



OUR ELECTRICITY TRANSMISSION NETWORK:

A VISION FOR 2020

A Summary of an Updated Report to the Electricity Networks Strategy Group

February 2012

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FOREWORD

by the Joint Chairs of ENSG

We welcome the 2012 ENSG Report as a valuable contribution to the ongoing discussions about how to develop our electricity infrastructure in order to address the challenges facing the sector, namely: the decarbonisation of electricity generation, meeting the Governments' 2020 renewables targets; maintaining security of supply; and managing the costs of the network.

This Summary of the full ENSG report ("2012 ENSG Report") sets out an updated high-level view of how the electricity transmission system might need to be reinforced to facilitate the achievement of the Government's 2020 renewables targets. It presents, in one accessible resource, the updated views of the three onshore electricity Transmission Owners¹, as developed with input from the Electricity Networks Strategy Group (ENSG) Working Group. It updates a report published in March 2009 entitled "Our Electricity Transmission Network: A Vision for 2020" ("2009 ENSG Report").

The 2012 ENSG Report is part of an ongoing process. In 2008, following the Transmission Access Review, the Government and Ofgem recognised that the potentially long lead times for expanding transmission capacity could impact upon meeting the 2020 renewables target. We therefore asked the Transmission Owners to set out the strategic transmission network investment that might be required to ensure that sufficient renewable generation could be accommodated on the network. We also invited the ENSG to provide input to this work. The subsequent 2009 ENSG Report was welcomed by stakeholders in industry and the wider community as recognition of the urgency of network investment to help meet the UK's energy and climate change goals.

The 2009 ENSG report contained a commitment to ensure that appropriate investment was taken forward in a timely manner. Since that time, the Transmission Owners have developed more detailed proposals for certain reinforcements, and have presented some of their proposals to the appropriate planning authorities. Similarly, proposals have been presented to Ofgem for decisions on whether that project is justified at the proposed time, and, if so,

¹ National Grid Electricity Transmission (NGET), Scottish Power Transmission (SPT) and Scottish Hydro Electric Transmission Ltd (SHETL)

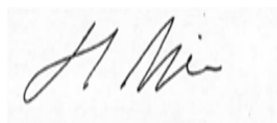
what the appropriate level of funding should be. Through the Transmission Investment Incentives framework, Ofgem has approved over £400million of funding since 2009. It is important to note, however, that neither the 2009 ENSG Report nor the updated 2012 ENSG Report prejudge future decisions by the Transmission Owners about what projects to develop, or decisions by planning authorities about whether to grant consents. Nor do the reports prejudge decisions by Ofgem about whether to grant funding or whether there could be benefits from a role for third parties in delivering certain projects.

The 2009 ENSG Report also contained a commitment to continue to monitor developments in generation and the network. At its meeting in February 2011 the ENSG asked the TOs to undertake updated studies in the light of developments in generation and the network since the 2009 ENSG Report was published. It also established a Working Group to provide input into this. The updated studies were drawn upon by the TOs when preparing their Business Plans for the next transmission price control (RIIO-T1), which includes mechanisms for funding reinforcements once the need has been established.

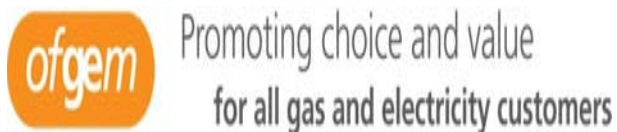
We thank all of those who contributed to producing the 2012 ENSG Report. It will serve as an important input into the future development of the electricity network, and a useful means of communicating potential network requirements to wider stakeholders. We would welcome feedback on the usefulness of this summary document and the 2012 ENSG Report, including content and presentation. Please provide any comments to ensg@decc.gsi.gov.uk



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Summary of the Updated Report to the Electricity Networks Strategy Group on the potential Strategic Reinforcements required to Facilitate Connection of New Generation to the GB Transmission Networks by 2020

1 Overview

The Electricity Networks Strategy Group (ENSG) is a high level forum, which brings together key stakeholders in electricity networks that work together to support Government in meeting the long-term energy challenges of tackling climate change and ensuring secure, clean and affordable energy.

The Group is jointly chaired by the Department of Energy and Climate Change (DECC) and Office of Gas and Electricity Markets (Ofgem) and its broad aim is to identify, and co-ordinate strategy to help address key strategic issues that affect the electricity networks in the transition to a low-carbon future. The ENSG Terms of Reference and membership are at Annex A.

This document is a summary of the full report² (“2012 ENSG Report”) which has been prepared by the Transmission Owners (TOs) with input from the ENSG Working Group³ to discharge an action placed on them by the ENSG to provide:

- *An update of the ENSG 2020 vision report incorporating network responses to changes to generation scenarios, technologies, policy developments, etc.*

This summary of the 2012 ENSG Report provides a high level accessible synopsis of the full report particularly for those not requiring full technical details. The reinforcements identified by the TOs are based on the Gone Green 2011 scenario. This scenario, developed by NGET, and updated annually in consultation with stakeholders, represents a potential

² Available at http://www.decc.gov.uk/en/content/cms/meeting_energy/network/ensg/ensg.aspx

³ Extract from ENSG WG Terms of Reference and membership at Annex B

generation and demand background which meets the UK targets of 15% of energy demand being provided by renewable sources and a 34% reduction in Green House Gas emissions by 2020. It would also meet the Scottish and Welsh Governments' 2020 renewable energy targets i.e. the equivalent of 100% of Scotland's electricity demand should be met from renewables and 7 TWh per annum of Welsh electricity production by 2020. It takes an holistic approach to the meeting of the targets i.e. assumes that heat and transport will also contribute towards meeting the targets. It estimates that in order to meet this target, approximately 30% of UK's electricity will have to come from renewable sources by 2020, with a corresponding 12% from heat and 10% from transport. A previous scenario (Gone Green 2008) was utilised in the report published in March 2009 entitled "Our Electricity Transmission Network: A Vision for 2020" ("2009 ENSG Report") and the Gone Green 2011 scenario takes the same holistic approach to meeting the 2020 environmental targets.

Gone Green takes into account the significant changes anticipated in the generation mix between now and 2020. Sensitivities have also been applied to the Gone Green 2011 scenario to reflect possible faster or slower deployment of offshore wind on a regional basis. The scenario and sensitivities particularly examine the potential transmission investments associated with the connection of large volumes of onshore and offshore wind generation that are required to meet the 2020 renewables targets and new nuclear generation.

The 2012 ENSG Report concludes that, provided the identified reinforcements are taken forward on time and the planning consents needed for network development works can be secured in a timely manner, then the reinforcements identified by the TOs in the report can be delivered to required timescales.

In the 2012 ENSG Report, the TOs have identified and estimated the regional costs of the potential transmission reinforcements that may be required to accommodate the connection of a range of new generation needed to meet the UK's renewable energy targets whilst, at the same time, facilitating the connection of other essential new generation that will be needed to maintain continued security of supply. To ensure that the identified reinforcements are sufficiently robust, they have been tested against a range of background scenarios, which take account of likely developments up to the year 2020. The total estimated cost of the potential reinforcements contained in the 2012 ENSG Report, based on the Gone Green 2011 scenario, is around £8.8bn and the resulting network would be able to accommodate a further 38.5GW of new generation (a little under half of the current generation), of which 23GW could be a combination of onshore and offshore wind generation. Details of these potential reinforcements are included in Chapter 5 "Potential transmission network

reinforcements". A summary table of changes to the Gone Green scenario and significant changes to potential reinforcements since the 2009 ENSG Report is at Annex C.

The increase in estimated costs compared to the 2009 ENSG Report (£4.7bn) is largely due to the updated report including the costs of possible provision of new subsea links from Scottish Islands⁴ to the mainland, the inclusion of further options for reinforcements notably a possible HVDC subsea link from North to South Wales and a possible third HVDC link between Scotland and England; and updating the base price. The Scottish Island links were considered as possibilities in the 2009 ENSG Report, but costs estimates were not available then. The subsea North to South Wales link has been raised as a possibility since the 2009 ENSG Report (with pre-construction funding approved by Ofgem).

Table 1 provides details of the cost difference totalling around £4bn between the 2009 ENSG Report and the updated report.

Feedback on the 2009 ENSG Report indicated that stakeholders would find the identification of possible alternative reinforcement options helpful. In drafting the 2012 ENSG Report, therefore, the TOs have undertaken more analysis to identify possible options for reinforcements. This is particularly relevant to the Scotland/England border, North Wales, South West, English East Coast/East Anglia, and London.

Any new transmission infrastructure works would require regulatory and planning approval which would require a number of actions by TOs including comprehensive routeing and siting studies, consultations and detailed environmental impact assessment.

⁴ Western Isles, Orkney Islands and Shetland Islands

Regions	2009 ENSG Report Cost (£m)	2012 ENSG Report Cost (2008/09 Price Base) (£m)	Difference (£m)	Comments
Scotland + Scotland-England Interface	2715	5740	+3025	Inclusion of Scottish Island connections The cost of the Western HVDC link, NGET – SHETL East Coast HVDC link 1, Series Compensation are updated since ENSG 2009 Possible NGET – SPT East Coast HVDC Link and Mersey Ring upgrade. These reinforcements were not considered in the 2009 ENSG Report
North Wales + Mid-Wales	575	1260	+685	New updated cost of Wylfa – Pentir double circuits Inclusion of Irish Sea – Pembroke HVDC Link
South West	340	430	+90	Updated cost of possible reinforcement
East Coast & Anglia	910	750	-160	In the 2009 ENSG Report, onshore HVDC reinforcements were considered in the Humber region. But the 2012 ENSG Report considers onshore AC reinforcements in this region and the cost of the onshore AC reinforcements is less than the cost of the onshore HVDC reinforcements
London	190	190	0	
Base Price Difference			+450	The base price difference from 2008/09 to 2010/11
Totals	4730	8820	4090	

Table 1: Cost difference between the 2009 and 2012 ENSG Reports

The 2012 ENSG Report focuses on the Main Interconnected Transmission System (MITS) and Scottish island connections. It does not propose developments in either interconnection or offshore transmission, which are covered by separate regimes with their own workstreams and regulation. The report does, however, consider potential interactions between interconnectors, offshore transmission, and the MITS, and has made certain assumptions about interconnection and offshore transmission. For example there are three regions (Scotland, North Wales, and the East Coast of England) where offshore wind connections may impact significantly on the MITS by 2020. For the purposes of the 2012 ENSG Report,

therefore, illustrative offshore network designs have been incorporated to assess the potential impact on the MITS in these regions. These illustrative offshore transmission system designs do not prejudge the outcome of the offshore transmission coordination project, nor do they represent any investment decisions and/or contractual arrangements or programme of the TOs, Offshore Transmission Owners (OFTOs) or third parties; nor do they imply the actual connection routes for new electricity transmission infrastructure. More generally, all relevant assumptions would need to be reviewed were the TOs to develop more detailed plans for reinforcing any particular area of the MITS.

Any transmission system reinforcement (including those identified by the TOs in the 2012 ENSG Report) would only be applied when all other possible network solutions have been explored and exhausted with the existing assets being fully utilised. Consideration has been given to employing the latest and possible future technologies, especially where additional economic and/or additional environmental benefits can be expected. Due account has been taken of the lead time required to develop robust engineering solutions and the need to obtain the necessary planning consents for each reinforcement. The TOs will keep these designs under review and consider suggestions to help ensure the right solution is developed.

The potential reinforcements are phased to be delivered in line with the prospective growth of renewable generation in each region. It is recognised that there will continue to be a degree of uncertainty about the volume and timing of generation growth in any given area. Developments in the market will continue to be monitored and the scenarios updated accordingly. Proposals for potential transmission reinforcements would be developed in such a manner as to ensure that options for future development are maintained at minimum cost. Undertaking pre-construction engineering work, for example, means that for each project construction can be commenced when there is sufficient confidence that transmission system reinforcement will be required. This is a least regret solution, i.e. the minimum commitment to secure the ability to deliver to required timescales.

2 Approach to Developing Scenarios

The 2012 ENSG Report takes a similar approach to the 2009 ENSG Report. A number of electricity generation and demand backgrounds have been developed. In their development, numerous factors were taken into account; particularly in relation to ensuring that the UK, Scottish and Welsh Government 2020 targets for renewable energy and the UK target for Greenhouse Gas emissions⁵ would be met. Such factors include the analysis of:

- closures of existing plants due to various legislation and age profile;
- contracted new connections for all types of plant;
- the potential for, and location of onshore and offshore wind generation; and
- the potential build rates for wind and new nuclear generating plant.

In developing a detailed generation background, issues such as: security of supply; the ability of the supply chain to deliver; and technological advances were taken into consideration. The potential reinforcement requirements identified in the 2012 ENSG Report are based on NGET's Gone Green 2011 scenario which has been developed through stakeholder engagement from the Gone Green 2008 scenario originally used for the 2009 ENSG Report. As with the Gone Green 2008 scenario, the Gone Green 2011 scenario assumes that the main generation in 2020 would be from gas and wind, with a greater role for nuclear and a reduced role for coal. The generation mix connecting to the transmission network in the Gone Green 2011 scenario for the year 2020 on which the 2012 ENSG Report is based, is presented in Figure 1.

⁵ The UK target for 2020 is a reduction of at least 34% in greenhouse gas emissions compared to 1990.

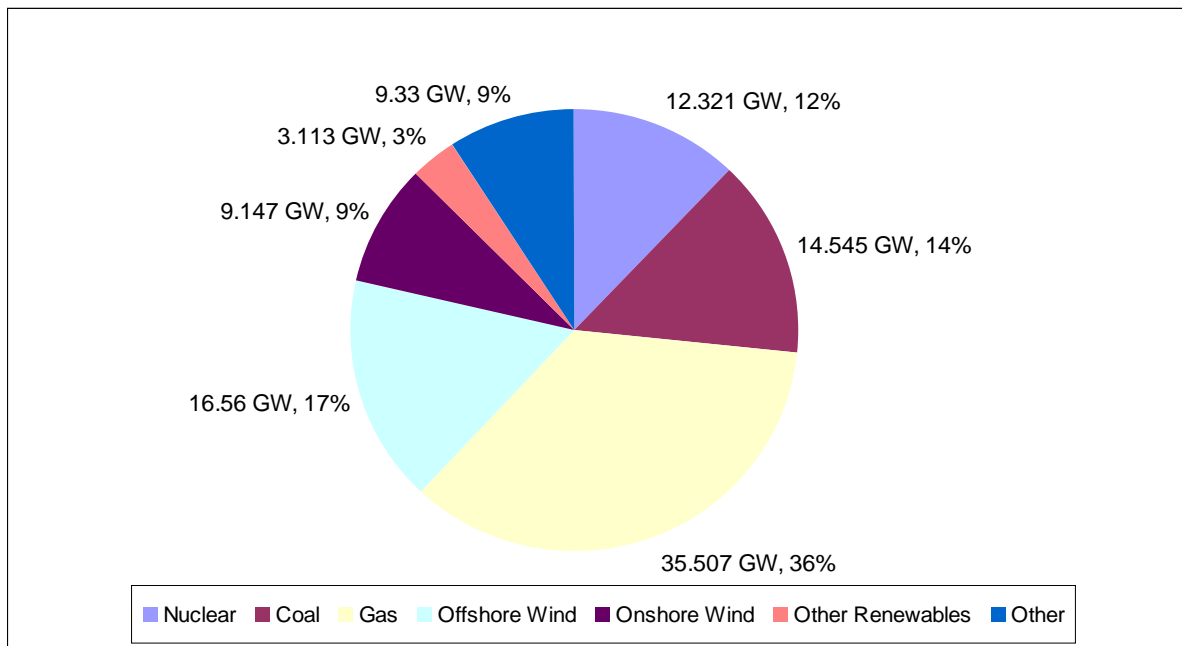


Figure 1: Generation mix in 2020 of the Gone Green 2011 Scenario Generation connected to Transmission network

In the 2009 ENSG Report sensitivities were applied to the Gone Green 2008 scenario to accommodate faster or slower development of onshore wind in Scotland. This was achieved by increasing offshore wind generation in England and Wales to compensate for any volumes of onshore wind in Scotland less than 11.4GW. For the 2012 ENSG Report sensitivities are also applied to the Gone Green 2011 scenario to consider the possible effects of faster or slower development of offshore wind generation in six GB regions. Under all sensitivities the 2020 renewable energy targets would still met.

The total offshore windfarm capacity connected is assumed to be in the region of 16.6GW by 2020. In considering how this offshore capacity could be achieved, it is assumed that around 8GW of projects in The Crown Estate announcements on offshore wind Rounds1 and 2 and Round 2 extensions will proceed to completion, with the remainder being made up from The Crown Estate Round 3 and Scottish Territorial Waters (STW) development sites.

The Gone Green 2011 scenario also assumes 11.2GW of onshore wind generation; 12.3GW of nuclear generation; and 41.7GW of gas generation.

The significant differences in assumptions between Gone Green 2011 and the Gone Green 2008 used in the 2009 ENSG Report are:

- Increase in nuclear capacity to reflect the existing Advanced Gas-Cooled Reactor (AGR) stations being assumed to receive ten-year life extensions and two new

nuclear installations connecting by 2020. This allows for a corresponding decrease in coal-fired generation and a subsequent decrease in carbon emissions.

- The Gone Green 2011 scenario also meets the UK's 2020 carbon reduction targets which have become more stringent since 2009. The carbon emission reduction target for 2020 in the Gone Green 2011 scenario is at least 34% on 1990 levels whereas it was previously a 29% reduction for the Gone Green 2008 scenario.
- The exclusion of energy used in the aviation sector from the overall target calculation which reduces the amount of renewable capacity required to meet the 15% target. This would also result in a reduction in the overall renewable capacity in the scenario. This reduction has been applied to wind generation capacity required as it is the main source of renewable energy.

These differences mean that not as much new generation needs to connect in the Gone Green 2011 (38.5GW) to meet the 2020 targets compared to Gone Green 2008 (45GW).

Gone Green 2011 has also been compared to the Renewable Energy Roadmap central range and lies at the upper end of that range for all renewable generation sources.

Not all new generation will connect to the transmission network which is the reason for the differences between total generation levels in the overall Gone Green 2011 scenario and those contained in Figure 1. Gone Green 2011 assumes around 14GW of embedded generation (generation connecting to the distribution network) by 2020. The developments in the generation market and the progress that Developers have made in obtaining planning consent and the subsequent build rate will be continued to be monitored and the Gone Green scenario updated accordingly.

The generation assumptions made for the 2012 ENSG Report are entirely independent from, and in no way pre-suppose, the outcome of individual planning decisions about projects on particular sites. For nuclear generation it should also be noted that life extensions are commercial decisions for operators and are subject to approval from the Office for Nuclear Regulation (ONR) and the Nuclear Decommissioning Authority (NDA).

3 Findings – Power Flows and Existing Transmission Capacity

As with the 2009 ENSG Report the predominant power flow on the National Electricity System (NETS) will continue to be from North towards the South.

In the North of Scotland, generation is assumed to significantly increase with onshore and offshore wind and marine renewables all contributing. The level of demand is not anticipated to increase significantly over the next decade. Accordingly, there is a predominant net export of energy from the region to the Central Belt of Scotland. Additional power flows in the Central Belt of Scotland, within the Scottish Power Transmission (SPT) network, would place a severe strain on the 275kV elements of the network and, in particular, the north to south and east to west power corridors.

The circuits between Scotland and England are already operating at their maximum capability. Under all the generation scenarios considered, the transfers from Scotland to England increase significantly. Reinforcements identified to relieve the boundary restrictions across these circuits result in power transfers on the Upper North network of the England and Wales transmission system exceeding network capability. South of the Upper North boundary the increased power flows south from Scotland and North West of England progressively diminish as they are offset by the closure and displacement of existing conventional generation along the way. Accordingly, while there are transmission overloads in northern England the effects are greatly muted as the flows travel towards the Midlands.

Offshore wind generation connecting in England and Wales, together with the potential connection of new nuclear power stations raises a number of regional connection issues; particularly in North Wales, South West England and along the English East Coast between the Humber and East Anglia. The anticipated increased power transfers across the North to Midlands boundary and/or the increased generation off the East Coast and/or Thames Estuary would also result in severe overloading of the northern transmission circuits securing London.

4 Approach to Determining Network Reinforcement

The range of potential power flows on the NETS has been determined on the basis of the currently authorised NETS (i.e. the existing NETS together with all the approved transmission system reinforcements assumed to be in place for the year 2015). Such authorised transmission reinforcements include:

- the Beaulieu – Denny 400kV line,
- the uprating of the transmission capacity between Scotland & England; and,
- the additional transmission capacity around North West and North East England.

The 2009 ENSG Report used the existing NETS SQSS⁶, but predominately focused on the application of the deterministic rules. A full-cost benefit analysis (CBA) was restricted to areas where the potential for high constraint cost had previously been identified, mainly the Scotland-England boundaries.

For the purpose of calculating Required Transfers (RT), the 2012 ENSG Report is based on the current NETS SQSS (version 2.1). This is consistent with the TOs' RIIO-T1 Business Plans submitted to Ofgem on 31 July 2011. However, the analysis is then further supplemented with the CBA analysis method (as set out in the GSR009 amendment to the NETS SQSS approved by the Gas and Electricity Markets Authority⁷ on 1 November 2011) for the NETS SQSS standards under the economy criterion; whereas the RIIO-T1⁸ Business Plans include a series of more detailed CBAs to help determine the necessary level of transmission investment. The Security Model criterion is not used in the analysis for the 2012 ENSG Report.

⁶ National Electricity Transmission System Security and Quality of Supply Standards

⁷ <http://www.ofgem.gov.uk/Pages/MoreInformation.aspx?docid=26&refer=Networks/Trans/ElecTransPolicy/SQSS>

⁸ RIIO is the Transmission Price Control for the period 2013/14-2020/21 for the TOs. This means Revenue=Incentives+Innovation+Outputs

Therefore the actual investment could depart from the results from applying either the rules in the accepted amendments, or the current rules today. However, GSR009 would be expected to provide a better overall view of what the optimum investment is likely to be and give a first-pass deterministic assessment likely to be closer to the right minimum cost answer. By providing a better 'first estimate' of the optimal capacity requirements it brings efficiency to the planning process as it provides a better starting point before a more detailed assessment is carried out and this will simplify and streamline the design process.

When identifying a shortfall in network capacity, consideration has been given to traditional solutions such as reconductoring circuits, upgrading to a higher voltage and constructing new lines. However, it is recognised that traditional methods of enhancing system capacity, particularly those which involve new overhead line routes, can be difficult to achieve due to planning constraints and environmental concerns. The TOs have therefore investigated the potential for new or previously unused technologies on the NETS in order to either enhance or maximise the use of existing assets or to provide new infrastructure with reduced environmental impact and an acceptable level of technological risk.

When considering the use of new technologies that have not previously been used on the NETS it is important to ensure that all issues associated with these systems (technical, commercial and environmental) are fully understood prior to commitment to construct. Discussions have already taken place with manufacturers to assess what technologies could be used in future network developments and what designs represent feasible options considering the required timescales. In many cases using new technologies appears to offer significant benefits over traditional design options. However, when comparing a new, or unused, technology with existing design options it is necessary to quantify any benefits or drawbacks accurately to ensure that the optimum design is selected. There is also a need to look towards "smarter" ways of operating the transmission network to meet the increasing challenge of integrating large amounts of variable renewable generation and the advent of varying demand profiles. This could comprise a number of techniques such as the use of dynamic ratings to enhance the thermal rating of lines; the use of automated and co-ordinated systems such as Quadrature Booster (QB) control; and co-ordinated High Voltage Direct Current (HVDC) control systems which work in parallel with the existing High Voltage Alternating Current (HVAC) networks.

5 Potential Transmission Network Reinforcements

5.1 Scotland

The volume of generation in Scottish Hydro Electric Transmission Limited's (SHETL's) north of Scotland area is expected to increase over the coming years due to the growing capacity of renewable generation such as The Crown Estate Round 3 offshore wind farms, STW wind farms, marine generation in the Pentland Firth and Orkney waters and numerous onshore wind farms within Scotland. Under the Gone Green 2011 scenario about 6.3GW of new generation would be connected by the end of 2020 in SHETL's area. This includes 3.5GW of onshore wind, 2.2GW of offshore wind and 0.6GW of marine generation. At present there is about 0.9GW of onshore wind and no offshore and marine generation connected to the SHETL system.

The volume of generation in SPT's central and south of Scotland area is similarly expected to increase over the coming years due to the growing capacity of onshore wind farms across the south of Scotland, together with STW wind farms and the Crown Estate Round 3 offshore wind farm in the Firth of Forth. Under the Gone Green 2011 scenario about 3.9GW of new generation would be connected in the SPT area by the end of 2020. This includes 2.3GW of onshore wind, 1GW offshore wind and 0.6GW of coal generation. Presently about 1.4GW onshore wind is connected to the SPT's area.

A number of options for reinforcements have been identified by the TOs which would meet the requirements from the Gone Green 2011 generation scenario for this area. These reinforcement options (and costs) do not include projects which are currently under construction; Beaully-Denny, Beaully-Dounreay and Beaully-Kintore are assumed to be in place from 2015 onwards. A number of other reinforcements have been included which would address potential regional transmission issues including the links to the main islands of Western Isles, Orkney and Shetland.

- **Caithness-Moray-Shetland (CMS) 600MW HVDC Link** from Caithness to Moray Coast via Moray Firth Offshore hub and associated reinforcements to accommodate existing and planned onshore and offshore renewable generation in Caithness, in the Moray Firth, and on Orkney and Shetland. The earliest possible completion date of this reinforcement is 2016.
- **East Coast AC 400kV Upgrade** to address capacity requirements on the east side of SHETL's area to enable the export of renewable energy from the north of Scotland to the demand centres in the south. The earliest possible completion date of this reinforcement is 2016.
- **East Coast Subsea HVDC Link** from Peterhead in the north of Scotland to north of England to provide a significant increase in north to south transfer capacity. Should there be more renewable generation connections in the north of Scotland, a second East Coast HVDC Link could be required to provide further capacity. The earliest possible completion date of this reinforcement is 2018.
- **Kintyre to Hunterston AC Subsea Link** could provide the necessary capacity to accommodate the renewable generation in the Kintyre and Argyll area. The earliest possible completion date of this reinforcement is 2015.
- **Orkney and Pentland Firth Subsea Link** An initial 132kV subsea link between the west Orkney mainland and Caithness would be required to accommodate the first tranches of marine sites, together with developing onshore renewables. As further marine generation deploys there is expected to be a requirement for an HVDC link of greater capacity around 2019-2021, with a delivery point on the Scottish mainland, linked to a main HVDC hub at Peterhead. The earliest possible completion date of this 132kV subsea link is 2015.
- **Western Isles 450MW HVDC Link** to accommodate potential increased wind generation in the Western Isles. The earliest possible completion date of this reinforcement is 2015.
- **Shetland Islands HVDC Link** to connect onshore wind from Shetland Islands to Moray Firth offshore hub. The earliest possible completion date of this reinforcement is 2017.

- further **Caithness reinforcement** to integrate the Caithness AC system with the Sinclairs Bay HVDC hub. The earliest possible completion date of this reinforcement is assumed be beyond 2020.
- **Beaully to Blackhillock Reinforcement** it is possible that further high capacity reinforcement between Beaully and Blackhillock may be required in the future. There are a number of options being considered to provide this capacity. The earliest possible completion date of this reinforcement is also assumed be beyond 2020.
- **Central 400kV Upgrade** (Denny – Wishaw) to meet increased transfer requirement from SHETL to SPTL areas. The earliest possible completion date of this reinforcement is 2017.
- **SPT East Coast 400kV Upgrade** (Kincardine – Harburn) to meet increased transfer requirement from SHETL area. The earliest possible completion date of this reinforcement is 2017

Figure 2 shows how the SHETL transmission system might look with the potential reinforcements.

Reinforced SHETL Transmission System

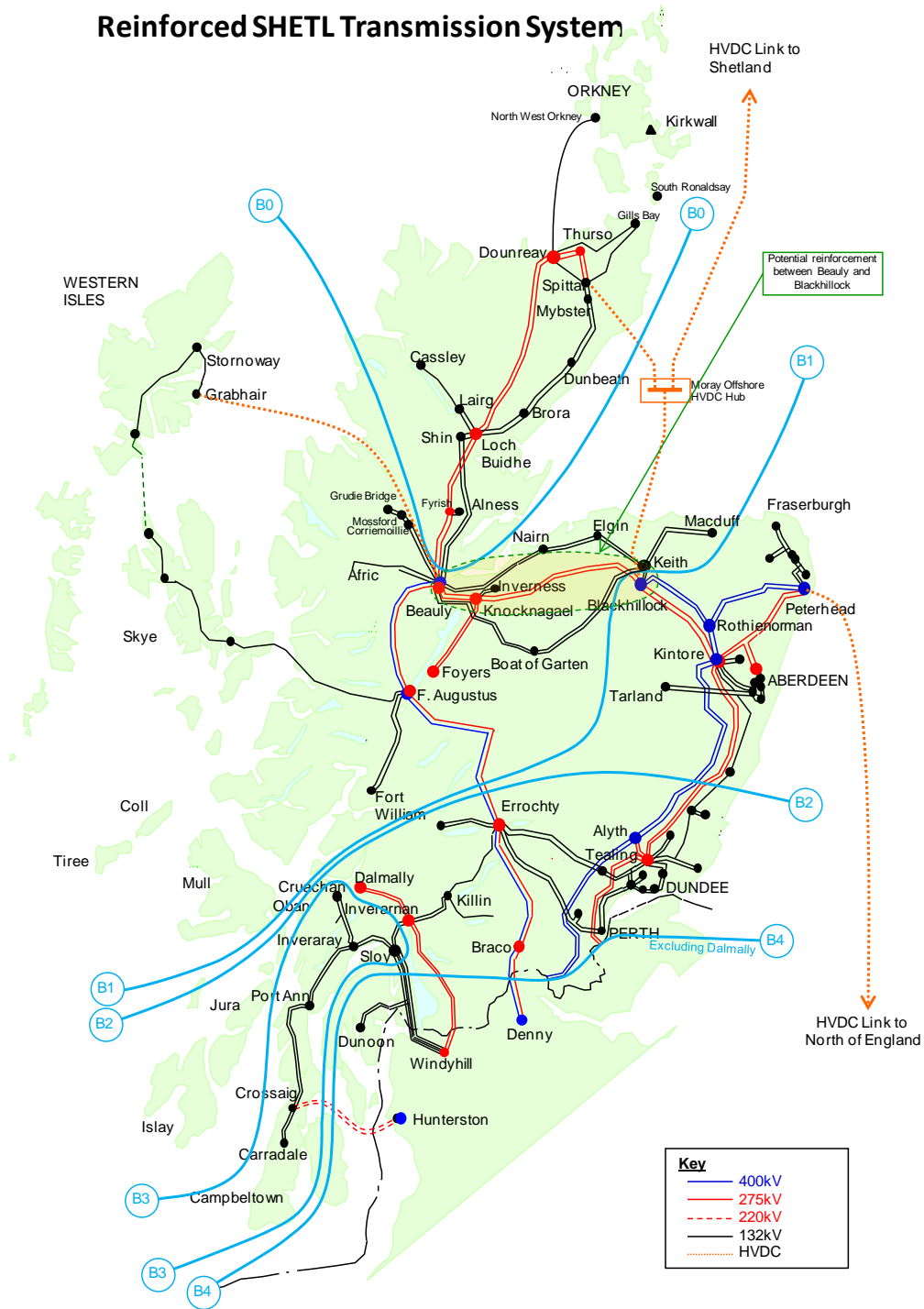


Figure 2: The north of Scotland transmission network showing potential reinforcements in 2020

Figure 3 shows how the SPT transmission system might look with the potential reinforcements.

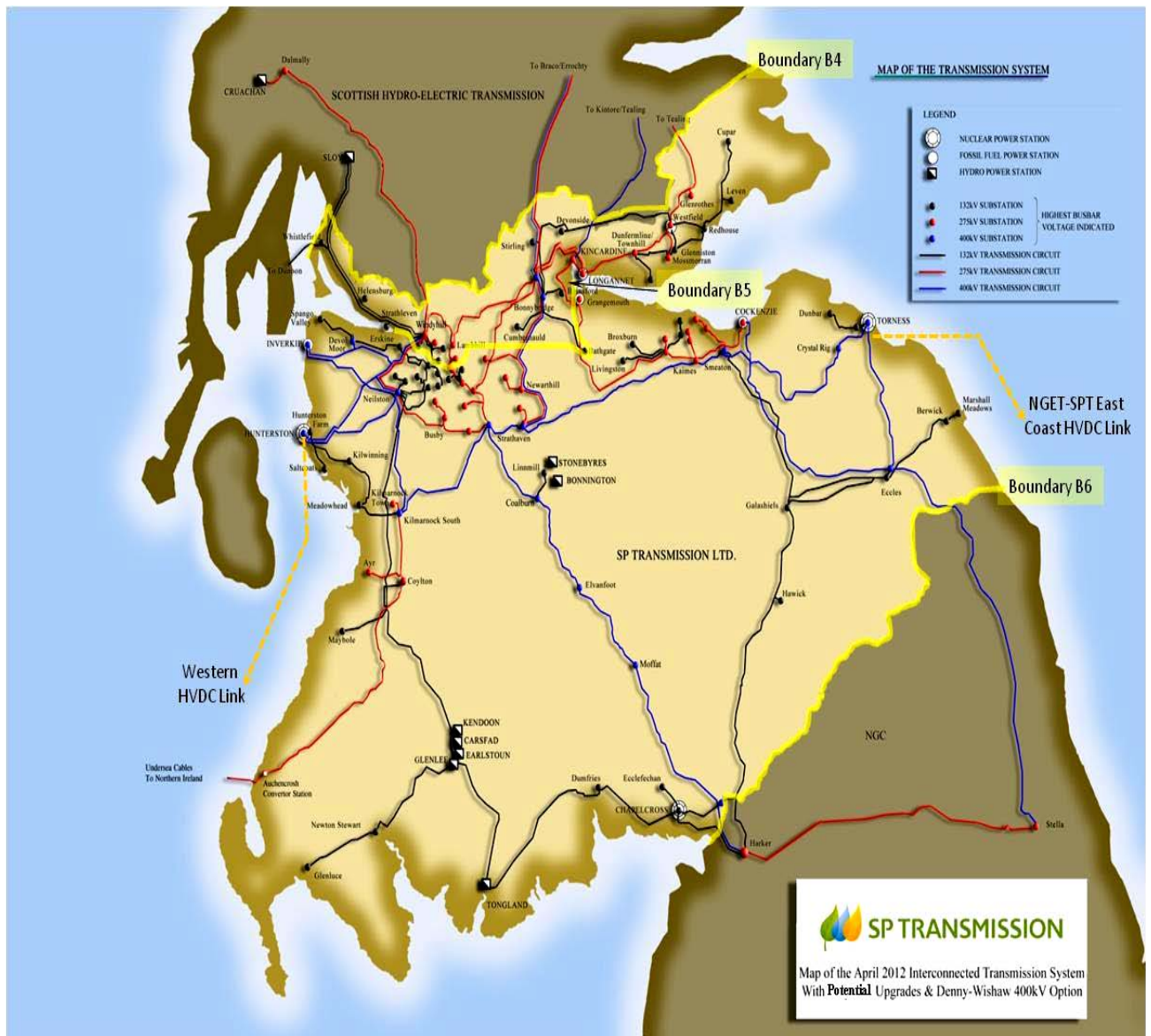


Figure 3: The SPT transmission system showing potential reinforcements

Cost

The total estimated cost of the possible set of reinforcements considered for Scotland is around £2.5bn for the Gone Green 2011 scenario. These costs exclude reinforcements shared from Scotland to England and Wales which are covered in the next section. Estimated costs for individual projects in all regions cannot generally be provided in the 2012 ENSG Report for commercial, procurement and legal reasons.

5.2 Scotland to England

In addition to facilitating the transfer of flows from North Scotland this area would also have 1.1GW of new generation connected under the Gone Green 2011 scenario. This includes

about 0.8GW of offshore wind and about 0.3GW of biomass generation. There is no offshore wind generation connected to the area at present. The capability of the Boundary B6 connecting the SPT and NGET networks is currently limited to 2.2GW by stability restrictions. Reinforcements to this boundary are due to complete in 2012/13, resulting in an export capability from Scotland to England and Wales of around 3.3GW. Further south Boundary B7 currently has a capability of around 3.6GW and Boundary B7a has a capability of 5.4GW. All of these other Scotland-England boundaries would become more constrained as power flow increase from Scotland, thus potentially requiring numerous reinforcements. In addition Boundary B7a also has potentially more generation to accommodate. The principal means of accommodating potentially significantly increased power flows would be through a Western HVDC link and East Coast HVDC Link. However, there are other potential reinforcement options that would add further capacity.

Incremental Reinforcement

Upgrades to the onshore transmission system will maximise the capability of the Scotland-England interconnection and enable the firm 4.4GW thermal capability of the existing overhead line routes to be utilised. These works will involve the installation of series and shunt compensation at a number of sites in southern Scotland and the north of England, together with the uprating of some circuits from 275kV to 400kV operation and reconductoring the overhead lines. The earliest possible completion date of these reinforcements is 2015.

Western HVDC Link

The project constructs a new HVDC link between Hunterston substation in central Scotland and Connah's Quay substation in North Wales. The connection will be via an undersea cable sited along the west coast of Great Britain. The project has already been allocated some funding by Ofgem for preconstruction works and further funding has been requested. The Western HVDC link will provide an increase in capacity of around 2.1GW to each of the three Scotland-England boundaries. The total capital cost for the HVDC link is estimated to be around £1bn as indicated in Ofgem's Transmission Investment Incentives (TII) regarding the Western HVDC link⁹. The earliest possible completion date of the western HVDC Link is 2015.

⁹ <http://www.ofgem.gov.uk/Pages/MoreInformation.aspx?docid=20&refer=Networks/Trans/ElecTransPolicy/CriticalInvestments/InvestmentIncentives>

East Coast Subsea HVDC Link

The Western HVDC link would provide sufficient transmission capacity until 2019 for Boundary B7 and until 2018 for Boundary B7a under the Gone Green 2011 scenario, after this point further reinforcement would be required. The NGET-SHETL East Coast HVDC link option would provide an additional 2.1GW of boundary capability to B6 boundary. Although the East Coast HVDC link would not cross the B7 and B7a boundaries, the improved load sharing that the link can provide would result in an increase in boundary capability, however this will not be the full 2.1GW as seen with the B4 and B6 boundaries. This total capital cost of the HVDC link is estimated to be circa £1.2bn¹⁰. The earliest possible completion date of the East Coast Subsea HVDC Link is 2018.

In addition there may be the potential option of offshore HVDC links to connect Round 3 offshore windfarms from Dogger Bank to the main AC transmission system. This approach could also provide an increase in boundary capability to the B7 and B7a boundary.

Reconductor Harker-Hutton-Quernmore

This reinforcement would provide sufficient transmission capability until 2016 for Boundary B7. This reinforcement would increase the post-fault winter capability of existing Harker-Hutton-Quernmore circuits from 1390MVA to 3100MVA per circuit. Thus the improvement in boundary capability is 1.4GW following this reinforcement. The earliest possible completion date of this reinforcement is assumed to be in 2014.

Mersey Ring

These investments provide for the voltage upgrade of the 275kV double circuit from Penwortham Substation through Washway Farm Substation to Kirkby Substation to 400kV operation and the associated substation works at Penwortham, Washway Farm and Kirkby. This Voltage Upgrade would be required to restore compliance with the NETS SQSS following the potential connection of several offshore wind farm projects, Combined Cycle Gas Turbine (CCGT) Plant and also to allow increased electricity exports from Scotland. The earliest possible completion date of the Mersey ring upgrade is 2018.

¹⁰ The cost is for indicative purpose only as the project is in its early stages of development. The uncertainty surrounding this project is high covering a number of aspects such as final routing, technology, commodity prices, and markets.

Only the major reinforcement options are presented in this summary report. There are a number of other reinforcement options which are included in the 2012 ENSG Report.

Figure 4 shows how the Scotland-England transmission network might look in 2020 with the potential reinforcements.

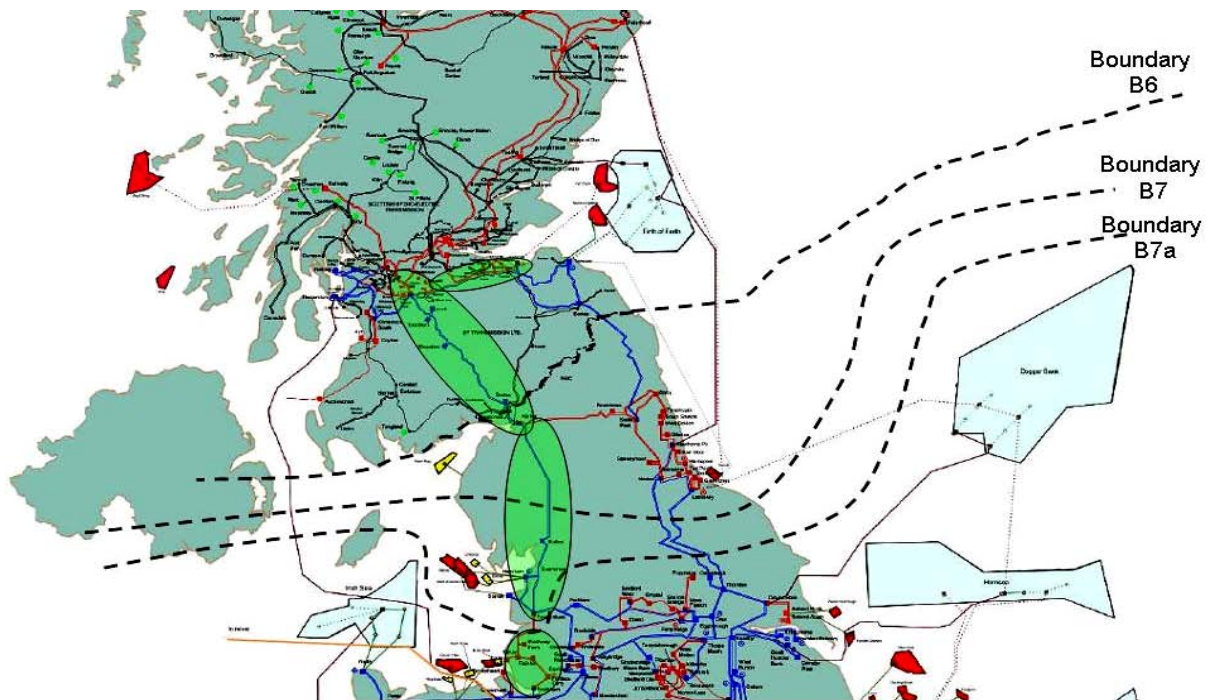


Figure 4 – Map of Scotland-England transmission circuits with possible location of reinforcements

Cost

The estimated cost of the possible set of reinforcements considered for boundary B6, B7 and B7a is around £3.5bn for the Gone Green 2011 scenario.

5.3 North to Midlands and Midlands to South

The capability of this region is sensitive to the changing generation backgrounds and is restricted by voltage limitations which vary throughout the year. The expected closure of existing CCGT generation plants under the Gone Green 2011 scenario on both sides of boundary B8 and B9 causes voltage depression around the boundaries. The Wylfa – Pembroke HVDC link identified in the North Wales region would provide additional thermal and voltage boundary capability to these boundaries. Alternatively voltage issues within Boundaries B8 and B9 can be solved by providing additional reactive power support.

Potential reinforcement options are shown in Figure 5.

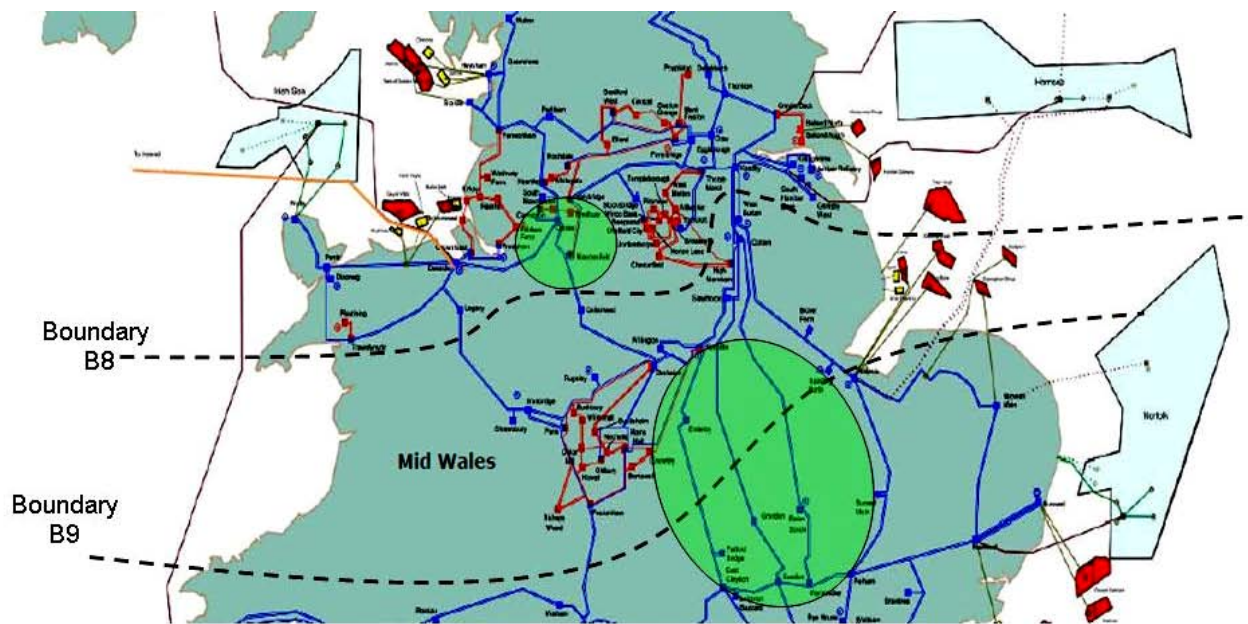


Figure 5 –Map of North to Midlands and Midlands to South boundaries with possible location of reinforcements

Cost

The estimated cost of the possible set of reinforcements considered for boundary B8 and B9 has been covered in the sections on North Wales and East Coast regions.

5.4 North Wales

A net increase of 2.8GW of generation is assumed to connect under the Gone Green 2011 scenario in the North Wales area by 2020. This includes a new nuclear power, Round 2 and Round 3 offshore wind, and an interconnector link to Ireland which is expected to complete before 2012/13. At present there is just under 1GW of nuclear generation, 2.1GW of thermal, 2GW of pumped storage generations connected to the North Wales transmission system.

Under the Gone Green 2011 scenario when the Round 3 Irish Sea windfarms and nuclear generation start to significantly impact on the boundary further reinforcement would be required in the form of:

- Two new transmission lines between Wylfa and Pentir.
- Installation of a second circuit between Pentir and Trawsfynydd.

The earliest possible completion dates of these reinforcements are 2018 and 2016 respectively.

A Wylfa - Pembroke HVDC link could also be required under the Gone Green 2011 Scenario as early as 2020. This reinforcement would be further justified if all the units of Wylfa C nuclear are operating at full capacity

Other onshore reinforcement which could be required:

- Reconductoring of the Trawsfynydd to Treuddyn Tee circuits.

The earliest possible completion dates of the Wylfa – Pembroke HVDC link and Trawsfynydd – Treuddyn Tee reconductoring are 2017 and 2014 respectively.

In addition an offshore co-ordinated network design option has been developed to accommodate 2GW of wind assumed by 2020 under Gone Green 2011 Scenario and could be expanded to a maximum zonal capacity of 4.2GW for the full Round 3 Irish Sea wind capacity. This design option would coordinate interconnection between the offshore platforms and the onshore transmission which could potentially reduce the number of connections to shore the cost of the connections and possibly provide circuit diversity to the offshore generation. These potential benefits would be dependent upon assumptions made for example on timing and scale of generation.

Figure 6 shows potential transmission network reinforcements in North Wales by 2020

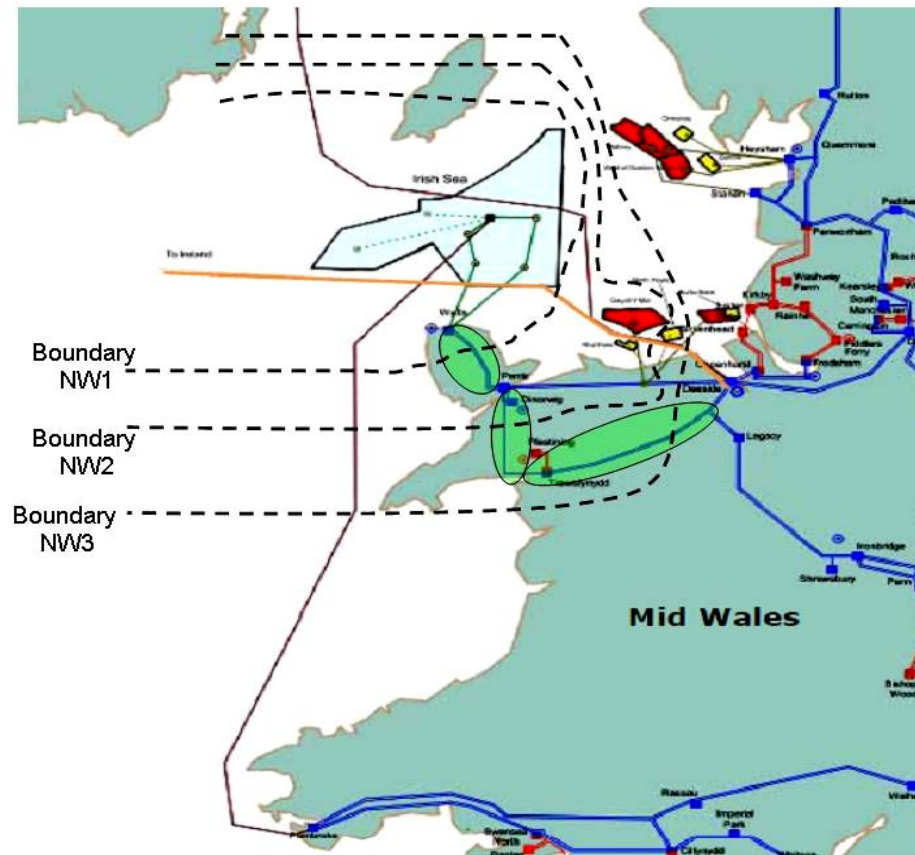


Figure 6: North Wales' transmission system with potential reinforcement options

Cost

The estimated cost of the possible set of reinforcements considered for North Wales is £1.12bn for the baseline Gone Green 2011 scenario.

5.5 Mid-Wales

Under the Gone Green 2011 scenario 360MW of onshore wind would connect to transmission system and 400MW to the Scottish Power Manweb distribution network. The capacity of the distribution network in the area is not sufficient to accommodate this generation unless transmission infrastructure is established in Mid-Wales. In order to provide a connection for the wind generation the following reinforcements have been considered. The earliest anticipated completion date of these reinforcements is 2016.

- Mid-Wales Substation
- Construction of a new 400kV double circuit from Mid-Wales to Legacy – Shrewsbury - Ironbridge circuits

- Establish a new single switch 400kV mesh substation at Shrewsbury and reconfigure the existing tee transformer arrangement such that it connects into the mesh substation.

The dates for the completion of these works are aligned with the generators' expected connection dates and are subject to the consenting and regulatory approvals process.

The first phase of public consultation was completed in June 2011, and the full set of need case, strategic optioneering and consultation reports can be found on the National Grid website¹¹. The other projects noted will also be subject to the Infrastructure Planning Commission (IPC) process with a need case and strategic option document being produced.

Figure 7 shows an indication of the area within the Mid-Wales region where reinforcements may be required.

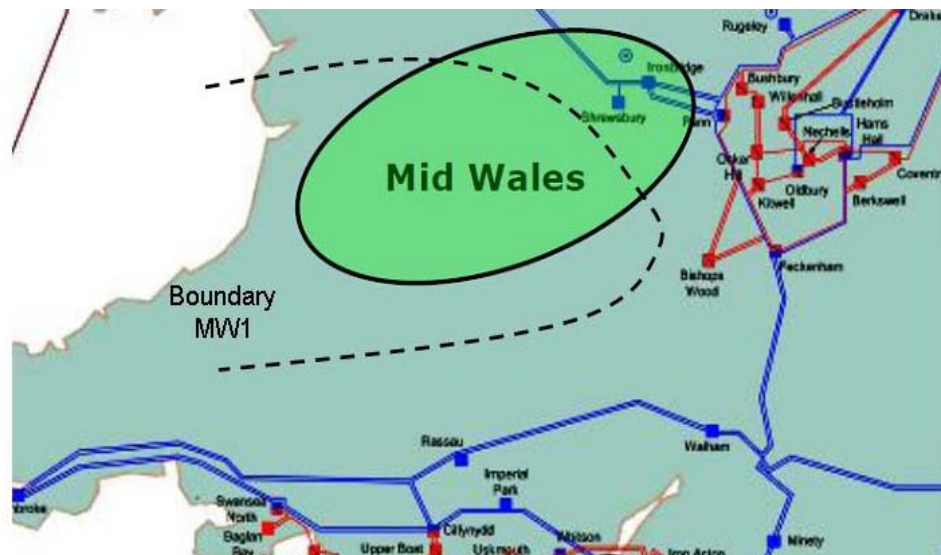


Figure 7: Map of Mid-Wales region with an indication of possible reinforcements

Cost

The cost of the reinforcements in the 2011 Gone Green scenario is estimated to be around £200m for this area.

5.6 South West

Under the Gone Green 2011 scenario 2.8GW of new generation is forecast to connect in the area up to 2020. The new generation comprises offshore wind, nuclear and a small amount

¹¹ <http://www.nationalgrid.com/uk/Electricity/MajorProjects/MidWalesConnection/>

of marine. Under this scenario, there is about 2.2GW of generation comprising nuclear and gas currently connected to the South West region.

A number of reinforcement options could be applied to accommodate this new generation. Only one of these options would be required to achieve compliance with NETS SQSS and it would be subject to the consenting and regulatory approvals processes.

- Hinkley Point- Bridgwater – Seabank 400kV AC Transmission Circuit
- Hinkley-Alternative Destinations 400kV AC Transmission Circuit
- HVAC subsea cable Hinkley Point-Seabank
- HVAC subsea cable Hinkley Point-Aberthaw
- HVDC cable Hinkley Point -Seabank
- HVDC cable Hinkley Point –Aberthaw

NGET announced, on 29th September 2011 following two years of extensive public consultation, its preferred route corridor for the Hinkley Point C connection. This route option mostly follows the existing 132kV distribution network which runs from Bridgwater to Seabank and will involve upgrading this corridor to 400kV operation (corresponding to one of the route options under SW-R02). Technology options have not been decided at the time of writing. Further information can be found on the dedicated Hinkley Point C connection website¹².

The earliest possible completion dates of the first two and remaining four reinforcement options are 2019 and 2017 respectively.

Figure 8 highlights the area within this region where potential reinforcements would be required.

¹² <http://www.nationalgrid.com/uk/electricity/MajorProjects/HinkleyConnection>

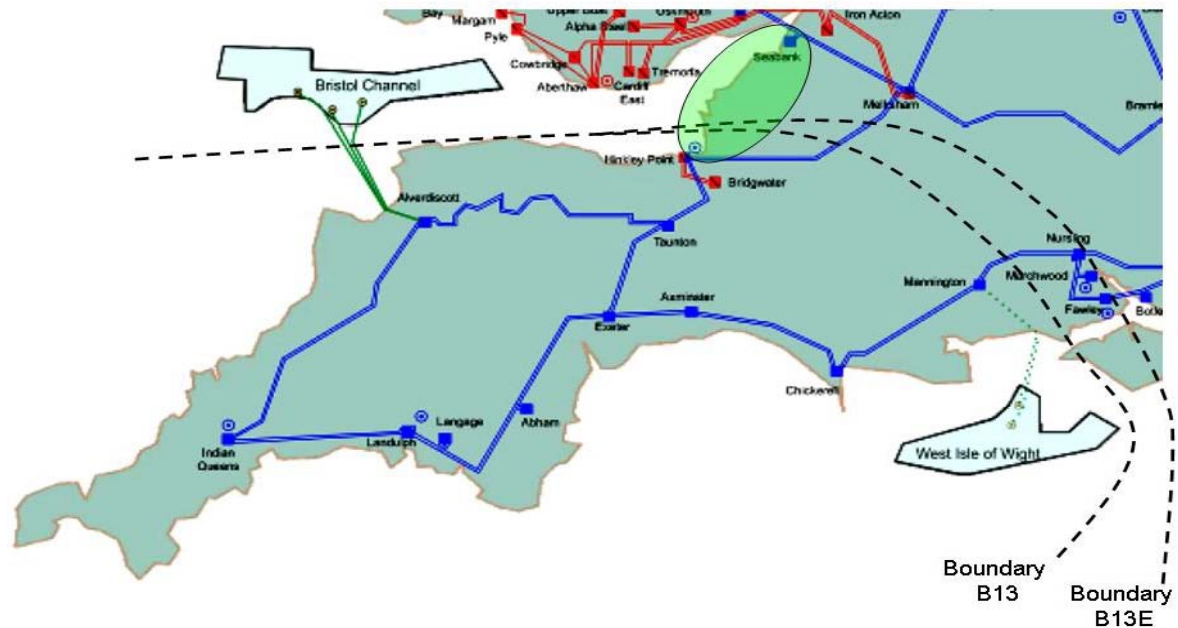


Figure 8: Map of South West transmission network with possible location of reinforcements

Cost

The total estimated cost of the possible reinforcement considered for this area under the 2011 Gone Green scenario is £450m.

5.7 English East Coast and East Anglia

The volume of generation off the East Coast is assumed to increase significantly over the study period under the Gone Green 2011 scenario. The East Coast has been extremely active in terms of proposed generation connections, with the three largest potential offshore wind developments (Dogger Bank, Hornsea and East Anglia, potentially amounting to around 25GW) all seeking to connect (at least in part) into this area. By 2020 the Gone Green 2011 scenario shows just under 6GW of offshore wind connecting in this region. In addition, there are a number of other, smaller, offshore wind developments, proposed new gas-fired generation and potential nuclear power stations. There is about 8.4GW generation currently connected within the region. This includes just over 7GW of gas and over 1GW of nuclear generation.

Given the high levels of potential generation and uncertainties about timing of connections and eventual scale of generation, a large number (21) of possible reinforcement options (onshore and offshore) have been identified for the East Coast & East Anglia region that could enable the transmission system to meet the required power transfer levels. 17 of these possible reinforcement options did not appear in the 2009 ENSG Report.

The potential onshore reinforcements with their earliest possible completion dates are:

- Norwich - Sizewell turn-in at Bramford & reconductoring (2015)
- Extend Bramford Substation (2015)
- Bramford – Twinstead two new circuits (2018)
- Braintree – Rayleigh reconductoring (2015)
- Rayleigh - Coryton – Tilbury reconductoring (2015)
- Killingholme South Substation and new Double Circuit to West Burton (2018)
- Grimsby West - South Humber Bank new double circuit (2018)
- South Humber Bank – Killingholme new double circuit (2018)
- Humber circuits reconductoring (2015)
- Walpole QBs (2015)
- Elstree - Waltham Cross – Tilbury uprating, reconductoring and QBs (2019)
- Barking – Lakeside uprating (2015)
- Kemsley - Littlebrook – Rowdown reconductoring (2015)
- Rayleigh Reactor installing reactor (2014)
- Tilbury - Kingsnorth - Northfleet East reconductoring (2015)

4 potential offshore reinforcements would connect Hornsea, and Dogger Bank offshore wind farms to each other and to connection points on the East Coast and East Anglia (Killingholme South, Creyke Beck and Walpole). A further 2 potential offshore reinforcements would connect Norfolk offshore wind farm to Bramford and Norwich Main. All of these reinforcements have the potential to provide additional security to the onshore and offshore networks. Fuller details are in the 2012 ENSG Report.

The Bramford – Twinstead two new circuits have been in public consultation since October 2009, and the full set of need case, strategic optioneering and consultation reports can be found on the National Grid website¹³. The other projects noted will also be subject to the IPC process with need case and strategic option documentation being produced.

¹³ <http://www.nationalgrid.com/uk/Electricity/MajorProjects/BramfordTwinstead/>

Figure 9 gives an indication of the possible transmission network reinforcements.

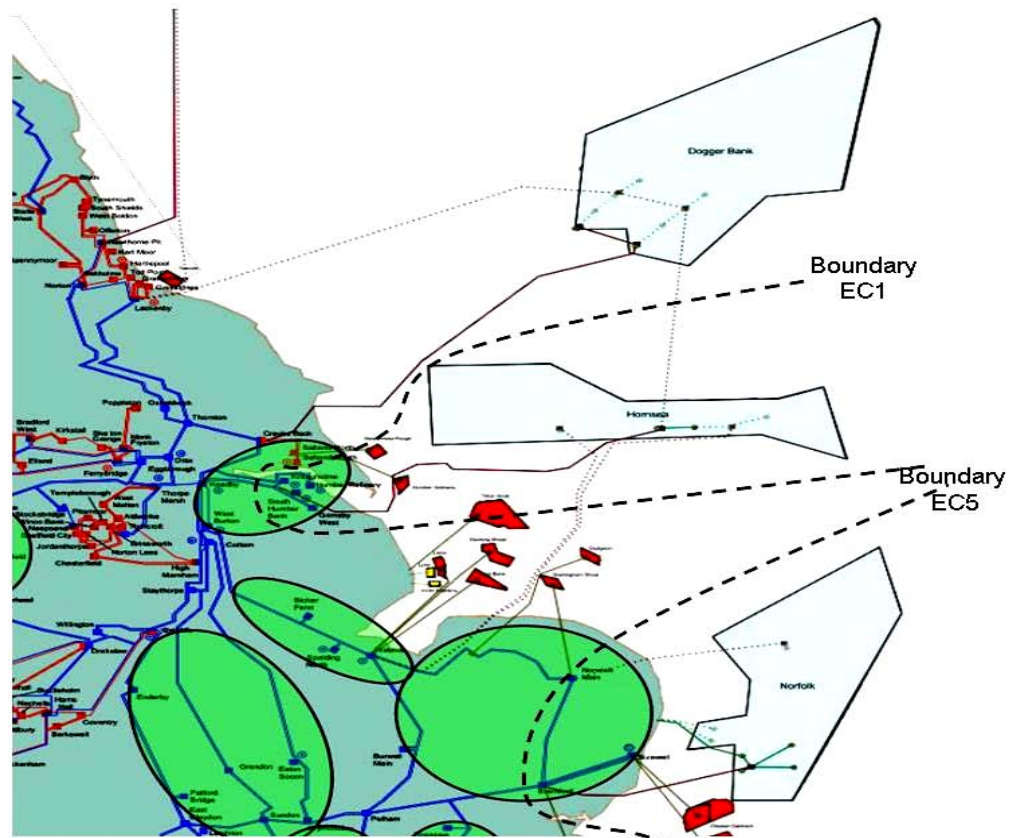


Figure 9: Map of the East Coast and East Anglia transmission network with possible location of reinforcements

Cost

The cost of reinforcing this region for the Gone Green 2011 base scenario is estimated to be around £790m.

5.8 London, Thames Estuary and South Coast

London is the largest demand centre in the UK and a large proportion of electricity generated nationally flows into the city from the adjacent regions. Regionally the only significant generation is focused in the lower Thames Estuary where there are large coal, oil and gas-fired stations generation support is provided by units further away, such as the nuclear power stations to the East of London. Demand can also be met through the existing interconnectors to France and the Netherlands. Consequently, the demand in London is predominantly met by transmission connections from remote generation sources. The area

is particularly sensitive to changes from the existing interconnectors to Europe. The commissioning of the Belgium-England interconnector (NEMO) coupled with the existing interconnectors to mainland Europe could potentially swing flows from 5GW import to 5GW export depending upon market conditions and generation/demand balance in the UK and Europe.

The potential reinforcement options to accommodate potential changes with their earliest possible completion dates are:

- Upgrade and reconductor the Hackney - Brimsdown - Waltham Cross double circuit which bypasses Tottenham substation (2015)
- Reconductor the Pelham – Rye House circuits (2015)
- St. John's Wood – Elstree – Sundon reinforcement (2018)
- Upgrading the 275KV overhead line route connecting substations at West Weybridge, Chessington and Beddington to 400kV (2018)

The Waltham Cross to Hackney reinforcement is currently the subject of public consultation, and the full set of need case, strategic optioneering and consultation reports can be found on the National Grid website. The other projects noted will also be subject to the IPC process with a need case and strategic option document being produced.

The final two options listed above did not appear in the 2009 ENSG Report.

Figure 10 shows possible transmission network reinforcements for this region.

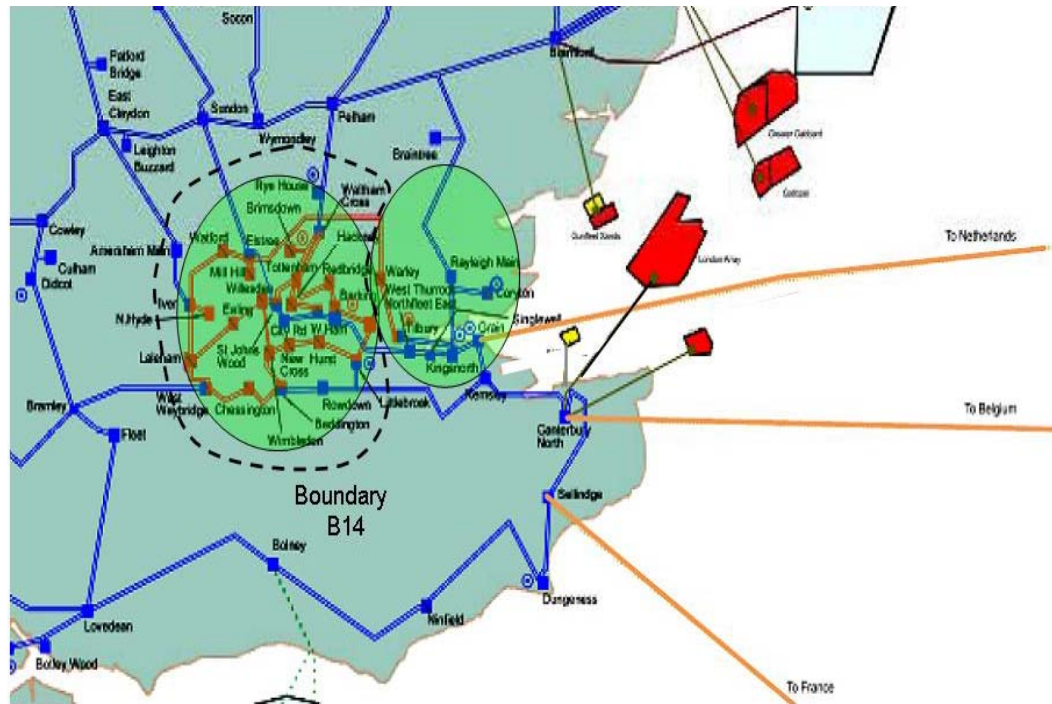


Figure 10: Map of London transmission network with location of possible reinforcements

Cost

The total estimated cost of the potential reinforcement options for this region under the 2011 Gone Green scenario is £200m under interconnector importing conditions and could rise up to £415m under exporting conditions.

5.9 Taking Investment Proposals Forward

A wide range of potential reinforcements have been identified by the TOs to achieve compliance against the generation background and sensitivities. The future possible reinforcements listed in the 2012 ENSG Report are only options identified by the TOs at this stage. Any network reinforcements at and above 132kV would be (or are already being) consulted on. This includes pre-application consultation and examination under the Planning Act 2008 in England & Wales (except for associated development, including substations in Wales which require local authority and Welsh Assembly approval) and under the Electricity Act 1989 for electricity networks and in Scotland under the Scottish Planning regime.

The constrained areas of the network which may require reinforcing have been classified as very strong need case and strong need case.

Very Strong Need Case areas are defined as existing or possible areas in the near future (up to 2015) of the transmission network where there is significant and uneconomical constraints, or where the likelihood of these constraints (or technical limitation) in the earlier years are high. It is also characterised by conditions affecting the area such as generation background or new reinforcements that are fairly certain. One example of such an area is the Scotland-England circuits which currently have derogations against the NETS SQSS in place.

Strong Need Case areas are defined as areas where the likelihood of significant network constraint is lower than in Very Strong Need Case areas and depend on assumptions about the generation and network conditions which are less certain and further out into the future (beyond 2015).

Figures 11 and 12 show the NETS with high level potential need case for reinforcements contained in the 2012 ENSG Report and the potential reinforcements respectively.

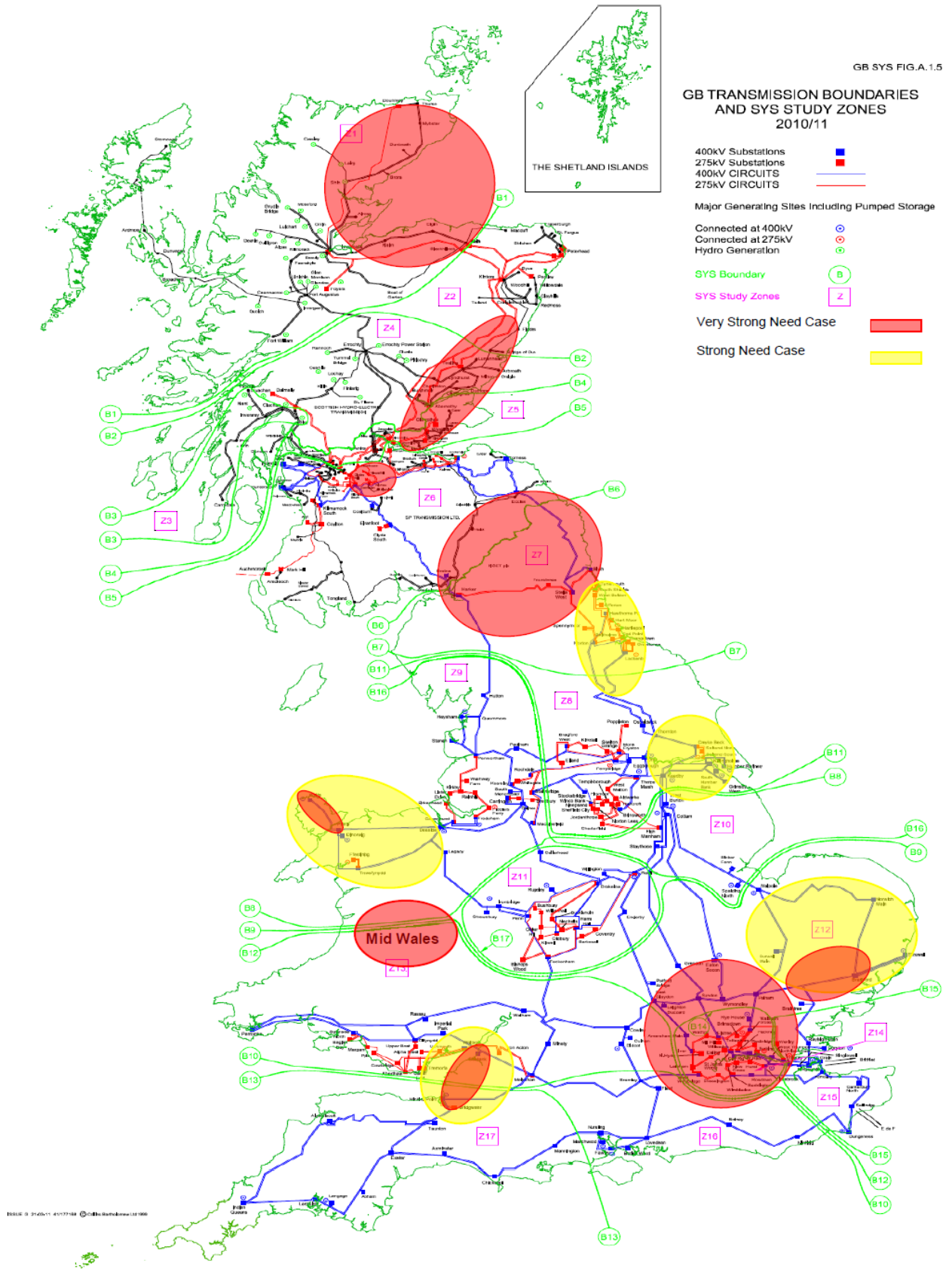


Figure 11: Map of NETS with high-level indication of potential regional needs case for reinforcements

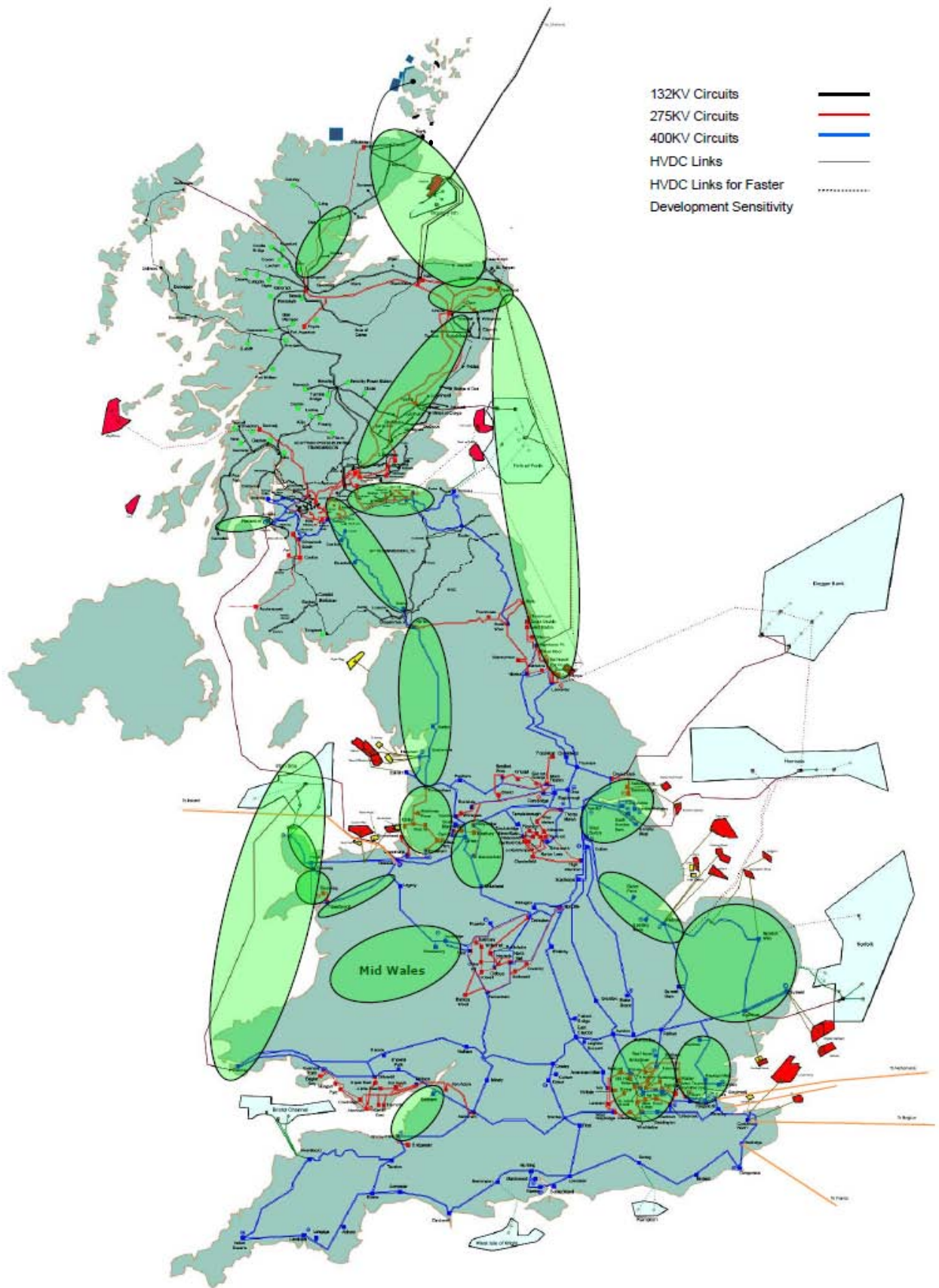


Figure 12: Map of NETS with Potential Reinforcements

6 Capital Cost of Potential Transmission Reinforcements

The estimated capex requirement to deliver the reinforcements to meet the Gone Green 2011 scenario identified in the 2012 ENSG Report and the amount of generation which can be accommodated is shown in Table 2. The estimated capex requirement to deliver the reinforcements would be subject to a rigorous review as part of the pre-construction engineering stage and to the Ofgem investment approvals process of any investment proposals put forward by the TOs.

Region	Generation Accommodated	Estimated Cost
Scotland	10.2GW	£2.5bn
Scotland-England	1.1GW	£3.56bn
North to Midlands and Midlands to South	3.7GW	-
North Wales	3.8GW	£1.12bn
Mid-Wales	0.36GW	£200m
South West	6.0GW	£450m
East Coast and East Anglia	10.8GW	£790m
London	3.3GW	£200m
Total	39.26GW*	£8.82bn

Table 2: Regional summary of estimated cost of reinforcements and additional generation that can be accommodated

Annex A

Electricity Networks Strategy Group – Terms of Reference 2011

The Electricity Networks Strategy Group (ENSG) provides a high level forum bringing together key stakeholders in electricity networks that work together to support Government in meeting the long-term energy challenges of delivering a thriving, globally competitive, low carbon energy economy.

Specifically the ENSG will:

- Develop and promote a high level 'vision' of how the UK electricity networks could play a full role in effectively and efficiently facilitating the increase in renewable and other low-carbon generation necessary to meet the EU 2020 renewables target and longer-term energy and climate change goals.
- Develop an understanding of the implications of policy for our electricity networks, identifying potential technical, commercial and regulatory barriers to meeting the UK renewables target and provide strategic advice on possible solutions.
- Maintain an overview of activities and developments that have potential to impact on the realisation of the high level 'vision' including the monitoring of network delivery. Advise on whether they provide a complete and coherent delivery and development path against the targets.
- Disseminate the results of its activities to the wider community of relevant stakeholders.
- Review its terms of reference, including the need for its continued operation, not more than 2 years from February 2011.

ENSG Membership

DECC	Jonathan Brearley Director, Energy Markets and Networks (Joint Chair)
Ofgem	Hannah Nixon Acting Senior Partner, Smarter Grids and Governance: Transmission (Joint Chair)
National Grid Electricity Transmission	Nick Winser Executive Director
SP Transmission	Jim Sutherland Asset Strategy Director
Scottish Hydro-Electric Transmission	Ian Funnell Director of Transmission
CE-Electric UK	Phil Jones President & CEO
Central Power Networks	John Crackett Managing Director
UK Power Networks	Barry Hatton Director Asset Management
Transmission Capital Partners	Chris Veal Managing Director
Energy Networks Association	David Smith Chief Executive
RWE Npower	David Mannering Director of Economic Regulation
Centrica	Sarwjit Sambhi Managing Director of Power Generation
EDF	Rob Rome Head of Transmission and Trading Arrangements
Vattenfall	Jason Ormiston Head of UK Regulatory and Public Affairs
Renewable Energy Systems	Patrick Smart UK Grid Connections Manager
Renewable-UK	Guy Nicholson Head of Grid
The Crown Estate	Chuan Zhang Programme Manager (Technology)
Scottish Government	Colin Imrie Head of the Energy Markets Division
Welsh Assembly	Ron Loveland Energy Advisor to the Welsh Government
DECC	Sandy Sheard Deputy Director, Future Electricity Networks Tom Luff Head of Onshore Electricity Networks

Annex B

ENSG Working Group Terms of Reference (Extract)

At the meeting on 14 February 2011, the ENSG agreed that a working group should be established to support the ENSG by scoping and delivering a work plan covering the three areas set out below. As ENSG develops its vision for the electricity network for 2020 and beyond, additional working groups may be assigned further tasks.

The ENSG Working Group's key task is to scope and deliver a work plan covering the following:

- i. An update of the ENSG 2020 vision report incorporating network responses to changes to generation scenarios, technologies, policy developments, etc.
- ii. Assessment and monitoring of network delivery to 2020 in a standardised format to enable ENSG and external stakeholders to see progress made on, and any challenges to, successful delivery.
- iii. Post-2020 generation and demand scenarios impacting on pre-2020 investment needs and post-2020 investment and other network solutions.

The Working Group should take into account and build upon related work, in particular that of the Offshore Transmission Coordination Group (which is gathering evidence and considering the future arrangements for developing the offshore grid), the Smart Grid Forum looking at long-term distribution network issues such as demand and distributed generation and the development of RIIO TO Business Plans which are due for completion by end July 2011.

The Working Group should maintain awareness of and take into account other related ongoing activities that have the potential to affect the conclusions and outputs of the Group.

The following have participated in the work of the Group relating to the ENSG 2020 Vision Updated Report

Tom Luff, Chair, DECC

Paul Hawker, DECC

Kristina Dahlstrom, DECC
Simon Cran-McGreehin, Ofgem
Andrew Hiorns, National Grid
Colin Bayfield, Scottish Power
Mike Barlow, SHETL
Bless Kuri, SHETL
Fiona Navesey, Centrica
Louise Schmitz, EDF
Stefan Leedham, EDF
Jeff Douglas, Central Networks
Mark Drye, CE-Electric UK
Mike Lee, Transmission Capital Partners
Sean Kelly, Transmission Capital Partners
Guy Nicholson, Renewable-UK
Alex Murley, Renewable-UK
Alan Claxton, Energy Networks Association
Chuan Zhang, The Crown Estate
Mike McElhinney, Scottish Government

Annex C

Summary of Significant Changes from the 2009 ENSG Report

		2009 ENSG Report	2012 ENSG Report	Comments
Generation (GW)	Coal	19.8	14.5	Increase in assumed nuclear generation due to potential 10-year extensions of existing plants. Results in lower coal generation. Differences in calculating the exclusion of energy used in aviation sector from overall target calculation reduces renewable capacity required to meet 15% target. This reduction applied to wind generation capacity as it is main source of renewable energy in the Gone Green 2011 scenario. Further details in Chapter 2 and the 2012 ENSG Report
	Gas	41	41.7	
	Nuclear	6.9	12.3	
	Wind	32.3	28.3	
	Other Renewable	8.2	7.2	
	Other	3.8	3.4	
	Total	112	107.4	
Offshore Wind	Coordinated Offshore Strategy	Not included	Illustrated offshore network designs included for Scotland, East Coast of England and North Wales	2012 ENSG Report uses illustrative offshore network designs where relevant and does not represent any investment decisions or contractual arrangements or programme of the Transmission Owners, Offshore Transmission Owners or Third Parties nor imply the actual connection routes for new electricity transmission infrastructure. DECC/Ofgem led offshore transmission coordination project is considering different offshore grid configurations under different generation scenarios and potential measures to enable different grid configurations should the analysis support such development.
Potential Reinforcements	Scotland	Potential connections for Scottish Islands	Estimated costs added	Costs for potential connections from Orkney Islands, Western Isles and Shetland Islands to the mainland have been included. A potential Caithness Moray Shetland reinforcement would possibly connect offshore wind as well as the Shetland and Orkney Islands and addressing potential onshore network constraints. In addition illustrative design for interconnection between offshore wind farms at Dogger Bank and Hornsea presented which could potentially provide additional security to onshore network. See "Offshore Wind" section in this table. Further details in Chapter 5 of this document and the 2012 ENSG Report
			Additional potential options added for Caithness Moray Shetland reinforcement	
	Scotland-England	Series compensation at the Norton – Spennymoor 400Kv double circuit	Not included	
		Potential reinforcements to accommodate increased power flows from Scotland to England	Additional potential reinforcements added:	
NGET - SPT East Coast HVDC Link				
Penwortham QBs				
Mersey Ring uprate			Further details in Chapter 5 of this document and the 2012 ENSG Report.	

		2009 ENSG Report	2012 ENSG Report	Comments
	North Wales	Potential reinforcements to accommodate possible nuclear and offshore wind generation	Additional potential reinforcement options added:	In addition an illustrative design for interconnection between offshore wind platforms in the Irish Sea and the onshore transmission network have been added which could potentially provide additional security to the onshore and offshore network. See "Offshore Wind" section in this table. Further details in Chapter 5 of this document and the 2012 ENSG Report.
			Wylfa-Pembroke HVDC link	
			New 400kV, Pentir – Wylfa single circuit	
			Pentir – Deeside Reconductoring	
			Pentir – Trawsfynydd Reconductor	
	South West	Hinckley – Seabank reinforcement to accommodate possible new generation	Alternative reinforcement options for Hinckley - Seabank	Further details in Chapter 5 of this document and the 2012 ENSG Report
	English East Coast & East Anglia	Potential Reinforcements to accommodate offshore wind and nuclear generation	Alternative onshore reinforcement options added:	In addition illustrative design for interconnection between offshore wind farms at Dogger Bank and Hornsea (and separately for Norfolk wind farm) which could potentially provide additional security to onshore network through connections along the East Coast and East Anglia. See "Offshore Wind" section in this table.
Braintree – Rayleigh				
Rayleigh - Coryton – Tilbury				
Killingholme South Substation and new Double Circuit to West Burton				
Grimsby West - South Humber Bank				
South Humber Bank – Killingholme				
London	Potential reinforcement to accommodate possible changes in generation location, interconnection and demand	Reinforcement options:	Further details in Chapter 5 of this document and the 2012 ENSG Report	
		Reconductor the Pelham – Rye House circuits.		
		St. John's Wood – Elstree – Sundon reinforcement		
Interconnector	Moyle(Northern Ireland-England)	Yes	Yes	Further details of interconnectors are in Chapter 2 of the 2012 ENSG Report
	IFA(France-England)			
	East-West Interconnector (Ireland-Wales)			
	Britned (Netherlands-England)	Yes	No	
	East-West Cable 1 (Pentir, Wales)			
	NEMO (Belgium-England)	No	Yes	
Norwegian (Norway-England)	No	Yes		

Annex D

Glossary

ACS Peak GB Demand

The estimated unrestricted winter peak demand on the National Electricity Transmission System for the Average Cold Spell (ACS) condition. This includes both transmission and distribution losses and represents the demand to be met by Large Power Stations (directly connected or embedded), Medium and Small Power Stations, which are directly connected to the National Electricity Transmission System, and by electricity imported into the National Electricity Transmission System from External Systems across External Interconnections.

AGR

An advanced gas-cooled reactor (AGR) is a type of nuclear reactor. These are the second generation of gas-cooled reactors in Great Britain, using graphite as the neutron moderator and carbon dioxide as coolant.

Boundary Capability

This is the maximum power, which can be transferred across a boundary without causing unacceptable conditions following specified outages as defined in the Licence Standard.

Capex

Capital Expenditure.

CCGT

Combined Cycle Gas Turbine. A collection of Generating Units (registered as a CCGT Module under the Grid Code) comprising one or more Gas Turbine Units (or other gas based engine units) and one or more Steam Units where, in normal operation, the waste heat from the Gas Turbines is passed to the water/steam system of the associated Steam Unit or Steam Units and where the component units within the CCGT Module are directly connected by steam or hot gas lines which enable those units to contribute to the efficiency of the combined cycle operation of the CCGT Module.

Deterministic Assessment

An assessment based on fixed set of rules.

Distribution Network

The 132kV and below electricity network in England and Wales and below 132kV electricity network in Scotland and Offshore.

Dynamic Ratings

Overhead line conductors get heated up when current is flowing through them. But, it can get cooled if wind is blowing at higher speed. Therefore at higher wind speed, more current flows through the conductor, which gets cooled off quickly due to the same high wind speed. So, the rating of the overhead line conductor could be increased during the wind blows at higher speed. Dynamic current rating is to utilise this concept and changing the conductor rating dynamically according to the wind speed.

Economy Criteria

The Economy Criterion requires sufficient transmission system capacity to accommodate all types of generation in order to meet varying levels of demand efficiently. The proposed approach involves a set of deterministic parameters which have been derived from a Cost Benefit Analysis (CBA) seeking to identify an appropriate balance between the constraint costs with the costs of transmission reinforcements.

Embedded Generation

Embedded Generation is also referred to as Distributed Generation. Embedded Generation is usually a small generators connected to the distribution system without having any access to the transmission network. These generators generally located near to the demand.

GEMA

Gas and Electricity Markets Authority also known as "The Authority" is the statutory body which governs Ofgem. GEMA's principal objective is to protect the interests of existing and future consumers in relation to gas conveyed through pipes and electricity conveyed by distribution or transmission systems. These interests include costs, the reduction of greenhouse gases and security of supply.

Generator

A person who generates electricity under licence or exemption under the Electricity Act acting in its capacity as a generator.

Great Britain or GB

Great Britain means the landmass of England and Wales and Scotland, including internal waters.

Grid System Review (GSR009)

Amendment report to NETS SQSS - Review of required boundary transfer capability with significant volumes of intermittent connection. The changes put increased emphasis on ensuring appropriate balance between the constraint costs with the costs of the transmission reinforcements. For areas where there are high volumes of renewable generation, this will drive the requirement for more transmission capacity than the application of the deterministic rules as set out in version 2.1 of the NETS SQSS.

GW

Gigawatt. 1,000,000,000 Watts.

HV

High Voltage

HVAC

High Voltage Alternating Current

HVDC

High Voltage Direct Current. A way of conveying electricity over very long distances with fewer transmission losses than an equivalent HVAC solution. It also provides greater control over the transmission of electricity including ability to change size and direction of power flow.

Interconnection

Apparatus for the transmission of electricity to or from the National Electricity Transmission System, or to or from a User System in Great Britain, into or out of an External System. External Interconnections may comprise several circuits operating in parallel.

Interconnection Allowance

An allowance in MW to be added in whole or in part to transfers arising out of the Planned Transfer Condition to take some account of non-average conditions (e.g. Power Station

availability, weather and demand). This allowance is calculated by an empirical method described in the NETS SQSS.

IPC

Infrastructure Planning Commission was established on 1 October 2009 under the Planning Act 2008 to streamline the planning system for nationally significant infrastructure projects (NSIPs) in England and Wales. In England, it examines applications for development consent from the energy, transport, waste, waste water and waste sectors. In Wales, it examines applications for energy and harbour development, subject to detailed provisions in the Act; other matters are for Welsh Ministers.

kV

Kilovolt (1000 volts)

MTS

Main Interconnected Transmission System. This comprises all the 400kV and 275kV elements of the National Grid Transmission System and, in Scotland, the 132kV elements of the National Electricity Transmission System but excludes Generation Circuits, transformer connections to lower voltage systems and External Interconnections between the National Grid Transmission System and External Systems.

MW

Megawatts, 1,000,000 Watts

NDA

Nuclear Decommissioning Authority is a non-departmental public body. It is a strategic authority that owns 19 sites and the associated civil nuclear liabilities and assets of the public sector. Its purpose is to deliver the decommissioning and clean-up of the UK's civil nuclear legacy in a safe and cost-effective manner, and where possible to accelerate programmes of work that reduce hazard.

NETS

National Electricity Transmission System – This comprises all onshore and offshore transmission networks ie above 132kV in England and Wales and 132kV and above in Scotland and Offshore.

NETS SQSS

National Electricity Transmission System Security and Quality of Supply Standard. The National Electricity Transmission System Security and Quality of Supply Standards (NETS SQSS) sets out a coordinated set of criteria and methodologies that Transmission Licensees (both onshore and offshore) shall use in the planning and operation of the National Electricity Transmission System. These will determine the need for services provided to the Transmission Licensees¹⁴.

NGET

National Grid Electricity Transmission plc. The electricity Transmission Owner for England and Wales. NGET is a member of the National Grid (“National Grid”) group of companies.

Ofgem

Office of the Gas and Electricity Markets the regulator of the GB energy market.

OFTO

Offshore Transmission Owner. Owner of transmission assets connecting offshore windfarms to the onshore network granted a licence through competitive tendering run by Ofgem.

ONR

The Office for Nuclear Regulation sets out in conditions attached to a nuclear site licence the general safety requirements to deal with the risks on a nuclear site

Planned Transfer

The power transfer arising from the Planned Transfer Condition. The Planned Transfer Condition is the scaling of the output capacities of all directly connected Power Stations and embedded Large Power Stations to equal the Average Cold Spell Peak Demand minus imports from External Systems.

Plant

Fixed and movable items used in the generation and/or supply and/or transmission of electricity, other than Apparatus.

¹⁴ <http://www.nationalgrid.com/uk/Electricity/Codes/gbsqsscode/DocLibrary/>

Plant Margin

The amount by which the total installed capacity of directly connected Power Stations and Embedded Large Power Stations and imports across directly connected External Interconnections exceeds the Average Cold Spell Peak Demand. This is often expressed as a percentage (e.g. 20%) or as a decimal fraction (e.g. 0.2) of the ACS Peak Demand.

QB

Quadrature Booster is a special types of transformers used in NETS to control the active power flow.

Rating

The post fault continuous rating of a Circuit is the maximum power flow that can be passed through the Circuit, following a fault on the National Electricity Transmission System, without damaging equipment, or infringing statutory clearances on overhead lines. This will normally be for a period within 24 hours. This rating varies for each season of the year, because of the effect of differing climatic conditions on equipment performance.

Reactive Power

Reactive power is a concept used by engineers to describe the background energy movement in an Alternating Current (AC) system arising from the production of electric and magnetic fields. These fields store energy which changes through each AC cycle. Devices which store energy by virtue of a magnetic field produced by a flow of current are said to absorb reactive power; those which store energy by virtue of electric fields are said to generate reactive power¹⁵.

Reconductoring

Replacing of overhead line or cable with high capacity conductor

Required transfer

Sum of the planned transfer of electricity across the network and full and half interconnector allowance in case of N-1 and N-2/N-D contingency respectively

RIIO-T1

RIIO-T1 is the first transmission price control to use the RIIO framework, and will run from 1 April 2013 to 31 March 2021. RIIO stands for Revenue=Incentives+Innovation+Outputs.

¹⁵ http://www.nationalgrid.com/NR/rdonlyres/43892106-1CC7-4BEF-A434-7359F155092B/3543/Reactive_Introduction_oct01.pdf

The TOs submitted initial electricity transmission business plans to Ofgem in July 2011 covering the RIIO-T1 period.

Security Model

Security model requires sufficient transmission system capacity such that peak demand can be met without intermittent generation.

Series Compensation

Series Compensation is a well established technology that primarily is used to reduce the electrical length of the transmission line by reducing the line reactance. The result is a significant increase in the transmission system transient and voltage stability.

SHETL

Scottish Hydro-Electric Transmission Ltd. The electricity Transmission Owner for Northern Scotland.

SPT

SP Transmission Ltd. The electricity Transmission Owner for Central and Southern Scotland

STW

Scottish Territorial Waters. The definition of this area is set out in The Scottish Adjacent Waters Boundaries Order 1999.

Thermal capability

The ability of a network to transmit maximum power without overloading any circuit.

TII

The Transmission Investment Incentives is a mechanism whereby Ofgem sets the allowance for, and monitors, transmission investment projects in most urgent need of funding, including some identified in the 2009 ENSG Report.

TIRG

Transmission Investment for Renewable Generation. This is a mechanism designed to fund transmission projects specific to connecting renewable generation outside of the price

control allowance to minimise delays. TIRG comprises four projects: Beaulieu Denny, Sloy, South West Scotland and the Scotland-England Interconnector¹⁶.

TO

Transmission Owner. Responsible for delivering and maintaining the GB electricity transmission network. In England & Wales the TO is National Grid Electricity Transmission (NGET); in Central and Southern Scotland it is SP Transmission (SPT) and for Northern Scotland the TO is Scottish Hydro Electric Transmission Ltd (SHETL)

Transmission Circuit

Part of the National Electricity Transmission System between two or more circuit-breakers which includes, for example, transformers, reactors, cables and overhead lines but excludes Busbars and Generation Circuits.

Transmission Licence

The Licence granted under Section 6(1)(b) of the Electricity Act 1989 (as amended by the Utilities Act 2000 and the Energy Act 2004).

Up-rating

Changing the capacity of existing overhead line by replacing the existing conductors with larger capacity conductors, or increasing the maximum operating temperature of the existing conductor.

¹⁶ <http://www.ofgem.gov.uk/Networks/Trans/ElecTransPolicy/CriticalInvestments/TIRG/Pages/TIRG.aspx>