for EU member states.

In January 2008 the European Commission published the 20% by 2020 package, which has become known as the '20-20-20' targets[39]. This package proposed committing the European Union to a 20% reduction in its greenhouse gas emissions; achieving a target of deriving 20% of the European Union's final energy consumption from renewable sources by 2020; and fulfilling a 20% reduction in primary energy use compared with projected levels by improving energy efficiency.

In order to achieve the overall European Union renewable energy target of 20% the proposal included individual targets for each Member State (with the UK's proposed target being 15%). The European Commission proposed binding legislation to implement the 20-20-20 targets. The 'climate and energy package' was agreed by the European Parliament and Council in December 2008 and became law in June 2009. The Renewable Energy Directive (2009/28/EC) also provides for Europe's Climate Change Opportunity, where the European Commission set the emissions reduction target at 20%, rising to 30% if there is an international agreement.

6.2 Environmental impact assessment (EIA) and strategic environmental assessment (SEA)

6.2.1 EIA Directive (2011/92/EU)

The EIA Directive has been in force since 1985. It describes which development projects require a mandatory EIA under EU law. The EIA Directive has been transposed into a number of different sets of EIA Regulations in the UK, all of which refer back to the original Directive's Schedule 1 and 2 for the definition of those development projects which require EIA. Developments that fall within the description of developments in Schedule 1 of the EIA Regulations automatically require an EIA to be undertaken. Developments that fall within Schedule 2 of the Regulations may require an EIA. For the purposes of offshore wind, projects with a capacity of more than 1MW are considered to be EIA developments. In relation to offshore renewables and their associated transmission infrastructure the requirement for EIA is likely to be prescribed within the following pieces of legislation:

- The Infrastructure Planning (Environmental Impact Assessment) Regulations 2009;
- Town and Country Planning (Environmental Impact Assessment) Regulations 2011;
- The Electricity Works (Environmental Impact Assessment) Regulations 2000
- The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2000;
- The Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2011; and
- The Planning (Environmental Impact Assessment) Regulations (Northern Ireland) 2012.

Offshore wind farm developments fall under Annex II of the EIA Directive, as 'installations for the harnessing of wind power for energy production (wind farms)'. As an Annex II development, wind farms require an EIA where they are likely to have significant effects on the environment by virtue of factors such as their nature, size or location.

The formal reporting mechanism for an EIA is the Environmental Statement (ES).

An ES must include the following information as a minimum:

- A description of the development comprising information on the site, design and size of the development;
- An outline of the main alternatives studied by the applicant and an indication of the main reasons for the applicant's choice, taking into account the environmental effects;
- The data required to identify and assess the main effects, which the development is likely to have on the environment;
- A description of the measures envisaged in order to avoid, reduce and, if possible, remedy significant adverse effects; and
- A Non-Technical Summary (NTS) of the information provided.

6.2.2 SEA Directive (2001/42/EC)

The SEA Directive has been in force since 2001, and has been transposed into UK law via The Environmental Assessment of Plans and Programmes Regulations (2004), The Environmental Assessment (Scotland) Act (2005) and The Environmental Assessment of Plans and Programmes Regulations (Northern Ireland) 2004. The Directive requires a mandatory environmental assessment for plans and programmes which fall under the following categories under Article 3(2):

a) Those which are prepared for agriculture, forestry, fisheries, energy, industry, transport, waste management, water management, telecommunications, tourism, town and country planning or land use and which set the framework for future development consent for projects listed in Annexes I and II to the Environmental Impact Assessment (EIA) Directive (2011/92/EU); or
b) Those which, in view of the likely effect on sites, have been determined to require an assessment pursuant to Article 6 or 7 of the Habitats Directive (92/43/EEC).

39 Commission of the European Communities. 20 20 by 2020 Europe's climate change opportunity. Available at: eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0030:FIN:EN:PDF [Accessed on 26/10/2012]

Key requirements for offshore wind under EIA and SEA Directives:

EIA

- All offshore energy generation of greater than 1 MW will require a statutory EIA, while installations of less than 1MW may require EIA.
- Onshore and offshore components of installations will be subject to EIA.
- The Infrastructure Planning (Environmental Impact Assessment) Regulations and The Town and Country Planning (Environmental Impact Assessment) Regulations should be considered.

SEA

Key relevant SEAs include:

- Scottish Marine Energy SEA[40]
- Scottish Offshore Wind SEA[41]
- Offshore Energy SEA[42]
- UK Offshore Energy SEA 2[43]
- Offshore Wind Farm Development (Round 2) SEA[44]

6.3 Rochdale Envelope/Design Envelope

The 'Rochdale Envelope' is an acknowledged approach to planning applications that require EIA, where details of a project have not been resolved at the time when the application is submitted. It is sometimes called a 'design envelope'.

The 'Rochdale Envelope' arises from case law[45]. These cases dealt with outline planning applications for a proposed business park in Rochdale. They address:

- Applications for outline planning permission under the Town and Country Planning Act (1990); and
- Consideration of an EIA in the context of an outline planning consent to enable compliance with the Council Directive 2011/92/EV as transposed by the Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1988.

The details of a project may change as it progresses through the pre-application stages. In order to accommodate this flexibility, and ensure that the ultimate project has been properly assessed, it has become routine practice to employ a 'Rochdale Envelope' approach to EIA. This is where the 'worst case scenario or option' (or more realistically a 'worst likely case scenario or option') is assessed for each individual impact so that it can be safely assumed that all lesser options will have less impact.

Detailed information that may not be available at the time of making a request for a scoping opinion in relation to an offshore wind farm includes:

- Type and number of turbines;
- Foundation type (this may depend upon the height and type of turbine and the seabed conditions);
- Location of the export cable route (whether this is buried or on the seabed);
- Location of the landfall point;
- The definitive location of any onshore substation; and
- Construction methods and timing.

The challenge for an EIA is to ensure that all the realistic and likely worst case variations of the project have been properly considered and clearly set out in the ES and such that the likely significant impacts have been adequately assessed. It may be possible to draft a Development Consent Order (DCO) in such a way as to allow some flexibility in the project. The project should be described in such a way that a robust EIA can be undertaken.

6.4 Consenting regime

This section outlines the consenting regime for offshore renewables. The diagram on the next page shows the regime in greater detail for the constituent parts of the UK.

6.4.1 England and Wales

In England and Wales, the planning regime for offshore renewables projects is complex and is dependent on the energy capacity of the proposed development.

For projects in English territorial waters[46], where generation is less than 100MW in capacity, the offshore components are consented by the Marine Management Organisation (MMO) through Section 36 of the Electricity Act 1989 (a consent to construct power generation plant) (s36) and a Marine Licence under the Marine and Coastal Access Act 2009 for works affecting the seabed. Onshore grid infrastructure components may be consented through the Town and Country Planning Act 1990 (as amended), or deemed within the s36 licence.

For projects in Welsh territorial waters, the Marine Licence is currently issued by the Welsh Government Marine Consents Unit, but this function will transfer to a new body (Natural Resources Wales) in 2013. The MMO issues s36 consents for projects in Welsh territorial waters.

English and Welsh projects over 100MW in capacity are classified as Nationally Significant Infrastructure Projects (NSIP), and as such require a DCO under the Planning Act 2008 (as amended). The Planning Inspectorate in England and Wales examines applications, with the ultimate decision being made by the Secretary of State for the Department of Energy and Climate Change (DECC).

Onshore infrastructure in England can be consented within the DCO, although in Wales separate planning permission is required for these under the Town & Country Planning Act 1990 (as amended). A Marine Licence under the Marine and Coastal Access Act 2009 may also be deemed within the DCO (unless it is a Marine Licence for Welsh Territorial Waters).

For projects over 100MW, the MMO becomes a statutory consultee under the Planning Act 2008 (as amended) and an enforcing body once the DCO/Deemed Marine Licence is issued.

40 The Scottish Government. A Strategic Environmental Assessment (SEA) to examine the environmental effects of developing wave and tidal power. Available at: www.scotland.gov.uk/Publications/2007/03/seawave
41 The Scottish Government. Strategic Environmental Assessment (SEA) of Draft Plan for Offshore Wind Energy in Scottish Territorial Waters. Available at: www.scotland.gov.uk/Publications/2010/05/14155353/0
42 DECC. Offshore Energy SEA. Available at: www.offshore-sea.org.uk/consultations/Offshore_Energy_SEA/index.php
43 DECC. Offshore Energy SEA 2. Available at: www.offshore-sea.org.uk/consultations/Offshore_Energy_SEA_2/index.php
44 DTI. Wind R2. www.offshore-sea.org.uk/consultations/Wind_R2/index.php
45 i.e. R.V. Rochdale MBC Ex Part C Tew 1999 - "the Rochdale case" and R. v Rochdale MBC ex parte Milne (no.2) 2000
46 Territorial waters are within 12 nautical miles of the coast. www.legislation.gov.uk/ukpga/1987/49

6.4.2 Scotland

Offshore consent applications for offshore wind farms in Scotland will be determined by the Scottish Ministers, acting through Marine Scotland, which is the Scottish Governmental body with responsibility for marine planning and licensing functions. Marine Scotland will issue an s36 consent under the Electricity Act 1989, and a Marine Licence under the Marine (Scotland) Act 2010.

It is possible to seek consent for buried cable infrastructure to connect to the grid, along with the offshore wind farm, in a single application under the Electricity Act 1989 in Scotland. In practice, most Scottish wind farms are seeking planning permission under the Town and Country Planning (Scotland) Act 1997 (as amended) and the Planning etc. (Scotland) Act 2006 for all onshore elements of the transmission infrastructure.

Project	Country	Legislation	Regulator	Onshore / MHWS / MLW / 12nm / REZ	
Offshore Wind Farm & Connection to Grid (Capacity < 100MW)	England	Town and Country Planning Act 1990	Local Planning Authority		Applies if onshore works are not deemed within S36 Consent
		Electricity Act 1989 (S36)	MMO		Extends onshore if onshore works are deemed within S36 Consent
		Marine and Coastal Access Act 2009	MMO		
	Wales	Town and Country Planning Act 1990	Local Planning Authority		
		Electricity Act 1989 (S36)	MMO		Extends onshore if onshore works are deemed within S36 Consent
		Marine and Coastal Access Act 2009	WG MCU/NRW		
		Marine and Coastal Access Act 2009	MMO		
	Scotland	Planning &c (Scotland) Act 2006	Local Planning Authority		
		Electricity Act 1989 (S36)	Marine Scotland		
		Marine (Scotland) Act 2010	Marine Scotland		
		Marine and Coastal Access Act 2009	Marine Scotland		
	N Ireland	Electricity (Northern Ireland) Order 1992	DETI NI		
		Planning (Northern Ireland) Order 1991	DOE NI/NIEA		
		Marine and Coastal Access Act 2009	DOE NI/NIEA	n/a	
Offshore Windfarm & Connection to Grid (Capacity >100MW)	England	Planning Act 2008 (as amended)	PINS/DECC		Onshore works consented as associated development. Marine licence deemed.
	Wales	Town and Country Planning Act 1990	Local Planning Authority		
		Marine and Coastal Access Act 2009	PINS/DECC		
		Planning Act 2008 (as amended)	WG MCU/NRW		
	Scotland	Planning &c (Scotland) Act 2006	Local Planning Authority		
		Electricity Act 1989 (S36)	Marine Scotland		
		Marine (Scotland) Act 2010	Marine Scotland		
		Marine and Coastal Access Act 2009	Marine Scotland		
	N Ireland	Electricity (Northern Ireland) Order 1992	DETI		
		Planning (Northern Ireland) Order 1991	DOE NI/NIEA		
		Marine and Coastal Access Act 2009	DOE NI/NIEA	n/a	
Additional transmission work onshore	England	Town and Country Planning Act 1990	Local Authority		
		Electricity Act 1989 (S37)	DECC		Required only for overhead lines < 132kV
		Planning Act 2008 (as amended)	PINS/DECC		Required only for overhead lines > 132kV
	Wales	Town and Country Planning Act 1990	Local Authority		
		Electricity Act 1989 (S37)	DECC		Required only for overhead lines < 132kV
		Planning Act 2008 (as amended)	PINS/DECC		Required only for overhead lines > 132kV
	Scotland	Planning &c (Scotland) Act 2006	Local Authority		
		Electricity Act 1989 (S37)	Scottish Government		Required only for overhead lines
	N Ireland	Planning (Northern Ireland) Order 1991	NI Planning Service		
		Electricity (Northern Ireland) Order 1992 (S40)	DETI NI		Required only for overhead lines

Consenting regime for offshore energy generation installation ***(Source: The Crown Estate)***

Note:
MHWS Mean High Water Springs
MLW Mean Low Water
12nm 12 nm territorial waters limit
REZ Renewable Energy Zone (UK Waters)

6.4.3 Northern Ireland

The offshore consenting regimes in Northern Ireland are undergoing reform as the Northern Ireland Marine Bill makes its way through the Northern Ireland Assembly. The current marine licensing system is based on the Marine Licensing Regulations (Northern Ireland) 2011.

The Electricity (Northern Ireland) Order 1992 states the construction, extension or operation of any generating station, the capacity of which exceeds 10 MW, requires the Department's consent under Article 39 of the Electricity (Northern Ireland) Order 1992. The installation of any overhead electric line requires (with certain limited exceptions) the Department's consent under Article 40 of the Electricity (Northern Ireland) Order 1992. Electricity licences (generation, transmission, distribution, supply and SEM Operator) are granted by the Northern Ireland Authority for Utility Regulation under Article 10 of the Electricity (Northern Ireland) Order 1992[47].

6.5 National planning policies on energy projects

National planning policies differ across England, Scotland, Wales and Northern Ireland, although there are similarities of approach. The high level overview described in this section is for England, with differences highlighted for Scotland, Wales and Northern Ireland as appropriate.

6.5.1 England

6.5.1.1 National Policy Planning Framework

The National Planning Policy Framework (NPPF), which was published on 27 March 2012, came into effect immediately, and summarises and replaces all the previous national planning policy and guidance documents (Planning Policy Statements and Planning Policy Guidance). The NPPF is the basis of development plan making and a material consideration in planning decisions.

In summary the National Planning Policy Framework states:
- The importance of an up-to-date Development Plan as the key document in determining applications;
- Sustainable development (in accordance with the Development Plan) should go ahead without delay, while conflicting development should be rejected; and
- In the absence of a Plan or relevant policy, applications should be granted unless 'any adverse impacts of doing so would significantly and demonstrably outweigh the benefits'[48] assessed against the NPPF.

6.5.1.2 Overarching National Planning Statement for energy (EN-1)

The overarching National Planning Statement (NPS)[49], published by DECC, sets out the Government's policy for delivery of major energy infrastructure and directs the Planning Inspectorate on the examination of applications made under the Planning Act 2008 (as amended). The NPS may also be material considerations within other planning applications. As outlined in the NPPF[50] National Policy Statements form a material consideration in decisions on planning applications.

EN-1 sets out the Government's energy and climate change objectives for the power sector, these are summarised as follows:
- To help deliver the UK's climate change commitments;
- To ensure that investment provides security of energy supply through a diverse and reliable mix of fuels and low carbon technologies;
- To further ensure that investment delivers an electricity grid with greater capacity and the ability to manage larger fluctuations in supply and demand;
- To ensure cost effective energy generation to help eliminate fuel poverty; and
- To contribute to sustainable development by seeking energy infrastructure development that helps reduce climate change while also minimising negative impacts on the local environment.

The Government recognises within the NPS that there is a significant need for new major energy infrastructure, which will have to be met by projects progressing quickly, given that developments such as nuclear power stations have very long lead-in times.

Furthermore, it is recognised that around 30% of electricity generation will need to be generated from renewable sources by 2020, with a significant proportion of this sourced from onshore and offshore wind generation. The continued development of offshore wind within the UK is therefore seen as being of vital importance to help ensure the UK is able to meet its binding energy targets.

47 www.detini.gov.uk/deti-energy-index/deti-energy-electricity.htm
48 DCLG. National Planning Policy Framework Available at: www.gov.uk/government/uploads/system/uploads/attachment_data/file/6077/2116950.pdf [Accessed 24 October 2012]
49 DECC. Overarching National Planning Statement for Energy (EN-1). Available at: www.decc.gov.uk/assets/decc/11/meeting-energy-demand/consents-planning/nps2011/1938-overarching-nps-for-energy-en1.pdf
50 DCLG. National Planning Policy Framework Available at: www.gov.uk/government/uploads/system/uploads/attachment_data/file/6077/2116950.pdf [Accessed 24 October 2012]

6.5.1.3 National Planning Statement for renewable energy infrastructure (EN-3)[51]

The NPS for Renewable Energy Infrastructure, alongside EN-1, covers:

- Any energy infrastructure for biomass and / or waste whose capacity exceeds 50MW;
- Any offshore wind farm whose capacity exceeds 100MW; and
- Any onshore wind farm whose capacity exceeds 50MW.

6.5.1.4 National Planning Statement for electricity network infrastructure (EN-5)[52]

The NPS for Electricity Network Infrastructure, together with EN-1, is the primary decision making guidance document for 'nationally significant' electricity network infrastructure in England and Wales.

The following types of nationally significant infrastructure are covered by EN-5:

- Above ground electricity lines of 132kV and above; and
- Other infrastructure for electricity networks that is associated with a NSIP.

EN-5 states that 'when considering impacts for electricity networks infrastructure, all of the generic impacts covered in EN-1 are likely to be relevant, even if they only apply during one phase of the development such as construction or only apply to one part of the development such as a sub-station.'

In addition, EN-5 sets out technology specific considerations for electromagnetic fields (EMF), which is not an impact considered in EN-1.

6.5.2 Wales

Nationally significant projects in Wales will fall under the scope of the Planning Act 2008 (as amended) and will be examined by the Planning Inspectorate. For smaller renewable projects there are a series of key planning policy documents which provide a framework within which project consent will be considered. The Planning for Renewable Energy (October 2010) and overarching Planning Policy Wales (February 2011) updated the policy position regarding onshore planning for transmission infrastructure.

6.5.3 Scotland

The Scottish National Planning Framework is supported by the Scottish Planning Policy (SPP), which is a statement of government policy on nationally important land use planning matters. The consolidated SPP sets out Scottish Government policy on a series of topics, including renewable energy.

With regard to offshore renewable energy generation, paragraph 192 of the SPP confirms that "Off-shore renewable energy generation presents significant opportunities to contribute to the achievement of Government targets. Although the planning system does not regulate offshore development, it is essential that development plans take into account the infrastructure and grid connection needs of the off-shore renewable energy generation industry".

Electricity Transmission issues are considered in paragraphs 157-161 which discuss the major reinforcements required as part of the on-going development of renewable energy, particularly in remoter coastal and upland areas of the country. Paragraph 157 sets out a presumption in favour of adequate grid connection for areas which planning authorities identify as preferred areas for renewable energy developments. The importance which the Scottish Government attaches to some of the grid reinforcement projects is reflected in the fact that many are designated National Developments (nationally significant developments) within the National Planning Framework.

The SPP confirms the integrated approach to development which is implemented through the onshore and marine planning and licensing systems to enable the realisation of the opportunity provided by offshore renewable development, to meet national targets for energy generation from renewables.

The Scottish Government also provides advice on a range of subjects through a series of Planning Advice Notes (PANs).

6.5.4 Northern Ireland

In Northern Ireland there is a framework of overarching Planning Policy Statements (PPS) which set out policies on land-use and other planning matters and apply to the whole of Northern Ireland. There is not currently a PPS which deals with energy or transmission issues. The primary document outlining the onshore planning policy is Planning Policy Statement 18: Renewable Energy. This guidance is supported by the Best Practice Guidance to Planning Policy Statement 18: Renewable Energy. Offshore cable infrastructure in Northern Ireland is consented under the Marine Licensing system which is supported by a series of guidance documents[53].

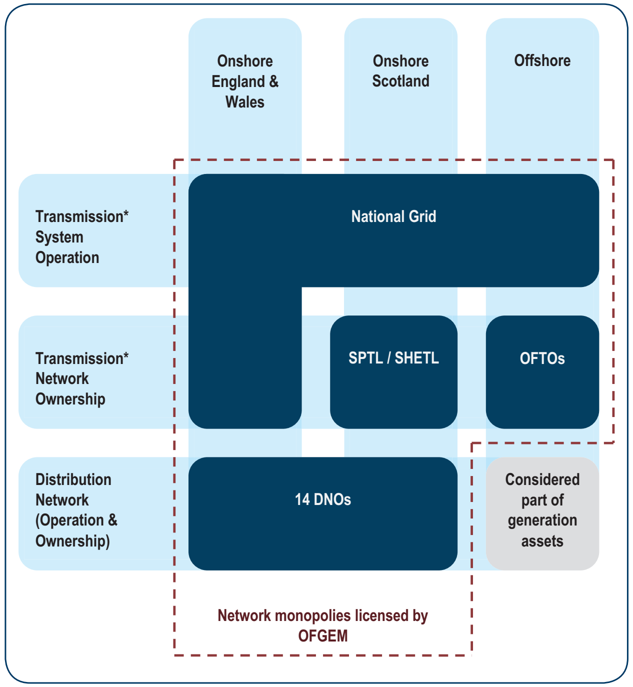
51 DECC. National Policy Statement for RenewableEnergy Infrastructure (EN-3). Available at: www.official-documents.gov.uk/document/other/9780108510793/9780108510793.pdf
52 DECC. National Policy Statement for Electricity Networks Infrastructure (EN-5). Available at www.official-documents.gov.uk/document/other/9780108510816/9780108510816.pdf
53 Available at the Department of Environment - Northern Ireland. www.doeni.gov.uk

7 Regulatory framework and connection process

This section provides an overview of the framework for regulating the connection of offshore renewable energy generation projects to the onshore network in Great Britain (GB). The regulatory framework and transmission ownership is Northern Ireland is also briefly discussed[54].

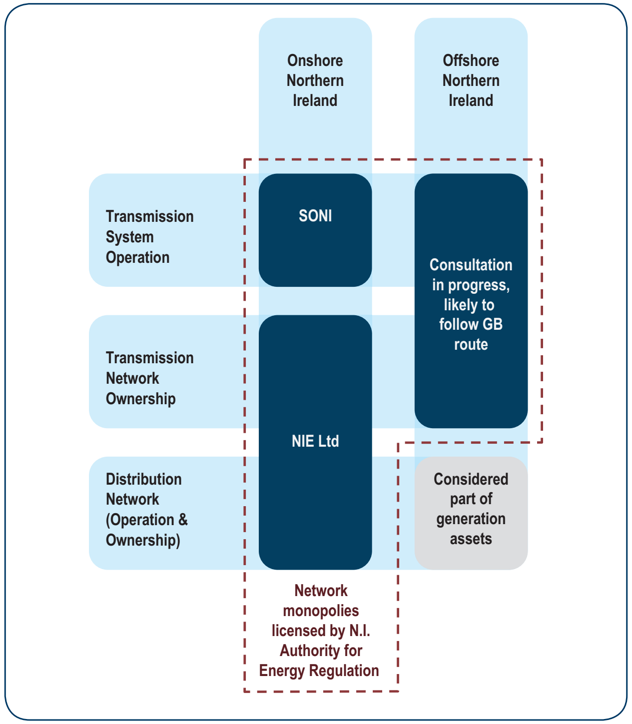
7.1 Regulatory framework and transmission ownership

The following diagram and text summarises the structure of ownership and operation across the GB electricity network.



* 'Transmission' defined as lines above 132kV in England and Wales onshore and 132kV and above in Scotland and offshore

The policy and regulatory framework for Northern Ireland, which is synchronously connected to the national grid of the Republic of Ireland, differs from that of the GB network as shown in the following figure.



7.1.1 Ofgem

Ofgem is the independent regulator for the gas and electricity markets in Great Britain, with associated statutory duties outlined in The Electricity Act 1989 (as amended).

Ofgem's role:

- protect the interests of existing and future consumers, wherever appropriate by promoting competition in gas and electricity markets, and regulating monopoly networks;
- help secure Britain's energy supplies;
- contribute to the drive to curb climate change aimed at sustainable development;
- administers Renewables Obligation, Feed-in Tariff and Renewable Heat Incentive;
- regulating network activities of transmission and distribution in Great Britain.

Permission to undertake transmission and distribution network activity is granted through a licence issued by the regulator or through an exemption granted by the Secretary of State. There are three onshore transmission owners (TOs) in Great Britain (distribution is considered further below):

- National Grid in England & Wales;
- Scottish Power Transmission Limited in the south of Scotland; and
- Scottish Hydro Electricity Transmission Limited in the north of Scotland.

Licences for onshore transmission have been granted based on historic monopoly networks and reflect industry structure at the time of privatisation in 1990 and a major market restructuring in the early 2000s. The licences are specific to a particular geographic location and network licences are subject to direct regulation (typically in terms of revenue allowances and meeting key outputs).

There is a separate regulatory regime for offshore transmission, which was introduced in 2009. Offshore Transmission Owners (OFTO) licences are granted by means of a competitive tender process run by Ofgem.

54 Given the majority of offshore generation projects in the UK currently do (and will continue) to connect into England, Scotland and Wales, the focus of this section of the document is on the arrangements in Great Britain. Whilst the policy and regulatory frameworks differ in Northern Ireland, they are considered sufficiently similar for the purpose of this document and not described in the same level of detail. The grid infrastructure described in this document will largely be the same for connections into Northern Ireland.

7.1.2 Northern Ireland Authority for Energy Regulation (NIAER)

NIAER, part of the Utility Regulator of Northern Ireland, is responsible for regulating the Province's electricity industry. Specific objectives are to protect the interests of consumers by ensuring appropriate competition within the industry and to licence suppliers, generators and transmission and distribution companies.

7.1.3 National Grid

National Grid owns and maintains the transmission network (consisting of lines at above 132kV) across England and Wales. In addition, National Grid is the licensed National Electricity Transmission System Operator (NETSO), which is responsible for operating the entire GB transmission system. This includes system balancing and being the contractual counterparty for connections to the transmission system, i.e.the NETSO contracts with generators directly for new connections with capacity provided by the TOs.

7.1.4 Scottish Power Transmission Limited (SPTL) and Scottish Hydro Electric Transmission Limited (SHETL or SHE Transmission)

SPTL and SHETL own the transmission network in southern and northern Scotland respectively (consisting of lines at 132kV and above). As discussed above, these entities assess grid applications to their networks in conjunction with National Grid.

7.1.5 System Operator for Northern Ireland (SONI)

SONI is the licensed TSO for Northern Ireland and is owned by Eirgrid, the state-owned licensed national transmission system operator (TSO) in Ireland.

7.1.6 Distribution Network Operators (DNOs)

DNOs own and operate regional grid systems carrying electricity from the transmission network to consumers. As with the TOs they are therefore natural monopolies within their region and as such are subject to 'price control' regulation by Ofgem. There are fourteen licensed DNOs owned by six different groups, with four further Independent DNOs running small networks embedded within DNO networks.

7.1.7 Offshore Transmission Owner (OFTOs)

An OFTO licence is required to own and operate transmission assets (defined as 132kV and above) that connect offshore electricity generation. Offshore transmission systems are defined as the part of network which runs from the offshore substation which connects the offshore renewable energy project to the point of connection to the onshore transmission system.

As of December 2012, six OFTO licences have been granted - to Transmission Capital Partners for the offshore transmission assets connecting the Barrow, Gunfleet Sands, Robin Rigg and Ormonde wind farms and Blue Transmission Investments Ltd for the Walney 1 and Walney 2 wind farms.

7.2 Grid connection process in Great Britain

7.2.1 Application process for transmission connection

In Great Britain, the basic process for obtaining a grid connection to the transmission system is to submit an application to National Grid in its role as NETSO. The process is as follows:

Submit an application to National Grid

↓

Applications for:

England and Wales transmission connection
Following submission, a connection offer is developed on the basis of the required capacity, the nature of the generating plant, and status (current and planned future) of grid infrastructure in the region.

Scotland transmission connection
If the application is for connection to the Scottish part of the transmission system owned by SPTL or SHETL, National Grid will review the application in conjunction with the relevant entity (SPTL or SHETL).

↓

The NETSO is then obliged to issue the offer to the applicant within a statutory 90 day period from the date the application is validated.

↓

Applicants then have a further 90 day period to decide whether to accept the offer. The 90 day period is subject to other interactive offers.

If there is a dispute in relation to the offer, which cannot be settled between the two parties, the case may be referred to Ofgem for determination.

Upgrade works to the transmission network infrastructure which are required to ensure a connection is technically feasible must be carried out by the network owner for all works behind and including the Main Interconnected Transmission System (MITS) substation.

Securing a grid connection by generation developers and other network users will incur underwriting costs and, in the event of terminating a connection agreement, there will be cancellation liabilities.

7.2.2 Distribution network connection

If the application is for connection to a distribution network, then it should be submitted to the relevant DNO (note for offshore wind this is likely to be restricted to small demonstration sites only now that Round 1 of offshore wind has been built). The DNO will then review the application (if necessary, in consultation with National Grid) and issue a connection offer within three months of receiving the request.

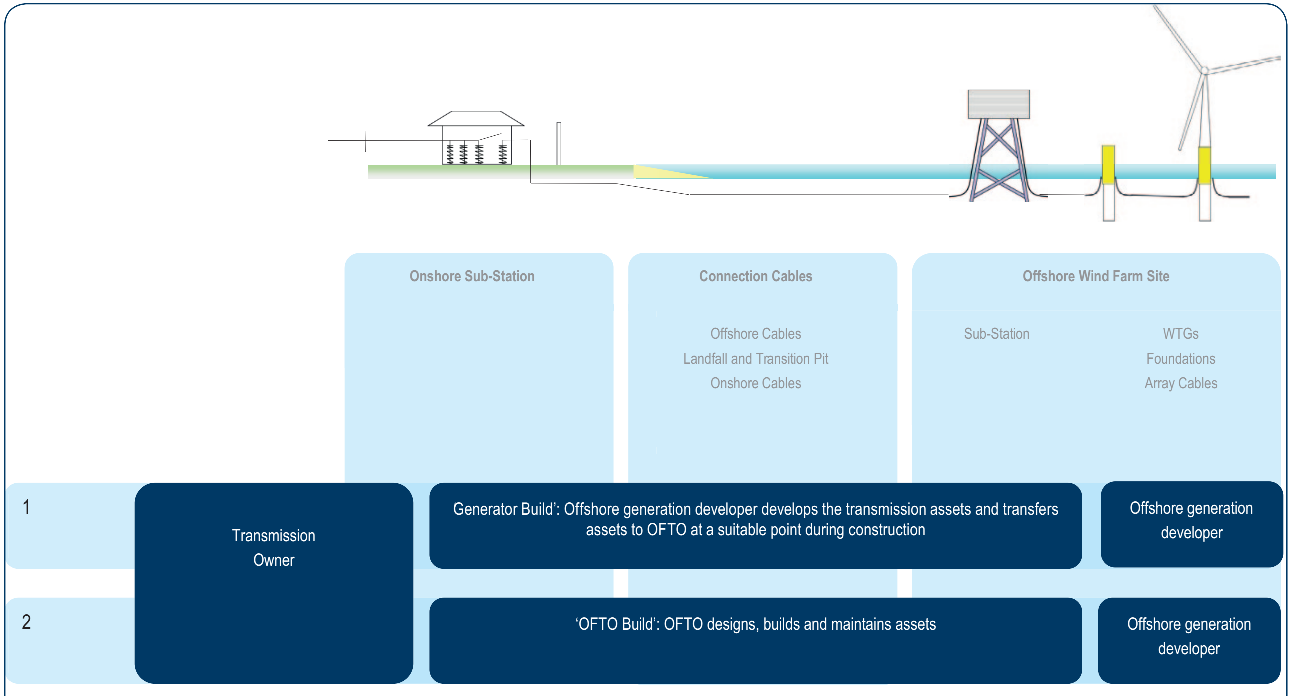
7.2.3 Build options and responsibilities

The relevant onshore network owner will perform ‘deep’ network reinforcements (i.e. cover the full cost of upgrading the network) up to and including the MITS node (or substation) into which an offshore wind farm will connect, including the construction of a new MITS node if necessary.

Under the OFTO regime, offshore transmission assets can either be built by the developer of an offshore generation project or by an OFTO. However, post construction the transmission assets must be owned by an OFTO. This is illustrated in the diagram below.

To date, all offshore transmission assets have been constructed by developers of offshore generation projects and then transferred to an OFTO post construction. This approach is expected to continue for the foreseeable future, although decisions will be made based on the particular circumstances of each project.

Two build options for OFTO assets:



Parties responsible for ownership and operation of transmission assets for offshore energy generation under the two build options for OFTO assets

7.3 Offshore transmission development in Great Britain

Since 2009, National Grid has published its Offshore Development Information Statement (ODIS) under their license requirement. The ODIS provided a range of scenarios for how the offshore transmission network could develop based on a range of generation deployment scenarios and also the design strategy adopted (either on point-to-point radial basis or under a more integrated approach). As of 2012, the ODIS and National Grid's Seven Year Statement (SYS) have been combined into a single Electricity Ten Year Statement (E-TYS). The first of these was published on 5 December 2012[55]. The document presents a range of likely scenarios for future onshore and offshore network development, and will be updated annually.

Key source of scenarios for future onshore and offshore network development:

- National Grid Electricity Ten Year Statement (E-TYS) 2012
- Yearly E-TYS updates going forward

Changes to transmission connection strategies are being considered for the future. Historically offshore generation projects have followed a radial connection model whereby individual connections are made for each wind farm direct to shore. Work is ongoing on the potential benefits of co-ordinating connections, potentially with transmission infrastructure being developed to connect more than one offshore generation project.

7.4 Regulatory framework and transmission ownership in Northern Ireland

The electricity industry in Northern Ireland was privatised in 1992. As for the rest of the UK, there are separate licences for each component of the value chain, with some companies holding multiple licences.

Northern Ireland is part of the 'All Ireland Single Electricity Market' and regulated by the Northern Ireland Authority for Utility Regulation (NIAUR or the Utility Regulator). The Utility Regulator ensures that each licensed activity is ring-fenced from other activities in the same group of companies. The Utility Regulator sets price limits for the monopolistic components of the electricity industry and ensures that end prices for consumers reflect efficient costs and reasonable levels of profitability.

There are three transmission licences and also a market operator licence:

- NIE Ltd holds a transmission licence in respect of the main transmission system.
- A second transmission licence is held by Moyle Interconnector Limited, a subsidiary of Mutual Energy Limited, who run the Moyle Interconnector assets linking the system to the GB system in Scotland.
- System Operator for Northern Ireland Limited (SONI), a subsidiary of EirGrid Plc., holds the transmission system operator licence for Northern Ireland.
- SONI also holds the Single Electricity Market operator licence for Northern Ireland, in conjunction with EirGrid.

Source: Royal HaskoningDHV

55 National Grid. Electricity Ten year Statement: UK electricity transmission, November 2012. Available at: www.nationalgrid.com/NR/rdonlyres/DF56DC3B-13D7-4B19-9DFB-6E1B971C43F6/57770/10761_NG_ElectricityTenYearStatement_LR.pdf

8 Glossary of terms and abbreviations

The table below includes terminology and abbreviations commonly associated with offshore renewable energy projects and their electrical transmission infrastructure. Not all terms in this table are used within this document.

Abbreviation	Terminology	Description
AC	Alternating Current	A movement of electric charge periodically reversing direction. Alternating current has been traditionally used for electricity transmission; however direct current (DC) may have some advantages over long distances or in submarine circumstances.
AIL	Abnormal Indivisible Load	An oversize / overweight load which cannot be broken down. They must be moved as a complete article.
AIS	Air Insulated Switchgear	Equipment to perform switching functions (interruption of fault current, electrical isolation of other equipment, and safe earthing of equipment) where bare conductors are used, and insulation between the conductors is provided by adequate clearance distances.
CAT	Cable Avoidance Tool	Hand-held tool used to detect presence of buried cables using radio frequencies.
Cefas	Centre for Environment, Fisheries and Aquaculture Science	An Executive Agency of Defra, Cefas undertake marine research and provide expert advice on environmental impacts.
CoS	Chamber of Shipping	A trade association for the UK's shipping industry.
CRoW	Countryside and Rights of Way Act (2000)	UK Act of Parliament enshrining, amongst other things, increased protection for SSSIs and threatened species.
DAS	Design and Access Statement	A short report explaining the design principles and concepts that have been applied to particular aspects of the proposal - these are the amount, layout, scale, landscaping and appearance of the development. DASs are required to accompany planning applications.
DC	Direct Current	A flow of electric charge only in one direction. Alternating current (AC) has been traditionally used for electricity transmission; however direct current may have some advantages over long distances or in submarine circumstances.
DCO	Development Consent Order	The consent required for an offshore energy generation development if it is above 100MW in capacity. It is granted by the relevant Secretary of State under the Planning Act 2008, following examination by the Planning Inspectorate.
DCLG	Department for Communities and Local Government	UK Government department responsible for planning; publisher of the National Planning Policy Framework (NPPF).
DECC	Department of Energy and Climate Change	UK Government department responsible for energy and climate change policy.
Defra	Department for Environment, Food and Rural Affairs	UK Government department body which previously held responsibility for climate change policy prior to the inception of DECC in 2008. Defra has responsibility for air quality policy and management, and compliance with habitats legislation.
DETI	Department of Enterprise, Trade and Investment	Northern Ireland government department responsible for administering onshore transmission licencing under the Electricity (Northern Ireland) Order 1992.

Abbreviation	Terminology	Description
DNO	Distribution Network Operator	Owners and operators of regional grid systems carrying electricity from the transmission network to consumers. There are fourteen licensed DNOs in GB, owned by six different groups, with four further Independent Distribution Network Operators running small networks embedded within a DNO network.
DoE	Department of the Environment	Northern Ireland government department responsible for administering planning legislation in Northern Ireland. Additionally responsible for the natural and built environment, and parent department to NIEA.
DPD	Development Plan Document	All the statutory component parts of the local development framework, e.g. core strategies, area action plans, site specifically allocation and supplementary planning documents. DPDs therefore set framework for planning in a local authority and are a key material consideration in the planning decisions.
DTI	Department for Trade and Industry	Defunct UK Government department; publisher of the 2003 Energy White Paper containing current UK emissions targets. Responsibilities and powers relevant to energy are now transferred to DECC.
EC	European Commission	The EC defines the general political direction and priorities of the European Union. It does not exercise any legislative functions.
EH	English Heritage	The government's statutory advisor on the historic environment for England (a non-department public body). In addition, they hold accessible resources on structures and sites of key historic value. The equivalent organisation in Wales is Cadw, Scotland Scottish Heritage and Northern Ireland Northern Ireland Environment Agency.
EHV	Extra High Voltage	In UK electricity industry practice, EHV is used to define voltage levels in electricity distribution systems, principally 33 kV, 66 kV (where this exists) and 132kV (in England & Wales). However the term is also used internationally to define the highest voltage levels of transmission systems.
EIA	Environmental Impact Assessment	A statutory process of Environmental Assessment required for all developments which may have significant environmental impacts. Offshore energy projects typically require an EIA.
EMF	Electromagnetic Field	Emission of electrical or magnetic energy which are produced where any electrical current flows.
EMR	Electricity Market Reform	Policy framework for reform of the UK electricity market. A key proposal involves introducing a new form of support for low carbon generation in the form of Contracts for Difference.
ES	Environmental Statement	The outcome of an EIA, an ES is an environmental report detailing the likely impacts of a development upon its environment. It will include mitigation measures required to reduce any impacts found. If an EIA is required, an ES must be submitted alongside a planning application.
E-TYS	Electricity Ten Year Statement	A document published by National Grid that presents a range of scenarios for future onshore and offshore network development. First published in Dec 2012, the E-TYS will be supplemented by yearly updates.
EU	European Union	The economic and political union of European member states.
FEPA	Food and Environment Protection Act 1985	UK act of parliament legislating for the licencing requirements for depositing article in the sea. Now superseded by the Marine and Coastal Access Act 2009 (England and Wales only).
GIS	Gas Insulated Switchgear	Equipment to perform switching functions (interruption of fault current, electrical isolation of other equipment, and safe earthing of equipment) where conductors are contained within a tank, and insulation between the conductors is provided by pressurised insulating gas. Substations using GIS are much more compact than those using AIS.
GW	Gigawatt	1,000,000,000 (1 billion) watts
HDD	Horizontal Directional Drilling	A process of lateral drilling using a specialist rig which is required when open-trenching is not possible e.g. when a cable route crosses an arterial road.
HVDC	High Voltage Direct Current	An electricity transmission option for the bulk transfer of electricity over long distances or in submarine circumstances. It presents an alternative to the more commonly used alternating current.

Abbreviation	Terminology	Description
ICPC	International Cable Protection Committee	The international submarine cable authority. Provides guidance on issues related to submarine cable security and reliability.
IMO	International Maritime Organisation	United Nations agency responsible for the safety of shipping and the prevention of marine pollution by ships. Provides key protocols, guidelines and information on marine pollution and shipping issues as relevant to offshore developments.
IPC	Infrastructure Planning Commission	Prior to 2012, held responsibility for examining applications for NSIPs. Duties now transferred to the Planning Inspectorate.
IRR	Internal Rate of Return	Equivalent to the effective interest rate of an investment, excluding external (environmental) factors.
JNCC	Joint Nature Conservation Committee	UK government advisory body on national and international nature conservation has the role of statutory nature conservation body in offshore waters.
kW	Kilowatt	1,000 (1 thousand) watts
LDF	Local Development Framework	The planning framework for a local authority, consisting of multiple development plan documents such as a core strategy, area action plans, site specific allocations and supplementary planning documents. The local development framework is a key material consideration in the planning decisions.
LPA	Local Planning Authority	Authority responsible for exercising duties under the Town and Country Planning Act 1990. These include reviewing planning applications. Local planning authorities often correlate with local authorities, but can also be a national park authority.
MCAA	Marine and Coastal Access Act	2009 Act of parliament that established the MMO, introduced the current system for licencing marine developments, and introduced current system for designating Marine Conservation Zones in England and Wales.
MCZ	Marine Conservation Zones	These are a type of marine protected area in England and Wales, designated under the Marine & Coastal Access Act 2009, which will exist alongside European marine sites to form an ecologically coherent network of marine protected areas.
MFA	Marine and Fisheries Agency	Predecessor to the MMO, the MFA was an executive agency of the UK government with responsibility for licensing and advice regarding the UK fishing industry. Relived of its powers in 2010.
MITS	Main Interconnected Transmission System	The main elements of the GB electricity transmission system.
MMO	Marine Management Organisation	A non-departmental government body created in 2010 with responsibility for (amongst other things) administering the marine licensing and consents system for marine developments in England and Wales, developing marine plans for England, and holding key resources on the state of the UK's marine regions.
MPA	Marine Protected Area	Umbrella term for marine conservation sites around the UK. They includes SPAs, SACs, SSSIs, Ramsar sites and MCZs.
MPS	Marine Policy Statement	Published in 2011, the UK MPS provides the policy framework for the planning system which applies to all new developments within UK marine areas. Marine Plans, outlining specific planning policy will follow, making reference to the MPS.
MVA	Mega volt-ampere	1,000,000 (1 million) Volt-Amperes (see FAQs)
MW	Megawatt	1,000,000 (1 million) watts
NE	Natural England	UK government advisory body on the natural environment. Natural England is a statutory consultee on the natural environment during an EIA.
NEAS	National Environmental Assessment Service	A unit of the Environment Agency with responsibility for assessing and managing the environmental risks of coastal and flood management strategies. They hold responsibility for reviewing EIA for these projects.
NIEA	Northern Ireland Environment Agency	UK government advisory body on the natural and built environment in Northern Ireland. NIEA is the Marine Licensing Authority for Northern Ireland.

Abbreviation	Terminology	Description
NETSO	National Electricity Transmission System Operator	Responsible for managing the operation of the GB transmission system, performed by National Grid. Separate function from ownership of the transmission networks.
NPPF	National Planning Policy Framework	Introduced in 2012, the NPPF, sets out the UK-wide planning policy. All local development frameworks must use the NPPF as the key consideration during creation. The NPPF replaces the pre-existing system of Planning Policy Guidance and Statements.
NPS	National Policy Statement	A UK-wide policy statement issued by a government department. In 2011 the UK government approved six NPSs for Energy (EN1-6). NPSs are a key consideration in the planning process for Nationally Significant Infrastructure Projects such as large offshore wind farms.
NSIP	Nationally Significant Infrastructure Project	Projects which are deemed major infrastructure developments, (as defined within the Planning Act 2008) and are therefore required to apply for a development consent order under the Planning Act 2008. For offshore energy generation, an NSIP is any development over 100MW generation capacity.
Ofgem	Office of Gas and Electricity Markets	Independent economic regulator for GB gas and electricity markets. Duties include regulating network monopolies (including TOs, DNOs and OFTOs) and administering environmental schemes such as the Renewables Obligation.
OFTO	Offshore Transmission Owner	An entity licensed by Ofgem to own and operate offshore transmission assets constructed to transport the electricity from offshore generation.
ODIS	Offshore Development Information Statement	Until 2011 National Grid issued a yearly ODIS on strategic planning. This worked alongside the Seven Year Statement. These two statements have now been replaced by the E-TYS.
ONO	Onshore Network Operator	An organisation responsible for an onshore transmission and/or distribution network in Great Britain. This is a term used in this document and is not a widely used term.
OREI	Offshore Renewable Energy Installation	Any offshore renewable energy generator, including wind farms, wave and tidal generators.
OSP	Offshore Substation Platform	Physical foundation for an offshore electrical substation.
PINS	Planning Inspectorate	The Planning Inspectorate examines applications for DCOs required under the Planning Act 2008.
POC	Point Of Connection	The point at which responsibility for the ownership and operation of the electrical system passes from a generating plant to the electricity network operator.
PPG	Planning Policy Guidance	Prior to 2012, along with PPSs PPGs provided the planning policy framework for the UK. They were superseded by the NPPF.
PPS	Planning Policy Statement	Prior to 2012, along with PPGs PPSs provided the planning policy framework for the UK. They were superseded by the NPPF.
RAV	Regulated Asset Value	Total value of assets of network monopolies; determined through the regulatory framework.
REZ	Renewable Energy Zone	The area of the sea outside of UK territorial waters to which the UK has claimed right to engage in exploitation for energy production from renewable sources. It was declared under the Energy Act 2004.
RO	Renewables Obligation	A UK government financial mechanism to incentivise renewable electricity generation. The RO places an obligation on UK electricity suppliers to source an increasing proportion of electricity they supply to consumers from renewable sources. It is administered by Ofgem. The RO is expected to be replaced by an alternative funding mechanism, as part of proposals for Electricity Market Reform.
ROV	Remotely Operated Vehicle	A device often used to lay and bury subsea transmission cables.
RSS	Regional Spatial Strategy	Provided a regional level planning policy framework for the UK prior to revocation in the Localism Act 2011.
RUK	RenewableUK	Trade and professional body for the UK wind and marine renewables industries. Formerly BWEA.

Abbreviation	Terminology	Description
s36	Section 36 consent	A consent to construct power generation plants, required for projects of <100MW generating capacity under the Electricity Act 1989. For offshore projects, granted by the MMO or Marine Scotland (formerly granted by DECC).
s37	Section 37 consent	A consent to construct overhead lines as laid out in the Electricity Act 1989. Consent is granted by the Secretary of State for Business, Enterprise and Regulatory Reform.
SAC	Special Area of Conservation	Protected sites designated under the UK Habitats Regulations (derived from the EU Habitats Directive). Sites are designated for contribution to conserving key habitats and species.
SEA	Strategic Environmental Assessment	A statutory process of environmental assessment required for all public plans and programmes which may have significant environmental impacts. Plans / programmes involving energy generation are typically required to produce an SEA.
SGT	Supergrid Transformer	Power transformers which interconnect the 400 kV and 275 kV transmission system with the distribution systems (typically 132kV or 66 kV).
SHETL	Scottish Hydro Electric Transmission Limited	Owns the transmission system in northern Scotland. Assesses grid applications to their networks in conjunction with National Grid.
SoS	Secretary of State	Cabinet minister in charge of a government department. SoS for Energy and Climate Change grants DCOs for energy generating NSIPs (following examination by PINS).
SPA	Special Protection Area	Protected sites designated under the UK Habitats Regulations (derived from the EU Birds Directive). Sites are designated for supporting rare and vulnerable birds and migratory species.
SPTL	Scottish Power Transmission Limited	Owns the transmission system in southern Scotland. Assesses grid applications to their networks in conjunction with National Grid.
SMA	Sensitive Marine Area	Non-statutory marine areas containing notable animal and plant communities and providing support to adjacent statutory sites e.g. SPAs.
SSSI	Site of Special Scientific Interest	UK protected sites designated under the Wildlife and Countryside Act 1981. Sites are designated for their wildlife or geological value.
SVC	Static VAR Compensator	Equipment including power-electronic devices, which can be controlled to produce or consume reactive power, with very fast response time. Reactive power flows in an electricity network can be used to control the voltage at specific points on the network.
SYS	Seven Year Statement	Until 2011 National Grid issued Seven Year Statements alongside their ODIS. These have now been replaced by the E-TYS.
TCE	The Crown Estate	The Crown Estate manages estates held by the Crown. This includes the majority of the UK seabed out to the 12 nautical mile limit. The Crown Estate has also been granted renewable energy rights within the Renewable Energy Zone. The Crown Estate is responsible for leasing areas of seabed for offshore renewable energy generation.
TCPA	Town and Country Planning Act (1990)	UK Act of Parliament codifying the planning process in England and Wales. Local Authorities' duties with regard to reviewing planning applications and the consents required by onshore transmission infrastructure are legislated for by the TCPA.
TSO	Transmission Systems Operator	NETSO is the TSO for Great Britain (see NETSO).
TW	Terawatt	1,000,000,000,000 (1 thousand billion watts)
MCU	Marine Consents Unit	A non-departmental Welsh Government body with responsibility for administering the marine licensing and consents system for marine developments. This role may change with the creation of the new government body Natural Resources Wales in 2013.
WTG	Wind Turbine Generator	A device that converts the energy in moving air into electrical energy.

Appendix I: Stakeholder consultation

In producing this document, a range of stakeholders have been consulted, including at a cross-stakeholder workshop, via an online survey and through bilateral meetings. We are grateful to all stakeholders for their input to the project.

Parties that provided input included[56]:

- ABB Ltd.
- Centrica
- CG Global
- DONG Energy
- Eneco
- Forewind
- Highlands Council
- Joint Nature Conservation Committee (JNCC)
- Mainstream Renewable Power
- Marine Management Organisation (MMO)
- National Grid
- Planning Inspectorate
- Planning Society
- Renewable UK
- RES
- RWE
- Siemens
- Suffolk County Council
- Warwick Energy

Source: Royal HaskoningDHV

56 Given the nature of the online survey, it is not possible to list all parties that participated. However, we are grateful for all contributions made.

Appendix II: Environmental and socio-economic considerations: further information

This appendix provides a reference resource for further information on specific environmental and socio-economic topics, relating to offshore renewables generation and transmission infrastructure.

The following tables provide guidance, policy and contact information for each topic, but are not intended to provide an exhaustive list. Tables are included for the following topics:

A. Offshore

A1	**Marine mammals**
A2	**Fish and shellfish**
A3	**Marine ecology and nature conservation**
A4	**Shipping and navigation**
A5	**Archaeology and heritage**
A6	**Ornithology**
A7	**Seascape and visual**
A8	**Commercial fisheries**
A9	**Marine and physical processes**
A10	**Marine and water sediment quality**
A11	**Other marine users**

B. Onshore

B1	**Archaeology and cultural heritage**
B2	**Dust and air quality**
B3	**Landscape and visual**
B4	**Noise and vibration**
B5	**Terrestrial ecology and nature conservation**
B6	**Traffic and access**
B7	**Waste**
B8	**Water resources and Land Quality**

C. General EIA

The following table explains each section of the tables in this appendix.

A1. Marine mammals			
	Function	Title	Links
A1.1 Guidance	Guidance document	Document details;	External link to guidance
	Good practice document	Document details;	External link to guidance
A1.2 Policy	Policy Document	Document details;	External link to policy
A1.3 Key contacts	Contacts for further information / contacts during planning process	Additional information e.g. what they may be able to help with	External link to contacts

A. Offshore

A1. Marine mammals			
	Function	Title	Links
A1.1 Guidance	EIA good practice guidance	Guidance on the Assessment of Effects on the Environment and Cultural Heritage from Marine Renewable Developments	N/A
	JNCC guidance	The protection of marine European Protected Species (EPS) from injury and disturbance: Guidance for the marine area in England and Wales and the UK offshore marine area	http://jncc.defra.gov.uk/pdf/JNCC_Guidelines_Piling%20protocol_August%202010.pdf
	JNCC guidance	Statutory Nature Conservation Agency Protocol for Minimising the Risk of Injury to Marine Mammals from Piling Noise	http://jncc.defra.gov.uk/pdf/JNCC_Guidelines_Piling%20protocol_August%202010.pdf
	IEEM guidance	Guidelines for Ecological Impact Assessment in Britain and Ireland: Marine and Coastal	http://www.ieem.net/data/files/Resource_Library/Technical_Guidance_Series/EcIA_Guidelines/Final_EcIA_Marine_01_Dec_2010.pdf
	The Crown Estate guidance	Approaches to Marine Mammal Monitoring at Marine Renewable Energy Developments: Final Report.	http://www.thecrownestate.co.uk/media/96247/marine_mammal_monitoring.pdf
	Cefas guidance	Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects.	N/A
	Scottish Natural Heritage guidance	Guidance on survey and monitoring in relation to marine renewables deployments in Scotland (Royal Haskoning 2011).	http://www.snh.gov.uk/docs/B925810.pdf
	Scottish Government guidance	Consenting, EIA and HRA Guidance for Marine Renewable Energy Developments in Scotland.	http://mhk.pnnl.gov/wiki/images/e/ec/Consenting%2C_EIA_and_HRA_Guidance_for_Scotland.pdf

A1. Marine mammals			
	Function	Title	Links
A1.2 Policy	International Nature Policy	Convention on International Trade in Endangered Species (CITES)	http://www.cites.org/
	European wide, Nature Conservation Policy	Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS)	http://www.ascobans.org/
	Europe wide, Nature Conservation Policy	The Berne Convention (1979)	N/A
	Europe wide, Nature Conservation Policy	Convention for the Protection of the Marine Environment of the North-East Atlantic	http://www.ospar.org/
	Europe wide, Nature Conservation Policy	The Conservation of Habitats and Species Regulations (2010)	http://www.legislation.gov.uk/uksi/2010/490/contents/made
	UK Policy Guidance	Offshore Marine Conservation (Natural Habitats, &c.) Regulations (as amended) (2007)	http://www.legislation.gov.uk/uksi/2012/1928/contents/made
	UK Policy Guidance	The Habitats Regulations 1994 (as amended in Scotland 2008)	http://www.legislation.gov.uk/ssi/2008/425/contents/made
	UK Policy Guidance	UK Post-2010 Biodiversity Framework	http://jncc.defra.gov.uk/pdf/UK_Post2010_Bio-Fwork.pdf
A1.3 Key contacts	UK government nature conservation advisory body -England	Natural England	http://www.naturalengland.org.uk/
	UK government nature conservation advisory body - Wales	Countryside Council for Wales	http://www.ccgc.gov.uk/default.aspx
	UK government nature conservation advisory body - Scotland	Scottish Natural Heritage	http://www.snh.gov.uk/
	UK government nature conservation advisory body - Northern Ireland	Northern Ireland Environment Agency	http://www.doeni.gov.uk/niea/
	UK government nature conservation advisory body	Joint Nature Conservation Committee	http://www.jncc.defra.gov.uk/
	Marine planning fisheries and marine regulation body.	Marine Management Organisation	http://www.marinemanagement.org.uk/

A1. Marine mammals			
	Function	Title	Links
	Fisheries surveys and data collection	Centre for Environment Fisheries and Aquaculture Science	http://www.cefas.defra.gov.uk/
	Marine wildlife NGO	Marine Conservation Society (MCS)	http://www.mcsuk.org/

A2. Fish and shellfish			
	Function	Title	Links
A2.1 Guidance	EIA good guidance	Guidance on the Assessment of Effects on the Environment and Cultural Heritage from Marine Renewable Developments	N/A
	Cefas guidance	Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects	N/A
	EIA guidance - Scotland	Consenting, EIA and HRA Guidance for Marine Renewable Energy Developments in Scotland.	http://mhk.pnnl.gov/wiki/images/e/ec/Consenting%2C_EIA_and_HRA_Guidance_for_Scotland.pdf
	Cefas Marine Consent Policy	Offshore wind-farms: guidance notes for EIA in respect of FEPA and CPA requirements	http://www.cefas.co.uk/publications/files/windfarm-guidance.pdf
A2.2 Policy	UK Policy Guidance	The Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007	http://www.legislation.gov.uk/uksi/2007/1842/contents/made
	UK Policy Guidance	The Conservation of Habitats and Species Regulations 2010	http://www.legislation.gov.uk/uksi/2010/490/contents/made
	UK Policy Guidance	The Habitats Regulations 1994 (as amended in Scotland 2008)	http://www.legislation.gov.uk/ssi/2008/425/contents/made
A2.3 Key contacts	Marine planning fisheries and marine regulation body.	Marine Management Organisation	http://www.marinemanagement.org.uk/
	UK government nature conservation advisory body	Joint Nature Conservation Committee (JNCC)	http://www.jncc.defra.gov.uk/
	Fisheries surveys and data collection	Centre for Environment, Aquaculture Science (Cefas)	http://www.cefas.defra.gov.uk/
	UK government nature conservation advisory body - England	Natural England	http://www.naturalengland.org.uk/
	UK government nature conservation advisory body - Wales	Countryside Council for Wales	http://www.ccgc.gov.uk/default.aspx

A2. Fish and shellfish			
	Function	Title	Links
	Fisheries regulations	Inshore Fisheries Conservation Authorities (IFCA's)	http://www.defra.gov.uk/environment/marine/wwo/ifca/
	Fisheries regulation (Scotland)	Inshore Fisheries Groups	http://www.scotland.gov.uk/Topics/marine/Sea-Fisheries/InshoreFisheries/IFGsMap
	Regulated designated areas of UK coast	Local Fisheries Committee	http://sabella.mba.ac.uk/175/01/The_regulations_of_the_local_sea_fisheries_committees_in_Engalnd_and_Wales.pdf
	Maritime safety and pollution prevention	International Maritime Organization	http://www.imo.org/Pages/home.aspx

A3. Marine ecology and nature conservation			
	Function	Title	Links
A3.1 Guidance	EIA good practice	Guidelines for ecological impact assessment in Britain and Ireland. Marine and Coastal. IEEM (2010)	http://www.ieem.net/data/files/Resource_Library/Technical_Guidance_Series/EcIA_Guidelines/Final_EcIA_Marine_01_Dec_2010.pdf
	EIA guidance	Consenting, EIA and HRA Guidance for Marine Renewable Energy Developments in Scotland.	http://mhk.pnnl.gov/wiki/images/e/ec/Consenting%2C_EIA_and_HRA_Guidance_for_Scotland.pdf
	International Maritime Organization guidelines	Guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species	http://www.imo.org/blast/blastDataHelper.asp?data_id=30766&f
A3.2 Policy	UK energy policy	Overarching National Policy Statement (NPS) for Energy (EN-1). DECC (2011)	http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/consents-planning/nps2011/1938-overarching-nps-for-energy-en1.pdf
	Policy guidance for different EIA areas	National Policy Statement for Renewable Energy Infrastructure DECC 2011	http://www.official-documents.gov.uk/document/other/9780108509360/9780108509360.pdf
	Europe wide nature conservation policy	EU Habitats Directive	http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm
A3.3 Key contacts	Marine planning fisheries and marine regulation body.	Marine Management Organisation	http://www.marinemanagement.org.uk/
	UK government nature conservation advisory body	Joint Nature Conservation Committee (JNCC)	http://www.jncc.defra.gov.uk/
	Fisheries surveys and data collection	Centre for Environment, Aquaculture Science (Cefas)	http://www.cefas.defra.gov.uk/
	Marine planning fisheries and marine regulation body	Scottish Natural Heritage	http://www.snh.gov.uk/

A3. Marine ecology and nature conservation			
	Function	Title	Links
	UK government nature conservation advisory body - Northern Ireland	Northern Ireland Environment Agency	http://www.doeni.gov.uk/niea/

A4. Shipping and navigation			
	Function	Title	Links
A4.1 Guidance	UK guidance	MCA Marine Guidance Notice 371 (MGN 371 Merchant + Fishing) OREIs Guidance on UK Navigational Practice, Safety and Emergency Response Issues	http://www.dft.gov.uk/mca/mcga-mnotice.htm?textobjid=0BD60265A97A9E76
	EIA Guidance	Guidance on the Assessment of Offshore Wind Farms - Methodology for Assessing Marine Navigational Safety Risks of Offshore Wind Farms	http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/files/file22888.pdf
	Health and Safety	Guidelines for Formal Safety Assessment (FSA) - MSC/Circ. 1023	http://www.imo.org/OurWork/Safety/SafetyTopics/Pages/FormalSafetyAssessment.aspx
	Health and Safety	MCA MGN 372 (MGN 372 M+F) OREIs Guidance to Mariners Operating in the Vicinity of UK OREIs	http://www.emec.org.uk/download/mgn372.pdf
	Health and Safety	Department of Environment and Climate Change (DECC) Guidance Notes on Safety Zones, DECC (2007);	http://www.decc.gov.uk/en/content/cms/meeting_energy/consents_planning/guidance/guidance.aspx#
	Offshore structure guidance	International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) - 0139 the Marking of Man-Made Offshore Structures, Edition one	http://www.orga.nl/index.php?page=231&l=en
	UK guidance	Royal Yachting Association (RYA 2011) position on Offshore Energy Developments.	http://www.rya.org.uk/SiteCollectionDocuments/legal/Web%20Documents/Environment/RYA%20Position%20OREI%20Wave%20-%20March%202012.pdf
	Kingfisher charts	GIS Charts	http://www.kisca.org.uk/charts.htm
A4.2 Policy	UK energy policy	National Policy Statement for Renewable Energy Infrastructure (EN-3), July 2011(Section 2.6)	http://www.official-documents.gov.uk/document/other/9780108509360/9780108509360.pdf
A4.3 Key contacts	Maritime safety	Marine and Coastguard Agency (MCA)	http://www.dft.gov.uk/mca/
	United Nations specialized agency for safety and security of shipping	International Maritime Organization	http://www.imo.org/Pages/home.aspx

A4. Shipping and navigation			
	Function	Title	Links
	Aids to navigation	Trinity House	http://www.trinityhouse.co.uk/
	Marine planning fisheries and marine regulation body.	Marine Management Organization	http://www.marinemanagement.org.uk/
	Aids to navigation (Scotland)	Northern Lighthouse Board	http://www.nlb.org.uk/
	Aids to navigation (Ireland)	Commissioners of Irish Lights	http://commissionersofirishlights.com/cil/about-cil.aspx

A5. Archaeology and heritage			
	Function	Title	Links
A5.1 Guidance	Seabed archaeological code	Code of Practice for Seabed Developers. Joint Nautical Archaeology Policy Committee (2006).	http://www.jnapc.org.uk/jnapc_brochure_may_2006.pdf
	Offshore heritage	Historic Environment Guidance for the Offshore Renewable Energy Sector. Wessex Archaeology (2007)	http://www.thecrownestate.co.uk/media/354779/2007-01%20Historic%20Environment%20Guidance%20for%20the%20Offshore%20Renewable%20Energy%20Sector.pdf
	Geotechnical investigations	Offshore Geotechnical Investigations and Historic Environment Analysis: Guidance for the Renewable Energy Sector. Emu (2011)	http://www.thecrownestate.co.uk/media/354783/2011-01%20Offshore%20Geotechnical%20Investigations%20and%20Historic%20Environment%20Analysis%20-%20Guidance%20for%20the%20Renewable%20Energy%20Sector.pdf
	European historic environment guidance	Guidance for Assessment of Cumulative Impact on the Historic Environment from Offshore Renewable Energy (COWRIE 2008)	http://data.offshorewind.co.uk/
	Archaeology planning advice -Scotland	Planning Advice Note 2/2011.	http://www.scotland.gov.uk/Publications/2011/08/04132003/0
A5.2 Policy	UK overview planning guidelines	National Planning Policy Framework - Section 12: Conserving the Historic Environment	http://www.communities.gov.uk/documents/planningandbuilding/pdf/2116950.pdf
	UK energy policy	Overarching NPS for Energy (EN-1) (DECC 2011a)	http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/consents-planning/nps2011/1938-overarching-nps-for-energy-en1.pdf
	UK renewable energy policy	National Policy Statement for Renewable Energy Infrastructure (EN-3), July 2011(Section 2.6)	http://www.official-documents.gov.uk/document/other/9780108509360/9780108509360.pdf
	Scottish Planning Policy	The Scottish Historic Environment Policy (SHEP)	http://www.historic-scotland.gov.uk/index/heritage/policy/shep.htm
A5.3 Key contacts	UK government heritage advisory body - England	English Heritage	http://www.english-heritage.org.uk/
	UK government heritage advisory body - Scotland	Historic Scotland	http://www.historic-scotland.gov.uk/heritage

A5. Archaeology and heritage			
	Function	Title	Links
	UK government heritage advisory body - Wales	CADW	http://cadw.wales.gov.uk/?skip=1&lang=en
	UK government heritage advisory body - Northern Ireland	Northern Ireland Environment Service	http://www.doeni.gov.uk/niea//

A6. Ornithology			
	Function	Title	Links
A6.1 Guidance	EIA guidance	Guidance on the Assessment of Effects on the Environment and Cultural Heritage from Marine Renewable Developments.	http://www.marinemanagement.org.uk/
	EIA guidance	Guidelines for Ecological Impact Assessment in Britain and Ireland, Marine and Coastal	http://www.ieem.net/data/files/Resource_Library/Technical_Guidance_Series/EcIA_Guidelines/Final_EcIA_Marine_01_Dec_2010.pdf
	Cefas report for EIA guidance	Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects.	Cefas. Report reference: ME5403 - Module 15. Issue date: 10th March 2011
	European bird guidance	Nature conservation guidance on offshore wind farm development. A Guidance Note on the Implications of the EC Wild Birds and Habitats Directives for Developers	http://webarchive.nationalarchives.gov.uk/20080915101357/http://www.defra.gov.uk/wildlife-countryside/ewd/windfarms/windfarmguidance.pdf
	European bird guidance	Developing Guidance on Ornithological Cumulative Impact Assessment for Offshore Wind Farm Developers (COWRIE, 2009).	http://www.marinedataexchange.co.uk/
A6.2 Policy	UK energy policy	Overarching NPS for Energy (EN-1) (DECC 2011a)	http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/consents-planning/nps2011/1938-overarching-nps-for-energy-en1.pdf
	UK renewable energy policy	National Policy Statement for Renewable Energy Infrastructure (EN-3), July 2011(Section 2.6)	http://www.official-documents.gov.uk/document/other/9780108509360/9780108509360.pdf
	EU Policy	Directive 2009/147/EC on the conservation of wild birds (The Birds Directive)	http://ec.europa.eu/environment/nature/legislation/birdsdirective/index_en.htm
	UK legislation	The Wildlife and Countryside Act 1981	http://www.legislation.gov.uk/ukpga/1981/69
	UK policy guidance	The UK Biodiversity Action Plan (UK BAP)	http://jncc.defra.gov.uk/default.aspx?page=5155
	Legislation	Natural Environment and Rural Communities (NERC) Act 2006	http://www.legislation.gov.uk/ukpga/2006/16/contents

A6. Ornithology			
	Function	Title	Links
	Legislation	The Nature Conservation (Scotland) Act 2004 (as amended)	http://www.legislation.gov.uk/asp/2004/6/contents
	Legislation	Wildlife and Natural Environment (Scotland) Act 2011;	http://www.legislation.gov.uk/asp/2011/6/contents/enacted
A6.3 Key contacts	Bird information	British Trust for Ornithology (BTO)	http://www.bto.org/
	Marine planning fisheries and marine regulation body.	Marine Management Organization	http://www.marinemanagement.org.uk/
	UK conservation group on bird species.	Royal Society for Protection of Birds	http://www.rspb.org.uk/

A7. Seascape and visual			
	Function	Title	Links
A7.1 Guidance	Landscape guidance	Landscape Character Assessment: Guidance for England and Scotland	http://www.naturalengland.org.uk/ourwork/landscape/englands/character/assessment/default.aspx
	IEMA guidance	Guidelines for Landscape and Visual Effect Assessment, second edition	http://www.naturalengland.org.uk/ourwork/landscape/englands/character/assessment/default.aspx
	CCW guidance	Guide to Best Practice in Seascape Assessment	http://www.ccw.gov.uk/pdf/Guide-to-best-practice-in-seascape-assessment.pdf
	Scottish guidance	Visual Representation of Wind Farms: Good Practice Guidance	http://www.snh.gov.uk/publications-data-and-research/publications/search-the-catalogue/publication-detail/?id=846
	UK legislation	Guidance on the Assessment of the Effect of Offshore Wind Farms: Seascape & Visual Impact Report	http://www.catpaisatge.net/fitxers/guies/eolics/file22852.pdf
A7.2 Policy	UK policy guidance	NPS for Electricity Network Infrastructure (EN-5) (DECC, 2011c).	http://www.official-documents.gov.uk/document/other/9780108510816/9780108510816.pdf
A7.3 Key contacts	UK government natural environment advisory body - Scotland	Natural England	http://www.naturalengland.org.uk/
	UK government natural environment advisory body - Scotland	Countryside Council for Wales	http://www.ccgc.gov.uk/default.aspx

A7. Seascape and visual			
	Function	Title	Links
	Historic places and archaeological remains - England	English Heritage	http://www.english-heritage.org.uk/
	UK government natural environment advisory body	Joint Nature Conservation Committee (JNCC)	http://jncc.defra.gov.uk/
	UK government natural environment advisory body - Scotland	Historic Scotland	http://www.historic-scotland.gov.uk/heritage
	UK government natural environment advisory body - Northern Ireland	Northern Ireland Environment Agency	http://www.doeni.gov.uk/niea//

A8. Commercial fisheries			
	Function	Title	Links
A8.1 Guidance	UK government policy	Marine Licensing requirements (replacing Section 5 Part II of the Food and Environmental Protection Act 1985 and Section 34 of the Coast Protection Act 1949)	http://www.legislation.gov.uk/ukpga/Geo6/12-13-14/74
	Local recommendations	British Wind Energy Association (2004)	http://www.bwea.com/
	EIA practice	Offshore Wind farms, Guidance note for Environmental Impact Assessment In respect of FEPA and CPA requirements - Version 2	http://www.cefas.co.uk/publications/files/windfarm-guidance.pdf
	SEA Guidance	UK Offshore Energy - Strategic Environmental Assessment. 2009	http://www.offshore-sea.org.uk/site/scripts/book_info.php?consultationID=16&bookID=11
	Fisheries guidance	Recommendations for Fisheries Liaison May 2008	http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/files/file46366.pdf
	UK industry-oil and gas	Fisheries Liaison Guidelines - Issue 5, 2008	http://www.oilandgasuk.co.uk/templates/publications/list.cfm
	UK Offshore Operators Association	August 2006. Guidelines to Improve Relations between Oil & Gas Industries and Near-shore Fishermen,	http://www.oilandgasuk.co.uk/
	International cable practice	February 2006 Fishing and Submarine Cables - Working Together	http://www.iscpc.org/
	Cefas Fishmaps/Fish DAC	Data on spawning and nursery grounds for fish and shellfish species	http://www.cefas.defra.gov.uk/publications-and-data/fishdac.aspx

A8. Commercial fisheries			
	Function	Title	Links
	Scottish Government	Consenting, EIA and HRA Guidance for Marine Renewable Energy Developments in Scotland.	http://mhk.pnnl.gov/wiki/images/e/ec/Consenting%2C_EIA_and_HRA_Guidance_for_Scotland.pdf
	SeaFish Assessment Guidance	Best Practice Guidance for Fishing Industry Financial and Economic Impact Assessments.	http://www.seafish.org/media/634910/ukfen%20ia%20best%20practice%20guidance.pdf
A8.2 Policy	UK energy policy	Overarching National Policy Statement (NPS) for Energy (EN-1). DECC (2011)	http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/consents-planning/nps2011/1938-overarching-nps-for-energy-en1.pdf
	National policy for renewable energy.	National Policy Statement for Renewable Energy Infrastructure (EN-3), July 2011(Section 2.6)	http://www.official-documents.gov.uk/document/other/9780108509360/9780108509360.pdf
A8.3 Key contacts	Applied marine science centre. Fisheries surveys data collection	Centre for Environment, Fisheries and Aquaculture Science (Cefas)	http://www.cefas.defra.gov.uk/
	Marine planning fisheries and marine regulation body.	Marine Management Organisation (MMO)	http://www.marinemanagement.org.uk/
	Regulation in UK districts	Inshore Fisheries Conservation Authorities (IFCAs)	http://www.defra.gov.uk/environment/marine/wwo/ifca/
	Stock assessment, advice centre, plans and coordinates marine research.	International Council for the Exploration of the Sea (ICES)	http://www.ices.dk/indexfla.asp
	Pan-industry fisheries body	Seafish	http://www.seafish.org/?area=true
	Marine planning fisheries and marine regulation body	Marine Scotland	http://www.scotland.gov.uk/Topics/marine/science
	Marine planning fisheries and marine regulation body	The Department of Agriculture and Rural Development (DARD)	http://www.dardni.gov.uk/index/fisheries-farming-and-food/marine_fisheries.htm

A9. Marine and physical processes			
	Function	Title	Links
A9.1 Guidance	Wind Farm advice	Using the Rochdale Envelope. PINS Advice Note Nine: Rochdale Envelope. February 2011	http://infrastructure.independent.gov.uk/wp-content/uploads/2011/02/Advice-note-9.-Rochdale-envelope-web.pdf
	BERR Atlas of UK information renewable energy resources	Renewables maps	http://www.renewables-atlas.info/
	EIA Guidance	Cefas (2004). Offshore Wind Farms. Guidance note for Environmental Impact Assessment in respect of FEPA and CPA requirements. Version 2.	http://www.cefas.co.uk/publications/files/windfarm-guidance.pdf

A9. Marine and physical processes			
	Function	Title	Links
A9.2 Policy	UK energy policy	Overarching NPS for Energy (EN-1) (DECC 2011a)	http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/consents-planning/nps2011/1938-overarching-nps-for-energy-en1.pdf
	UK energy policy	National Policy Statement for Renewable Energy Infrastructure (EN-3), July 2011(Section 2.6)	http://www.official-documents.gov.uk/document/other/9780108509360/9780108509360.pdf
A9.3 Key contacts	Applied marine science centre. Fisheries surveys and data collection	Centre for Environment, Fisheries and Aquaculture Science (Cefas)	http://www.cefas.defra.gov.uk/
	Marine planning fisheries and marine regulation body	Marine Management Organisation (MMO)	http://www.marinemanagement.org.uk/
	UK government nature conservation advisory body	Joint Nature Conservation Committee (JNCC)	http://jncc.defra.gov.uk/
	UK government natural environment advisory body - England	Natural England (NE)	http://www.naturalengland.org.uk/
	UK government natural environment advisory body - Wales	Countryside Council for Wales	http://www.ccgc.gov.uk/default.aspx
	UK government natural environment advisory body - Scotland	Scottish Natural Heritage	http://www.snh.gov.uk/about-snh/
	Scotland's environmental regulator	http://www.sepa.org.uk/about_us.aspx	http://www.sepa.org.uk/about_us.aspx
	UK government natural environment advisory body - Northern Ireland	Northern Ireland Environment Agency	http://www.doeni.gov.uk/niea/

A10. Marine and water sediment quality			
	Function	Title	Links
A10.1 Guidance	UK guidance	Water quality guidelines and standards in the marine environment	http://www.ukmarinesac.org.uk/activities/water-quality/wq4.htm
	Cefas guidance	Centre for Environment, Fisheries and Aquaculture Science Action Levels	http://www.cefas.defra.gov.uk/media/562541/cefas%20action%20levels.pdf

A10. Marine and water sediment quality			
	Function	Title	Links
	Scottish Government	Consenting, EIA and HRA Guidance for Marine Renewable Energy Developments in Scotland.	http://mhk.pnnl.gov/wiki/images/e/ec/Consenting%2C_EIA_and_HRA_Guidance_for_Scotland.pdf
	SEPA	SEPA Pollution Prevention Guidance (PPG) Notes	N/A
A10.2 Policy	UK energy policy	Overarching National Policy Statement (NPS) for Energy (EN-1). DECC (2011)	http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/consents-planning/nps2011/1938-overarching-nps-for-energy-en1.pdf
	National policy on renewable energy	National Policy Statement for Renewable Energy Infrastructure (EN-3), July 2011(Section 2.6)	http://www.official-documents.gov.uk/document/other/9780108509360/9780108509360.pdf
	EU Policy	Water Framework Directive (WFD)	http://ec.europa.eu/environment/water/water-framework/index_en.html
	EU Policy	Dangerous Substances Directive (76/464/EEC)/ / Priority Substances Directive	http://ec.europa.eu/environment/water/water-dangersub/76_464.htm
	EU Policy	Marine Strategy Framework Directive (MSFD) (2008/56/EC)	http://www.defra.gov.uk/environment/marine/msfd/
	EU Policy	Bathing Waters Directive (76/160/EEC)	http://rod.eionet.europa.eu/obligations/21
	International shipping policy	MARPOL Convention 73/78.	http://www.imo.org/about/conventions/listofconventions/pages/international-convention-for-the-prevention-of-pollution-from-ships-(marpol).aspx
	National Policy	Water Environment and Water Services (Scotland) Act (WEWS) 2003	http://www.scotland.gov.uk/Topics/Environment/Water/15561/WFD/WEWSAct
A10.3 Key contacts	Protection of the marine environment of the North-East Atlantic.	OSPAR	http://www.ospar.org/
	Safety and security of shipping	International Maritime Agency	http://www.imo.org/Pages/home.aspx
	Protect and improve the environment	Environment Agency	http://www.environment-agency.gov.uk/
	Scotland's environmental regulator	http://www.sepa.org.uk/about_us.aspx	http://www.sepa.org.uk/about_us.aspx
	UK government natural environment advisory body - Northern Ireland	Northern Ireland Environment Agency	http://www.doeni.gov.uk/niea/

A11. Other marine users			
	Function	Title	Links
A11.1 Guidance	International guidance	International Cable Protection Committee (ICPC) recommendations, particularly numbers 2, 3, 5, 7 and 13	http://www.iscpc.org/
	UK guidance	UK Cable Protection Committee (UKCPC) Guideline 06	http://www.ukcpc.org.uk/guidelines.asp
	Kingfisher Information Services	Maps	http://www.kisca.org.uk/charts.htm
	Seazone hydrospatial datasets	Marine maps GIS	http://www.seazone.com/dataHydroSpatial.php
A11.2 Policy	UK energy policy	NPS for Renewable Energy Infrastructure (EN-3) (DECC 2011a).	http://www.official-documents.gov.uk/document/other/9780108509360/9780108509360.pdf
	UK renewable energy policy	National Policy Statement for Renewable Energy Infrastructure (EN-3), July 2011(Section 2.6)	http://www.official-documents.gov.uk/document/other/9780108509360/9780108509360.pdf
A11.3 Key contacts	Policy guidance and climate change.	Department of Energy and Climate Change (DECC)	http://www.decc.gov.uk/
	British marine aggregate industry	British Marine Aggregate Producers Association (BMAPA)	http://www.bmapa.org/
	Information and representation for industry.	Oil and Gas UK DEAL	https://www.ukdeal.co.uk/dp/jsp/PleaseLoginDeal.jsp
	Past coal mining	The Coal Authority	http://coal.decc.gov.uk/
	Seabed owner	The Crown Estate	http://www.thecrownestate.co.uk/
	Fisheries surveys and data collection	Centre for Environment, Fisheries and Aquaculture Science (Cefas)	http://www.cefas.defra.gov.uk/
	Digital marine mapping	Seazone hydrospatial	http://www.seazone.com/dataHydroSpatial.php

B. Onshore

B1. Archaeology and cultural heritage			
	Function	Title	Links
B1.1 Guidance	Archaeological assessment process	IFA standards and guidance on undertaking archaeological assessment. Institute for Archaeologists (IFA) (2008)	http://www.archaeologists.net/codes/ifa
	Paleolithic remains identification	Identifying and Protecting Palaeolithic Remains: Archaeological Guidance for Planning Authorities and Developers. English Heritage (1998)	http://www.helm.org.uk/

B1. Archaeology and cultural heritage			
	Function	Title	Links
	Aircraft crash sites	Military Aircraft Crash Sites: archaeological guidance on their significance and future management. English Heritage (2002)	http://www.english-heritage.org.uk/publications/military-aircraft-crash-sites/milaircsites.pdf
	Desk based archaeological assessments	Standards and Guidance for Archaeological Desk Based Assessments	http://www.archaeologists.net/codes/ifa
	Archaeology planning advice	Planning Advice Note 2/2011.	http://www.scotland.gov.uk/Publications/2011/08/04132003/0
B1.2 Policy	UK overview planning guidelines	National Planning Policy Framework - Section 12: Conserving the Historic Environment	http://www.communities.gov.uk/documents/planningandbuilding/pdf/2116950.pdf
	Scottish Planning policy	The Scottish Historic Environment Policy (SHEP)	http://www.historic-scotland.gov.uk/index/heritage/policy/shep.htm
B1.3 Key contacts	UK government heritage advisory body - England	English Heritage	http://www.english-heritage.org.uk/
	UK government heritage advisory body - Scotland	Historic Scotland	http://www.historic-scotland.gov.uk/heritage
	UK government heritage advisory body - Wales	CADW	http://cadw.wales.gov.uk/?skip=1&lang=en
	UK government heritage advisory body - Northern Ireland	Northern Ireland Environment Service	http://www.doeni.gov.uk/niea//
	Planning administration	Local Planning Authority	http://www.planningportal.gov.uk
	Planning authority advisor	County Archaeologist	Contact relevant local authority
	Geological value records	Local Environmental Records Centre	http://www.alerc.org.uk/find-an-lrc.html

B2. Dust and air quality			
	Function	Title	Links
B2.1 Guidance	Construction impacts on air quality	Guidance on the Assessment of the Impacts of Construction on Air Quality and the Determination of their Significance. Institute of Air Quality Management (2012)	http://www.iaqm.co.uk/text/guidance/construction_guidance_2012.pdf
	Air quality assessment for LAs	Local Air Quality Management Technical Guidance. Defra (2009)	http://www.defra.gov.uk/publications/files/pb13081-tech-guidance-laqm-tg-09-090218.pdf
	Traffic air quality impacts assessment	Highways Agency Design Manual for Roads and Bridges (DMRB) screening tool. Highways Agency (2007)	http://www.dft.gov.uk/ha/standards/guidance/air-quality.htm

B2. Dust and air quality			
	Function	Title	Links
B2.2 Policy	Air quality and planning process	Development Control: Planning for Air Quality 2010 Update. Environmental Protection UK (2010)	http://www.iaqm.co.uk/text/guidance/epuk/aq_guidance.pdf
B2.3 Key contacts	Environmental health enforcement	Environmental Health Office	Contact relevant local authority
	Provides guidance on personal safety	Health and Safety Executive	http://www.hse.gov.uk/
	Provides information on air quality and standards within Scotland	Air Quality Scotland	http://www.scottishairquality.co.uk/

B3. Landscape and visual			
	Function	Title	Links
B3.1 Guidance	Landscape and visual impact assessment	Guidelines for Landscape and Visual Impact Assessment (GLVIA). IEMA (2002)	N/A
	Offshore wind visual impact	Guidance on the Assessment of the Impact of Offshore Wind Farms: Seascape and Visual Impact Report. DTI (now BERR) (2005)	N/A
	Landscape character assessment	Landscape Character Assessment: Guidance for England and Scotland - Topic Paper 6: Techniques and Criteria for Judging Capacity and Sensitivity. SNH and the Countryside Agency (2002)	http://www.naturalengland.org.uk/Images/lcatopicpaper6_tcm6-8179.pdf
	Photography in landscape and visual impact assessment	Use of Photography and Photomontage in Landscape and Visual Assessment (Advice Note 01/11). Landscape Institute (2011)	http://www.landscapeinstitute.org/PDF/Contribute/LIPhotographyAdviceNote01-11.pdf
	Landscape impact of overhead lines	Guidelines for the routeing of new high voltage overhead transmission lines ('The Holford Rules'). National Grid (1993)	http://www.nationalgrid.com/NR/rdonlyres/E9E1520A-EB09-4AD7-840B-A114A84677E7/41421/HolfordRules1.pdf
	Landscape impact of substations	Guidance on Siting of Substations ('The Horlock Rules'). National Grid	http://www.nationalgrid.com/NR/rdonlyres/E9E1520A-EB09-4AD7-840B-A114A84677E7/41421/HolfordRules1.pdf
	Traffic impacts upon visual amenity	Highways Agency, Design Manual for Road and Bridges Volume 11. Highways Agency (2012)	http://www.dft.gov.uk/ha/standards/dmrb/
B3.2 Policy	UK overview planning guidelines	National Planning Policy Framework	http://www.communities.gov.uk/documents/planningandbuilding/pdf/2116950.pdf

B3. Landscape and visual			
	Function	Title	Links
B3.3 Key contacts	UK government natural environment advisory body - England	Natural England	http://www.naturalengland.org.uk/
	UK government natural environment advisory body - Wales	Countryside Council for Wales	http://www.ccgc.gov.uk/default.aspx
	UK government natural environment advisory body - England	English Heritage	http://www.english-heritage.org.uk/
	UK government natural environment advisory body - Scotland	Historic Scotland	http://www.historic-scotland.gov.uk/heritage
	Local landscape officer	Relevant local authority	Contact relevant local authority

B4. Noise and vibration			
	Function	Title	Links
B4.1 Guidance	British Standard on noise and vibration control	BS 5228 (Parts 1 and 2): Code of Practice for noise and vibration control on construction and open sites. (2009)	http://www.persona.uk.com/A5dunstable/deposit-docs/DD-051.pdf http://www.persona.uk.com/a1elkesley/DD_docs/DD-176.pdf
	Traffic noise level calculation	Calculation of road traffic noise. DTI (1988)	N/A
	Traffic noise and vibration impacts on	Design Manual for Road and Bridges: Volume 11, Part 3, Section 7 - Noise and vibration. Highways Agency (2012)	http://www.dft.gov.uk/ha/standards/dmrb/
	British Standard on buildings and vibration	BS 7385-2: Evaluation and measurement for vibration in buildings. (1993)	http://www.persona.uk.com/ashton/Core_docs/New/D40.pdf
	British Standard on people and vibration	BS 6472-1: Guide to evaluation of human exposure to vibration. (2008)	http://www.persona.uk.com/ashton/Core_docs/New/D72.pdf
	British Standard on buildings and noise reduction	BS 8233 Sound insulation and noise reduction for buildings. (1999)	N/A
	Acceptable noise levels	Guidelines for community noise. WHO (1999)	http://www.bvsde.paho.org/bvsci/i/fulltext/noise/noise.pdf
	British Standard noise and residential areas	BS 4142: Method for rating industrial noise affecting mixed residential and industrial areas.	N/A
	Scottish government advice	Planning Advice Note 1/2011: Planning and Noise	http://www.scotland.gov.uk/Publications/2011/02/28153945/1

B4. Noise and vibration			
	Function	Title	Links
B4.2 Policy	National planning policy	The National Planning Policy Framework (Department for Communities and Local Government (DCLG), 2012)	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/6077/2116950.pdf
B4.3 Key contacts	Environmental health enforcement	Environmental Health Office	Contact relevant local authority
	Provides guidance on personal safety	Health and Safety Executive	http://www.hse.gov.uk/
	Scotland's environmental regulator	http://www.sepa.org.uk/about_us.aspx	http://www.sepa.org.uk/about_us.aspx

B5. Terrestrial ecology and nature conservation			
	Function	Title	Links
B5.1 Guidance	Ecological Impact Assessment	Guidelines for Ecological Impact Assessment in the United Kingdom. IEEM (2006	http://www.ieem.net/data/files/Resource_Library/Technical_Guidance_Series/EcIA_Guidelines/Final_EcIA_Marine_01_Dec_2010.pdf
B5.2 Policy	UK energy policy	Overarching National Policy Statement (NPS) for Energy (EN-1). DECC (2011)	http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/consents-planning/nps2011/1938-overarching-nps-for-energy-en1.pdf
	UK electricity network policy	NPS for Electricity Network Infrastructure (EN-5). DECC (2011)	http://www.official-documents.gov.uk/document/other/9780108510816/9780108510816.pdf
	SAC legislation	Habitats Directive (Council Directive 92/43/EEC)	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:1992:206:0007:0050:EN:PDF
	SPA legislation	Birds Directive (Directive 2009/147/EC)	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:020:0007:0025:EN:PDF
	UK policy guidance	UK Biodiversity Action Plan	N/A
	UK Policy Guidance	UK Post-2010 Biodiversity Framework	http://jncc.defra.gov.uk/pdf/UK_Post2010_Bio-Fwork.pdf
	Legislation	Natural Environment and Rural Communities (NERC) Act 2006	http://www.legislation.gov.uk/ukpga/2006/16/contents
B5.3 Key contacts	UK government nature conservation advisory body - England	Natural England	http://www.naturalengland.org.uk/
	UK government nature conservation advisory body - Wales	Countryside Council for Wales	http://www.ccgc.gov.uk/default.aspx
	UK government nature conservation advisory body - Scotland	Scottish Natural Heritage	http://www.snh.gov.uk/

B5. Terrestrial ecology and nature conservation			
	Function	Title	Links
	UK government nature conservation advisory body - Northern Ireland	Northern Ireland Environment Agency	http://www.doeni.gov.uk/niea/
	UK government nature conservation advisory body	Joint Nature Conservation Committee (JNCC)	http://www.jncc.defra.gov.uk/
	Provider of local environmental information	Local Wildlife Trust	http://www.wildlifetrusts.org/local
	Provider of ornithological and habitats information	Royal Society for the Protection of Birds	http://www.rspb.org.uk/

B6. Traffic and access			
	Function	Title	Links
B6.1 Guidance	General best practice guidelines	Best Practice Guidelines for Wind Energy Development. BWEA (now Renewable UK) (1994)	http://ec.europa.eu/energy/res/sectors/doc/wind_energy/best_practice.pdf
	Transport assessment procedure	Guidance for Transport Assessment. DTI (2007)	http://www.dft.gov.uk/publications/guidance-on-transport-assessment/
	Road traffic impact assessment	Guidelines for the Assessment of Road Traffic. IEMA (2003)	N/A
B6.2 Policy	UK energy policy	Overarching National Policy Statement (NPS) for Energy (EN-1). DECC (2011)	http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/consents-planning/nps2011/1938-overarching-nps-for-energy-en1.pdf
	UK electricity network policy	NPS for Electricity Network Infrastructure (EN-5). DECC (2011)	http://www.official-documents.gov.uk/document/other/9780108510816/9780108510816.pdf
	Traffic considerations for impact assessment	Design Manual for Road and Bridges. Highways Agency (2012)	http://www.dft.gov.uk/ha/standards/dmrb/
	New street design	The Manual for Streets. DTI/DCLG (2007)	http://assets.dft.gov.uk/publications/manual-for-streets/pdfmanforstreets.pdf
	Scottish planning policy	Scottish Planning Policy (SPP) he Provision of Roadside Facilities on Motorways and Other Trunk Roads in Scotland,	http://www.scotland.gov.uk/Publications/2005/08/16154406/44096
B6.3 Key contacts	Statutory consultee for developments impacting on national road network	Highways Agency	http://www.highways.gov.uk/
	National transport agency - Scotland	Transport Scotland	http://www.transportscotland.gov.uk/
	Statutory consultee for developments impacting on local roads	Local Highways Authority	Contact local highways authority

B7. Waste			
	Function	Title	Links
B7.1 Guidance	Site waste management plans	Department for Environment, Food and Rural Affairs: Non-statutory guidance for site waste management plans	http://archive.defra.gov.uk/environment/waste/topics/construction/pdf/swmp-guidance.pdf
B7.2 Policy	Site waste management plans	The Site Waste Management Plan Regulations 2008 S.I. No. 314	http://www.legislation.gov.uk/uksi/2008/314/contents/made
	Issue of pollution and waste permits	The Environmental Permitting Regulations 2010 (as amended)	http://www.legislation.gov.uk/ukdsi/2010/9780111491423/contents
B7.3 Key contacts	Competent authority for waste	Environment Agency	http://www.environment-agency.gov.uk/business/topics/waste/default.aspx
	Waste removal responsibility	Local authority	http://local.direct.gov.uk/LDGRedirect/index.jsp?mode=1.1

B8. Water resources and Land Quality			
	Function	Title	Links
B8.1 Guidance	River Basin Management	River Basin Management Plans (RBMP)	http://www.environment-agency.gov.uk/research/planning/33106.aspx http://www.sepa.org.uk/water/river_basin_planning.aspx http://www.doeni.gov.uk/niea/water/wfd/themes/riv_bsn_mngt_plng.htm
	Catchment Abstraction Management	Catchment Abstraction Management Plans (CAMS)	http://www.environment-agency.gov.uk/research/planning/40197.aspx http://www.sepa.org.uk/water/river_basin_planning/area_advisory_groups/tweed/actions_planned.aspx
	General procedures	The Contaminated Land Report Series	http://www.environment-agency.gov.uk/research/planning/33710.aspx
	Contaminant incidence response guidelines	PPG 21 Incident Response Planning	http://cdn.environment-agency.gov.uk/pmho0309bpna-e-e.pdf
	Contaminant incidence response guidelines	PPG 22 Incident Response - dealing with spills	http://cdn.environment-agency.gov.uk/pmho0411btez-e-e.pdf
	Contaminant hazards during construction	PPG 6 Pollution Prevention Guidance for working at construction and demolition sites	http://www.doeni.gov.uk/niea/ppg06.pdf
	Water pollution from construction	C532 (Control of Water Pollution from Construction Sites). CIRIA (2001)	http://www.orkneywind.co.uk/advice/SEPA%20Pollution%20Advice/ciria%20c532.pdf
	Water pollution from construction	C648 (Control of Water Pollution from Linear Construction Projects). CIRIA (2006)	http://www.orkneywind.co.uk/advice/SEPA%20Pollution%20Advice/ciria%20c648.pdf?PHPSESSID=ve85v5ruoa3opn4t62d6de44o2

B8. Water resources and Land Quality			
	Function	Title	Links
B8.2 Policy	Control on pollutant emissions to groundwater	The Groundwater Regulations (1998)	http://www.legislation.gov.uk/uksi/1998/2746/contents/made
	SAC Directive	The Groundwater Directive 2006/118/EC	http://rod.eionet.europa.eu/instruments/625
	Legislation	Water Resources Act 1991	http://www.legislation.gov.uk/ukpga/1991/57/contents
	Legislation	Groundwater (England and Wales) Regulations 2009	http://www.legislation.gov.uk/uksi/2009/2902/contents/made
	Legislation	The Water Environment (Groundwater and Priority Substances) (Scotland) Regulations 2009	http://www.legislation.gov.uk/ssi/2009/420/contents/made
	Legislation	The Private Water Supplies Regulations, 2009	http://dwi.defra.gov.uk/stakeholders/legislation/pwsregs2009.pdf
	Legislation	The Water Environment (Controlled Activities Regulations) (Scotland) Regulations 2011	http://www.legislation.gov.uk/sdsi/2011/9780111012963/contents
	Policy Guidance	Water Framework Directive (Council Directive 2000/60/EC) The Water Environment and Water Services (Scotland) Act 2003 The Water Environment (Water Framework Directive) Regulations (Northern Ireland) 2003 (Statutory Rule 2003 No. 544) for Northern Ireland	http://ec.europa.eu/environment/water/water-framework/index_en.html
	Legislates for rules regarding water body quality	Water Environment (Water Framework Directive) (England and Wales) Regulations (2003)	http://www.legislation.gov.uk/uksi/2003/3242/contents/made
	UK overview planning guidelines	National Planning Policy Framework - Section 12: Conserving the Natural Environment	http://www.communities.gov.uk/documents/planningandbuilding/pdf/2116950.pdf
	UK energy policy	Overarching National Policy Statement (NPS) for Energy (EN-1). DECC (2011)	http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/consents-planning/nps2011/1938-overarching-nps-for-energy-en1.pdf
	UK renewable energy Infrastructure Policy	NPS for Renewable Energy Infrastructure (EN-3). DECC (2011)	http://www.official-documents.gov.uk/document/other/9780108510793/9780108510793.pdf
	UK electricity network policy	NPS for Electricity Network Infrastructure (EN-5). DECC (2011)	http://www.official-documents.gov.uk/document/other/9780108510816/9780108510816.pdf
	Contaminated land and remediation notices	Contaminated Land (England) Regulations 2006 SI 1380	http://www.legislation.gov.uk/uksi/2006/1380/contents/made
	Site waste management plans	The Site Waste Management Plan Regulations 2008 S.I. No. 314	http://www.legislation.gov.uk/uksi/2008/314/contents/made
	Defining environmental duty of care	Environmental Protection (Duty of Care) Regulations 1991 SI 2839 (as amended)	http://www.legislation.gov.uk/uksi/1991/2839/contents/made

B8. Water resources and Land Quality			
	Function	Title	Links
	Control on pollutant emissions to groundwater	The Groundwater Regulations (1998)	http://www.legislation.gov.uk/uksi/1998/2746/contents/made
	Issue of pollution and waste permits	The Environmental Permitting Regulations 2010 (as amended)	http://www.legislation.gov.uk/ukdsi/2010/9780111491423/contents
	Control on pollutant emissions	The Environmental Damage (Prevention and Remediation) Regulations 2009 SI 153	http://www.legislation.gov.uk/uksi/2009/153/contents/made
	Site investigations	British Standard BS5930:1999, The Code of Practice for Site Investigations	http://www.bsigroup.com/en-GB/about-bsi/uk-national-standards-body/
	Contaminated sites	British Standard BS10175:2001, Investigation of Potentially Contaminated Sites,	http://www.bsigroup.com/en-GB/about-bsi/uk-national-standards-body/
B8.3 Key contacts	Environmental monitoring and permitting	Environment Agency	http://www.environment-agency.gov.uk/business/topics/water/default.aspx
	Potential receptors for water contamination	Local Water Company	http://www.water.org.uk/home/our-members/find-water-company
	Permitting for industrial emissions	Local Authority	Contact relevant local authority
	UK government natural environment advisory body - England	Natural England	http://www.naturalengland.org.uk/
	UK government natural environment advisory body - Wales	Countryside Council for Wales	http://www.ccgc.gov.uk/default.aspx
	UK government natural environment advisory body - Scotland	Scottish Natural Heritage	http://www.snh.gov.uk/about-snh/
	UK government natural environment advisory body - Northern Ireland	Northern Ireland Environment Agency	http://www.doeni.gov.uk/niea/
	Potential receptors for land contamination	Water companies	http://www.water.org.uk/home/our-members/find-water-company
	Monitoring of land / water pollution	Environment Agency	http://www.environment-agency.gov.uk/homeandleisure/pollution/water/default.aspx
	Contamination migration issues	Neighbouring Landowners	N/A
	Scotland's environmental regulator	Scottish Environmental Protection Agency	http://www.sepa.org.uk/about_us.aspx

C. General EIA

C. General			
	Function	Title	Links
C1.1 Guidance	General EIA Guidance	Institute of Environmental Management & Assessment (IEMA) (2004). Guidelines for Environmental Impact Assessment.	Contact IEMA
	General EIA Guidance	Institute of Environmental Management & Assessment (IEMA) (2011). The State of Environmental Impact Assessment Practice in the UK.	Contact IEMA
	General EIA Guidance	Scottish National Heritage (2012) Environmental Assessment Handbook	Contact IEMA
	EIA Guidance document	Environmental impact assessment: circular 02/1999	https://www.gov.uk/government/publications/environmental-impact-assessment-circular-02-1999
	EIA Guidance document	Planning Circular 3 2011: The Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2011	http://www.scotland.gov.uk/Resource/Doc/350238/0117228.pdf
C1.2 Policy	EIA Directive 2011/92/EU	DIRECTIVE 2011/92/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 13 December 2011	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:026:0001:0021:EN:PDF
C1.3 Key contacts	Environmental professional body	Institute of Environmental Management and Assessment (IEMA)	http://www.iema.net/
	Environmental professional body	Chartered Institute of Water and Environmental Management (CIWEM)	http://www.ciwem.org/
	Scotland's environmental regulator	Scottish Environmental Protection Agency (SEPA)	http://sepa.org.uk/
	UK government natural environment advisory body - Northern Ireland	Northern Ireland Environment Agency (NIEA)	http://www.doeni.gov.uk/niea/
	England and Wales environmental regulator	Environment Agency (EA)	http://www.environment-agency.gov.uk/

Appendix III: Frequently asked questions

Where does electricity go after it is generated?

Electricity cannot be stored in large quantities, so electricity entering the system is moved around the country for immediate use. In Great Britain, this national electricity supply is maintained by National Grid in its role as the National Electricity Transmission System Operator (NETSO). A key function of the NETSO is to constantly 'balance' the supply and demand across the system. This is a process of always ensuring that the grid has sufficient electricity at any moment it is needed, which can vary greatly due to changing domestic and industrial demand and variable supply due to power station faults or changing wind conditions for wind energy generation.

Most consumers are not connected to the high voltage national transmission system. As such, electrical energy is transferred from the national transmission system to local distribution networks. These local networks run at lower voltages (up to and including 132kV in England & Wales and below 132kV in Scotland). Electricity from distribution networks is in turn transformed at a neighbourhood level to 400V (i.e. 240V in single phase) for domestic consumption.

How will variable wind energy adequately supply our continuous demand?

All electricity systems must accommodate a constantly varying level of demand for power. The electricity grid is designed to accommodate this variability and the mechanisms that enable changes in demand to be accommodated can also accommodate changes in output from variable generation sources like wind power.

In Great Britain, National Grid studies show how the GB electricity system could be operated satisfactorily to meet targets for 2020 with 27 GW of wind generation, though with some additional costs, for example for additional reserve capacity[57 58]. In the longer term there are numerous technological options to facilitate much greater amounts of wind power - such as improved interconnection with other countries, intelligent management of supply and demand through a 'smart grid' and adequate energy storage capacity.

How can offshore renewable energy projects help meet renewable energy targets?

The Committee on Climate Change advised the government that 30% of electricity generation in the UK should come from renewable sources by 2020. This is in line with the government's targets under the Renewable Energy Directive to achieve 15% of energy use from renewable sources by 2020.

How do you assess possible environmental impacts of offshore renewable energy projects and their associated electrical transmission infrastructure?

Large electrical transmission developments are required, under EU and UK law, to undertake a statutory Environmental Impact Assessment (EIA) into the possible effects of construction, operation and decommissioning upon sensitive environmental receptors. This legal requirement is set down in the EIA directive (2011/92/EU) of the European Council.

The Environmental Impact Assessment process consists of the following:

- Screening - assessing a site for whether an EIA is to be required.
- Scoping - ruling out environmental receptors to which no impact is likely, and focussing on receptors where there is a risk of impact. This process should involve consultation with external stakeholders to provide outside opinion of where impacts may require further investigation.
- Impact Assessment process - standardised process of assessing impacts of development upon environmental receptors, carried out by technical specialists.
- Consultation - community and stakeholder consultation to determine acceptability
- Publication - submission and publication of an Environmental Statement (ES) based on the outcomes of the impact assessment process. The ES will include, as a minimum:

a) A description of the development comprising information on the site, design and size of the development;
b) An outline of the main alternatives studied by the applicant and an indication of the main reasons for the applicant's choice, taking into account the environmental effects;
c) The data required to identify and assess the main effects, which the development is likely to have on the environment;
d) A description of the measures envisaged in order to avoid, reduce and, if possible, remedy significant adverse effects; and
e) A non-technical summary (NTS) of the information provided.

What are the wider community benefits associated with transmission infrastructure construction?

Electrical transmission is heavily reliant on the local economy during construction. Local contractors and materials can be required for fencing, cable ducting, substation construction and machinery hire. Local contractors will in addition be required for substation maintenance. Substations do not fall under the requirements of the community infrastructure levy, however to achieve community benefit through transmission development developers may have the option to allocate a community fund for community projects after construction; however there is no legal requirement.

57 National Grid. Electricity Ten Year Statement 2012. Accessible at: www.nationalgrid.com/uk/Electricity/ten-year-statement/
58 National Grid. Operating the electricity transmission networks in 2020 - Update June 2011. Accessible at: www.nationalgrid.com/uk/Electricity/Operating+in+2020/

What are electromagnetic fields, and what risk do they pose to the public?

Electromagnetic fields (EMFs) are produced where any electrical current flows, hence electromagnetic fields are emitted by all electrical devices or natural electrical phenomenon such as lightning. Higher voltage and greater current produce stronger fields.

Electromagnetic fields associated with electricity produce non-ionising radiation, i.e. radiation which is insufficiently powerful to break molecular bonds. Chief health concerns regarding this form of radiation are linked to its capacity to heat up human tissue where the fields are sufficiently powerful. Despite this concern, the WHO (World Health Organisation) guidelines[59] (developed by International Commission on Non-Ionizing Radiation Protection and reviewed and referenced by WHO) currently state that no conclusive evidence has been found to indicate that there are any health consequences resulting from exposure to low level electromagnetic fields.

The 'WHO guidelines' indicate that safe levels of magnetic fields are 100 µT for the general public, or 500 µT for workers. The magnetic fields from buried cables exceed these limits, with the strength of the fields mitigated by passage through the earth to reach the surface. Electric fields underneath overhead lines can be as high as 10 kV/m, which is higher than the WHO safe limit of 5 kV/m. However, the strength of fields drops off rapidly with distance from source, with values returning to background levels within 50-100m from overhead lines. Substations produce almost no electrical fields, as the grounded metal security fence surrounding the compound dissipates the majority of the fields and prevent them from emanating from the site.

In the UK, the Government policy on EMFs is that power lines should comply with the aforementioned 'WHO guidelines' in terms of the 1999 EU Recommendation. In 2009 two voluntary Codes of Practice were developed and agreed between the Energy Networks Association (ENA) and the Government. Both Codes of Practice have been applied in England, Scotland, Wales and Northern Ireland.

What is the difference between MW and MWh?

MW (Megawatts) refers to power, i.e. the amount of energy being produced or transmitted per second.

MWh (Megawatt-hours) refers to energy. If a wind turbine produces 1 MW for a duration of one hour, it has produced 1 MWh of electrical energy. Similarly, if a domestic electric kettle (typically 3 kW rating) is switched on for 2 minutes, it has used 6 kW-minutes of electrical energy, or 0.1 kWh, or 0.0001 MWh.

What is the difference between MW and MVA?

For the purposes of this document, MW and MVA can be assumed to be the same. Both describe the amount of electrical energy per second (i.e. power, see above) which is being produced or transmitted. Alternatively, if used to describe electrical equipment, the terms describe the maximum amount of electrical energy per second which the equipment is capable of producing or transmitting.

The difference between MW and MVA is that the former term strictly covers only electrical power, i.e. capable of doing useful work, whereas the latter term also includes the 'reactive power' which flows without producing useful work (see below).

What is the difference between power factor and capacity or load factor?

Power factor is a term used in electrical engineering to quantify the reactive power (see below) flowing in a circuit, normalised by the 'active' or useful power. The exact relationship is slightly more complex than a simple ratio of these quantities, but for the purposes of this document it is sufficient to note that electrical engineers will seek to design and operate the system to keep the power factor close to 1.0 or 'unity power factor'. Power factor can never exceed 1.0, and normally is in the range 0.85 to 1.0.

The terms 'capacity factor' and 'load factor', which can be used interchangeably, mean the ratio, over a long period such as a year or longer, of the energy actually produced by the generator, to the energy it could have produced if it had operated at full output for the entire period.

Wind generation typically achieves capacity factors in the range 20% to 35%, depending on the location and the design. In extremely windy locations such as Shetland, capacity factors of over 50% may be achieved. Conventional fossil-fired electricity generation is not constrained by availability of the 'fuel', unlike wind, but is constrained by reliability, and by its ability to compete on price against other generators for a finite electricity demand. The cheapest may achieve capacity factors of 80% or possibly 90%, whereas the most expensive generators are used only to meet very rare peaks in electricity demand, and may only operate for a few hundred hours a year, with capacity factors of a few percent.

What is the reactive power and why does it need to be compensated?

'Reactive power' is a concept used by electrical engineers to describe the flows of electrical energy between elements of an AC electrical system, without producing useful work in the 'loads'.

Some elements of the electrical system act as capacitors, i.e. they store energy in electric fields within their structure. Cables are a good example: the conductors are charged up to some voltage, whereas on the other side of the insulating material there is a metallic screen or armour which is effectively at earth potential. There is therefore an electric field between the conductor and the earthed elements, and energy is stored in this field. For an AC system, this energy is constantly charged and discharged as the instantaneous voltage alternates.

Similarly, other elements of the electrical system act as inductors, i.e. they store energy in magnetic fields within their structure. The most common source of 'inductance' is a transformer, which depends on creating magnetic fields in its core in order to function. Electrical energy is stored in this

59 International Commission on Non-Ionizing Radiation Protection. ICNIRP guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 ghz). Health Physics 74 (4):494-522; 1998. Available at www.icnirp.org/documents/emfgdl.pdf

magnetic field, and is constantly charged and discharged as the instantaneous voltage alternates.

The net effect is that instantaneous electrical power oscillates between the inductances and the capacitances, changing direction with every cycle of the AC voltage. This power is real, but does no useful or active work. It is hence called ‘Reactive Power’. In fact, Reactive Power contributes to resistive losses. Electrical engineers seek to minimise reactive power flows to the economic minimum. Reactive power compensation is one way to do so.

There is an additional complication, which is that in some cases reactive power flows can be useful in controlling the voltage at points on the electricity system.

What is monopole HVDC and what is bipole HVDC and sea return?

For an HVDC connection, pairs of cables (a ‘bipole’ arrangement) may be used, one with a positive polarity conductor, and another a negative polarity conductor. The cables in this case are a single core construction.

It is possible for HVDC transmission to be achieved with a single cable (called ‘monopole’). In this case, the return path is provided by current flowing through the earth or through the sea (‘sea return’). This may cause greater electromagnetic fields. This may be used as a short-term measure when there is a failure of one cable or its associated equipment.

Where can I find more information?

Further information on energy legislation, targets and renewable energy policy can be found on the DECC website: www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/renewable_ener.aspx

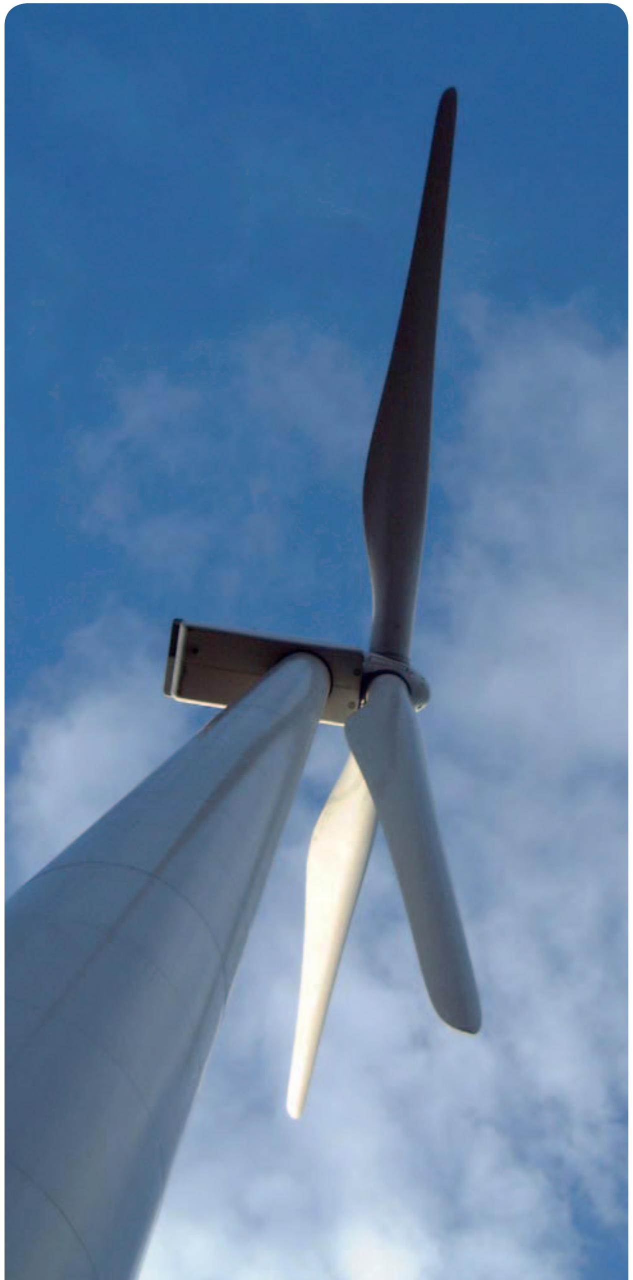
Further information about wind and marine renewable energy, including state of the industry reports and industry information, can be found on the RenewableUK website: www.renewableuk.com/index.html

Further information on the electricity transmission system within the UK, including technical details of electricity transmission, can be found on the National Grid website: www.nationalgrid.com/uk/Electricity/

Further information on marine (wave and tidal) energy production can be found on the EMEC website: www.emec.org.uk/marine-energy/

Further information on electricity regulation in Great Britain can be found on the Ofgem website: www.ofgem.gov.uk/Networks/Pages/Ntwrks.aspx

Further information on electricity regulation in Northern Ireland can be found on the NIAUR website: www.uregni.gov.uk



Source: Royal HaskoningDHV

Appendix IV: Typical connection scenarios

This appendix defines typical connection design scenarios (A-D) outlined in **Section 3** of the document, and major elements of transmission infrastructure.

IV.1 Connection scenarios - definition

The connections are based on four main scenarios with sub-scenarios, as shown in **Table IV.1**. These scenarios are illustrated in the section IV.3 of this appendix.

It should be noted that alternatives exist for each scenario which can include:

- Landfalls including transition pits;
- Indoor or outdoor substation equipment;
- DC cable configurations (such as monopolar configuration, bi-polar configuration, etc.); and
- Overhead lines instead of onshore buried cables, both for AC and (less likely) for HVDC.

Table IV.1: Connection scenarios

Name	Definition of connection	Connection to shore	Transformer included?	Example
A	Connection direct to Onshore Network Operator substation	AC	N/A	None identified
B1	Connection to Onshore Network Operator substation, with a new onshore substation located next to an existing substation	AC	Yes	Thanet, London Array and most of other existing offshore wind farms in the UK
B2	Connection to Onshore Network Operator substation with a new onshore substation located next to an existing substation	DC	Likely	No DC connection examples in the UK yet
C1	Connection to Onshore Network Operator substation with a new onshore substation located far from an existing substation, possibly near landfall	AC	Yes	None identified
C2	Connection to Onshore Network Operator substation with a new onshore substation located far from an existing substation, possibly near landfall	DC	Likely	None identified
D1	Tee-connection to existing Onshore Network Operator overhead line with a new onshore substation located possibly near landfall	AC	Yes	None identified
D2	Tee-connection to existing Onshore Network Operator overhead line with a new onshore substation located possibly near landfall	DC	Likely	None identified

IV.2 Connection scenarios - major items in each scenario

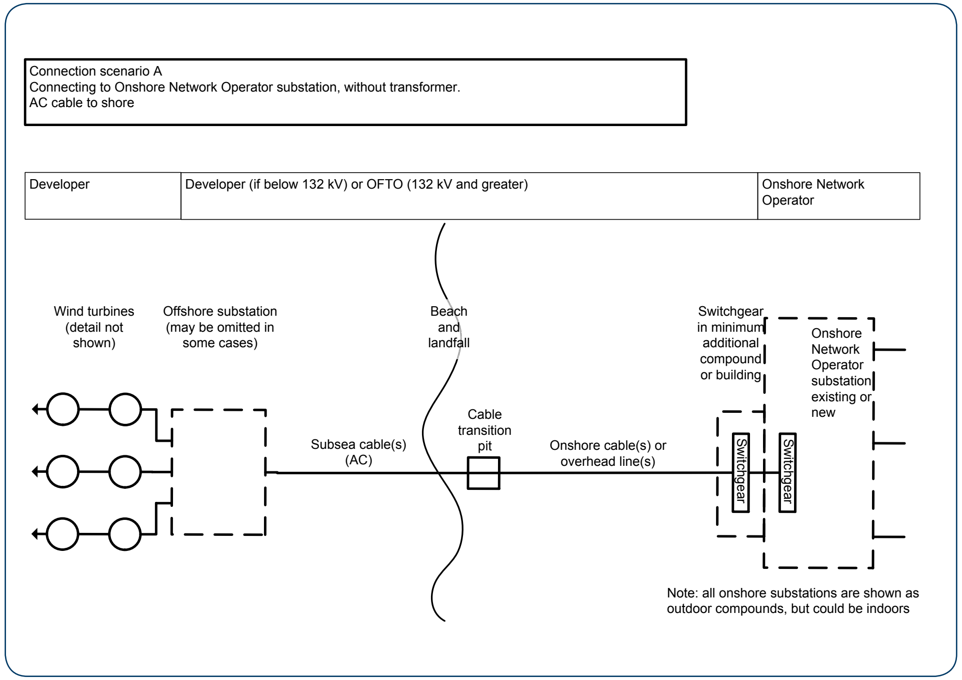
Table IV.2: Major items of equipment

Item	Used in	Comments	Reference in the main body of the document
Offshore AC substation	All (may not be necessary for some scenarios)	Contains combinations of transformers, switchgear and auxiliary equipment. Detail not required for this study.	4.1
Offshore AC/DC converter station	B2, C2, D2	Contains combinations of transformers, AC switchgear, AC/DC converters and auxiliary equipment. Detail not required for this study.	4.1
Subsea AC cable, main section	A, B1, C1, D1	Includes trenching, installation, burial, protection by e.g. rock dumping or otherwise	4.2
Subsea AC cable, landfall	A, B1, C1, D1	Larger cross-section may be used through intertidal area and dunes etc. May be installed through ducts. May use directional drilling.	4.3
Subsea DC cable, main section	B2, C2, D2	Includes trenching, installation, burial, protection by e.g. rock dumping or otherwise	4.2
Subsea DC cable, landfall	B2, C2, D2	Larger cross-section may be used through intertidal area and dunes etc. May be installed through ducts. May use directional drilling.	4.3
Transition pit or chamber	All (may not be necessary for C1, C2, D1, D2)		4.3
Underground cable, AC	A, B1, C1, C2, D1, D2		5.1
Overhead line, AC,	A, B1, C1, C2, D1	132 kV upwards. One tower can carry two circuits.	5.2
Underground cable, HVDC	B2, C2, D2		5.1
Overhead line, HVDC	B2	Uncommon in the UK	5.2
Onshore AC substation	All		5.3
Switchgear, outdoor	All, as alternative to indoor	Significant variation in size and appearance depending on voltage: 33 kV to 400 kV	5.3.2
Switchgear, indoor	All, as alternative to outdoor	In control building, not visible.	5.3.3
Power transformer	B1, B2, C1, C2, D1, D2	May be multiple transformers. May be omitted in some cases.	5.3.4
Reactive compensation and filtering equipment, outdoors	A, B1, C1, D1. May not be necessary in some cases	Comprises reactors and capacitors. May include power-electronic devices, in which case these will be in a container or building.	5.3.5
Reactive compensation and filtering equipment, indoors	A, B1, C1, D1. May not be necessary in some cases	Not visible.	5.3.5
Measurement transformers	All.		5.3.6
Overhead line gantry	B1, B2, C1, C2, D1, D2		5.3.7

Item	Used in	Comments	Reference in the main body of the document
Cable termination and tee-in point from underground cable to existing overhead line	D1, D2	Under some circumstances, it may be possible for the connection from the wind farm to be connected to an existing transmission tower ('pylon') rather than at a substation. New structures needed on transmission tower at low level to support 'cable sealing ends'.	5.3.8
Security and control building	B1, B2, C1, C2, D1, D2	Size varies. Contains indoor items listed above, and also protection relays, telecommunications, auxiliary power, standby batteries, and staff welfare facilities. Also palisade fence, lighting columns, vehicle access.	5.3.9
Onshore DC/AC converter station	B2, C2, D2	Converter is indoors. Most of the equipment found in an AC substation will also be used and will be outdoors.	5.4
Works at existing Onshore Network Operator Substation	A, B1, B2, C1, C2	Some combination of additional busbars, switchgear bay, overhead line terminations, extension of compound.	N/A

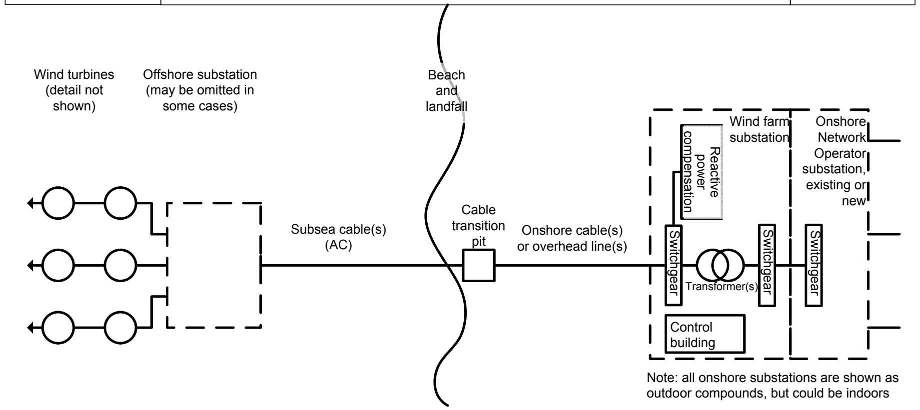
IV.3 Connection scenarios - illustrations

Connection Scenario	Definition of connection scenario
A	Connection direct to Onshore Network Operator substation
B1	Connection to Onshore Network Operator substation, with a new onshore substation located next to an existing substation
B2	Connection to Onshore Network Operator substation with a new onshore substation located next to an existing substation
C1	Connection to Onshore Network Operator substation with a new onshore substation located far from an existing substation, possibly near landfall
C2	Connection to Onshore Network Operator substation with a new onshore substation located far from an existing substation, possibly near landfall
D1	Tee-connection to existing Onshore Network Operator overhead line with a new onshore substation located possibly near landfall
D2	Tee-connection to existing Onshore Network Operator overhead line with a new onshore substation located possibly near landfall



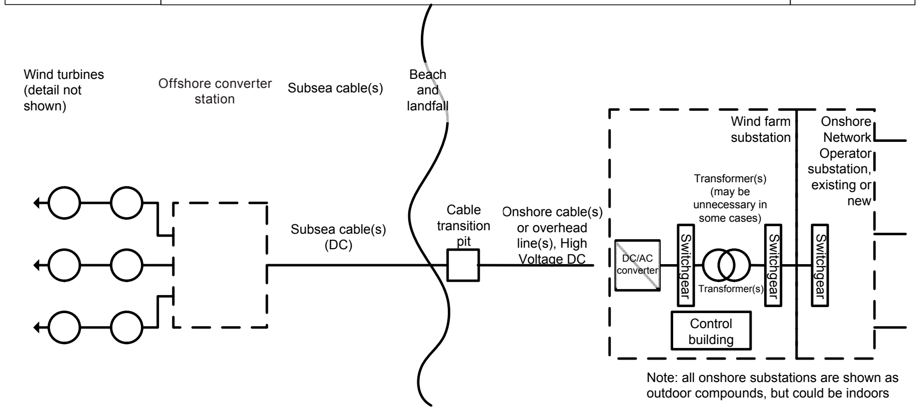
Connection scenario B1
Connecting to Onshore Network Operator substation, with transformer.
AC cable to shore

Developer	Developer (if below 132 kV) or OFTO (132 kV and greater)	Onshore Network Operator



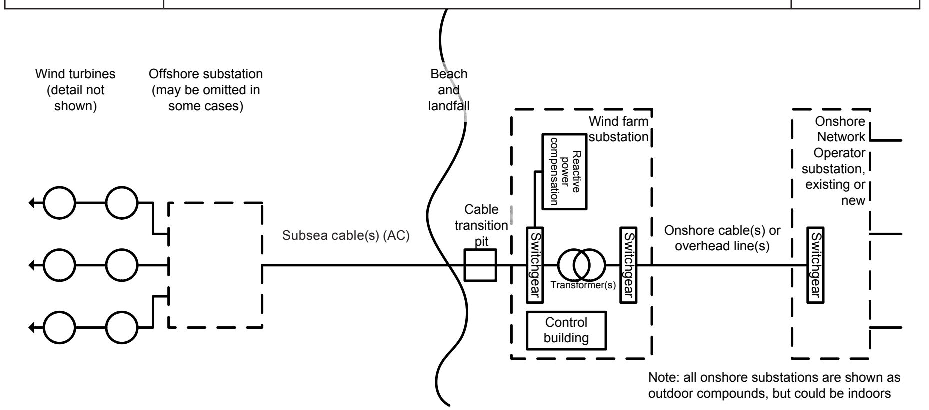
Connection scenario B2
Connecting to Onshore Network Operator substation, with transformer.
DC cable to shore

Developer	Developer (if below 132 kV) or OFTO (132 kV and greater)	Onshore Network Operator



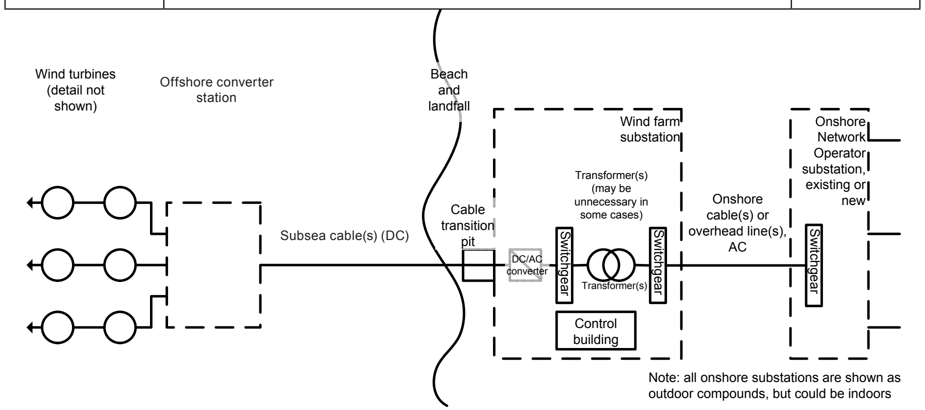
Connection scenario C1
Connecting to Onshore Network Operator substation, with separate substation near landfall.
AC cable to shore

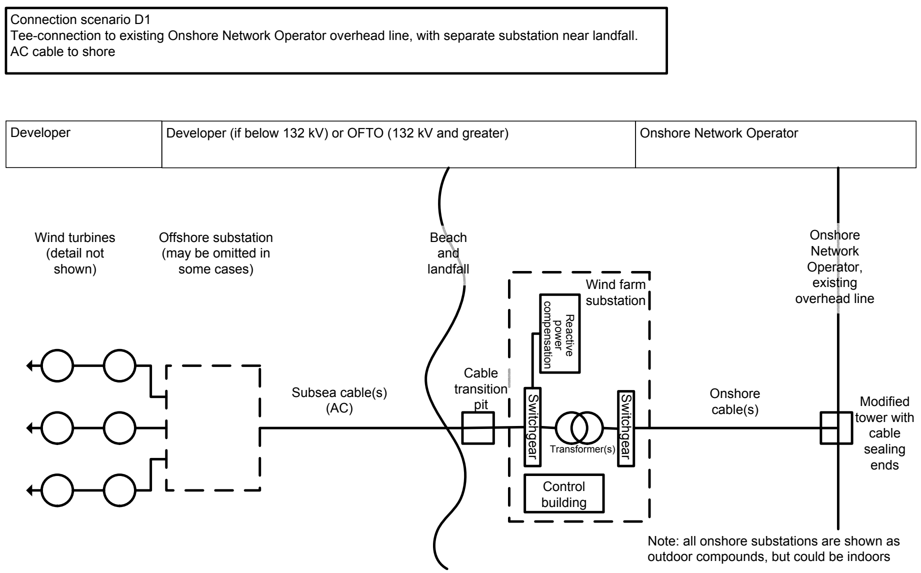
Developer	Developer (if below 132 kV) or OFTO (132 kV and greater)	Onshore Network Operator

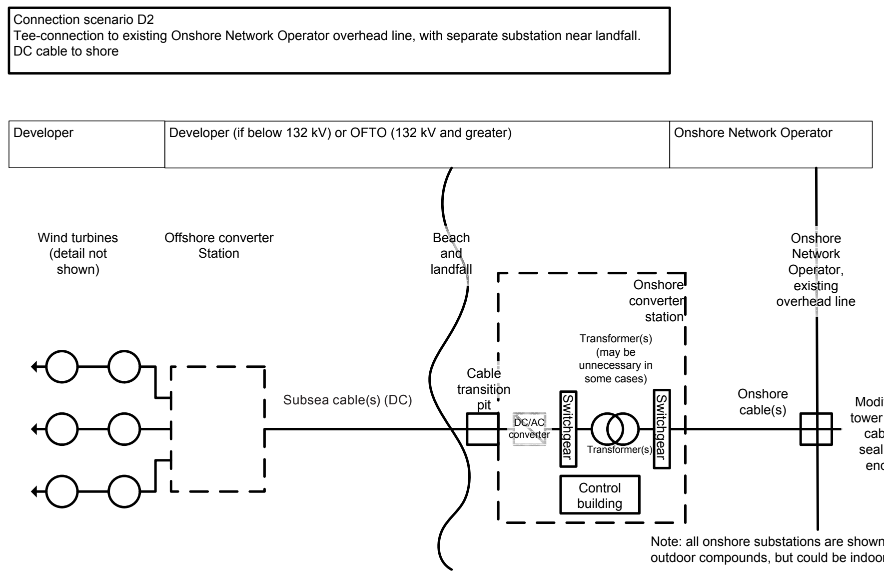


Connection scenario C2
Connecting to Onshore Network Operator substation, with separate substation near landfall.
DC cable to shore

Developer	Developer (if below 132 kV) or OFTO (132 kV and greater)	Onshore Network Operator




Connection scenario D1
Tee-connection to existing Onshore Network Operator overhead line, with separate substation near landfall.
AC cable to shore
Developer
Developer (if below 132 kV) or OFTO (132 kV and greater)
Onshore Network Operator
Wind turbines (detail not shown)
Offshore substation (may be omitted in some cases)
Beach and landfall
Onshore Network Operator, existing overhead line
Wind farm substation
Reactive power compensation
Subsea cable(s) (AC)
Cable transition pit
Switchgear
Transformer(s)
Switchgear
Onshore cable(s)
Modified tower with cable sealing ends
Control building
Note: all onshore substations are shown as outdoor compounds, but could be indoors


Connection scenario D2
Tee-connection to existing Onshore Network Operator overhead line, with separate substation near landfall.
DC cable to shore
Developer
Developer (if below 132 kV) or OFTO (132 kV and greater)
Onshore Network Operator
Wind turbines (detail not shown)
Offshore converter Station
Beach and landfall
Onshore Network Operator, existing overhead line
Onshore converter station
Transformer(s) (may be unnecessary in some cases)
Subsea cable(s) (DC)
Cable transition pit
DC/AC converter
Switchgear
Transformer(s)
Switchgear
Onshore cable(s)
Modified tower with cable sealing ends
Control building
Note: all onshore substations are shown as outdoor compounds, but could be indoors

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