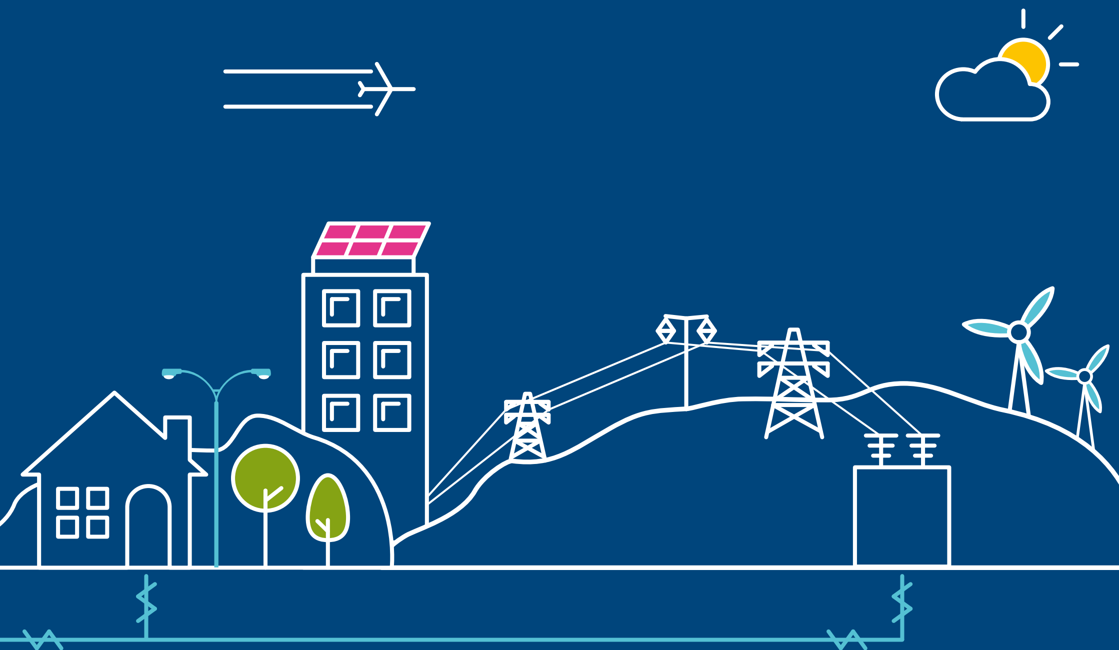
nationalgrid

Electricity Ten Year Statement 2015

UK electricity transmission



NOVEMBER 2015

The Electricity Ten Year Statement (ETYS) is part of the annual electricity transmission planning cycle and describes the future needs of the transmission network.

The ETYS is one of our Future of Energy documents; the others are the Future Energy Scenarios (FES), the Gas Ten Year Statement (GTYS) and the System Operability Framework (SOF), plus the soon-to-be-published Network Options Assessment (NOA) report. I hope you agree that together these documents create a clear and compelling story of the future.

We use our Future Energy Scenarios (published in July 2015) to establish future network development needs. The scenarios were based on our stakeholders' views and represent visions of the future energy landscape. The FES, and the network development polices from each network company, are the starting points for transmission network planning. This planning allows us to make strategic investments in our transmission networks.

A big change in this year's ETYS is the further development of the Integrated Transmission Planning and Regulation (ITPR). The ITPR includes new licence arrangements for planning and delivering the GB transmission networks. They will ensure that we can facilitate the electricity system's long-term development in a coordinated, economic and efficient way.

The ITPR arrangement means that National Grid, as System Operator, has been given additional responsibilities to identify the preferred options for GB transmission network investment.

At the end of that identification process, we'll publish an annual Network Options Assessment (NOA) report. The report will describe the transmission development options and the optimum selection of those options to meet the network development needs detailed in this ETYS. The first NOA report is due by 31 March 2016 and will include the information that was previously published in the 'Network Development and Opportunities' chapter of the ETYS.

This means that this year's ETYS is shorter than previous issues.

We listened to your feedback on having a standalone document about future operability challenges and opportunities and decided to continue publishing the System Operability Framework (SOF). To avoid repetition, we have removed the 'System Operation' chapter from the ETYS, so please read the ETYS in conjunction with the SOF. We hope this makes it easy for you, our customers and stakeholders, to explore the topics most relevant to you.

We received valuable feedback from you on how to improve the ETYS and other information we provide. Following this, we developed a new Customer Connection Interface Tool[1] to help you early in the National Electricity Transmission System (NETS) connection process. The tool, which has been released at the same time as ETYS, gives user-friendly information about the NETS in England and Wales. We hope you find it useful. I also hope this ETYS is useful and interesting.

Thank you for your support and feedback on our Future of Energy processes and ETYS publications.

We aim to carry on improving the information we give you. If you have any ideas about what we should publish please tell us at one of our stakeholder engagement activities – you can find details of our engagement plans in Chapter four of this document. Your views will help us shape our next ETYS production. I encourage you to tell us what you think by writing to us at **transmission.etys@nationalgrid.com**, completing our feedback form at **https://www.surveymonkey.com/r/ETYS2015**, talking to us at stakeholder events or meeting us at National Grid House.

Richard Smith
Head of Network Capability, Electricity

[1] http://www2.nationalgrid.com/WorkArea/DownloadAsset.aspx?id=43739

Executive summary

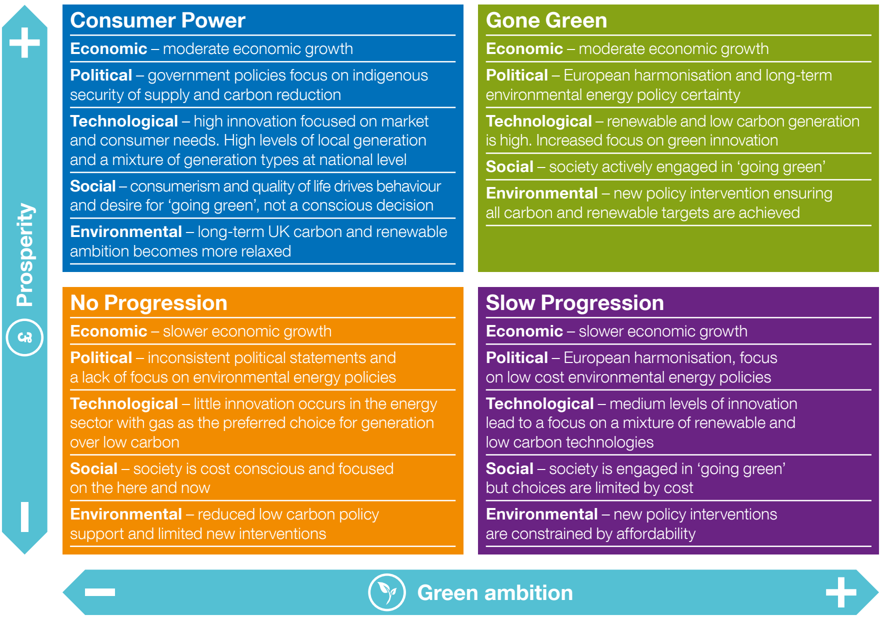
The Electricity Ten Year Statement (ETYS) shows the likely future transmission requirements of bulk power transfer capability of the National Electricity Transmission System (NETS).

We publish the ETYS annually in our role as System Operator (SO).

We assess transmission requirements by analysing the 2015 Future Energy Scenarios (FES, Figure 1). The scenarios are based on our experience, industry knowledge and work with our stakeholders. We use these credible scenarios as the basis for planning transmission network investment.

Our planning also includes factors such as interconnectors and contracted connection dates that influence transmission development locally. All this information helps us capture a wide range of future needs. For efficient planning, as we look further into the future where uncertainty increases, fewer details are included in our analysis. So beyond 10 years where uncertainty is higher than today, we only focus on major trends and power flows.

Figure 1
2015 Future Energy Scenarios



The FES were developed before the General Election and the subsequent policy changes. We believe that whatever the policy change outcome it is expected that the results will sit within the range covered by the scenarios.

We compare future transmission capability requirements with current system capability to establish how the network will need reinforcing. These requirements are presented in the form of boundary transfer capability, and we group the boundaries into regions based on their geographic locations. This document does not show specific local works for individual transmission connections but it does aim to tell customers about investment needs for wider works. It does this by outlining the future investment needed on the NETS.

The transmission network is designed to have enough capacity to carry power from areas of generation to areas of demand. The supply and demand of energy is changing, with generation becoming more geographically dispersed. At the same time, the energy landscape will change as we move into a low carbon future, so developing the transmission networks will be essential as we prepare for future challenges.

Key findings of our analysis

- More wind generation connections in Scotland will lead to continued increases in north-to-south transmission requirement. The transmission network will need new capacity to transport power across Scotland and much of England to meet southern demand.
- New nuclear plants will connect towards the periphery of the network. With the latest technology, they will be much larger than the generators they are replacing at the same locations. These parts of the network usually have connections with limited capacity, and the extra transmission capacity needed by the new plants means the local transmission networks will have to be developed.
- Our FES suggests there will be more interconnectors and greater capacity connecting the GB electricity system to Europe in the future. These interconnectors are expected to connect around the country (mainly in the south) both importing and exporting power. They will vary the NETS power-flow mix, and mean some parts of the networks will need to be developed.
- Ageing assets and environmental regulations mean that many thermal generators have closed or will close over the next decade. When there are closures near demand centres there is less support for the system, which makes operating the network more challenging.
- Over the past few years there has been unprecedented growth in embedded generation connecting across the country, mainly solar power in the south. This, along with decreasing reactive demand in our system, presents new challenges that we will continue to work with the industry to meet.
- Given the changing energy landscape, off-peak conditions become increasingly important as a driver of investment. Therefore we will consider with Ofgem and the industry how best to reflect this requirement in future years.

We are responding to these future network reinforcement needs. One recently completed development is the upgraded Beauly to Denny circuits. The upgrade has improved transmission capability across Scotland and provides much needed capacity to transport renewable energy. Last year we recommended that the Transmission Owners (TOs) should continue constructing the series and shunt reactive compensation and the Western HVDC Link across the Anglo-Scottish boundary. These two projects continue to progress and will provide new capacity to support the increasing north-to-south power flows once completed.

Reinforcement options include onshore construction, integrated offshore developments and operational or commercial solutions. Under the Integrated Transmission Planning and Regulation (ITPR) arrangement, we will publish our preferred options, based on national economic assessments, in the Network Options Assessment (NOA) report.

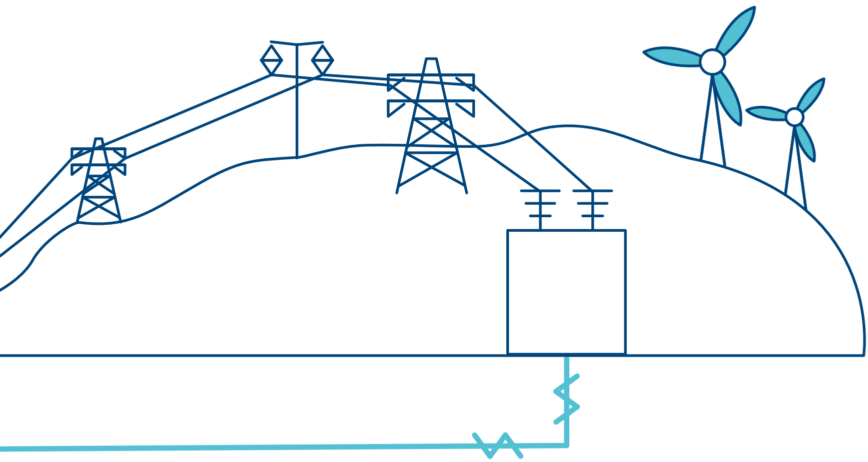
Executive summary

This document gives an overview of the categories of solutions we consider when we are planning for the future transmission network. It does not, however, include details of potential reinforcement options to meet the network requirements. Those options will be in the new NOA report, to be published by 31 March 2016.

We want the ETYS to evolve and each year we ask you to help us shape the document. We would welcome any views on the content and scope of this year's document and we would like to know what changes you want made to future versions. We are happy to receive feedback of any kind from you through:

- customer seminars
- operational forums
- responses to the ETYS email **transmission.etys@nationalgrid.com**
- feedback form at **https://www.surveymonkey.com/r/ETYS2015**
- bilateral stakeholder meetings.

Please get in touch.



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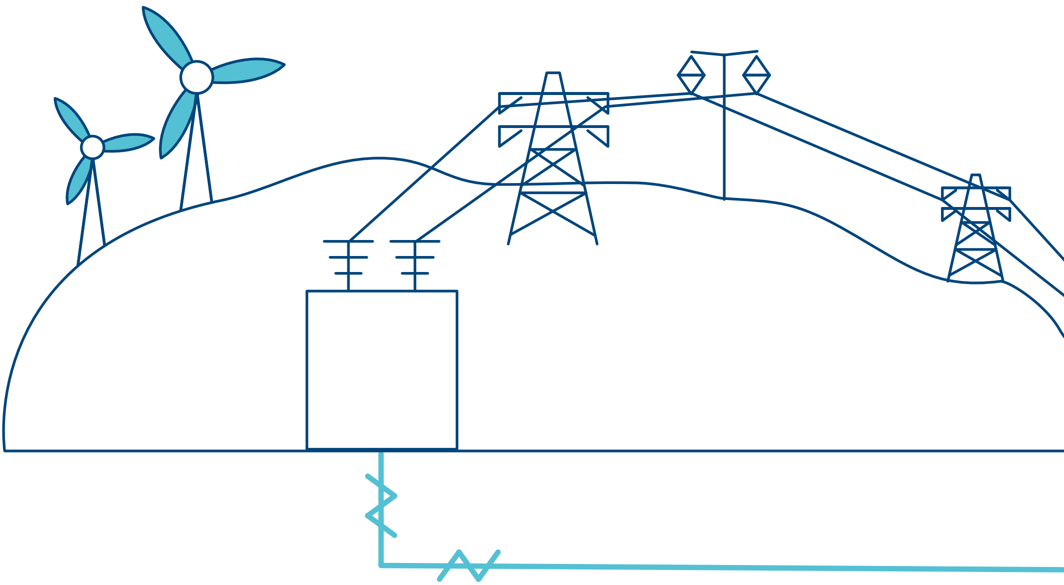


Chapter one

Introduction

Introduction

The Electricity Ten Year Statement (ETYS) presents National Grid's view regarding the future transmission requirements of bulk power transfer capability. As the National Electricity Transmission System Operator (NETSO), we identify these requirements as part of our annual network development process.

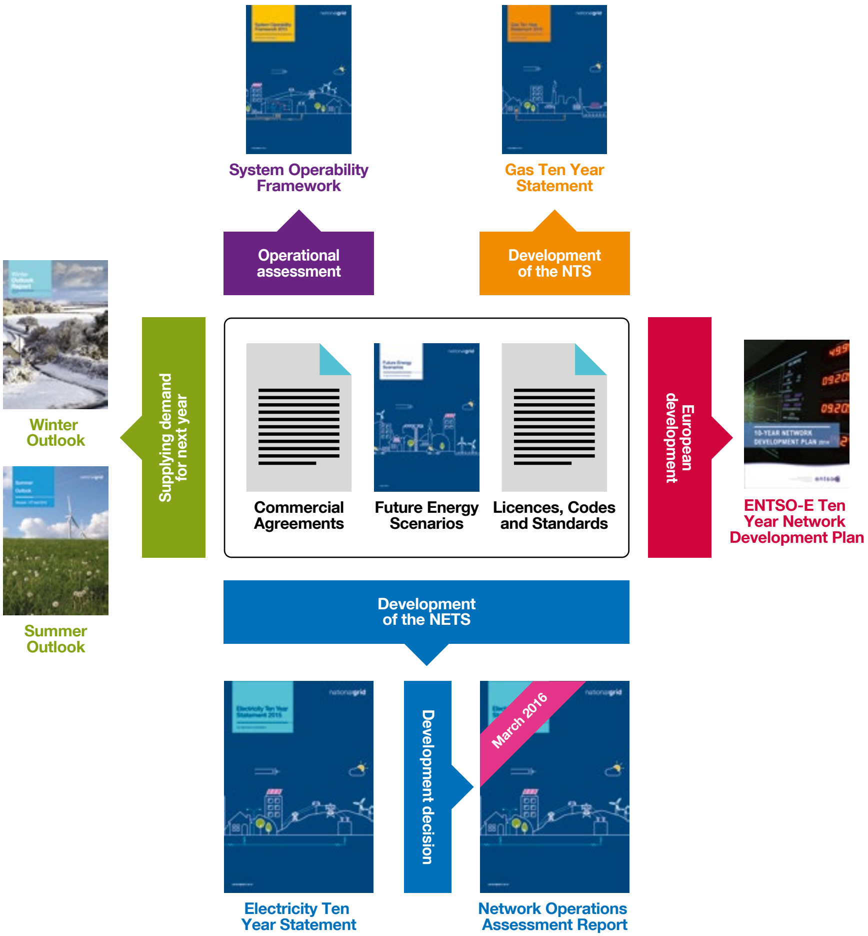
This is our fourth ETYS. We publish it for you, our stakeholders, and we want to continue developing it in response to your feedback.

We produce the ETYS in our role as the NETSO, with input from the Transmission Owners (TOs) in Scotland (SHE Transmission and SP Transmission), and in England and Wales (the TO business within National Grid).

This document is part of a suite of publications underpinned by our Future Energy Scenarios (FES). We use the FES as a consistent base for the analysis in the ETYS and its sister publications – the Gas Ten Year Statement (GTYS) and the System Operability Framework (SOF) – when we are assessing the potential development of the gas and electricity transmission networks.

Figure 1.1 shows the relationship of the ETYS to some of the other documents we publish about the GB transmission network. The ETYS focuses on the future transmission requirements of the NETS, based on the analysis of the four Future Energy Scenarios and any related sensitivities.

Figure 1.1
National Grid publications



Introduction

1.1 Background

The ETYS was originally developed to bring together several of our previous publications, including the Seven Year Statement (SYS) and Offshore Development Information Statement (ODIS). The result was a single document containing relevant and timely information about the onshore, offshore and interconnected networks.

We have restructured the 2015 ETYS, so some of the areas covered previously are now separated into different documents.

The former ETYS Chapter five (System Operation) is now a separate, annually updated document called the System Operability Framework. Published at the same time as the ETYS, the new document provides information about complex system operation concerns and opportunities.

Following conclusion of the Integrated Transmission Planning and Regulation (ITPR) project[2], transmission developments and how they are assessed will now be published as part of a new Network Options Assessment (NOA) report. The first NOA report will be published in March 2016 and will replace most of the former ETYS Chapter four (Network Development and Opportunities). In the 2015 ETYS, the Way Forward chapter outlines our plan leading up to the publication of the first NOA report.

Ofgem published its initial ITPR conclusions in September 2014, along with a set of proposals designed to make planning in electricity transmission more efficient and coordinated and to make delivering assets more efficient. This followed a consultation which ended in November 2014; the final conclusions were published in March 2015.

[2] https://www.ofgem.gov.uk/publications-and-updates/integrated-transmission-planning-and-regulation-itpr-project-final-conclusions

1.2
Differences between TYNDP, ETYS and NOA

The Ten Year Network Development Plan (TYNDP) is published in accordance with Regulation (EC) 714/2009. The regulation requests the European Network of Transmission System Operators for Electricity (ENTSO-E) to produce the non-binding community-wide TYNDP every two years. The next publication is due in December 2016. Although 2014 TYNDP, 2015 ETYS and the first NOA report all highlight the future of energy networks, there are important differences that separate the three.

Firstly, the TYNDP is produced every two years whereas the ETYS and the NOA report are produced annually. The TYNDP focuses on pan-European projects in which the analysis was conducted by regional groups. The submitted information and analysis is updated every two years. However, given the time required for analysis and publication work, there will be a two-year time lag in respect of scenario data. For example, the 2016 TYNDP will be based on 2014 FES data and system reinforcement options considered for 2014 ETYS.

Secondly, different projects qualify for inclusion within each document. In the TYNDP, the list of projects includes the chosen preferred option from the ETYS (which will now be published in the NOA report); but it also includes additional projects which meet additional criteria of the TYNDP such as security of supply benefits. Furthermore, projects that are associated wholly with GB and meet the ENTSO-E cost benefits analysis (CBA) criteria have been included within the TYNDP, which lays down specific rules on the grouping or ‘clustering’ of projects. GB has five clusters of individual projects: the Anglo-Scottish cluster, East Coast cluster, East Anglia cluster, Wales cluster and the London cluster.

Introduction

1.3
Network development process

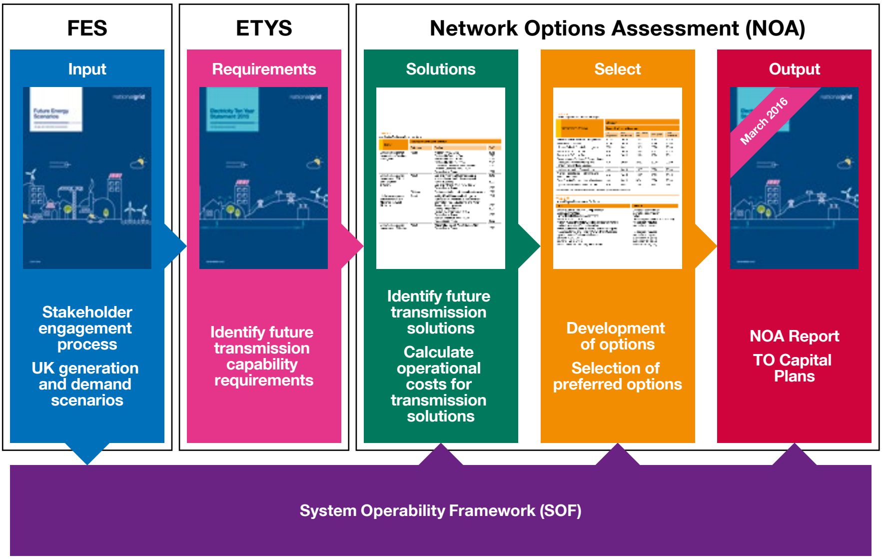
The network development process for NETS planning starts with the Future Energy Scenarios which provide a plausible range of future background conditions to assess against.

We apply the FES to transmission system models and then analyse them, to investigate their effects on the network and identify future transmission requirements.

From these requirements we devise a set of potential network reinforcement solutions by developing options that have already been created or by working up new ideas. The TOs provide the build options; and the SO and TOs provide the non-build options.

Finally, we analyse the options and decide how to develop the network in the most economic and efficient way. An overview of this process is shown in Figure 1.2 below.

Figure 1.2
ETYS document separation



Only the first stages of the network development process are now included in the ETYS. The demonstration of possible network developments and their selection is now part of the new NOA document.

Transmission system planning

The ETYS uses energy scenarios, rather than just the contracted background (the current contracted position is for 258[3] new projects totalling 82GW of capacity), so that we can explore a range of more credible outcomes. We developed our scenarios as part of a comprehensive industry consultation and we use them to assess the development of the transmission network against a range of plausible generation and demand backgrounds.

The analysis in this document covers a detailed 10-year study period (2015 to 2025), with less detailed analysis of the period from 2025 to 2035. This approach helps to align the ETYS with our other publications and provides a longer-term view.

The National Electricity Transmission System Security and Quality of Supply Standards (NETS SQSS) sets out criteria and methodologies that transmission licensees (onshore and offshore) use when planning and operating the NETS.

Through this ETYS document we explain how the NETS SQSS criteria determine future requirements. We also highlight the challenges we face in developing the transmission network.

[3] Information from TEC register and interconnector register on 10 Aug 2015.

Introduction

1.4
Improving your experience

At our customer and stakeholder engagement events in 2014 and 2015, we asked you how you would like the ETYS to develop. The main sources of feedback were face-to-face meetings at the electricity customer seminars and responses sent to our ETYS email address.

You told us you wanted easy and quick access to relevant, user-friendly information. So we have been developing an interactive tool that allows you to view details about current and future generation connections, sites and development times in the NETS.

The latest version of the tool (published alongside the ETYS) provides information about transmission substations in England and Wales.

Continuing the conversation

Email us with your views on ETYS at:
transmission.etys@nationalgrid.com
and we will get in touch.

Join our mailing list to receive ETYS email updates. You can register at:
http://www.nationalgrid.com/updates

Please see Chapter four for our stakeholder activities programme for 2015/16.

We are developing the CCIT in stages – this is an SO-supported tool that requires significant input from the TOs which currently only covers the England and Wales transmission network. We have started discussions with the Scottish TOs to review the potential benefits of extending the tool to include information of the Scottish transmission network. Based on stakeholders feedback, we will together explore the requirements to maintain the tool to provide GB-wide coverage.

We hope you will benefit from the changes made to the 2015 ETYS and its sister publications, including more detailed information on how we develop and operate the system, both economically and efficiently.

Chapter two

The Future Energy Scenarios

The Future Energy Scenarios

2.1 Future Energy Scenarios (FES)

To establish the future investment that is needed on the transmission system we must first understand the requirements of future power demand (active and reactive) and the potential sources of generation that may connect to the network. We do this by producing our FES, which scope out the potential envelope of power demand and generation.

Stakeholders are fundamental in the development of our FES, driving the range, content and progress of our analysis. Your feedback is important and helped us to produce the credible set of 2015 scenarios – Gone Green, Slow Progression, No Progression and Consumer Power – that were approved by Ofgem, our regulator. We published our scenarios in July 2015[4].

Gone Green
Gone Green is a world where green ambition is not restrained by financial limitations. New technologies are introduced and embraced by society, so all carbon and renewable targets are met on time.

Slow Progression
Slow Progression is a world where slower economic growth restricts market conditions. Money that is available is spent on low-cost, long-term solutions to achieve decarbonisation (although later than the target dates).

No Progression
No Progression is a world focused on achieving security of supply at the lowest-possible cost. With low economic growth, traditional sources of gas and electricity dominate and there is little innovation that affects how we use energy.

Consumer Power
Consumer Power is a world of relative wealth, fast-paced research and development and spending. Innovation centres on meeting the needs of consumers who want to improve their quality of life.

The range of scenarios is based on the energy trilemma of affordability, sustainability and security of supply. Figure 2.1 shows how the scenarios consider different levels of affordability and sustainability, with security of supply implicit in all scenarios. The matrix provides an overview of the economic, political, technological, social and environmental factors that apply to each of the scenarios.

[4] http://fes.nationalgrid.com/fes-document/

Figure 2.1
2015 Future Energy Scenarios

Consumer Power

Economic – moderate economic growth

Political – government policies focus on indigenous security of supply and carbon reduction

Technological – high innovation focused on market and consumer needs. High levels of local generation and a mixture of generation types at national level

Social – consumerism and quality of life drives behaviour and desire for 'going green', not a conscious decision

Environmental – long-term UK carbon and renewable ambition becomes more relaxed

Gone Green

Economic – moderate economic growth

Political – European harmonisation and long-term environmental energy policy certainty

Technological – renewable and low carbon generation is high. Increased focus on green innovation

Social – society actively engaged in 'going green'

Environmental – new policy intervention ensuring all carbon and renewable targets are achieved

No Progression

Economic – slower economic growth

Political – inconsistent political statements and a lack of focus on environmental energy policies

Technological – little innovation occurs in the energy sector with gas as the preferred choice for generation over low carbon

Social – society is cost conscious and focused on the here and now

Environmental – reduced low carbon policy support and limited new interventions

Slow Progression

Economic – slower economic growth

Political – European harmonisation, focus on low cost environmental energy policies

Technological – medium levels of innovation lead to a focus on a mixture of renewable and low carbon technologies

Social – society is engaged in 'going green' but choices are limited by cost

Environmental – new policy interventions are constrained by affordability

Prosperity (+ / –)

Green ambition (– / +)

For each scenario the demand and generation background are shown at a transmission level; and embedded generation is shown as a reduction in demand level. For the purposes of the ETYS, the analysis period covers 2015/16 to 2035/36 inclusive. Read the 2015 Future Energy Scenarios document for more information.

We also use the Contracted Background for comparison purposes in ETYS. It refers to all generation projects that have a signed connection agreement with the NETSO. We have made assumptions about closures only where we have been notified of a reduction in Transmission Entry Capacity (TEC) or there is a known closure date because of binding legislation like the Industrial Emissions Directive (IED).

The ETYS uses these scenarios as the basis of the network analysis. This analysis gives us the base capability of different boundaries in the network – we use this in Chapter three to assess the future network requirements. It also gives us the technical information we need to assess the different options of reinforcement in the NOA report.

The Future Energy Scenarios

2.2 Demand

This section describes the NETS demand assumptions for the four scenarios.

Demand definition

For the purposes of ETYS, demand is shown at its assumed peak day level. This assessment of electricity network adequacy uses peak day demand because this demand and generation event is at the heart of the system reinforcement analysis.

For the purposes of identifying transmission network investment, we have selected the peak Average Cold Spell (ACS) unrestricted National Demand definition. Here is how the Grid Code defines National Demand:

"The amount of electricity supplied from the transmission system plus that supplied by embedded large power stations, transmission losses, minus the demand taken by station transformers and pumped storage units. It does not include any Exports."

We define unrestricted National Demand by assuming there is no triad avoidance or commercial demand side response. This increases the demand levels we look at, because we want to consider a case where customer demands are unconstrained by commercial factors.

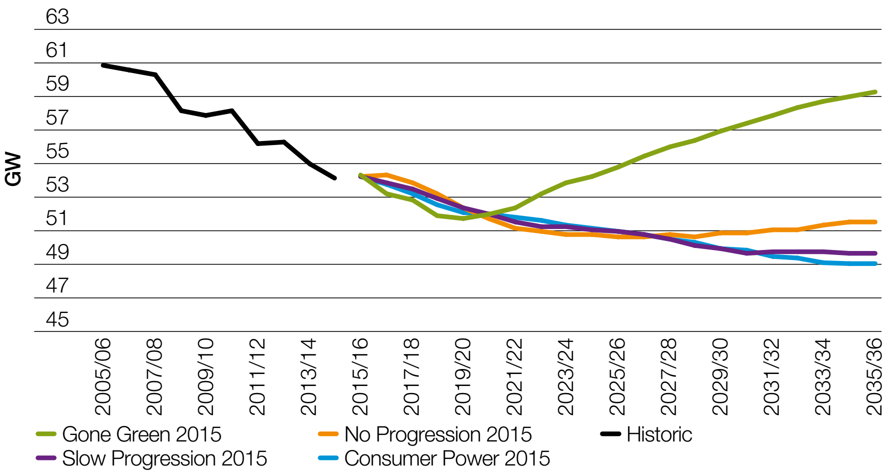
ACS is defined as a particular combination of weather elements that give rise to a level of peak demand. There is a 50% chance that weather alone will push peak demand above that level.

Peak active demand

Between 2005/06 and 2014/15, peak transmission demand fell by around 1% a year. We believe the reasons for this include more embedded generation, economic factors, energy prices and increased energy efficiency.

In all scenarios, demand is mainly pushed down by differing levels of embedded generation and, to a lesser degree, smart meter rollout. Industrial demand falls in all scenarios (see Figure 2.2). As the population increases, residential demand rises at different rates in the scenarios because of the different numbers of appliances and electric vehicles used, and their energy efficiency.

Figure 2.2
Peak active ACS unrestricted National Demand



Gone Green

Demand falls at first because there is more embedded generation and improved energy efficiency. It increases significantly towards 2020. This is mainly because heat is being decarbonised in the residential and commercial sectors, in line with government policies and targets.

Slow Progression

Demand falls at around 0.5% a year, because of increasing levels of embedded generation along with lower economic growth and energy efficiency. Heat is not decarbonised rapidly, so government decarbonisation targets are missed by a number of years.

No Progression

In No Progression, demand falls at first because of energy-efficiency measures and embedded generation. Demand slowly increases after the 2020s as the population increases and the commercial sector grows. Low levels of energy efficiency fail to offset the growth in demand.

Consumer Power

Consumer Power has a similar profile to Slow Progression, but for different reasons. Residential consumerism is high, pushing demand up. Embedded generation capacity is highest in this scenario, so there is reduced demand on the NETS. Low gas prices encourage fuel switching and there are many small-scale combined heat and power units (micro-CHP).

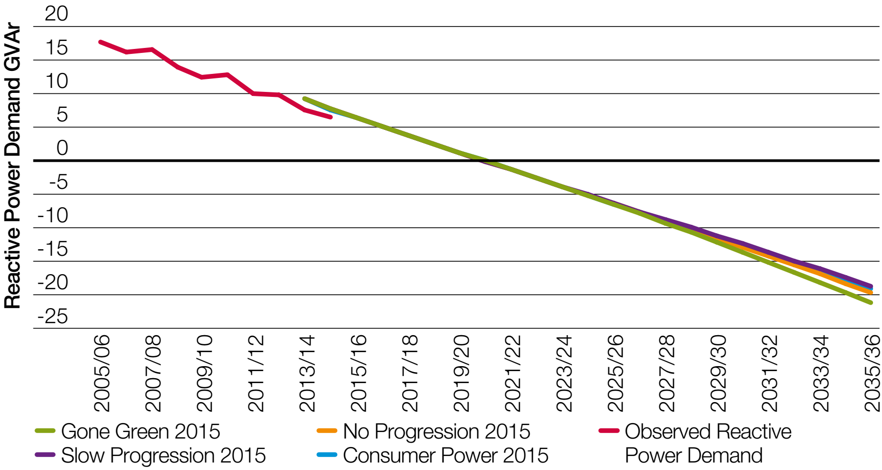
The Future Energy Scenarios

Peak reactive demand
Peak demand for reactive power from the transmission network has been falling since 2005/06 – a trend that continued during winter 2014/15. For our 2015 scenarios we have assumed that reactive demand on the transmission system will continue to fall.

In 2014 we assumed that reactive power would not reverse to export from the distribution networks to the transmission networks.

As there is no sign of slowing in the reactive demand decreases, in 2015 we model scenarios where reactive demand continues to fall unhindered. The distribution networks will see changes in reactive power flow, leading ultimately to the export of reactive power into the transmission network. The scenarios consider variations in consumer and industrial activity to give a view of future reactive demands. As you can see from Figure 2.3, the variation remains very small.

Figure 2.3
Peak reactive ACS unrestricted National Demand and observed historic data



The reactive demand at the distribution network interfaces depends on the demand types connected to the distribution networks, as well as the construction and loading of the distribution networks. When lightly loaded, demands with high power factor correction and networks with high proportions of cable (instead of overhead circuits) tend to produce reactive power rather than absorb it. These things, along with more embedded generation, changes in demand types and other factors, could all contribute to the changes we are seeing in national reactive demand.

We are involved in the REACT project (Reactive Power Exchange and CharacTerisation), an industry study to understand the causes of and potential solutions to reactive demand changes. You can find out more at **http://www.manchester.ac.uk/research/luis.ochoa/research**

2.3
Generating capacity

This section provides more detail on the generation backgrounds and outlines the key changes over the period to 2035 for each scenario.

Generation backgrounds
The transmission generation backgrounds are created at an individual generator unit level. For each scenario, we have made assumptions about the connection timescales for future plant and the lifespan of existing plant.
Our assumptions incorporate many different factors, including planning consent, contractual connect dates, environment legislation and up-to-date market intelligence that we get through our stakeholder engagement programme and from journals and press releases.

Generation capacity – definition
The values shown in this section are for installed capacity (shown at 100%) that is classed as 'transmission generation capacity'. As a general rule, what we are dealing with here is generation capacity classified as 'large'[5] – small and medium generation that is not included in generation backgrounds is accounted for in the assessment of transmission demand.

[5] National Grid: What size is my power station classed as?
http://www2.nationalgrid.com/uk/services/electricity-connections/new-connection/

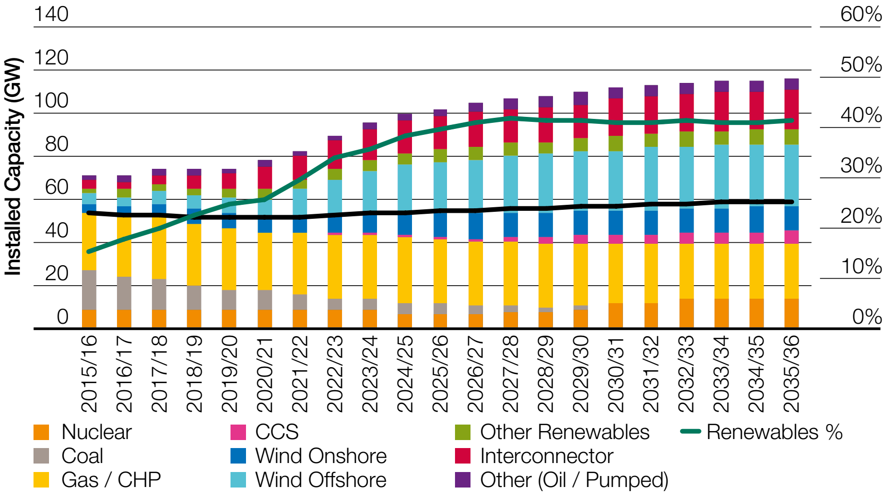
The Future Energy Scenarios

Gone Green

Our Gone Green scenario meets the climate change targets, helped by a strong green agenda and underlying growth in the economy. Achieving the climate change targets means that significant volumes of renewable generation – especially wind – have to be deployed in the run-up to 2020.

After 2020, as the country decarbonises the electricity sector, low-carbon technologies, like nuclear and carbon capture and storage (CCS) and new emerging technologies (marine), gain a foothold. Conventional thermal generation adds flexibility and options to the generation mix whilst significant volumes of the existing thermal generation close as they opt out of new environment legislation. Figure 2.4 illustrates the capacity mix for the Gone Green scenario over the next 20 years.

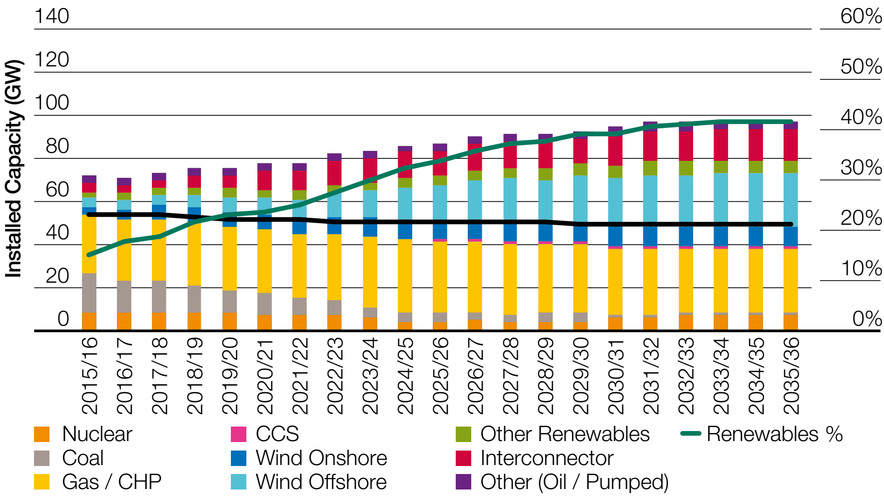
Figure 2.4
Gone Green (transmission) generation mix



Slow Progression

Our Slow Progression scenario is shaped by the transition to low-carbon and renewable technologies. Financial constraints mean that these technologies are deployed more slowly than in the Gone Green scenario, especially after 2020. The conventional generation mix continues to be dominated by gas-fired generation because financial limitations hamper the deployment of new technologies and other low-carbon technologies. Figure 2.5 illustrates the capacity mix for the Slow Progression scenario through to 2035.

Figure 2.5
Slow Progression (transmission) generation mix



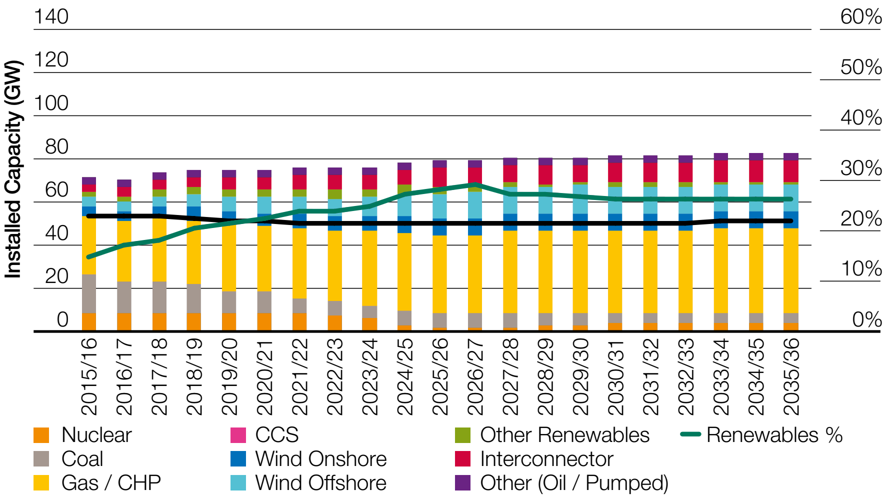
The Future Energy Scenarios

No Progression

Our No Progression scenario is dominated by established and comparatively cheaper forms of generation. This situation arises because of the financial constraints and lack of focus on decarbonising the economy (see Figure 2.6).

New emerging technologies are commercially unsuccessful and financial constraints limit the deployment of traditional low-carbon technologies. The generation mix is dominated by gas-fired generation with a minimal deployment of renewable generation. The emphasis is on security of supply at the lowest possible cost.

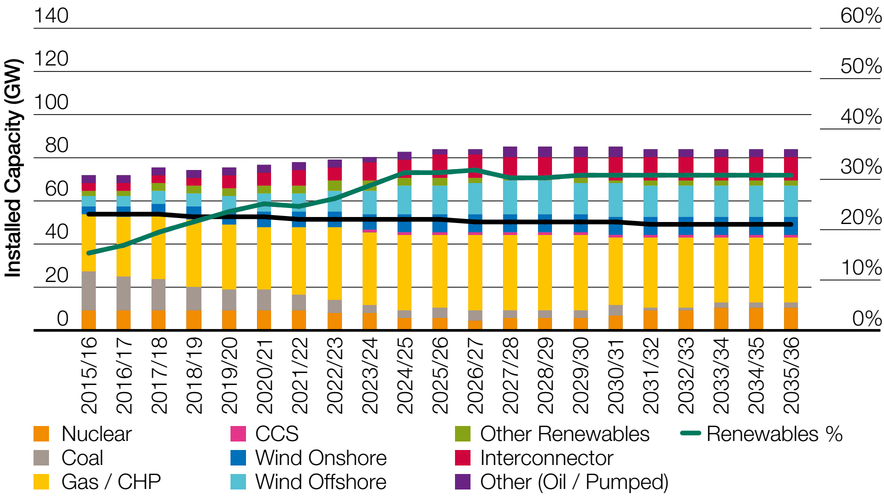
Figure 2.6
No Progression (transmission) generation mix



Consumer Power

Our Consumer Power scenario has significant volumes of generation connected at a local level. Large-scale generation is dominated by established technologies (see Figure 2.7). The lack of political consensus for a centralised carbon reduction policy restricts the emergence of large-scale, low-carbon and renewable technologies like CCS and marine. These are limited to demonstration sites because they remain unattainable on a commercial scale.

Figure 2.7
Consumer Power (transmission) generation mix



The Future Energy Scenarios

2.4
Contracted background (generation)

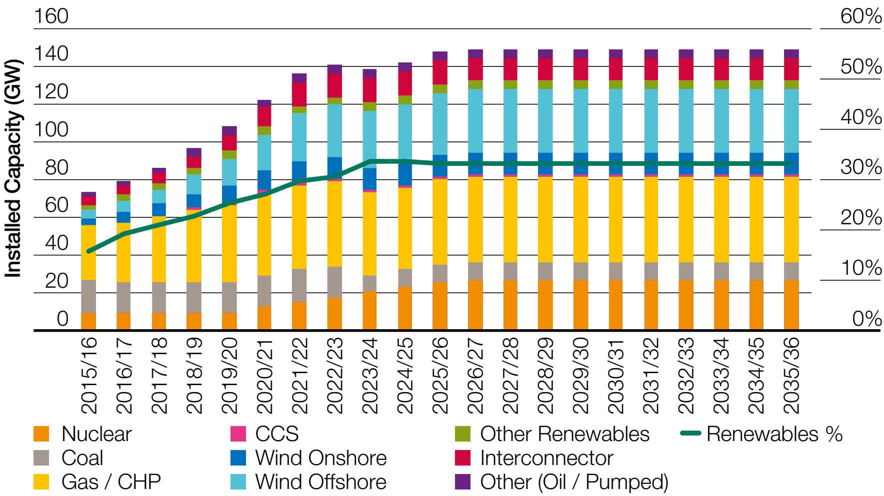
The contracted background provides the formal contractual generation landscape. It incorporates all existing generation and new future projects which will make use of the NETS.

The contracted background (see Figure 2.8, which is based on the contractual position at the end of June 2015) includes all generation (new and existing) that has a contractual agreement with the NETSO for access rights to the NETS.

Over the next five years, the contracted background will be dominated by the deployment of renewable technologies, with a particular emphasis on offshore wind. This strong build rate aligns with the government's climate change targets for this period. Traditional forms of generation will be dominated by gas-fired and nuclear, and both technologies have a robust new build programme over the next 10 years.

The contracted background has additional capacity connected to the NETS, compared to the FES – this is down to our assumptions about closures in the existing generation fleet and the connection dates of new projects. The contracted background shows the grid connection date for new projects as requested by the developers. The scenario backgrounds will consider a wider range of issues (including the contracted date) that may come into play when a new power station connects to the NETS.

Figure 2.8
Contractual background (generation)



The Future Energy Scenarios

2.5
European interconnection

The FES provides information on interconnector capacity levels and flows for peak periods for our analysis in the ETYS.

The number of interconnectors and their capacity levels for FES 2015 have increased from FES 2014 due to greater regulatory certainty as a result of Ofgem's cap and floor regime for interconnectors. For peak flows, we have greater imports across all scenarios at times of GB system stress. The 2015 FES also suggests that we may see connection to more countries than previously by means of a diverse spread of connection points.

Current and planned interconnection
You can find the up-to-date details of transmission contracted interconnectors from the interconnector TEC Register page: **http://www2.nationalgrid.com/UK/Services/Electricity-connections/Industry-products/TEC-Register/**

There are further projects that have applied for Projects of Common Interest (PCI) status under the EU's Trans-European Networks (Energy) (TEN-E) regulations, and other projects that are already in the public domain, such as in the Ten-Year Network Development Plan (TYNDP). These are set out in Table 2.1 below.[6] There may be others of which we are currently unaware.

Similar to our approach to the transmission generation backgrounds, we have made assumptions about the connection timescales. Once again, we consider a range of factors including planning consent, contractual connect dates, environment legislation and up-to-date market intelligence.

[6] http://ec.europa.eu/energy/infrastructure/pci/doc/2013_pci_projects_country.pdf

Table 2.1
Interconnectors

Name	Owner(s)	Connects to	Capacity	Key dates
Operational interconnectors				
IFA	NGIL and RTE	France	2000MW	Operational since 1986
Moyle	NI Energy Holdings	Northern Ireland	450MW to NI (295MW to GB)	Operational since 2002
BritNed	NG and TenneT	The Netherlands	1200MW	Operational since 2011
EWIC	Eirgrid	Ireland	500MW	Operational since 2012
Contracted interconnectors				
ElecLink	Eleclink Ltd	France	1000MW	Contracted for 2016
Nemo	NGIL and Elia	Belgium	1000MW	Contracted for 2018
NSN	NGIL and Statnett	Norway	1400MW	Contracted for 2019
IFA 2	NGIL and RTE	France	1000MW	Contracted for 2019
FABLink	FabLink Ltd	France via Alderney	1400MW	Contracted for 2020
Northconnect	Agder Energi, E-CO, Lyse and Vattenfall AB	Norway	1400MW	Contracted for 2021
Viking Link	NGI Holdings	Denmark	1000MW	Contracted for 2022
Projects of Common Interest or TYNDP Projects (applied for PCI status or pre-feasibility studies announced)				
Name	**2014 TYNDP Project Reference**	**PCI Reference**	**Capacity**	**Connects to**
Nemo	74	1.1.1	1000MW	Belgium
Belgium-GB 2	121	1.2	1000MW	Belgium
IFA 2	25	1.7.2	1000MW	France
FABLink	153	1.7.1	1400MW	France
ElecLink	172	1.7.3	1000MW	France
Interco Iceland-UK	214	n/a	800–1200MW	Iceland
Greenwire	185	1.9.1	1500MW	Ireland
Codling Park	n/a	1.9.2 and 1.9.3	500–1000MW	Ireland
Energy Bridge	n/a	1.9.4, 1.9.5 and 1.9.6	5000MW	Ireland
MAREX	228	1.11.4	1500MW	Ireland
Irish-Scottish Isles	189	1.9.2	1000MW	Northern Ireland
NSN	110	1.10	1400MW	Norway
North Connect	190	n/a	1400MW	Norway
Viking Link	167	n/a	1000MW	Denmark
Second Interconnector Belgium-UK	121	n/a	1000MW	Belgium
New GB-Netherlands Interconnector	n/a	n/a	1000MW	The Netherlands
Larne Storage	n/a	1.12	500GWh	Northern Ireland

The Future Energy Scenarios

2.6
Applying the FES in system planning

Earlier in this chapter we discussed the content of the scenarios at a high level, summarised by the types, sizes and timing of generation and the level of background demand. We apply the scenario data to the NETS network models so that we can analyse the network and assess performance.

2.6.1 Application of demand data
The FES demand backgrounds provide us with the forecast ACS peak demand. To facilitate the planning analysis, we group data by zones according to their geographic distribution and the network topology.

2.6.2 Application of generation data
The NETS SQSS outlines the dual criteria (security and economy) approach that we use to form the system capability requirement based on generation and demand data – there is more detail about it in Chapter three. Here we focus on how the generation data is applied in our assessment to meet national demand that results in a planned transfer condition.

2.6.2a MITS planning – security criterion
The security criterion aims to develop a transmission system that facilitates conventional generation by supplying demand at times when intermittent generation is not available.

In a scenario, if we have a high margin of generation capacity, we use a ranking order to help identify generation units that are most likely to operate at times of ACS peak demand. This approach allows us to be realistic about the capacity of directly connected and large embedded power stations in our analysis. To maintain the balance of demand and generation, we scale the contributory units to match the demand requirement.

Ranking order
When the generation backgrounds have been finalised, we rank the generator units according to how likely it is that they'll operate.

For existing generation we do this by looking at how the unit operated during the previous two winter periods (beginning of December to the end of January).

For future plant, we consider the fuel type of the unit. We assume that low-carbon plant is more likely to operate as baseload, and that new thermal plant is likely to be more efficient than existing thermal generation so we give it a higher ranking. The ranking order we use to determine the operation of future plant is shown in Table 2.2.

Table 2.2
Ranking order

Rank	Fuel type
1	Interconnectors
2	Offshore wind
3	Marine
4	Hydro tranche 1
5	Nuclear (new)
6	Hydro tranche 2
7	Onshore wind
8	Hydro tranche 3
9	Nuclear (existing)
10	CCS
11	Biomass
12	Gas thermal (new)
13	Existing plant per operation calculation and hydro tranche 4
14	Pumped storage
15	Gas turbines

The method described for ordering plant in terms of operational history is a general rule. We apply it pragmatically, supported by judgement and market intelligence. For example, a plant may have achieved a low ranking based on the previous winter's operational data, but it could be that this was down to a unique set of circumstances that are unlikely to be repeated in the future (for example, a plant that has been mothballed but market intelligence suggests it may return in the future). So plant rankings may be revised, to make them more realistic.

2.6.2b MITS planning – economy criterion

The economy criterion identifies transmission capability that will result in overall efficiency of generation and transmission costs.

Across all our scenarios, we use three categories for generation units: non-contributory, directly scaled and variably scaled. Non-contributory plants, like OCGTs, are not included in the dispatched generation background. Directly scaled plants, like wind and nuclear, use the scale specified by the NETS SQSS (see Table 2.3). We use variably scaled plants to maintain the balance of demand and generation.

The Future Energy Scenarios

Table 2.3
List of directly scaled plants and the associated scaling factors

Fuel type	Scaling factor
Interconnectors importing to GB	100%
Nuclear	85%
Coal-fired stations fitted with CCS	85%
Gas-fired stations fitted with CCS	85%
Wind	70%
Tidal/wave	70%
Pumped storage	50%

This dual-criteria approach allows us to assess the system capability requirement in order to maintain security of supply and facilitate the generation market to operate in the most economic and efficient way.

Chapter three explains how we use this dual-criteria approach to determine network capability and regional requirements.

Chapter three

- The electricity transmission network
- NETS boundaries
- Case study: Anglo-Scottish boundary year-round capability
- Overview of transmission solution options

The electricity transmission network

3.1 Introduction

As the GB energy landscape continues to change in the years and decades to come, the NETS will face significant challenges. The transmission network must respond and adapt so that it can keep transporting power from source to demand. To make sure we develop the network in an efficient, coordinated and economic way, we must first understand the future requirements.

When we assess future requirements, we need to bear in mind that we have more than 80GW of signed contracts for new generation to connect to the NETS. The development of interconnectors connecting Great Britain to the rest of the Europe will also have a big impact on future transmission requirements.

In our experience, it is unlikely that all customers will connect exactly as contracted today – indeed, many may never connect. We cannot know exactly how much and when generation will close and new generation will connect, so we use the FES (discussed in Chapter two) to decide on credible ranges of future transmission requirements.

Using the system boundary concept helps us to calculate NETS capabilities and the future transmission requirements of bulk power transfer capability.

The transmission system is split by boundaries[7] that cross important power-flow paths where there are limitations to capability or where we expect additional bulk power transfer capability will be needed. We apply the NETS SQSS[8] to work out the requirements.

In this chapter we describe the NETS characteristics and our role as the NETSO in developing the transmission network. We also discuss each of the NETS boundaries, grouped together as regions, to help you gain an overview of the total requirements, both regionally and by boundary.

[7] Please note that these boundaries will be reviewed annually and updated as appropriate.

[8] http://www2.nationalgrid.com/UK/Industry-information/Electricity-codes/System-Security-and-Quality-of-Supply-Standards/

3.2
NETS and our role as NETSO

The NETS is mainly made up of 400kV, 275kV and 132kV assets connecting separately owned generators, interconnectors, large demands and distribution systems. As the NETSO, we are responsible for managing the system operation of the transmission networks in England, Wales, Scotland and offshore.

3.2.1 Transmission networks

The 'transmission' classification applies to assets at 132kV or above in Scotland or offshore. In England and Wales it relates to assets at 275kV and above.

National Grid owns the transmission network in England and Wales and is the NETSO. The transmission network in Scotland is owned by two separate transmission companies: SHE Transmission in the north of Scotland and SP Transmission in the south of Scotland. The offshore transmission systems are also separately owned.

Nine licensed offshore transmission owners (OFTOs) have been appointed through the transitional tendering process. They connect operational offshore wind farms that were given Crown Estate seabed leases in allocation rounds 1, 2 and 3. Further OFTO appointments will be made through the enduring tender process.

With the expected replacement of nuclear generators and the growth in renewables like wind as primary sources of energy, generation is moving away from the demand centres towards the periphery of the network. The same is true for interconnector connection points. This means we have to move power over longer distances.

Wind power is mainly being developed to the north and east of the system, especially in Scotland. This has increased power transfers from north to south, which in turn has triggered associated reinforcement requirements.

Interconnectors are network cables connecting neighbouring countries. They could reduce the total cost of GB's electricity system, increase the security of supply to British consumers and support the utilisation of renewable energy. Because they can import and export power, they introduce more variability to the NETS power flow – this is something that needs to be considered carefully when planning the transmission network. There are four existing interconnectors between Great Britain and other electricity markets. During the next 10 years we are expecting to see more interconnectors further developing our network.

To manage these challenges, when we are developing future transmission capacity we use a flexible approach based on many different scenarios. This approach allows us to respond to any variability in future requirements. It also minimises the risk of asset stranding.

The electricity transmission network

3.2.2 The role of System Operator (SO)

As part of our NETSO role, we identify future transmission requirements and communicate with the TOs on what we expect the future bulk power transfer capability needs to be.

Our regulator, Ofgem, has consulted with industry and stakeholders about enhancing the role of the SO, first through Electricity Market Reform and more recently through the Integrated Transmission Planning and Regulation (ITPR) project.

ITPR project

Ofgem set up the ITPR project to consider how to coordinate network investment with multiple TOs (who have different objectives and drivers) and how to deliver this investment efficiently and economically.

Ofgem's ITPR final conclusions[9] set out new enhanced SO outputs including the NOA process, which is based on the assessment criteria in the England and Wales Network Development Policy. The process will identify the SO preferred options for reinforcements to the transmission networks in England, Wales, Scotland and offshore. The SO will provide more support to TOs on Strategic Wider Works (SWW) submissions and to offshore developers by leading a gateway process for funding if there will be wider network benefit.

The ITPR project will also introduce onshore competition for electricity transmission assets that meet the proposed criteria: new, high value and separable. In RIIO-T1, SWW projects which are outside of incumbent TO baselines that meet these criteria may be contested. At time of publication of the ETYS, Ofgem is consulting on arrangements for competitive tenders in onshore transmission. For more information on the consultation "Extending competition in electricity transmission: proposed arrangements to introduce onshore tenders" please visit Ofgem's consultation website: **https://www.ofgem.gov.uk/publications-and-updates/extending-competition-electricity-transmission-proposed-arrangements-introduce-onshore-tenders**

As stated in Chapter one, we have responded to the ITPR final conclusions by making changes to this year's ETYS, including publishing the SO preferred options for reinforcements in a separate NOA report in March 2016. Read Chapter four for details of what we have got planned in the lead-up to the NOA report being published.

[9] https://www.ofgem.gov.uk/publications-and-updates/integrated-transmission-planning-and-regulation-itpr-project-final-conclusions

NETS boundaries

3.3
NETS boundaries

To provide an overview of existing and future transmission requirements, and report the restrictions, we developed the concept of boundaries. A boundary splits the system into two adjacent parts, crossing critical circuit paths that carry power between the areas where power flow limitations may be encountered.

The transmission network is designed to ensure that there is enough transmission capacity to send power from areas of generation to areas of demand.

Limiting factors on transmission capacity include thermal circuit rating, voltage constraints and/or dynamic stability. Each factor is assessed to determine the network capability. In preparing this year's ETYS document, the main focus of our analysis is thermal and voltage issues. Where there are known stability issues, these are reflected in the analysis presented in this report. The base capability of each boundary in this document refers to the winter 2015 capability.

The maximum power transfers sustainable across a boundary have been determined against existing and future potential network topologies, to assess adequacy against a range of future requirements.

Defining the boundaries has taken many years of operation and planning experience of the transmission system. The NETS and boundaries have developed around major sources of generation, significant route corridors and major demand centres. A number of recognised boundaries are regularly reported for consistency and comparison purposes. When significant transmission system changes occur, new boundaries may be defined and some existing boundaries either removed or amended.

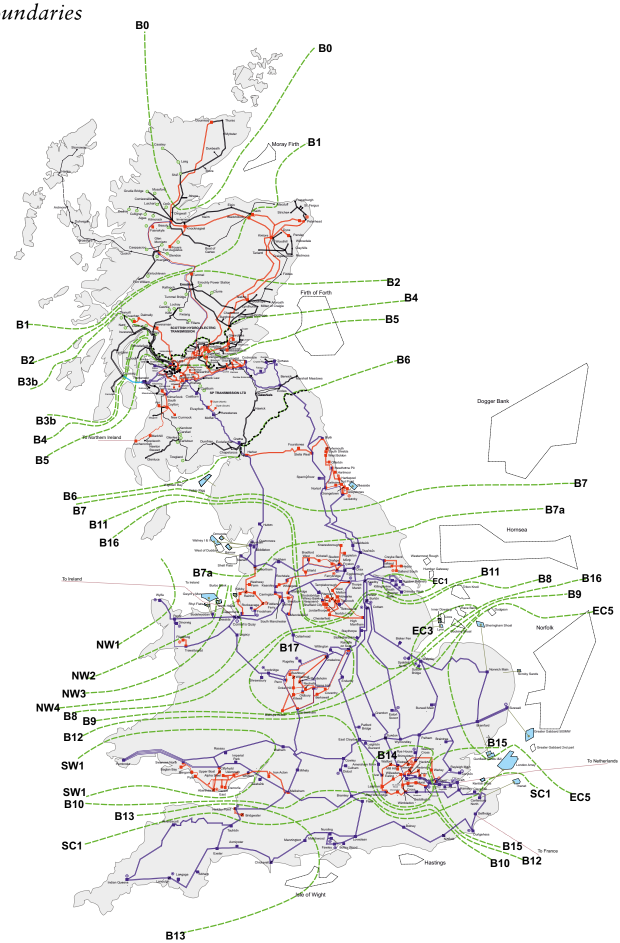
In recent years, many new boundaries have been added as the future generation seeks to connect to new, non-traditional locations. So transmission reinforcements have been required in areas not previously considered.

NETS boundaries

Boundary map

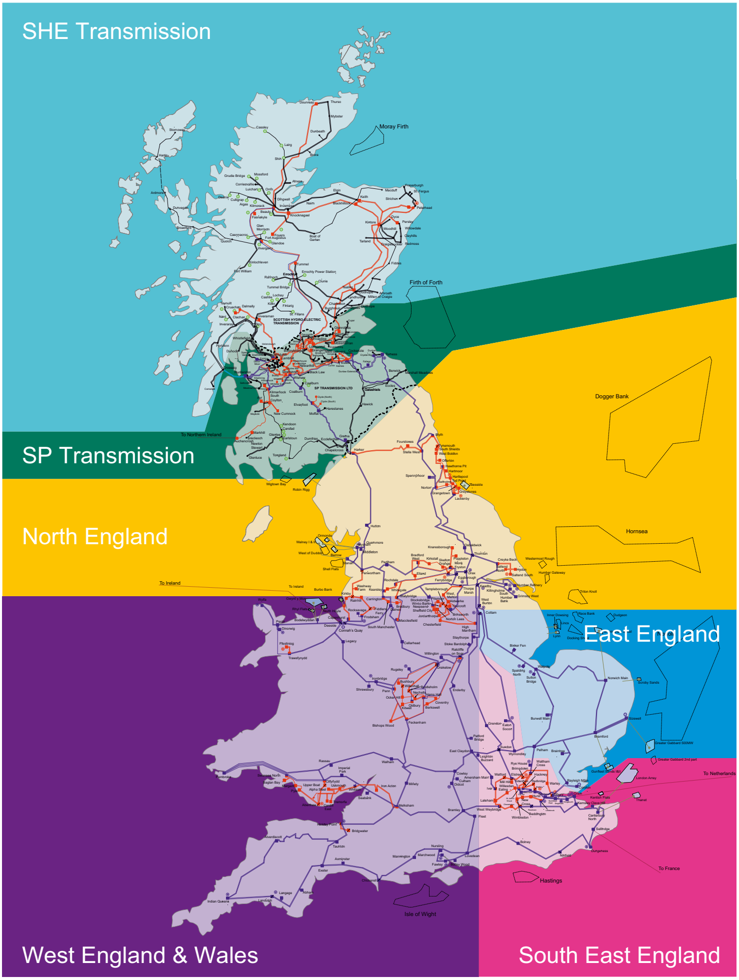
Figure 3.1 shows all the boundaries we have considered for this year's analysis. Over the years we have continuously developed the transmission network to ensure there is sufficient transmission capacity to effectively transport power across the country. As a result of network development, some boundaries are now not reported due to them becoming redundant. In the next section, we highlight only the boundaries that need further development to satisfy future transmission requirements.

Figure 3.1
ETYS GB boundaries



To help describe related issues we have grouped the boundaries into six regions as shown in Figure 3.2.

Figure 3.2
Regional map



NETS boundaries

NETS SQSS requirements and determination of capability

The National Electricity Transmission System Security and Quality of Supply Standard (NETS SQSS) specifies methodologies for assessing local generator boundaries and wider system boundaries. The differences lie primarily in the level of generation and demand modelled, which in turn directly affects the level of boundary transfer to be accommodated:

- **Local boundaries** – for all the local boundaries selected in this statement there is more generation than demand within the group under consideration, so they are all net power export boundaries. In such areas, the generation is set at its transmission entry capacity (TEC) or at a level that may reasonably be expected to arise during the course of a year of operation

- **Wider boundaries** – in the case of wider system boundaries the overall generation is selected and scaled according to the security and economy criteria defined in the NETS SQSS and described below. The demand level is set at national peak. We set up the planned transfer condition by matching the generation and demand level, as discussed earlier in Chapter two, Section 2.6. Furthermore, for each system boundary an extra interconnection or boundary allowance is calculated and added to the planned transfer level to give a required transfer level. In this way the standard seeks to ensure that peak demand will be met, allowing for generator unavailability and system variations.

For wider boundary studies, the security and economy criteria are both applied to the generation background.

The security criterion – aims to ensure that demand can be supplied securely, without reliance on intermittent generators or imports from interconnectors. The background is established by:

- setting the output from intermittent generators and interconnectors to zero
- using the ranking order shown in Chapter two to identify the conventional generation units that are most likely to operate at times of ACS peak demand to achieve a plant margin not greater than 20%, based on the TEC of the generators
- uniformly scaling the output of these generators to meet demand.

Required transfer level of security transfer condition is then established by the application of an interconnection allowance.

As we move into a low carbon economy, the energy landscape will change. The existing criteria set by the NETS SQSS will be reviewed as part of the SQSS review group activity with a mind to update the standard to reflect developments in generation, demand and interconnectors.

The economy criterion – as increasing volumes of intermittent generation connect to the GB system, the requirements to develop the transmission network change significantly. It is important we assess these requirements in a way in which the interests of the consumers is best protected. The economy criterion aims to identify the additional transmission capability that will result in overall efficiency of generation and transmission costs. To achieve this, a single background condition is specified for analysis:

- the appropriate agreed direct and variable scaling factors are applied to all generation so that the generation output meets the ACS peak demand
- the chosen scaling factors are those that will enable the plant to run with the lowest marginal cost, while taking into account that intermittent generation is not likely to operate consistently at 100 per cent output.

Required transfer level of economy transfer condition is then established by the application of a boundary allowance.

Further explanation can be found in NETS SQSS: Chapter four and Appendices C, D, E and F.

Interpreting the boundary graphs

When presenting the scenarios and sensitivities for the boundaries, it is not practical to show everything at once. This is because there would be extensive overlapping of results and far more information than could be displayed clearly. So we have simplified the boundary graphs using the style shown in Figure 3.3.

For most wider boundaries, in which both the security and economy criteria have a boundary required transfer in the same direction, a single graph is shown with one requirement line for each scenario. Each point in each single scenario line is the largest magnitude value of both the economy and security criteria.

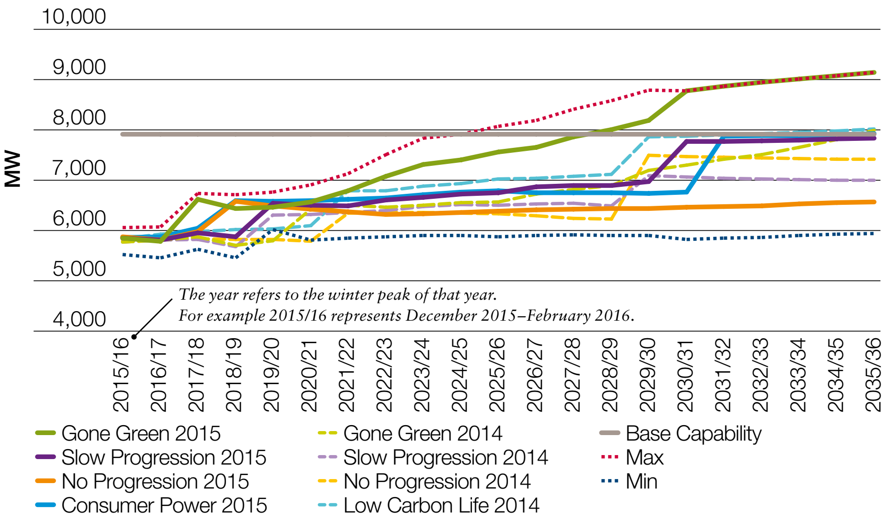
For wider boundaries in which the economy and security criteria can produce boundary flows in different directions, two separate graphs are shown. This mostly applies to Northern and Scottish boundaries.

For local boundaries, we have shown the net export requirements.

A maximum and minimum line that represents the respective highest and lowest magnitude requirement of all the four 2015 scenarios and interconnector sensitivities is shown for each boundary.

NETS boundaries

Figure 3.3
Example of required transfer and base capability for a boundary



Continuing the conversation

Email us with your views on ETYS at:
transmission.etys@nationalgrid.com
and we will get in touch.

Join our mailing list to receive ETYS email updates. You can register at:
http://www.nationalgrid.com/updates

Please see Chapter four for our stakeholder activities programme for 2015/16.

Chapter three

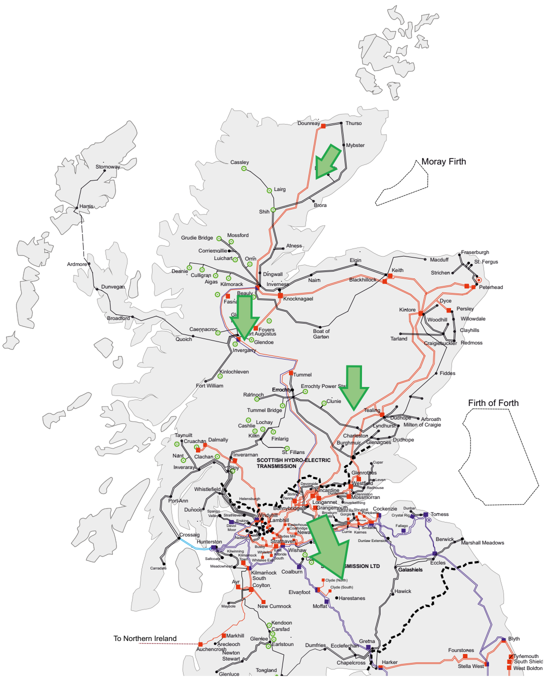
Scottish boundaries

3.3.1 Scottish boundaries

Introduction

The following section describes the Scottish transmission networks up to the transmission ownership boundary with the England and Wales transmission network. The onshore transmission network in Scotland is owned by SHE Transmission and SP Transmission but is operated by National Grid as NETSO. The following boundary information has been provided by the two Scottish transmission owners.

Figure 3.4
Scottish transmission networks (with arrows illustrating major power flows)



Scottish boundaries

Primary challenge statement:
Scotland is experiencing large growth in renewable generation capacity in remote locations, with required connection to a relatively low-capacity and sparse-transmission network.

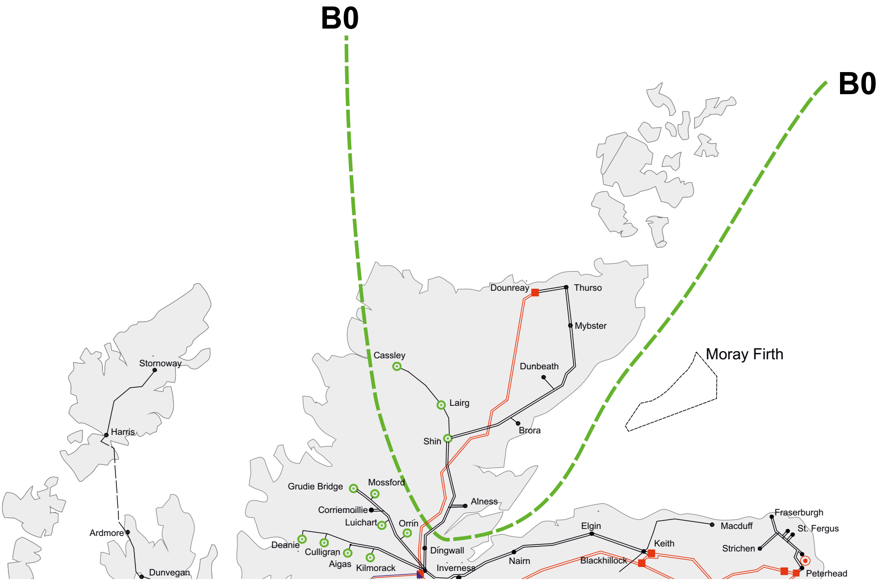
Regional drivers
The restrictions of the Scottish boundaries are often caused by the rapidly increasing generation capacity, mostly from renewable sources, connecting within Scotland. The need to transport this generation through the Scottish networks to southerly demand centres in England provides drivers for network development in Scotland and North of England.

The forecast increase in renewable generation in Scotland will result in the following:

- Limitation on power transfer from generation in remote locations to the main transmission routes (B0, B1)
- Argyll and the Kintyre peninsula is an area with significant renewable generation activity. A local boundary assessment is needed, to show potential for high generation output and network limitations to power flow (B3b)
- Limitation on power transfer from north to south of Scotland (B1, B2, B4, B5):
  - Generation in the north of Scotland is increasing over time because of the high volume of new contracted renewable generation seeking connection in the SHE transmission area. So boundary transfers across B1, B2, B4 and B5 are also increasing.
  - The present capability of some of these boundaries is insufficient to satisfy the boundary transfer requirements for the first few years under some scenarios. This is because of generation being connected ahead of the required reinforcement, in accordance with the Connect and Manage access framework. The increase in the required transfer capability of these boundaries over the ETYS period indicates the need to reinforce the transmission system in order to create the extra capacity for power transfer from the north to the south of Scotland.
- Limitation on exporting power through Scotland and into England (B2, B4, B5, B6):
  - The high volume of new contracted renewable generation seeking connection throughout Scotland is expected to create significant power flows through the Scottish networks to reach demand in England. Renewable generation connection throughout Scotland is expected to increase across all ETYS scenarios, so the increase in the required transfer capabilities over the ETYS period indicates the need to reinforce the transmission system in order to create the extra capacity for exporting power from Scotland to England.

Boundary B0 – Upper North SHE Transmission

Figure B0.1
Geographic representation of boundary B0

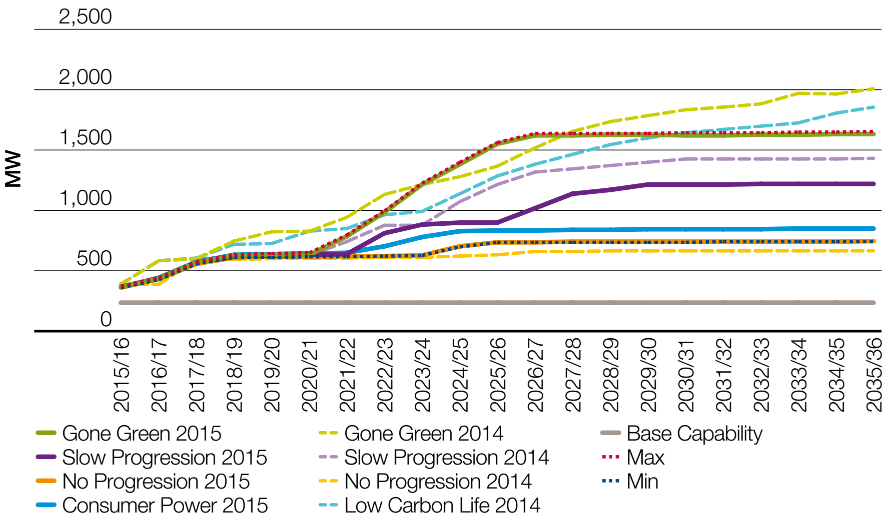


Boundary B0 separates the area north of Beauly, comprising north Highland, Caithness, Sutherland and Orkney. The existing transmission infrastructure north of Beauly is relatively sparse.

The boundary cuts across the existing 275kV double circuit and 132kV double circuits extending north from Beauly. The 275kV overhead line takes a direct route north from Beauly to Dounreay, while the 132kV overhead line takes a longer route along the east coast and serves the local grid supply points at Alness, Shin, Brora, Mybster and Thurso. The Orkney demand is fed via a 33kV subsea link from Thurso.

Scottish boundaries

Figure B0.2
Required transfer and base capability for boundary B0



Boundary requirements and capability

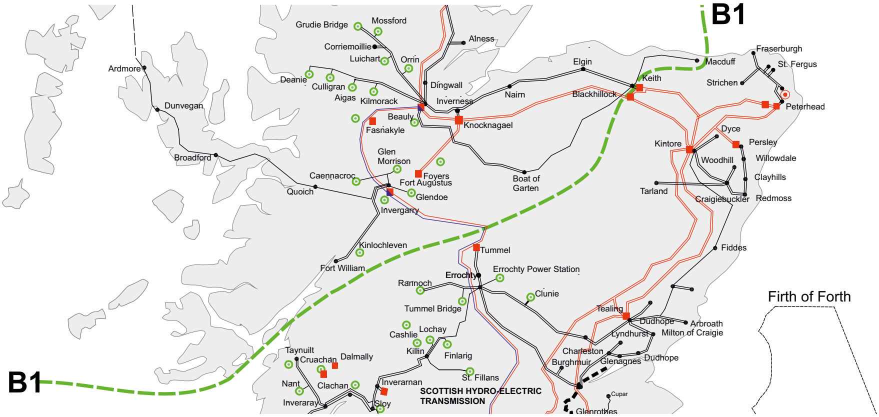
Figure B0.2 above shows the required boundary transfers for B0 from 2015 to 2035. The boundary capability is currently 0.25GW.

The power transfer through B0 is increasing due to the substantial growth of renewable generation north of the boundary. This generation is primarily onshore wind, with the prospect of significant marine generation resource in the Pentland Firth and Orkney waters in the longer term.

Reinforcement of boundary B0 is required and the Caithness–Moray reinforcement project is presently being implemented to achieve this. This approved project is due for completion in 2018 and comprises an HVDC link between a new substation at Spittal in Caithness and Blackhillock in Moray, along with associated onshore reinforcement works. The onshore works include rebuilding the 132kV double circuit line between Dounreay and Spittal at 275kV, a short section of new 132kV line between Spittal and Mybster, new 275/132kV substations at Fyrish (near Alness), Loch Buidhe (to the east of Shin), Spittal (5km north of Mybster) and Thurso.

Boundary B1 – North West SHE Transmission

Figure B1.1
Geographic representation of boundary B1



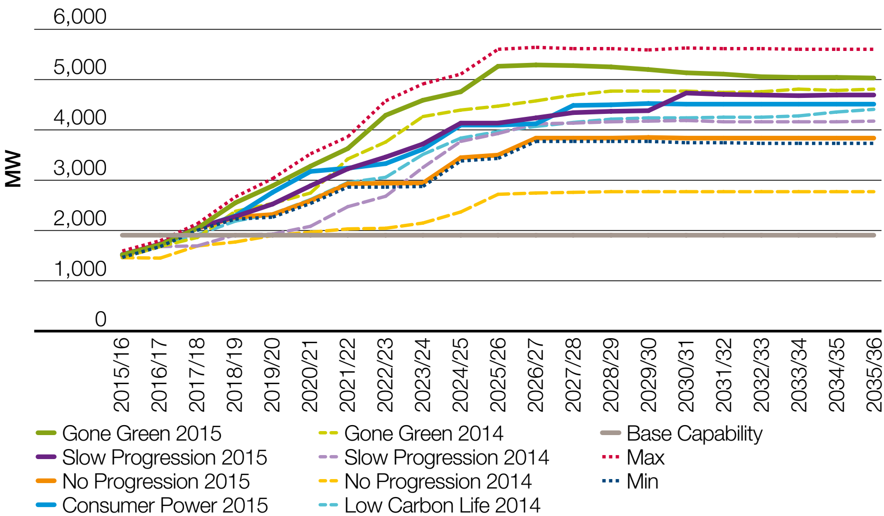
Boundary B1 runs from the Moray coast near Macduff to the west coast near Oban, separating the north-west of Scotland from the southern and eastern regions. The area to the north and west of boundary B1 includes Moray, north Highland, Caithness, Sutherland, Western Isles, Skye, Mull and Orkney. The boundary crosses the 275kV double circuit running eastwards from Beauly, the 275/132kV interface at Keith and the double circuit running south from Fort Augustus.

The existing transmission infrastructure in this area comprises 275kV and 132kV assets. Some of the large new generation projects are remote from any form of strong transmission infrastructure so new infrastructure is required, both for connection and to support power export out of the area.

In all the generation scenarios there is an increase in the power transfer through B1 due to the large volume of renewable generation connecting to the north of this boundary (see Figure B1.2). Although this is primarily onshore wind and hydro, there is the prospect of significant additional wind, wave and tidal generation resources being connected in the longer term. The contracted generation behind boundary B1 includes the renewable generation on the Western Isles, Orkney and the Shetland Isles as well as a considerable volume of large and small onshore wind developments. A large new pump storage generator is also planned in the Fort Augustus area. Some marine generation is also expected to connect in this region during the ETYS time period. This is supplemented by existing generation, which comprises around 800MW of hydro and 300MW of pumped storage at Foyers.

Scottish boundaries

Figure B1.2
Required transfer and base capability for boundary B1



Boundary requirements and capability

Figure B1.2 above shows the required boundary transfers for B1 from 2015 to 2035. The boundary capability from winter 2015 is circa 1.9GW.

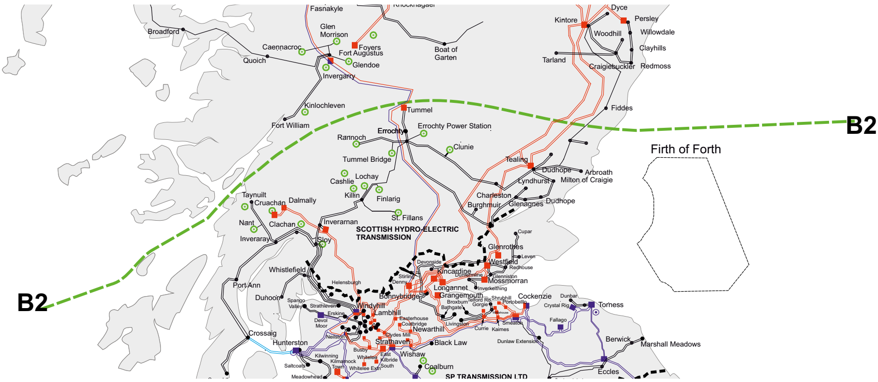
New renewable generation connections north of the boundary are expected to result in a large increase in export requirements across the boundary (see Figure B1.2). All generation north of boundary B0 also lies behind boundary B1.

Two key reinforcement projects are due to be commissioned this winter to allow for the increasing requirement to export power across boundary B1. The Beauly to Denny reinforcement due for completion in 2015 extends from Beauly in the north to Denny in the south, providing additional capability for boundary B1 as well as boundaries B2 and B4. The second project comprises the replacement of conductors on the 275kV line between Beauly, Blackhillock and Kintore and also completes in 2015.

The Caithness–Moray HVDC scheme presently under development with expected delivery in 2018 will provide further enhancement to the B1 boundary capability.

Boundary B2 – North to South SHE Transmission

Figure B2.1
Geographic representation of boundary B2



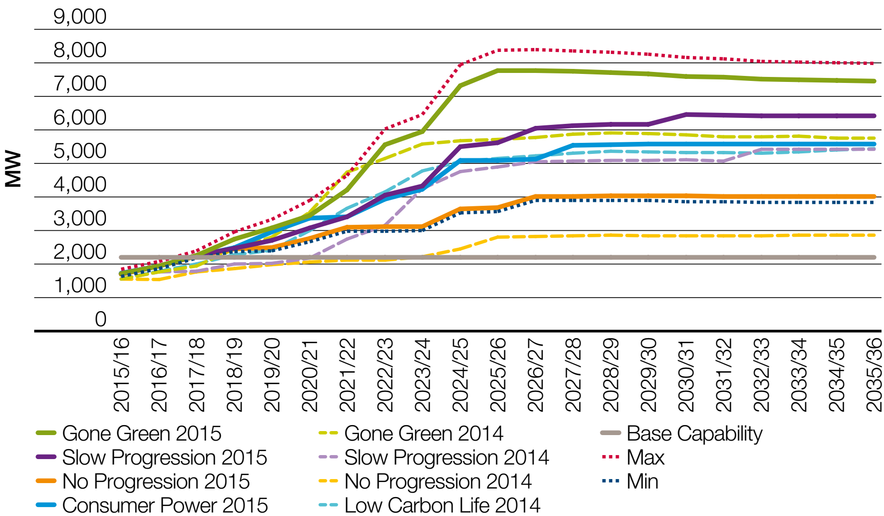
The generation behind boundary B2 includes both onshore and offshore wind, with the prospect of significant marine generation resource being connected in the longer term. There is also the potential for additional pumped storage plant to be located in the Fort Augustus area. The thermal generation at Peterhead lies between boundaries B1 and B2, as do several offshore windfarms and the proposed future North Connect interconnector with Norway.

Boundary B2 cuts across the Scottish mainland from the east coast between Aberdeen and Dundee to near Oban on the west coast. The boundary cuts across the two 275kV double circuits and a 132kV single circuit in the east as well as the double circuit running southwards from Fort Augustus. As a result it crosses all the main north-south transmission routes from the north of Scotland.

As described in boundary B1, the Beauly–Denny project is a key reinforcement that increases the capability across boundaries B1, B2 and B4. This project is currently under construction and is due for completion by winter of 2015.

Scottish boundaries

Figure B2.2
Required transfer and base capability for boundary B2



Boundary requirements and capability

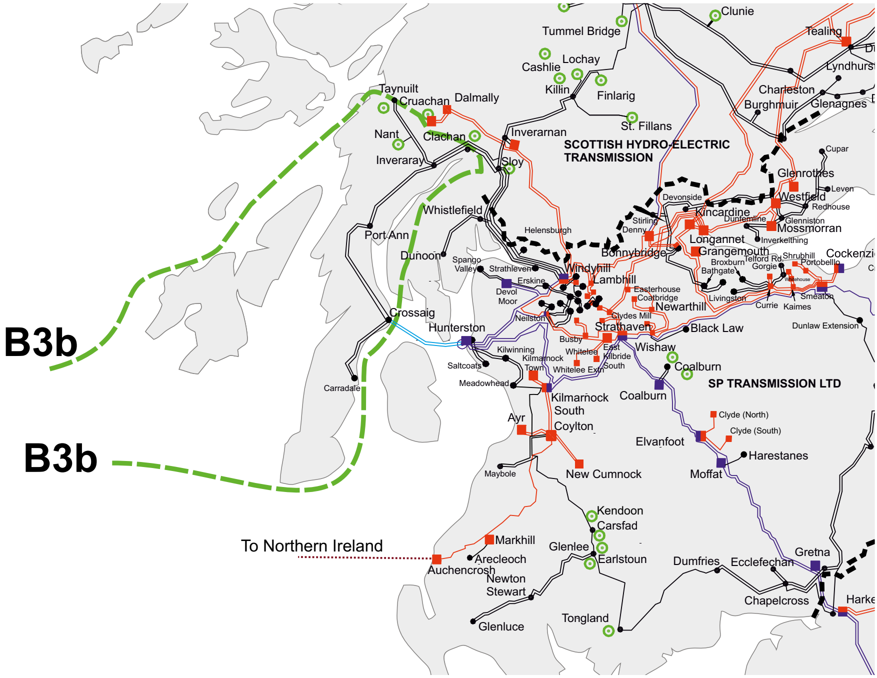
Figure B2.2 above shows the required boundary transfers for B2 from 2015 to 2035. The boundary capacity from winter 2015 is circa 2.2GW.

The forecast boundary transfers for boundary B2 are increasing at a significant rate because of the high volume of contracted renewable generation seeking connection to the north of the boundary.

The increase in the required transfer capability for this boundary across all scenarios indicates the need to reinforce the transmission system. The Beauly to Denny reinforcement, which is due for completion this winter, provides significant additional network capacity and increases boundary B2's north-south capability.

Boundary B3b – Argyll and Kintyre

Figure B3b.1
Geographic representation of boundary B3b



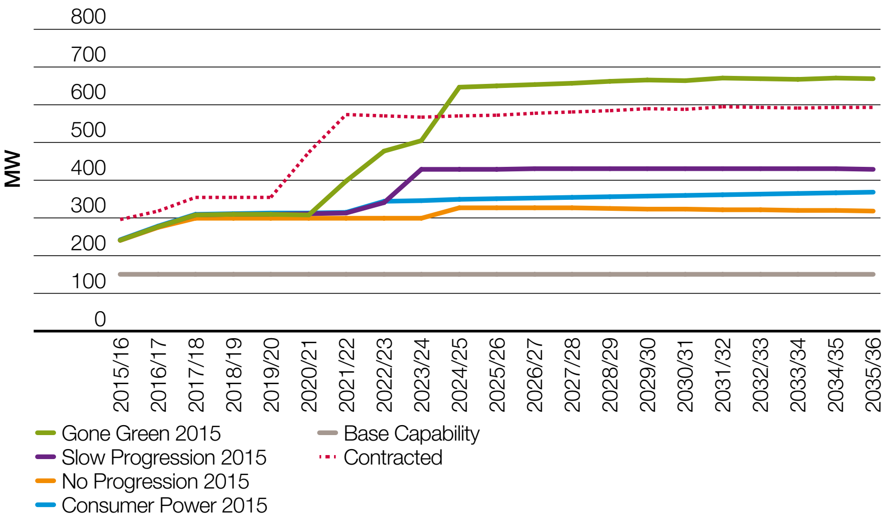
In the Argyll and Kintyre area the 132kV network is relatively weak with a low capacity, so a local boundary assessment is used to show limitations to generation power flow. Boundary B3b encompasses the Argyll and the Kintyre peninsula, cutting across the existing 132kV circuits between Inveraray and Sloy substations.

A key reinforcement is under construction in the Kintyre area, comprising two 220kV AC subsea cables between a new substation at Crossaig (to the north of Carradale) on Kintyre and Hunterston in Ayrshire. A 15km section of existing 132kV double circuit line between Crossaig and Carradale is also being rebuilt.

Chapter three

Scottish boundaries

Figure B3b.2
Net export requirements and base capability for boundary B3b



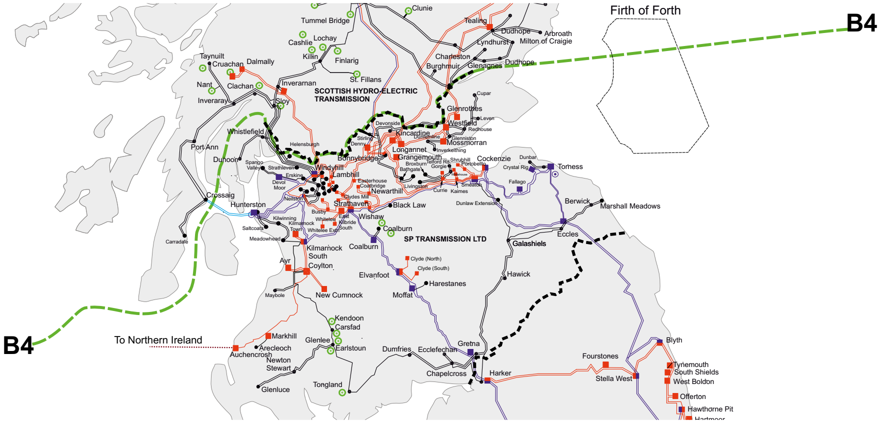
Boundary requirements and capability

Figure B3b.2 above gives the capability of the B3b local boundary and a view of the maximum and minimum export requirements from 2015 to 2035. The boundary capability is 0.15GW.

The forecast power transfers across boundary B3b are increasing at a significant rate because of the high volume of connected and contracted renewable generation seeking connection in Argyll and Kintyre. The present boundary capability is around 150MW, rising to around 400MW on completion of the Kintyre–Hunterston link (due in 2015). There is still significant interest and proposed connection activity in the area, and it is likely that further reinforcement of this network will be required in the future.

Boundary B4 – SHE Transmission to SP Transmission

Figure B4.1
Geographic representation of boundary B4



Boundary B4 separates the transmission network at the SP transmission and SHE Transmission interface running from the Firth of Tay in the east to near the head of Loch Long in the west. With increasing generation in the SHE transmission area for all generation scenarios, the required transfer across boundary B4 is expected to increase significantly over the period covered by the ETYS.

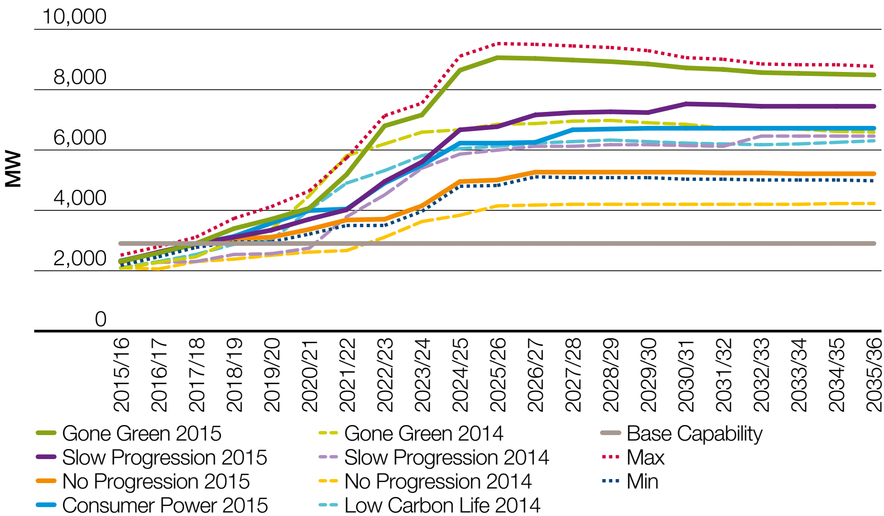
The boundary is crossed by 275kV double circuits to Kincardine and Westfield in the east and two 132kV double circuits from Sloy to Windyhill in the west. An existing B4 crossing 132kV double circuit to Bonnybridge, near Denny will be replaced by a major reinforcement across boundary B4. Scheduled for completion by winter 2015, this Beauly to Denny upgrade involves the replacement of the existing 132kV double circuit route between Beauly and Denny with a new 400kV tower construction. One circuit on the new route will operate at 400kV and the other at 275kV.

The new Kintyre–Hunterston double circuit is also scheduled to be in service for Winter 2015. This development provides two additional circuits crossing B4 between a new 132kV substation at Crossaig in Kintyre and the 400kV busbars at Hunterston in Ayrshire.

The prospective generation behind boundary B4 includes around 2.7GW from Rounds 1–3 and Scottish Territorial waters offshore wind located off the coast of Scotland.

Scottish boundaries

Figure B4.2
Required transfer and base capability for boundary B4



Boundary requirements and capability

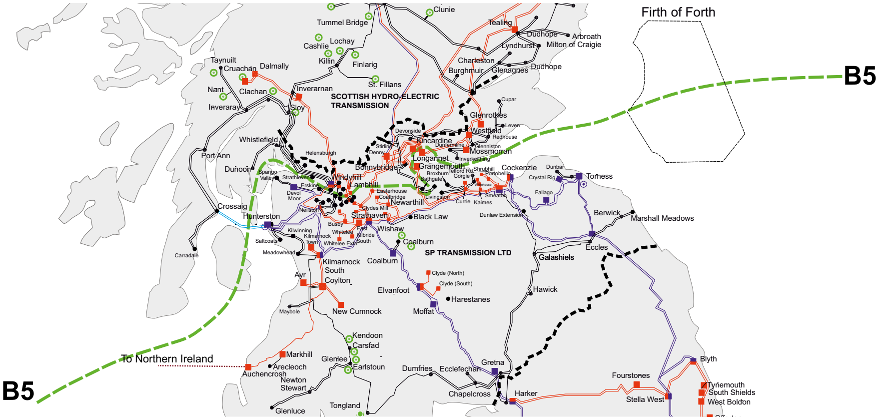
Figure B4.2 above shows the required boundary transfers for B4 from 2015 to 2035. The boundary capability from winter 2015 is circa 2.9GW.

In all of the ETYS scenarios, the power transfer through boundary B4 increases because of the significant volumes of generation connecting north of the boundary, including all generation above boundaries B0, B1 and B2. This is primarily onshore and offshore wind generation, with the prospect of significant marine generation resource being connected in the longer term. The contracted generation behind boundary B4 includes around 2.7GW of offshore and over 5GW of large onshore wind generation.

The increase in the required transfer capability indicates the need to reinforce the transmission network across boundary B4. The current boundary B4 capability is sufficient to satisfy the boundary transfer requirement for the first few years under the Gone Green scenarios, however future B4 reinforcement may be required.

Boundary B5 – North to South SP Transmission

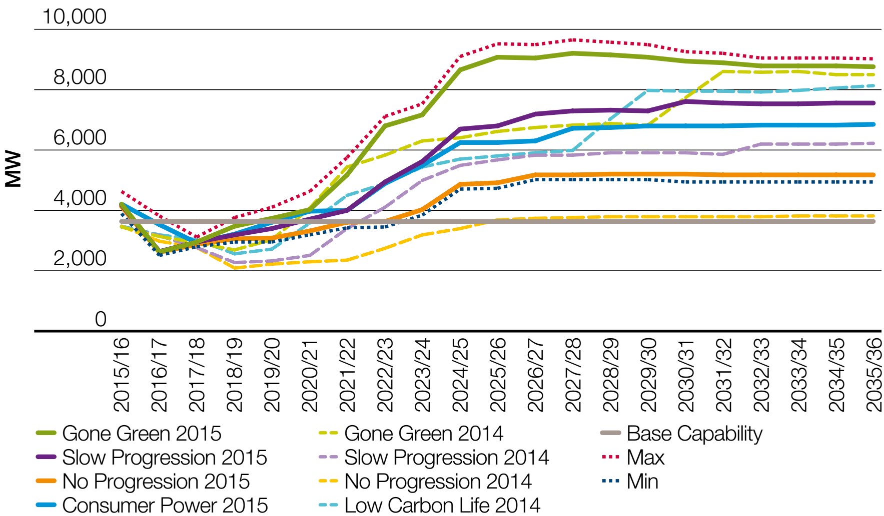
Figure B5.1
Geographic representation of boundary B5



Boundary B5 is internal to the SP Transmission system and runs from the Firth of Clyde in the west to the Firth of Forth in the east. The generating stations at Longannet and Cruachan, together with the demand groups served from Windyhill, Lambhill and Bonnybridge 275kV substations, are located to the north of boundary B5. The existing transmission network across the boundary comprises three 275kV double circuit routes: one from Windyhill 275kV substation in the west and one from each of Kincardine and Longannet 275kV substations in the east.

Scottish boundaries

Figure B5.2
Required transfer and base capability for boundary B5



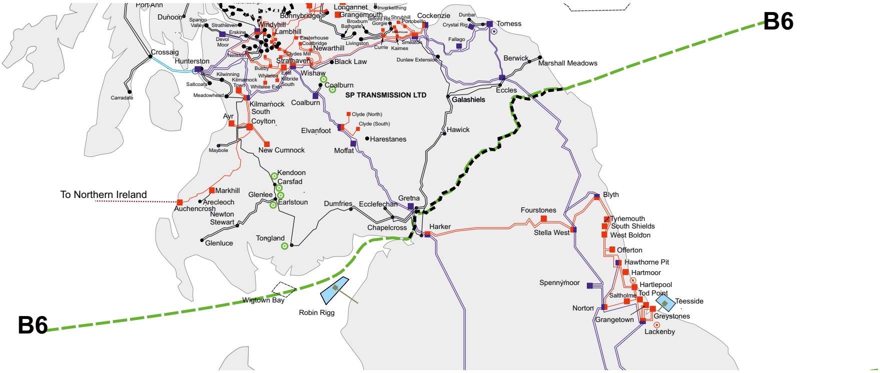
Boundary requirements and capability
Figure B5.2 above shows the required boundary transfers for B5 from 2015 to 2035.

The capability of the boundary is presently limited by thermal considerations to around 3.5GW.

In all of the ETYS scenarios there is an initial significant reduction in required transfer capability across boundary B5 due to the cessation of generation at Longannet. This is followed by an increase in export (north to south) requirement over time, due to a large volume of generation connections throughout the north of Scotland, primarily on and offshore wind.

Boundary B6 – SP Transmission to NGET

Figure B6.1
Geographic representation of boundary B6



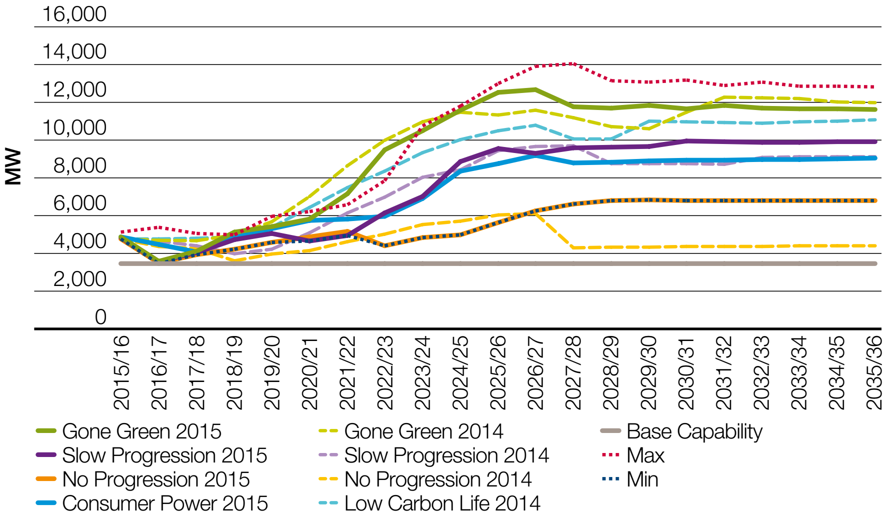
Boundary B6 separates the SP Transmission and the National Grid Electricity Transmission (NGET) systems. The existing transmission network across the boundary primarily consists of two double-circuit 400kV routes. There are also some 132kV circuits across the boundary, which are of limited capacity. The key 400kV routes are from Gretna to Harker and from Eccles to Stella West. Scotland contains significantly more installed generation capacity than demand, increasingly from wind farms. Peak power flow requirements are typically from north to south at times of high renewable generation output.

To secure the peak demand in Scotland at times of low wind generation output, approximately 3GW of generation will be required in Scotland. After the Western HVDC link is completed for 2017/18, this generation requirement is expected to fall to approximately 1.5GW in the period to the end of the current decade. This requirement can be met by existing conventional generation, including pump storage and hydro, in Scotland.

Small embedded generation within Scotland can make a significant change to the boundary requirements. There is more than 2000MW of small embedded wind generation capacity that could be installed by 2030 – this could increase the required boundary capability for B6 by up to 1400MW.

Scottish boundaries

Figure B6.2
Economy-required transfer and base capability for boundary B6



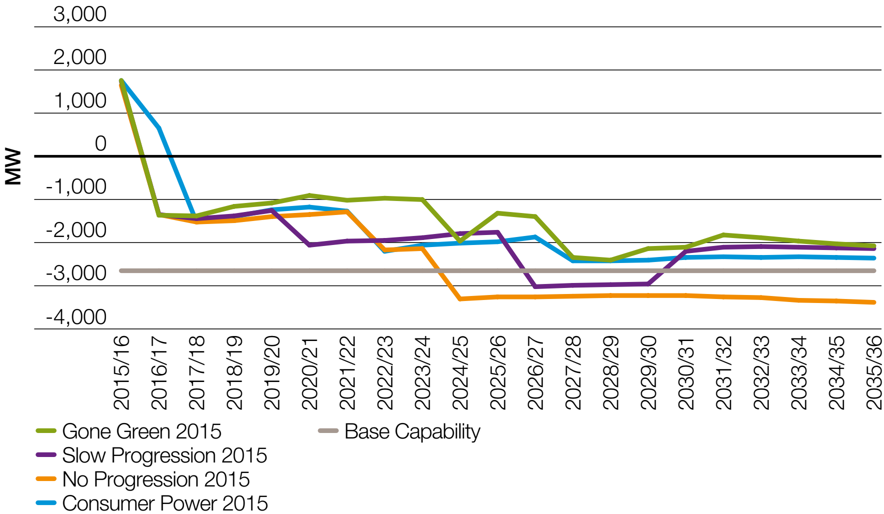
Boundary requirements and capability

Figure B6.2 above shows the economy required transfers for boundary B6 from 2015 to 2035. The capability of boundary B6 is currently a thermal limit at around 3.5GW but will increase to around 4.4GW when the series compensation scheme is completed in 2016. This will increase further to around 6.6GW when the Western HVDC Link is completed in 2017.

Across all scenarios there is an increase in the required export capability from Scotland to England due to the connection of additional generation in Scotland, primarily onshore and offshore wind. This generation increase is partially offset by the expected closure of ageing coal, gas and nuclear plants, the timing of which varies in each scenario. The requirement for very large transfers (above 6GW) is delayed until 2021 at the earliest.

Figure B6.3 below shows the security-required transfer for boundary B6 with power flow south to north represented at negative values. The transmission capability of boundary B6 for power flows north is sufficient to satisfy requirements in the near future.

Figure B6.3
Security-required transfer and base capability for boundary B6



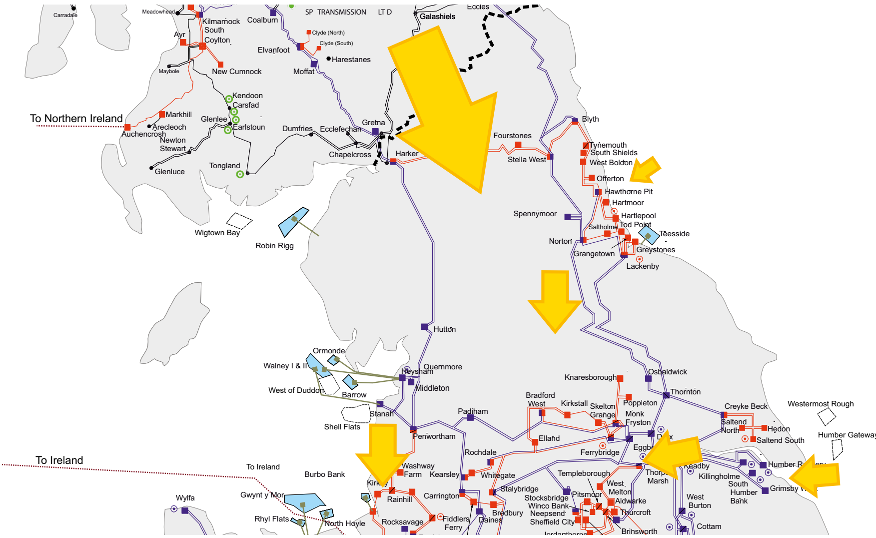
Northern boundaries

3.3.2 Northern boundaries

Introduction

The following section describes the transmission network between Scotland and the north midlands. North England includes boundaries B7, B7a, B11 and, enclosing the Humber region, boundary EC1.

Figure 3.5
North England transmission networks (with arrows illustrating major power flows)



Primary challenge statement:
Rapidly growing north to south power flows, greatly exceeding existing system capability, driven by renewable generation connections.

Regional drivers
The restrictions of the northern boundaries are often caused by the rapidly increasing generation connected to Scotland, Humber and North East England. The need to transport this generated power through Scotland and North England to demand centres further south gives network development drivers for this region. For efficient development, any work needs to be coordinated both north and south of the region.

The forecast increase in generation from Scotland and East Coast will see:

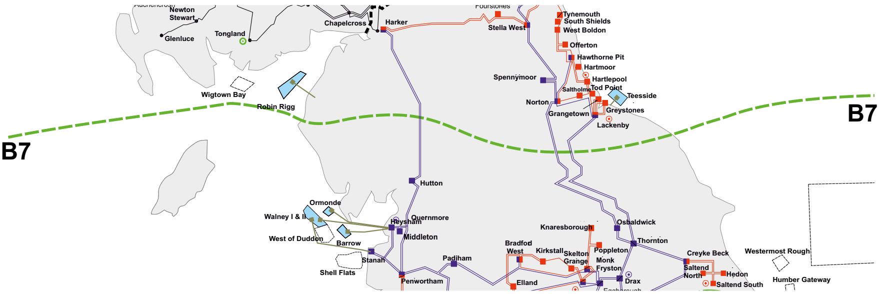
- Limitation on power transfer from Scotland to England (boundaries B6, B7, B11)
  - Boundary B6 is currently limited by thermal compliance and system stability.
  - The network in Scotland is connected to England via two sets of 400kV double circuits: Harker–Elvanfoot/Gretna and Stella West–Eccles, which are overhead line routes each over 100km long. There are also some smaller 132kV circuits with limited capacity. There are high reactive power losses due to the long routes having high impedance. As the power flow increases, the reactive power loss in the circuits also increases. So at a high transfer level, if the losses are not compensated they will eventually lead to voltage depression at the receiving end – which in this case is the English side of the circuits.
  - A stability issue arises when a fault appears on one of the two double-circuit routes, because the Scottish system may be left with only one double-circuit connection to the English system. This significantly increases the impedance in the connection between the two systems and exposes the system to instability at high transfer level.
  - Previous analysis has led to the construction of the Anglo-Scottish compensation and the Western HVDC Link. If the works continue and are commissioned over the next two years, the voltage and stability capability of boundary B6 will be improved and instead be limited by thermal restriction. As generation continues to connect in Scotland, the increasing transfer will reach this thermal restriction in the next couple of years.
  - So there is a driver to develop the network in order to maintain the voltage at the receiving end on the English side at compliance level, and to increase the thermal capability of the circuits connecting Scotland and England to cope with the forecasted increase in generation connecting in Scotland.
- Limitation on power transfer out of North East England (boundary B7)
  - Once the power flows through the Scottish to English boundaries, on the east side it enters the network in North East England and continues to flow south via two sets of 400kV double circuits – Norton–Osbaldwick–Thornton and Lackenby–Thornton. As the generation forecast to connect to North East England increases, adding to the through-flow generation from Scotland, the circuits exporting power to the south will be increasingly stressed and will eventually reach their thermal limit.
  - So there is a driver to develop the network to increase the thermal capability of the circuits exporting power from North East England to the south of the country.

Northern boundaries

- Limitation on power transfer from Cumbria to Lancashire (boundary B7a)
  - On the west side of the network, south of the Scotland to England boundaries, power flows from North Midlands to West Midlands via two branches of circuits: a 400kV branch of Penwortham–Padiham/Daines and a 275kV branch of Penwortham–Kirkby to Deeside. As the power flow increases in the future, the two branches will be stressed to their thermal limit; in particular the 275kV branch may require an upgrade to operate at higher voltage level so that its thermal capability can be increased.
  - So there is a driver to develop the network in order to increase the thermal capability of the circuits exporting power from North Midlands to the south of the country.

Boundary B7 – Upper North

Figure B7.1
Geographic representation of boundary B7

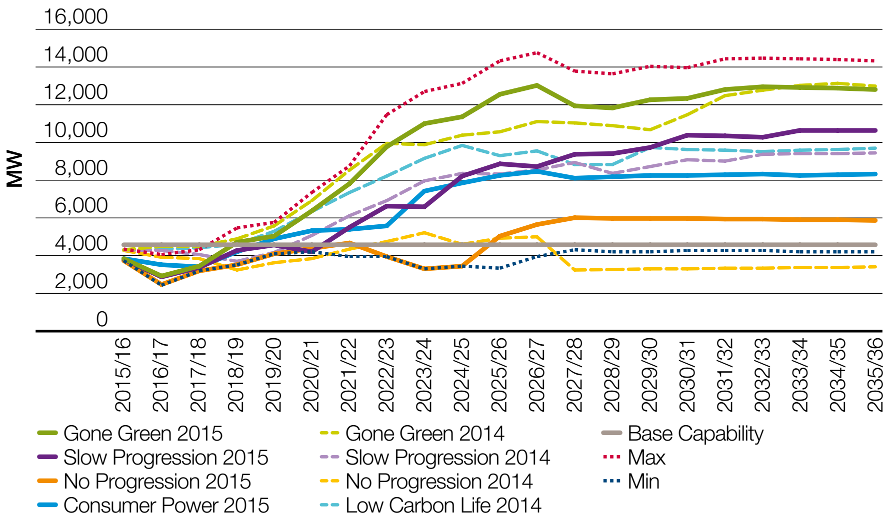


Boundary B7 bisects England south of Teesside. It is characterised by three 400kV double circuits: two in the east and one in the west. The area between boundaries B6 and B7 used to have a surplus of generation so exported power – when added to the exported power from Scotland, this was putting significant requirements on boundary B7.

However, since the generation in the area between boundaries B6 and B7 has reduced, the associated generation surplus has declined as well. Although the requirement of boundary B7 has reduced, it is still exposed to the large Scottish exports.

In the future large amounts of onshore and offshore wind will be connecting north of this boundary increasing the transfer requirements.

Figure B7.2
Economy-required transfer and base capability for boundary B7



Boundary requirements and capability

Figure B7.2 above shows the economy-required transfers for boundary B7 from 2015 to 2035. The boundary capability is currently limited by voltage compliance at 4.6GW for a fault on the circuits from Hutton to Penwortham and Heysham. The boundary capability will be improved when the Series and Shunt Compensation and Western HVDC Link are introduced in 2016 and 2017.

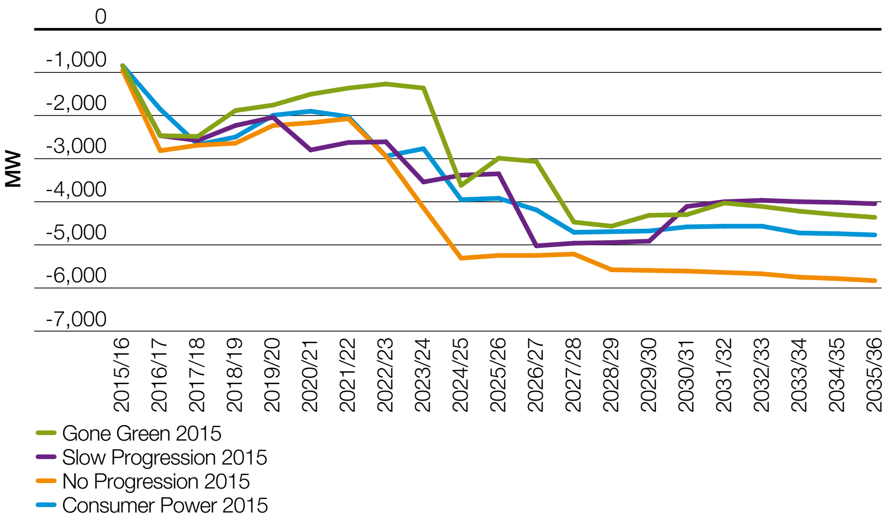
All the scenarios experience an increase of capability requirements due to the increase of generation north of boundary B7. Although ageing coal, gas and nuclear plants are closing north of the boundary across these scenarios, this is offset by the vast amount of onshore and offshore wind. The only scenario not showing a significant trend is No Progression – this is mainly due to the lack of significant offshore and onshore wind connections after 2021.

The Gone Green and Consumer Power scenarios show that the requirement for transfers above 5GW is delayed until 2019 (and until 2020 for Slow Progression). However, this trend does apply to No Progression scenario from 2025 onward.

The security-required transfer for boundary B7 places a requirement for capability for a south-to-north power flow as shown in Figure B7.3. Capability is sufficient to meet the expected requirements.

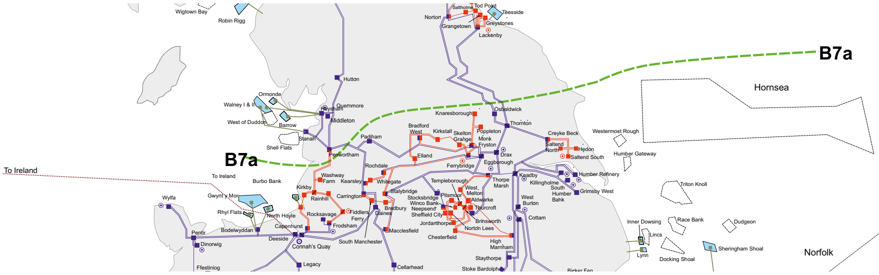
Northern boundaries

Figure B7.3
Security-required transfer for boundary B7



Boundary B7a – Upper North

Figure B7a.1
Geographic representation of boundary B7a



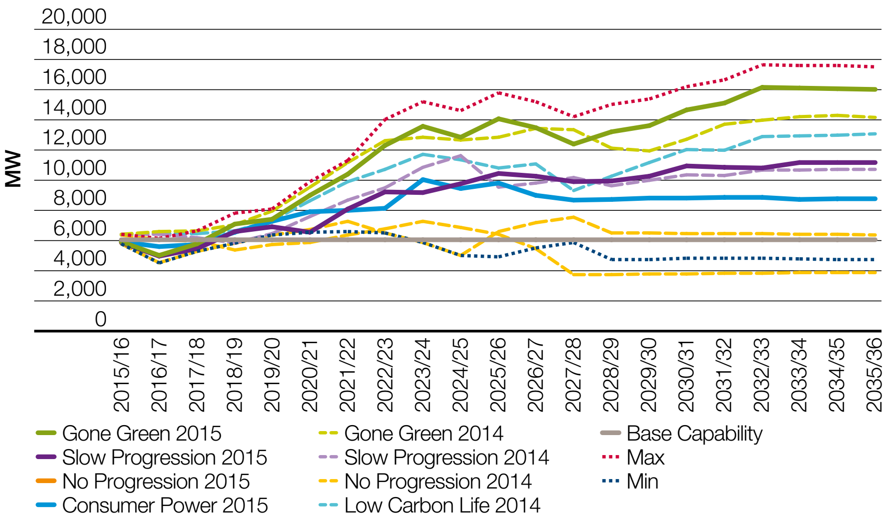
Boundary B7a bisects England south of Teesside and into the Mersey Ring area. It is characterised by three 400kV double circuits (two in the east, one in the west) and one 275kV circuit. Between boundaries B6 and B7a was traditionally an exporting area with a surplus of generation – when added to the exported power from Scotland this puts significant requirements on boundary B7a.

With the reduction of generation in the area between boundaries B6 and B7a, its requirement has reduced but is still exposed to the large Scottish exports.

In the future large amount of onshore and offshore wind connecting north of this boundary will increase the transfer requirements.

Northern boundaries

Figure B7a.2
Economy-required transfer and base capability for boundary B7a



Boundary requirements and capability

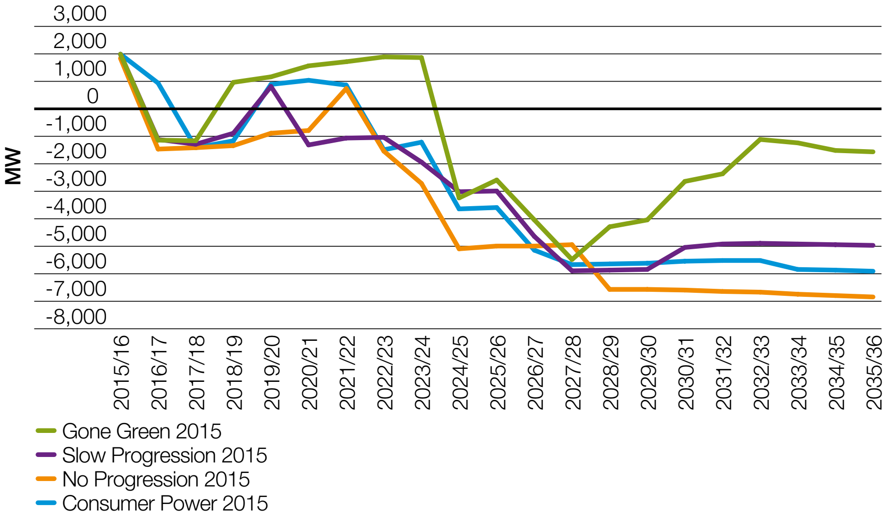
Figure B7a.2 above shows the economy-required transfers for boundary B7a from 2015 to 2035. The boundary capability is currently a thermal limit at around 5GW for a double circuit fault on the Padiham–Penwortham and Carrington–Penwortham circuits overloading one of the Kirby to Lister Drive circuits. This limit happens when Kirby and Rainhill substations are run three-way split and solid, respectively. However, the thermal capability can be increased to about 6GW when these substations are run two-way split where, for the same worst trip, one of the Penwortham to Kirby circuits gets overloaded. The introduction of the Western HVDC Link will increase the boundary limit to around 8.7GW (a thermal limit for outage of Penwortham–Carrington circuit and SGT6 of Penwortham substation which overloads Padiham–Penwortham circuit).

Across all scenarios the required transfer stays relatively static until 2018 when there is a rapid increase in the Gone Green, Consumer Power and Slow Progression scenarios. The increase in the No Progression scenario is less pronounced. The rapid increase is due to a number of onshore and offshore wind farm connections in England and Scotland; fewer of these are part of the No Progression scenario.

Just like the other boundaries further north with a lot of wind capacity behind them, boundary B7a has a security requirement to ensure demand is met when the intermittent generation is not operational. Figure B7a.3 below shows the security-required transfer for boundary B7a.

Chapter three

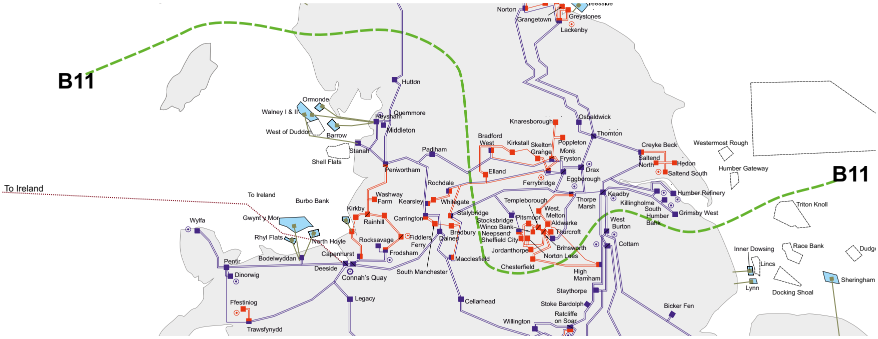
Figure B7a.3
Security-required transfer for boundary B7a



Northern boundaries

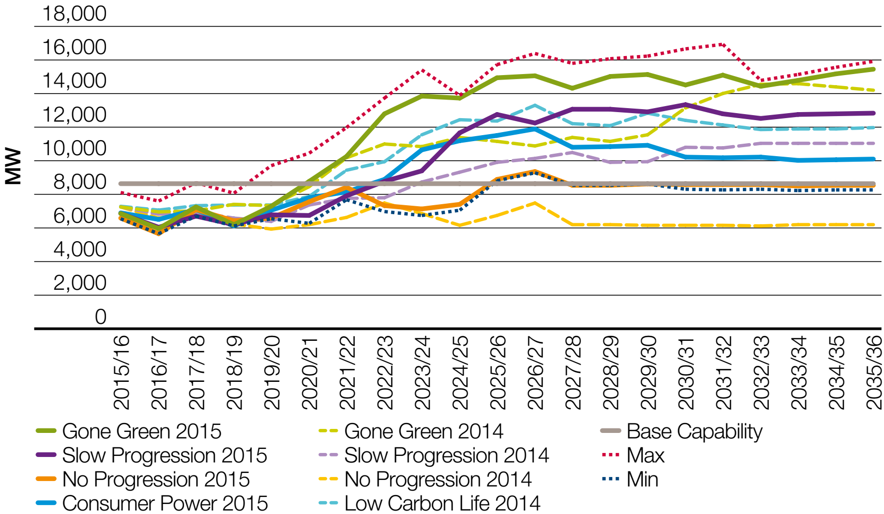
Boundary B11 – North East and Yorkshire

Figure B11.1
Geographic representation of boundary B11



Boundary B11 intersects the north of England. From west to east it crosses through the Harker–Hutton 400kV circuits, before sweeping south across three pairs of circuits between the Yorkshire and Cheshire/Lancashire areas. It then runs east between Nottinghamshire and Lincolnshire south of the Humber area, cutting across the Keadby–Cottam and Keadby–West Burton lines. To the north and east of the boundary are the power-exporting regions of Scotland, Yorkshire and the Humber. This boundary is significant to the NETS system because along with boundary B7 it allows us to focus on east-west flows and the effects of generation in the Aire Valley and Humber areas.

Figure B11.2
Required transfer and base capability for boundary B11



Boundary requirements and capability

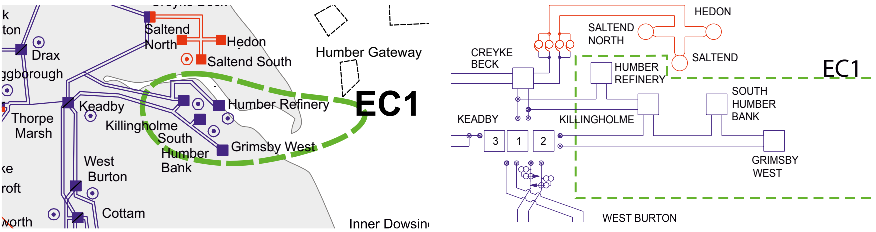
Figure B11.2 above shows the required transfers for boundary B11 from 2015 to 2035. The boundary capability is currently 8.6GW, limited by voltage compliance following a double-circuit fault on the Penwortham–Quernmore circuits.

All scenarios show an increasing requirement beyond 2018. The Gone Green scenario suggests a significant increase in requirements in the next ten years. Slow Progression and Consumer Power also show considerable increases in transfer requirements in the long term. The drive behind this is increasing generation north of the boundary, mostly from renewables.

Northern boundaries

Boundary EC1 – Humber

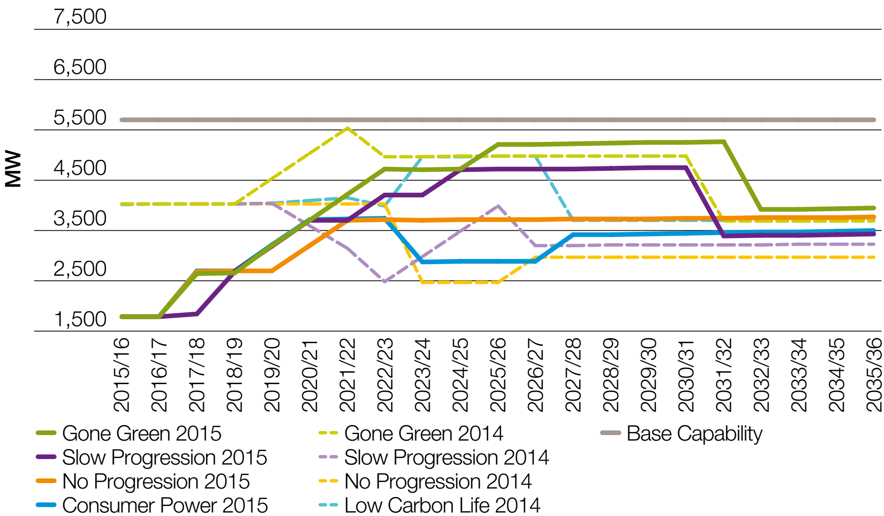
Figure EC1.1
Geographic and single-line representation of boundary EC1



Boundary EC1 is an enclosed local boundary consisting of four 400kV circuits that export power to the Keadby substation.

Killingholme is the only substation within the boundary that is connected by more than two transmission circuits.

Figure EC1.2
Net export requirements and base capability for boundary EC1



Boundary requirements and capability

Figure EC1.2 above shows export requirements for boundary EC1 from 2015 to 2035. The boundary capability is currently a thermal limit at 5.7GW for a double-circuit fault on the Creyke Beck–Keadby–Killingholme and Creyke Beck–Keadby–Humber Refinery, overloading the Keadby–Killingholme circuit.

The region becomes a less congested area of the transmission system due to the closures of some existing conventional plants, providing opportunity to connect new generation. Our scenarios consider the potential for new offshore wind farm connections, as well as closures across the existing conventional plants.

The Slow Progression and Gone Green scenarios show an increase in export requirements until 2024 and 2025 respectively as renewable offshore generation connects. However, this is offset in later years with the closures of conventional plants.

The Consumer Power and No Progression scenarios show an increase in export requirements until 2020. With a lower level of expected renewables connection, combined with the closures of existing conventional plants, the requirement remains the same for No Progression, and drops in the case of Consumer Power.

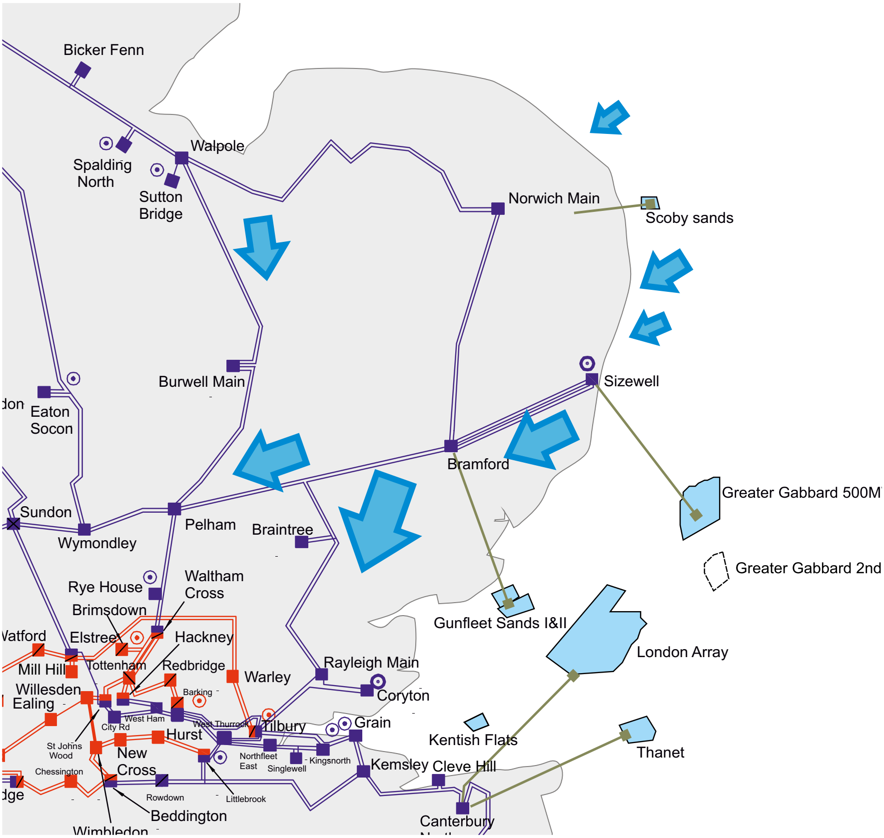
Eastern boundaries

3.3.3 Eastern boundaries

Introduction

The East England region includes the counties of Norfolk and Suffolk. The transmission boundaries EC3 and EC5 cover the transmission network in the area. Both boundaries are considered local, based on the generation and demand currently connected.

Figure 3.6
East England transmission networks (with arrows illustrating major power flows)



Chapter three

Primary challenge statement:
With a large amount of generation, mainly offshore wind and nuclear, and the potential of a new interconnector to be connected in the area, supply will exceed local demand significantly which will cause heavy circuit loading and voltage depressions.

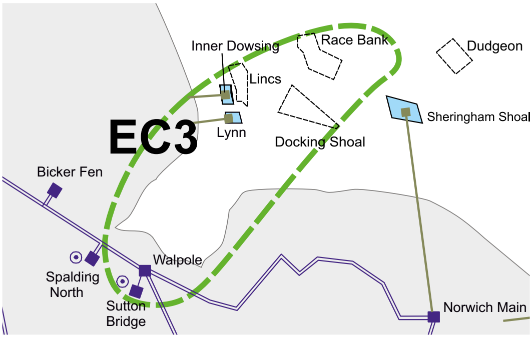
Regional drivers
The forecast increase in generation within East Anglia will see:

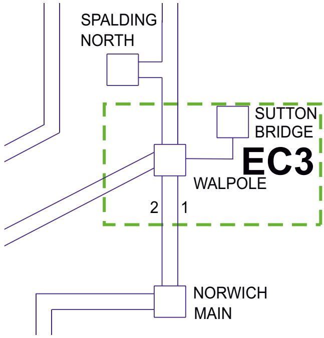
- Limitation from East Anglia to Greater London and South East England (boundaries EC3 and EC5)
  - The East England region is connected by several sets of long 400kV double circuits, including Bramford–Pelham/Braintree, Walpole–Spalding North/Bicker Fen and Walpole–Burwell Main. When a fault happens on one set of these circuits, some of the power has to flow a long distance to reach the rest of the network and continue to flow into Greater London and South East England.
  - As the power flow increases because of new generation connection in East Anglia, the reactive power losses in these high impedance routes also increase. So at a high transfer level, if the losses are not compensated they will eventually lead to voltage depression at the receiving end of these routes.
  - Stability becomes an additional concern when some of the large generators connect, further increasing the size of the generation group in the area. Losing a set of double circuits when a fault happens will lead to significant increases in the impedance of the connection between this large generation group and the remainder of the system. As a result, the system may be exposed to a risk of instability as transfers increase.
  - It is also important to ensure that all the transmission routes in the area will have sufficient thermal capacity to cope with the export requirement under post-fault conditions.
  - So there is a driver to develop the network in the East England region, in order to ensure that it has sufficient capability to export the power safely and securely to the rest of the system.

Eastern boundaries

Boundary EC3 – Wash

Figure EC3.1
Geographic and single-line representation of boundary EC3

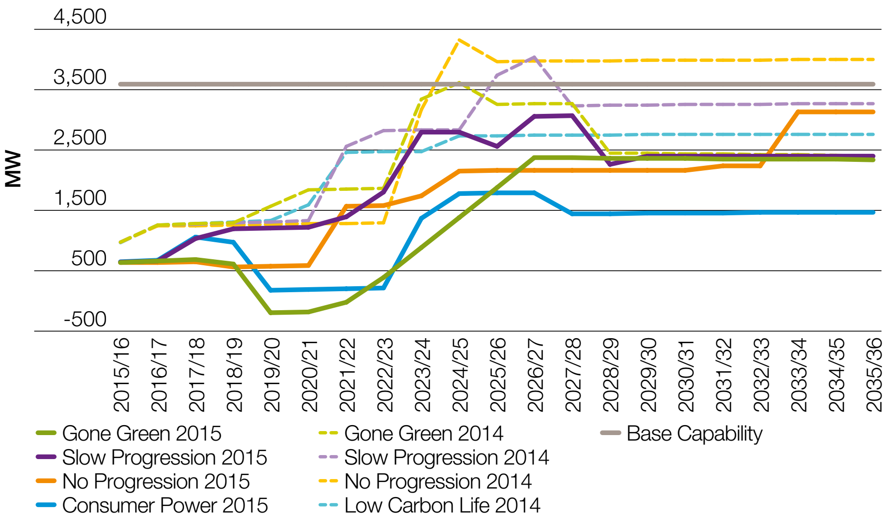




Boundary EC3 is a local boundary surrounding the Walpole substation. It includes six 400kV circuits out of Walpole; two single circuits (Walpole–Bicker Fen and Walpole–Spalding North) and two double circuits (Walpole–Norwich and Walpole–Burwell Main).

Walpole is a critical substation in supporting significant generation connections, high demand and high network power flows along the East Coast network, which is why it is selected for local boundary assessment.

Figure EC3.2
Net export requirements and base capability for boundary EC3



Boundary requirements and capability

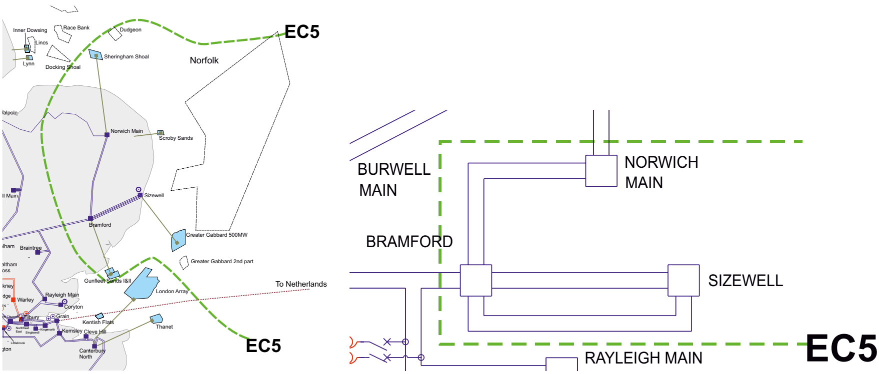
Figure EC3.2 above shows the export requirements for boundary EC3 from 2015 to 2035. The boundary capability is currently a thermal limit at 3.6GW for a double circuit fault on the Bicker Fen–West Burton double circuits which overloads the Walpole–Burwell Main circuits.

The plots show that the export requirements of the boundary increase across all scenarios but that the present capability should be sufficient for at least the next few years.

Eastern boundaries

Boundary EC5 – East Anglia

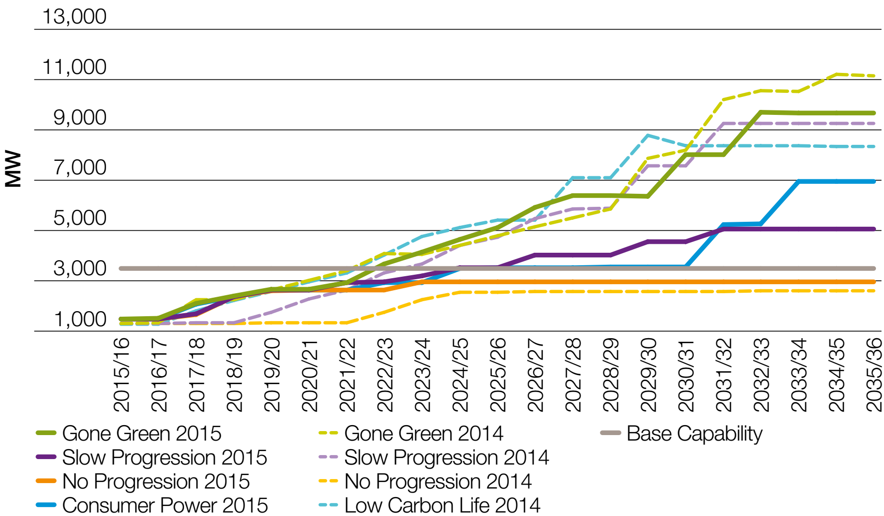
Figure EC5.1
Geographic and single-line representation of boundary EC5



Boundary EC5 is a local boundary enclosing most of East Anglia with 400kV substations at Norwich, Sizewell and Bramford. It crosses four 400kV circuits that mainly export power towards London.

The coastline and waters around East Anglia are attractive for the connection of offshore wind projects including the large East Anglia Round 3 offshore zone that lies directly to the east. The existing nuclear generation site at Sizewell is one of the approved sites selected for new nuclear generation development.

Figure EC5.2
Net export requirements and base capability for boundary EC5



Boundary requirements and capability

Figure EC5.2 above shows the export requirements for boundary EC5 from 2015 to 2035. The boundary capability is currently a voltage compliance limit at 3.5GW for a double-circuit fault on the Bramford–Pelham and Bramford–Braintree–Rayleigh Main circuits.

The growth in offshore wind and nuclear generation capacities connecting behind this boundary greatly increase the transfer capability requirements.

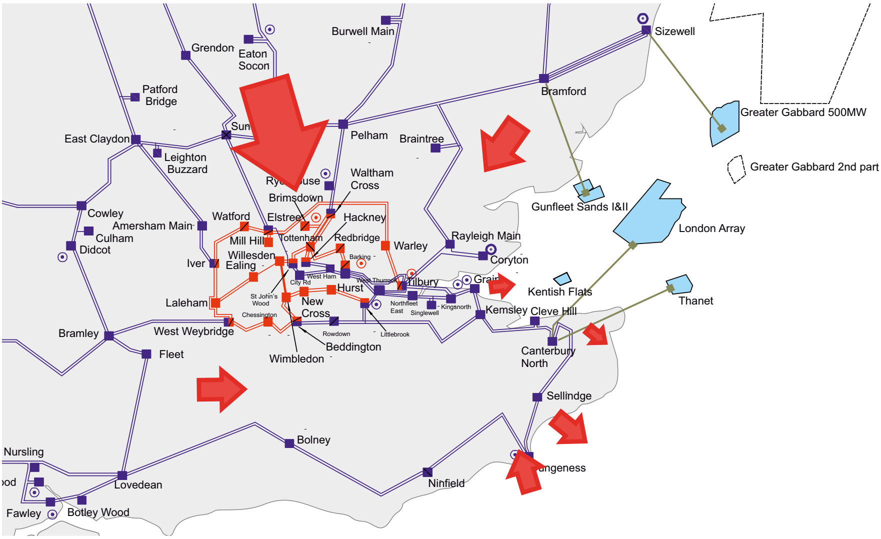
South Eastern boundaries

3.3.4 South Eastern boundaries

Introduction

The South East region has a high concentration of power demand and generation, with much of the demand found in London and generation in the Thames Estuary. Interconnection to central Europe is present along the South East Coast and influences power flows in the region by being able to import and export power with Europe. The South East region includes boundaries B14, B15 and SC1.

Figure 3.7
South East England transmission networks (with arrows illustrating major power flows)



Primary challenge statement:
High demand in London and possible coincidental interconnector exports drive power through north London and the Thames Estuary, causing heavy circuit loading and voltage depressions.

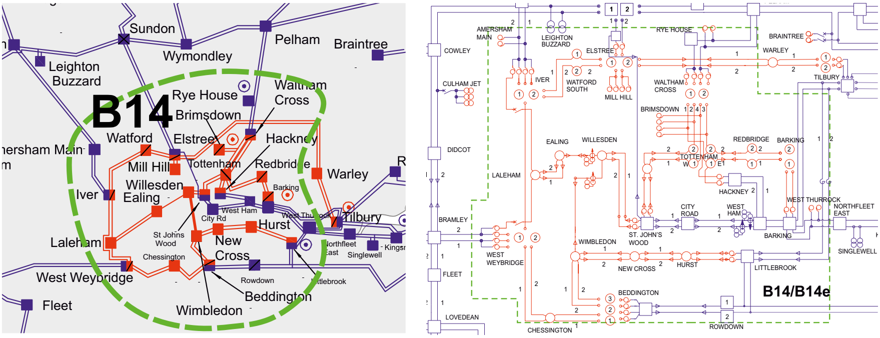
Regional drivers
As generation increases in the north of the country, and the interconnectors in the South East region are put onto export operation, the regional network will see:

- Limitation from the Midlands into South England (boundaries B14 and B15)
  - High demand in London traditionally drives the heavy north to south flows through the GB network. This has always put the transmission routes connecting the Midlands and South England on heavy loading conditions during the GB system peak.
  - With more interconnectors expected over the next 10 years, an increased draw of power could be seen through the major Midlands to South routes and through London when the interconnectors export.
  - This will put these major transmission routes and the circuits connecting the Greater London area close to the thermal capacity limits.
  - Most transmission networks within Greater London are currently operating at 275kV. As the power that flows through London to the interconnectors on the South Coast increases, the network will have to be developed in order to improve its utilisation or to create new capacity.
- Limitation in the South Coast (SC1)
  - The South Coast is connected to the rest of the system by only one set of 400kV double circuits of over 200km long stretching from Kemsley to Lovedean. In the next 10 years the capacity of interconnectors connecting along this transmission route is forecast to reach 4GW, with a further 1GW capacity connecting near Grain.
  - If a fault happens on one end of this transmission route, power will be forced to flow a very long distance to reach the interconnector connection points. Combining the South Coast's high demand with these interconnector exports drives a high power flow through this route – the only one in post-fault condition.
  - At a high transfer level, if the losses in these long circuits with high impedance are not compensated, they will eventually lead to voltage depression along the route.
  - As the amount of interconnector capacity increases over time, it is important to ensure that the thermal capability of the transmission route is high enough to sustain the growth in requirement.
  - So there is a driver to develop the network in order to maintain the voltage in the South Coast at compliance level, and to increase the thermal capability of the circuits connecting the region so that they can cope with the forecasted increase in interconnectors.

South Eastern boundaries

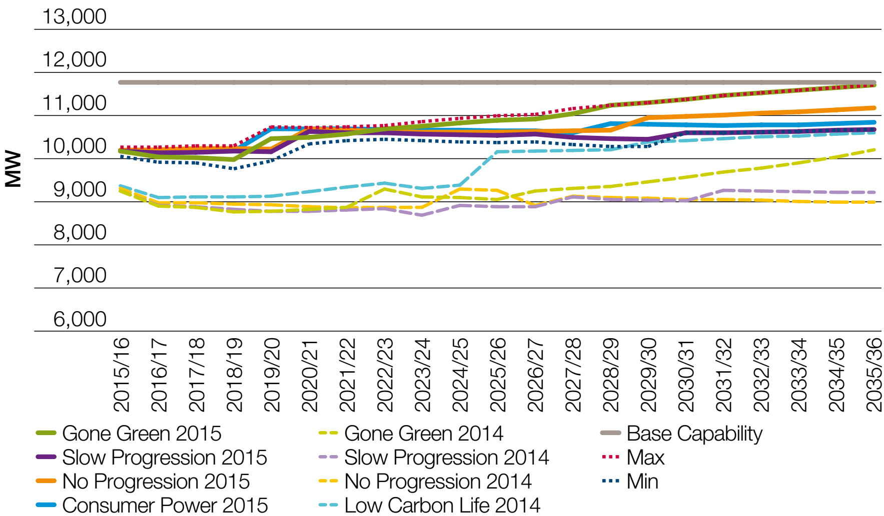
Boundary B14 – London

Figure B14.1
Geographic and single-line representation of boundary B14



Boundary B14 encloses London and is characterised by high local demand and a small amount of generation. London's energy import relies heavily on surrounding 400kV and 275kV circuits. The circuits entering from the north can be particularly heavily loaded at winter peak conditions. The circuits are further stressed when the European interconnectors export. The North London circuits can also be a bottleneck for power flow from the East Coast and East Anglia regions as power flows through London north to south.

Figure B14.2
Required transfer and base capability for boundary B14



Boundary requirements and capability

Figure B14.2 shows the required transfers for boundary B14 from 2015 to 2035. The boundary capability is currently limited by voltage constraints at 11.8GW for a double-circuit fault on the Pelham–Rye House–Waltham Cross routes or the Bramley–West Weybridge circuits.

As the transfer of this boundary is mostly dictated by the contained demand, the future requirements mostly follow the demand in the scenarios. The small variations in future requirements are due to generation changes.

The Slow Progression scenario shows a lower boundary requirement than the Gone Green scenario, as the few conventional plants within the boundary are expected to continue operation in Slow Progression.

Our scenarios consider that during peak demand condition the European interconnectors will import power to GB. Therefore this alleviates the stress on the North London circuits. Boundary capability has increased this year as a result of the importing nature of European interconnectors and falling local reactive demand within London, thereby alleviating a previous voltage constraint.

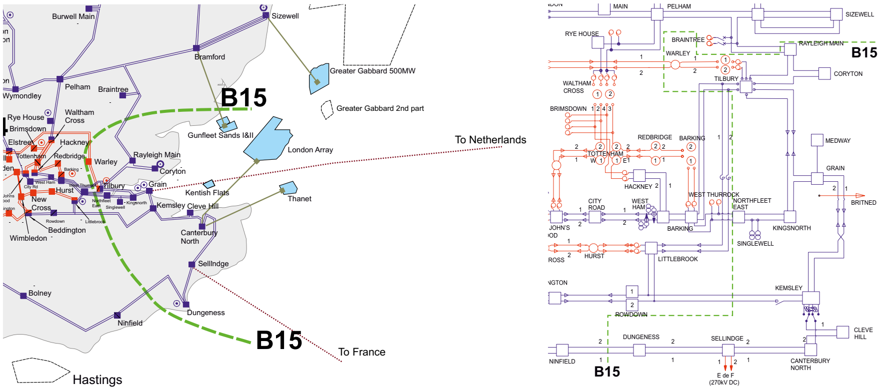
We also consider the scenario sensitivities associated with interconnector operation, as this affects the boundary capability. When the European interconnectors in the area export power from GB, the north-to-south power flows across London to the Thames Estuary and south of Kent, putting additional stress on the North London circuits.

Chapter three

South Eastern boundaries

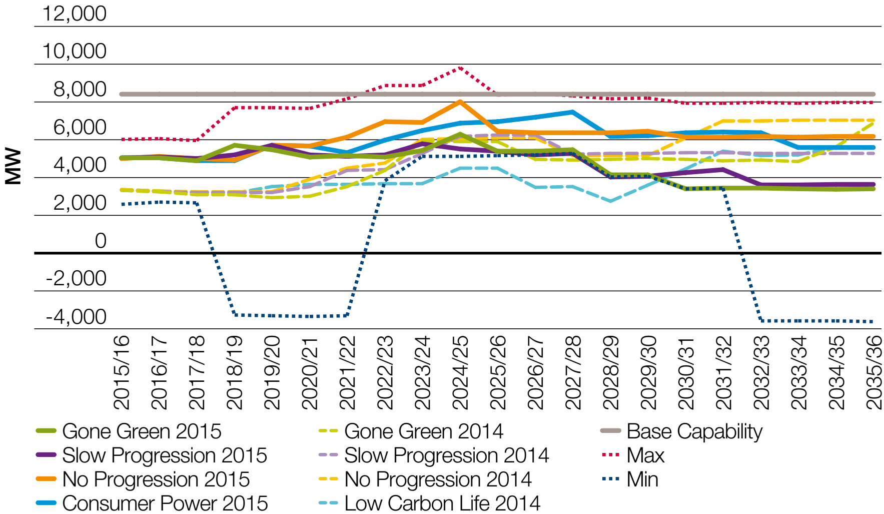
Boundary B15 – Thames Estuary

Figure B15.1
Geographic and single-line representation of boundary B15



Boundary B15 is the Thames Estuary boundary, enclosing the south east corner of England. It has significant thermal generation capacity and some large offshore wind farms to the east. With its large generation base, the boundary normally exports power to London. With large interconnectors at Sellindge and Grain connecting to France and the Netherlands, power flow of boundary B15 is greatly influenced by their power flows. With agreements in place for new interconnectors to France and Belgium within boundary B15, the boundary power flows will become dominated by the interconnector activity.

Figure B15.2
Required transfer and base capability for boundary B15



Boundary requirements and capability

Figure B15.2 above shows the required transfers for boundary B15 from 2015 to 2035. The boundary capability is currently a thermal limit at 8.5GW for a double-circuit fault on the Grain–Kingsnorth and Grain–Tilbury circuits.

The large differences from the core scenarios to the minimum and maximum requirements result from the sensitivities of interconnectors importing and exporting.

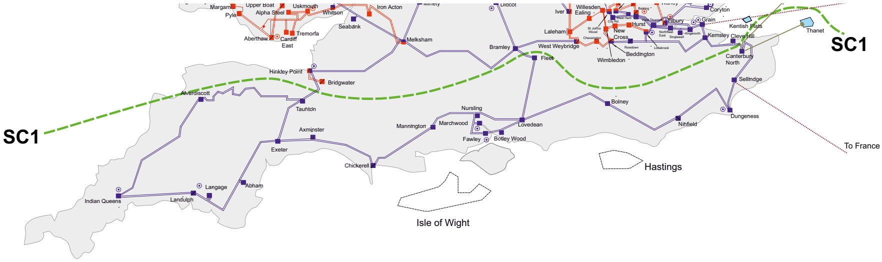
The interconnectors connected within this boundary are expected to import during winter peak. This leads to the boundary exporting. The required transfers across this boundary are fairly constant between all four scenarios, and begin to deviate post-2020 as assumptions on gas plants and timings are reflected.

The boundary capability is primarily for interconnector importing. With sensitivities for the interconnectors exporting to Europe, the boundary can switch to an importing state – but only when new interconnectors connect.

South Eastern boundaries

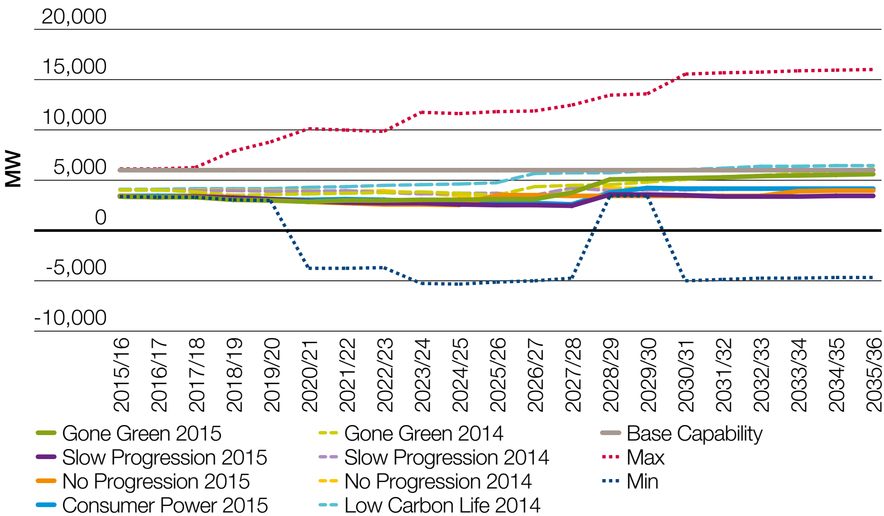
Boundary SC1 – South Coast

Figure SC1.1
Geographic representation of boundary SC1



The South Coast boundary SC1 runs parallel with the South Coast of England between the Severn and Thames Estuaries. At times of peak winter GB demand the power flow is typically north to south across the boundary, with more demand enclosed in the south of the boundary than supporting generation. Interconnector activity can significantly influence the boundary power flow. The current interconnectors to France and the Netherlands connect at Sellindge and Grain respectively. Crossing the boundary are three 400kV double circuits with one in the east, one west and one in the middle between Fleet and Bramley.

Figure SC1.2
Required transfer and base capability for boundary SC1



Boundary requirements and capability

Figure SC1.2 above shows the required transfers for boundary SC1 from 2015 to 2035. The boundary capability is currently a thermal loading limit at 6GW following a double-circuit fault on the Bramley–Didcot circuits.

In the base scenarios all interconnectors are assumed to be importing from Europe but the boundary limit occurs under interconnector export conditions.

The FES suggest some large new generators will connect to south of the SC1 boundary but the biggest potential driver for SC1 will be the connection of new continental interconnectors. With their ability to transfer power in both directions, boundary SC1 could be stressed much harder than would be normal with conventional generation and demand.

The most important consideration for this boundary is the scenario sensitivities associated with interconnector operation, as this greatly affects the boundary capability. These sensitivities are shown as the maximum and minimum requirements of the boundary.

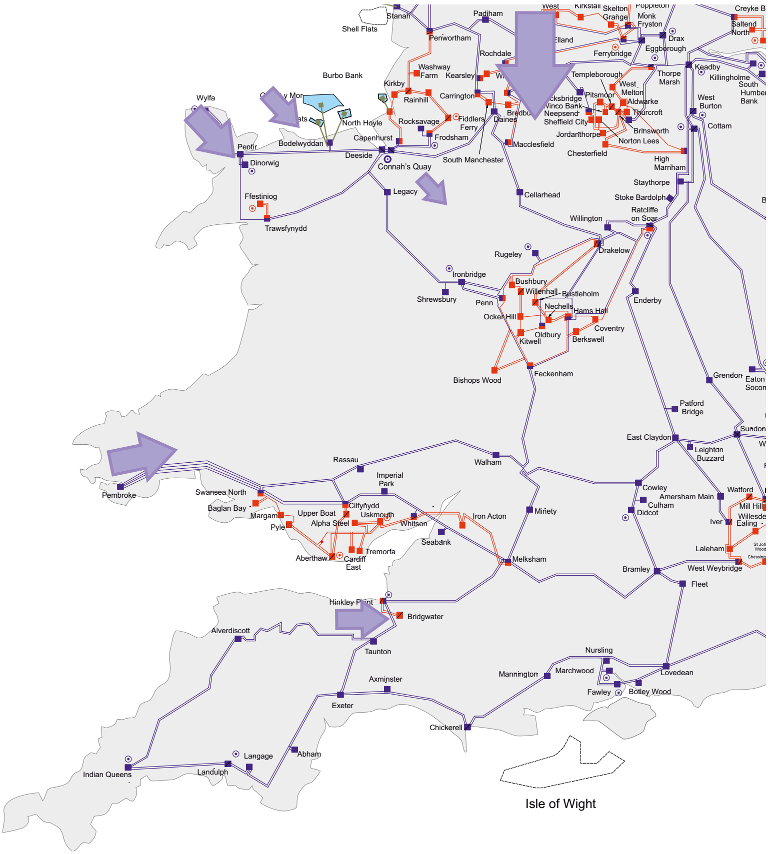
Western boundaries

3.3.5 Western boundaries

Introduction

The Western region covers the remaining boundaries on the system including Wales, the Midlands and the South West. Some of the boundaries are closely related, such as those for North Wales, but the region also covers large wider boundaries such as B8, B9, B13 and B17.

Figure 3.8
Wales and South West England transmission networks (with arrows illustrating major power flows)



Primary challenge statement:
Rapidly growing north to south power flows, increasing generation in Wales and new nuclear generation in the South West drive power through the Midlands (where various plant closures happen) and the South Coast, causing heavy circuit loading and voltage depressions.

Regional drivers
As the generation continues to increase in the north, and wind and nuclear generation connect to South West England and Wales, the network in this region will see:

- Limitation on power transfer through the Midlands (boundaries B8, B9, B17)
  - As generation increases in the north, the large demand in the Midlands and further south of the country creates the increasingly high north to south power flows through the networks around the Midlands. These heavy power flows will stress the transmission routes in the future and could push these routes close to their thermal capability.
  - This leads to the need to develop the network around the Midlands to ensure there will be enough thermal capability to sustain the future increase in power flows through the region.
- Limitation on power export from North Wales (boundaries NW1, NW2, NW3, NW4)
  - A large amount of generation, mainly wind and nuclear, is expected to connect to North Wales. The transmission network in the area is connected by only a few 400kV circuits with limited capacity.
  - Further increase in generation in the area will require network development in order to create new transmission capacity for exporting excess generation to the rest of the system.
- Limitation on power export from South Wales (boundary SW1)
  - A large amount of generation, mainly tidal, is expected to connect to South Wales. The transmission network in the area is connected by some 275kV circuits and only a few 400kV circuits with limited capacity.
  - It will require new transmission capacity for exporting excess generation to the rest of the system as generation in the area increases.
- Limitation on power transfer from South West England to South East England (boundary B13)
  - As wind and nuclear generation connects to South West England, the generation in the area may exceed the amount of demand at time of GB system peak and result in increasing power flows towards the high demand area in South East England.
  - As the two areas are only connected by a few long transmission routes, it is important to ensure that future network development in the area will create the thermal capacity required for west to east power flow during interconnectors' export operation.

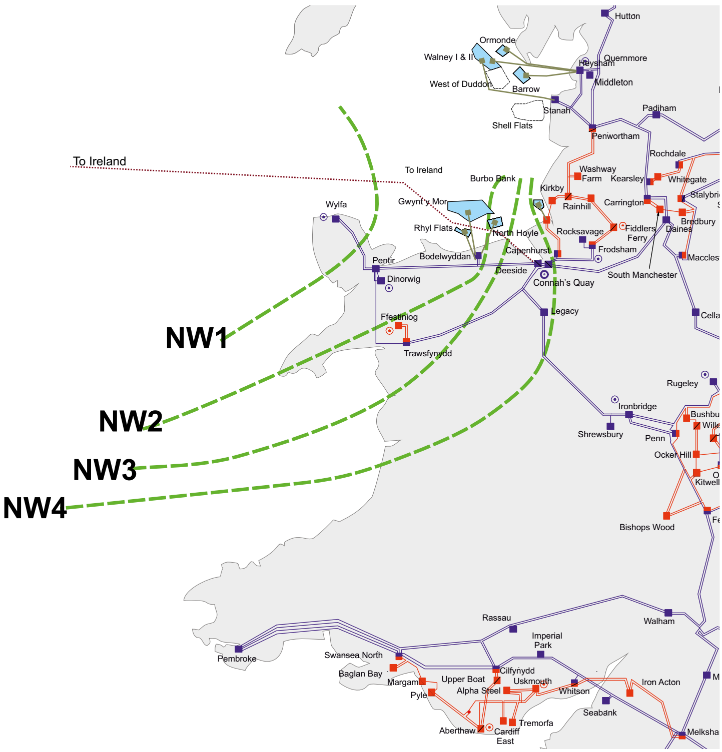
Western boundaries

North Wales – overview

The onshore network in North Wales comprises a 400kV circuit ring that connects Pentir, Deeside and Trawsfynydd substations. A 400kV double-circuit spur crossing the Menai Strait and running the length of Anglesey connects the now decommissioned nuclear power station at Wylfa to Pentir. A short 400kV double-circuit cable spur from Pentir connects Dinorwig pumped storage power station.

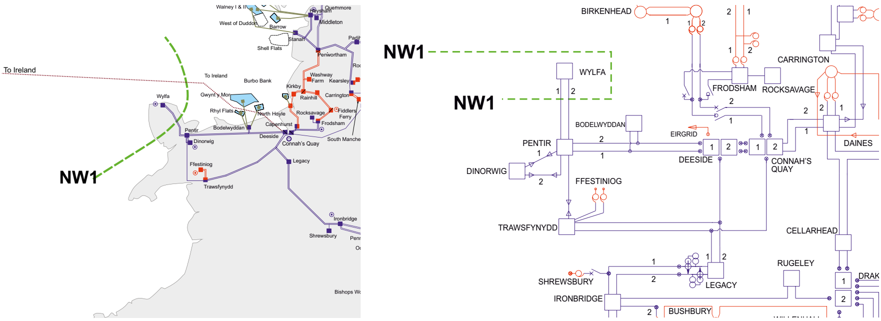
In addition, a 275kV spur traverses north of Trawsfynydd to Ffestiniog pumped storage power station. Most of these circuits are of double-circuit tower construction. However, Pentir and Trawsfynydd within the Snowdonia National Park are connected by a single 400kV circuit, which is the main limiting factor for capacity in this area.

Figure 3.9
Geographic representation of North Wales boundaries



Boundary NW1 – Anglesey

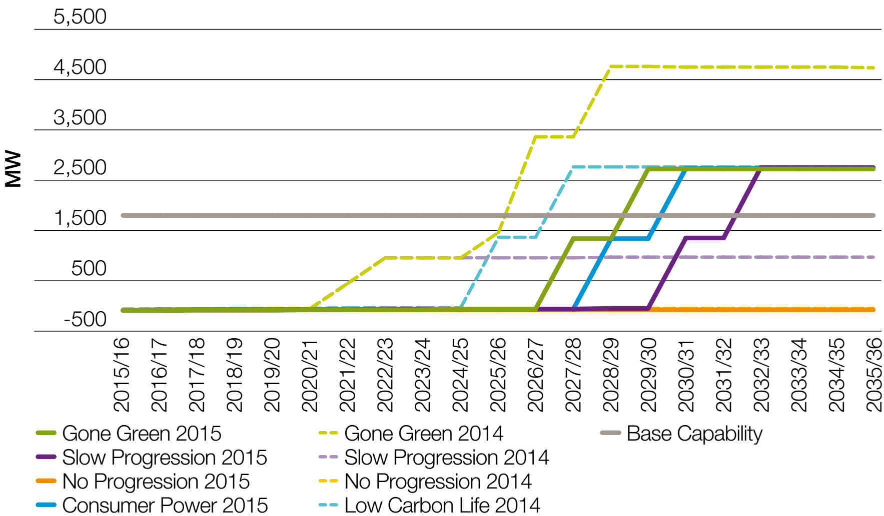
Figure NW1.1
Geographic and single-line representation of boundary NW1



Boundary NW1 is a local boundary crossing the 400kV double circuit that runs along Anglesey between Wylfa and Pentir substations.

Western boundaries

Figure NW1.2
Net export requirements and base capability for boundary NW1



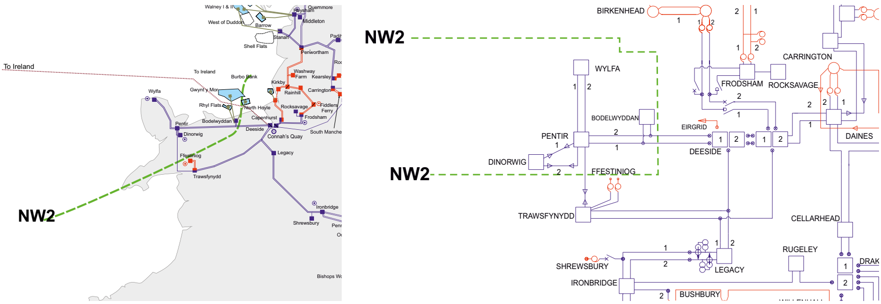
Boundary requirements and capability

Figure NW1.2 above shows the export requirements for boundary NW1 from 2015 to 2035. Transfer capability is limited by the infeed loss risk criterion set in the SQSS, which is currently 1,800MW. If the infeed loss risk criterion is exceeded, the boundary will need to be reinforced by adding a new transmission route across the boundary.

The scenarios all show a similar requirement until 2026 where they diverge.

Boundary NW2 – Anglesey and Caernarvonshire

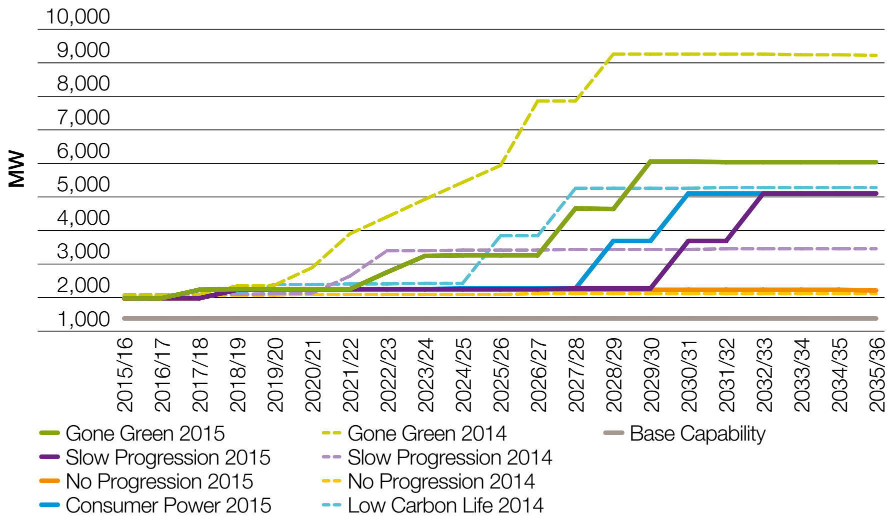
Figure NW2.1
Geographic and single-line representation of boundary NW2



This local boundary bisects the North Wales mainland close to Anglesey. As shown in Figure NW2.1 above, it crosses through the Pentir to the Deeside 400kV double circuit and the Trawsfynydd 400kV single circuit.

Western boundaries

Figure NW2.2
Net export requirements and base capability for boundary NW2



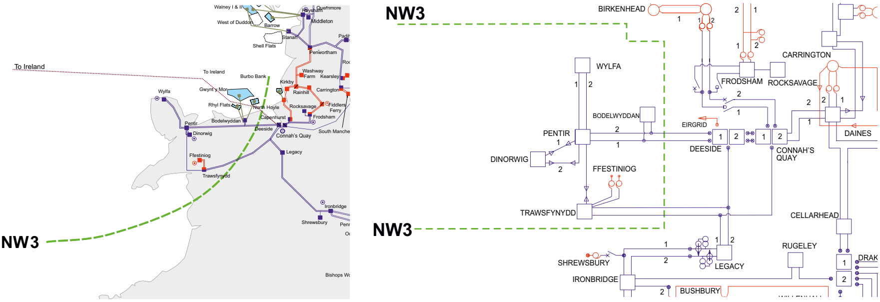
Boundary requirements and capability

Figure NW2.2 above shows the export requirements for boundary NW2 from 2015 to 2035. The boundary capability is a thermal limit at 1.4GW for a double-circuit fault on the Deeside–Bodelwyddan–Pentir circuits.

The scenarios all show a similar requirement until 2022 where they diverge due to different assumptions of when wind and nuclear generation will connect.

Boundary NW3 – Anglesey and Caernarvonshire and Merionethshire

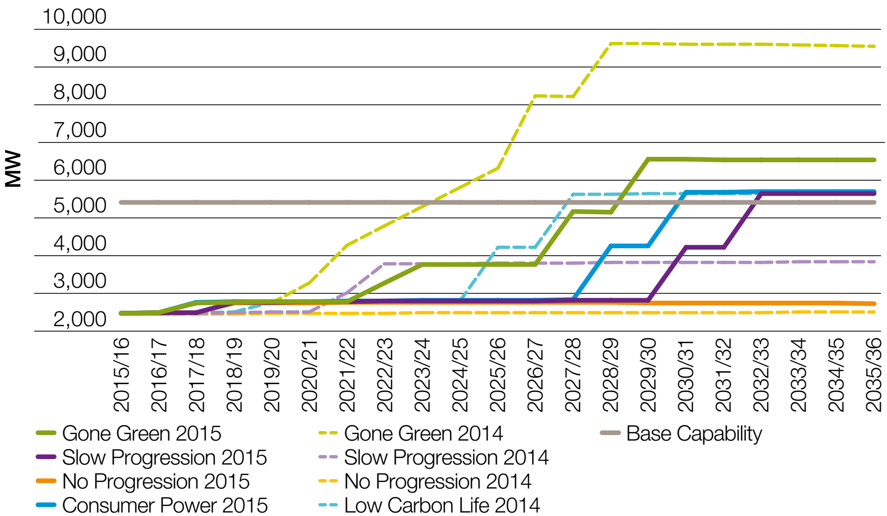
Figure NW3.1
Geographic and single-line representation of boundary NW3



Boundary NW3 (see Figure NW3.1) provides capacity for further generation connections in addition to those behind boundaries NW1 and NW2. It is defined by a pair of 400kV double circuits from Pentir to Deeside and Trawsfynydd to the Treuddyn Tee.

Western boundaries

Figure NW3.2
Net export requirements and base capability for boundary NW3



Boundary requirements and capability

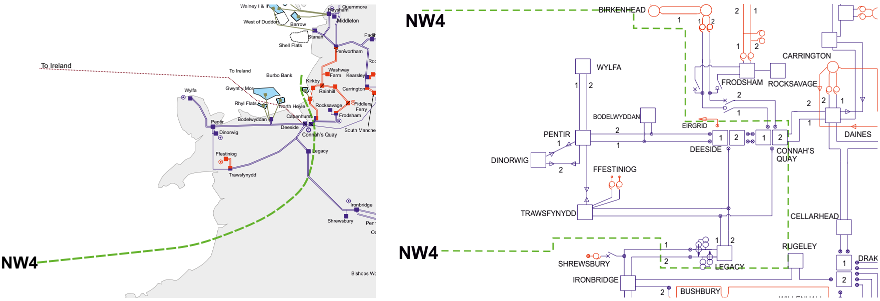
Figure NW3.2 above shows the export requirements for boundary NW3 from 2015 to 2035. The boundary capability is a thermal limit at 5.4GW for a double-circuit fault on the Deeside–Trawsfynydd–Legacy circuits.

The reconductoring of leg sections Trawsfynydd–Treudden has now been completed.

The scenarios all show a similar requirement until 2022 where they diverge due to different assumptions of when wind and nuclear generation will connect.

Boundary NW4 – North Wales

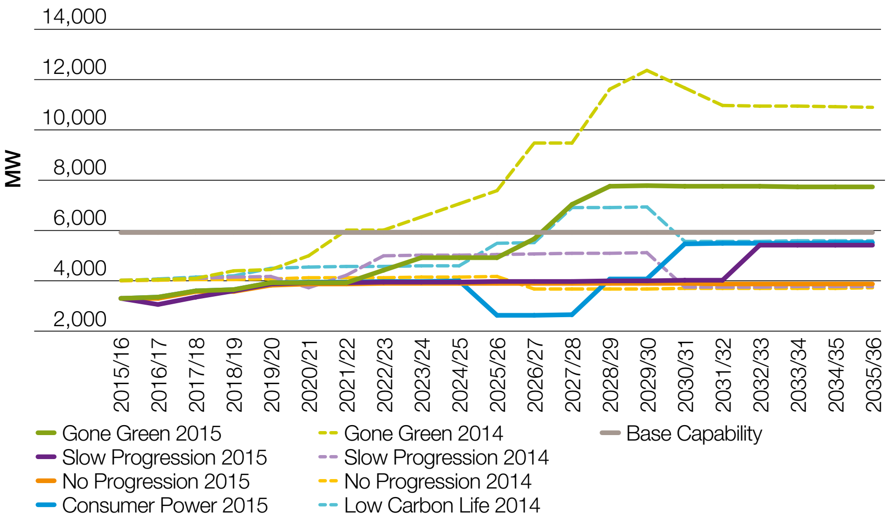
Figure NW4.1
Geographic and single-line representation of boundary NW4



Boundary NW4 covers most of North Wales. Given that it contains fairly low generation and demand, it is currently considered as a local boundary, although it is on the threshold of becoming a wider boundary. As the developments in the enclosed area happen, it may well become a wider system boundary.

Western boundaries

Figure NW4.2
Net export requirements and base capability for boundary NW4



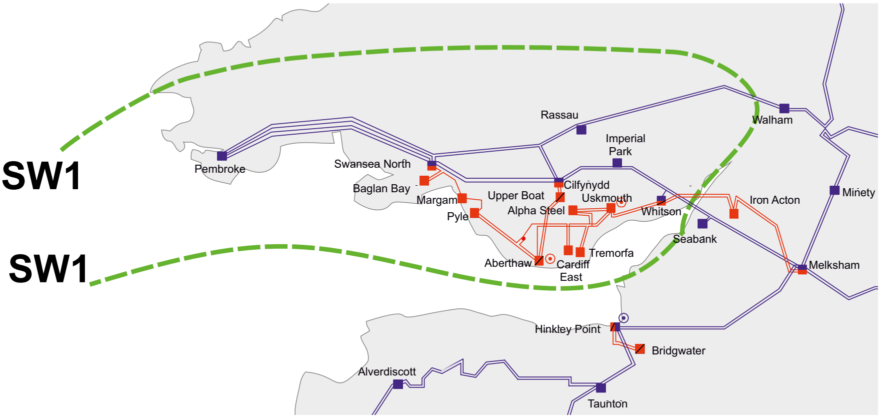
Boundary requirements and capability

Figure NW4.2 above shows the export requirements for boundary NW4 from 2015 to 2035. The boundary capability is a voltage compliance limit at 5.9GW for a double-circuit fault on Connah's Quay–Dianes circuits.

The scenarios all show a similar requirement until 2022 where they diverge due to different assumptions of when wind and nuclear generation will connect.

Boundary SW1 – South Wales

Figure SW1.1
Geographic representation of boundary SW1

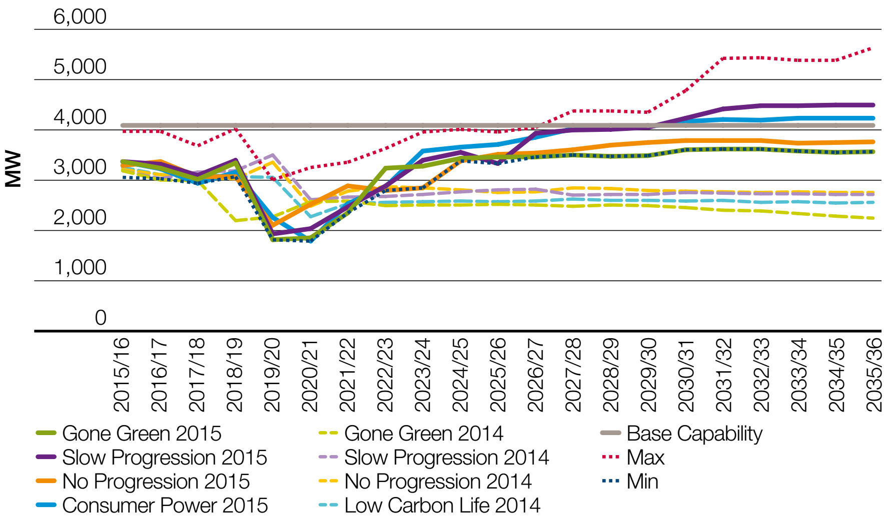


Boundary SW1 encloses South Wales and is considered a local boundary. Within the boundary are a number of thermal generators including Pembroke and Severn Power which are both powered by gas, and Aberthaw powered by coal. Some of the older power stations are expected to close in the future but significant amounts of new generation capacity are expected to connect, including generators powered by wind, gas and tidal.

South Wales includes demand consumption from the major cities, including Swansea and Cardiff, and the surrounding industry.

Western boundaries

Figure SW1.2
Net export requirements and base capability for boundary SW1



Boundary requirements and capability

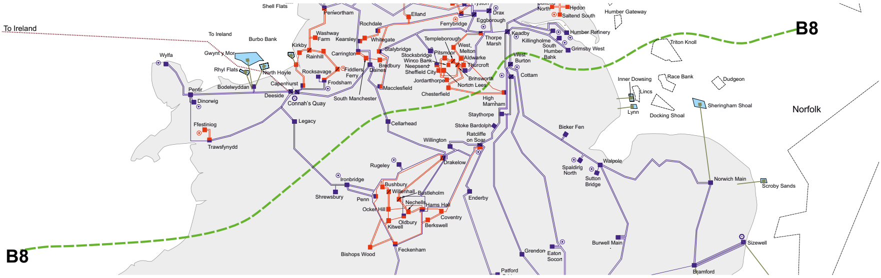
Figure SW1.2 above shows the export requirements for boundary SW1 from 2015 to 2035. The boundary capability is a thermal limit at 4.1GW for a fault on the Iron Action–Whitson and Imperial Park–Melksham circuits.

The plots for the scenarios and sensitivities show a short-term reduction in requirements between 2019 and 2020 due to the expected closures of existing conventional plants.

The rapid increase in requirements post-2020 across all scenarios is caused by the connection of some new thermal plants, and in the later years a vast amount of renewable generation.

Boundary B8 – North to Midlands

Figure B8.1
Geographic representation of boundary B8



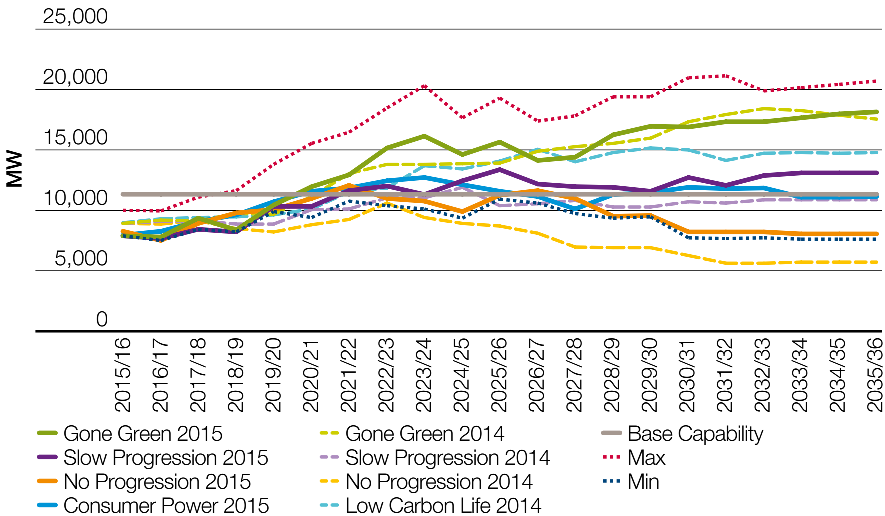
The North to Midlands boundary B8 is one of the wider boundaries that intersects the centre of GB, separating the northern generation zones including Scotland, Northern England and North Wales from the Midlands and southern demand centres. The boundary crosses four major 400kV double circuits, with two of those passing through the East Midlands while the other two pass through the West Midlands, and a limited 275kV connection to South Yorkshire.

Generation from Scotland continues to be transported south, leading to the high transfer level across B8. The east of B8 is traditionally a congested area due to the large amount of existing generation in the Humber and Aire Valley regions.

The east areas also suffer from high fault levels, which constrain the running arrangements of several substations in the area.

Western boundaries

Figure B8.2
Required transfer and base capability for boundary B8



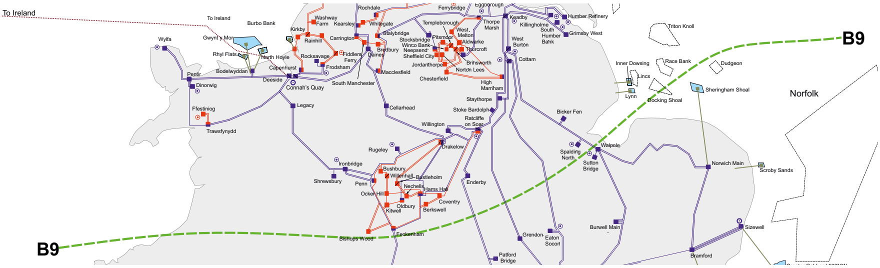
Boundary requirements and capability

Figure B8.2 above shows the required transfers for boundary B8 from 2015 to 2035. The boundary capability is a thermal limit at 11.4GW for a double-circuit fault on the Legacy–Trawsfynydd circuits which overloads the Cellarhead–Drakelow circuits.

Across all scenarios there is a steady increase in the generation behind boundary B8 until 2022, when the No Progression, Slow Progression and Consumer Power scenarios decrease or flatten out. Gone Green 2015 has a more rapid increase than Gone Green 2014 because of an increased amount of embedded wind.

Boundary B9 – Midlands to South

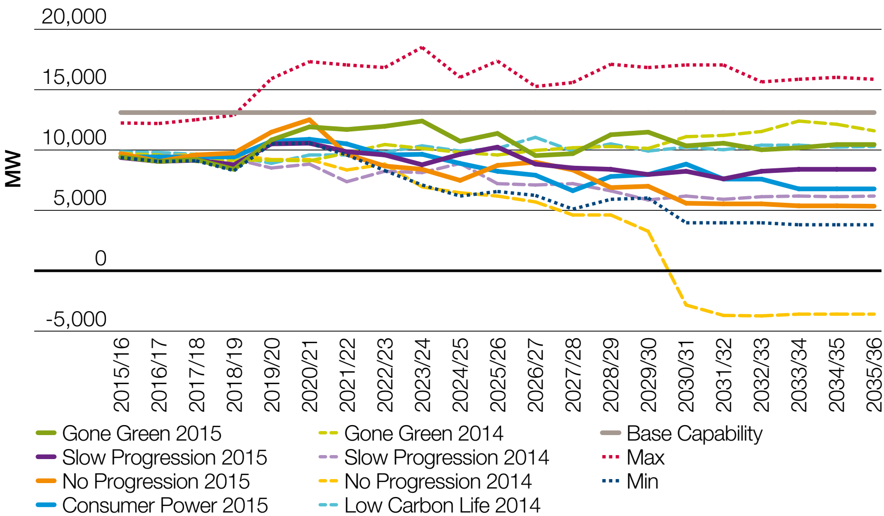
Figure B9.1
Geographic representation of boundary B9



The Midlands to South boundary B9 separates the northern generation zones and the Midlands from the southern demand centres. The boundary crosses five major 400kV double circuits, transporting power from the north over a long distance to the southern demand hubs, including London. These long and typically heavily loaded circuits present voltage compliance challenges, so delivering reactive compensation support in the right area is key for maintaining high transfer capability. Developments in the East Coast and the East Anglia regions, such as the locations of offshore wind generation connection and the network infrastructure requirements, will have a significant impact on the transfer requirements and capability of boundary B9.

Western boundaries

Figure B9.2
Required transfer and base capability for boundary B9



Boundary requirements and capability

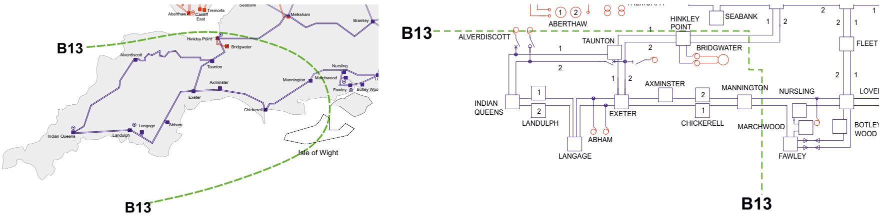
Figure B9.2 above shows the required transfers for boundary B9 from 2015 to 2035. The boundary capability is a voltage compliance limit at 13.1GW for a double-circuit fault on the Spalding North–Bicker Fen–West Burton and Walpole–Bicker Fen–West Burton circuits.

The Gone Green scenario remains quite steady as onshore and offshore wind replaces conventional coal and gas plant. In the Slow Progression scenario the conventional plants are closing more quickly than they are being replaced by wind.

With the amount of interconnectors planning to connect north of the boundary, the required transfers across boundary B9 will vary greatly depending on the operation of these interconnectors.

Boundary B13 – South West

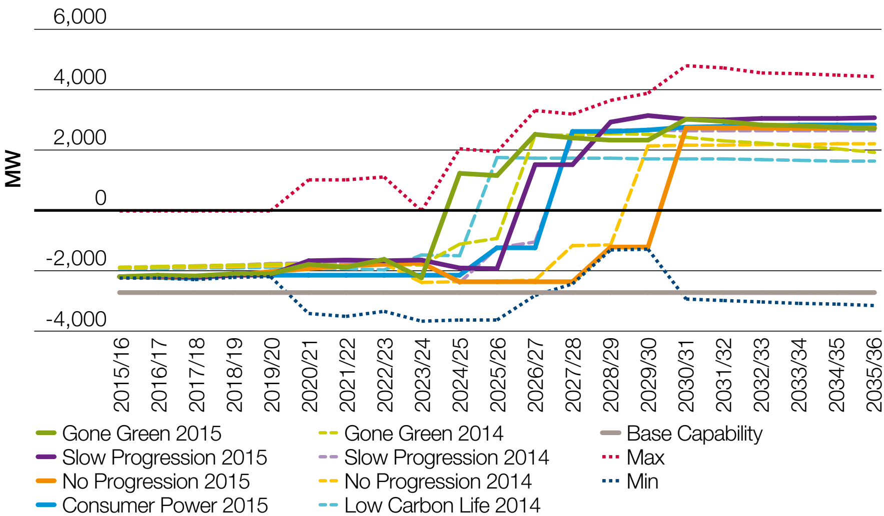
Figure B13.1
Geographic and single-line representation of boundary B13



Wider boundary B13 is defined as the southernmost tip of the UK below the Severn Estuary, encompassing Hinkley Point in the South West and stretching as far east as Mannington. The boundary crossing circuits are the Hinkley Point to Melksham double circuit and the Mannington circuits to Nursling and Fawley. The southwest peninsula is a region with a high level of localised generation and demand. The boundary is currently an importing boundary, with the demand being higher than the generation at peak demand conditions. With the potential connection of new generation and interconnectors to the South West – including new nuclear and wind generation – the boundary is expected to change to export power more often than import.

Western boundaries

Figure B13.2
Required transfer and base capability for boundary B13



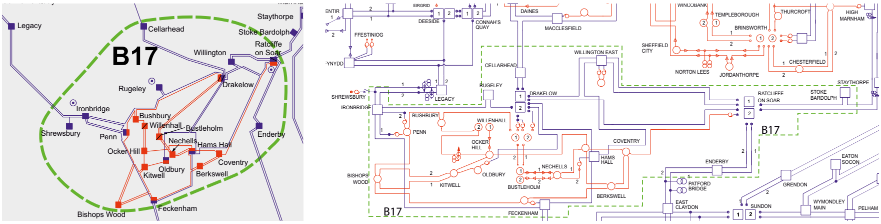
Boundary requirements and capability

Figure B13.2 above shows the required transfers for boundary B13 from 2015 to 2035. The boundary capability is a voltage collapse limit at 2.7GW for a double-circuit fault on the Chickerell–Exeter and Axminster–Exeter circuits.

It can be seen that until new generation or interconnectors connects there is very little variation in boundary requirements, and that the current importing boundary capability is sufficient to meet the short-term needs. The large size of the potential new generators wishing to connect close to boundary B13 is likely to push it to large exports and require additional boundary capacity.

Boundary B17 – West Midlands

Figure B17.1
Geographic and single-line representation of boundary B17

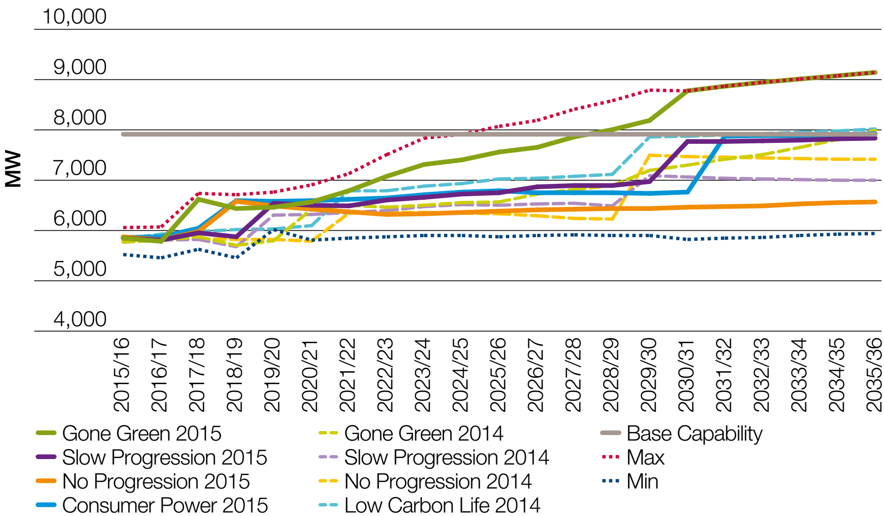


Enclosing the West Midlands, boundary B17 is heavily dependent on importing power from the North because local generation is insufficient. Boundary B17 is surrounded by five 400kV double circuits but internally the circuits in and around Birmingham are mostly 275kV.

Much of the north to south power flows seen by boundaries B8 and B9 also pass straight through boundary B17, putting significant loading on these circuits that is not apparent on this boundary's requirements.

Western boundaries

Figure B17.2
Required transfer and base capability for boundary B17



Boundary requirements and capability

Figure B17.2 above shows the required transfers for boundary B17 from 2015 to 2035. The current boundary capability is a voltage compliance limit at 7.9GW due to double circuit outage of Cellarhead–Daines and Cellarhead–Macclesfield. The required transfers resulting from the scenarios suggest a general increase in importing boundary requirements after 2017 – this is due to reducing output from the enclosed thermal generation, rather than a significant increase in local demand.

Reduced availability of local thermal generation possesses some challenges for boundary B17. The resulting reduction of reactive power support to maintain voltage compliance decreases the boundary capability to support local demand. At times of high demand, some relief to maintaining voltages is given by the gradual decline in reactive power demands seen by the system (see Chapter two).

Increasing north to south power flows in the circuits crossing this boundary also work to reduce the boundary capability. Particularly limiting are the circuits entering Cellarhead from the north and the Shrewsbury circuits on the west.

Case study: Anglo-Scottish boundary year-round capability

3.4 Case study: Anglo-Scottish boundary year-round capability

Across the network there are many constrained boundaries that we manage on a day-to-day basis, one of which is the Anglo-Scottish boundary. Elsewhere in this chapter network capability focuses on winter peak power flows and winter peak capability. However, to ensure that the network is adequately designed for full year-round operation, further work is done on evaluating other key times of the year. This can include summer peak, summer minimum and other times such as autumn and spring peaks. The type of power transfer limits associated with the network will remain, such as thermal, voltage and stability. However, the absolute limits of the network would be expected to change.

A case study of the Anglo-Scottish boundary, which has recently been evaluated based on year-round capacity, is shown below.

Seasonal factors

There are many reasons why constraints manifest themselves at times other than winter peak including changes due to the network configuration, generation and demand patterns, transmission equipment outage patterns or the characteristics of transmission equipment related to ambient temperatures. Evaluating the system based on whole year-round planning conditions will allow a future network design to be the most economic and efficient based on expected full year-round operation.

This case study considers the Anglo-Scottish boundary of the system in a Scotland importing condition, which is sending power from England to Scotland. The analysis takes into account different periods of the year and associated generation and demand backgrounds. In Scotland the generation background considers times of the year when there may be little output from wind farms.

Securing the peak demand in Scotland at times of low wind generation output requires around 3GW of generation. After the Western HVDC link is completed for 2017/18, this generation requirement is expected to fall to approximately 1.5GW at winter peak demand in the period to the end of the current decade. This requirement can be met by existing conventional generation, including pump storage and hydro, in Scotland.

Case study: Anglo-Scottish boundary year-round capability

Figure 3.10
Anglo-Scottish boundary flows for 2014/15
(positive for Scotland to England, negative for England to Scotland)

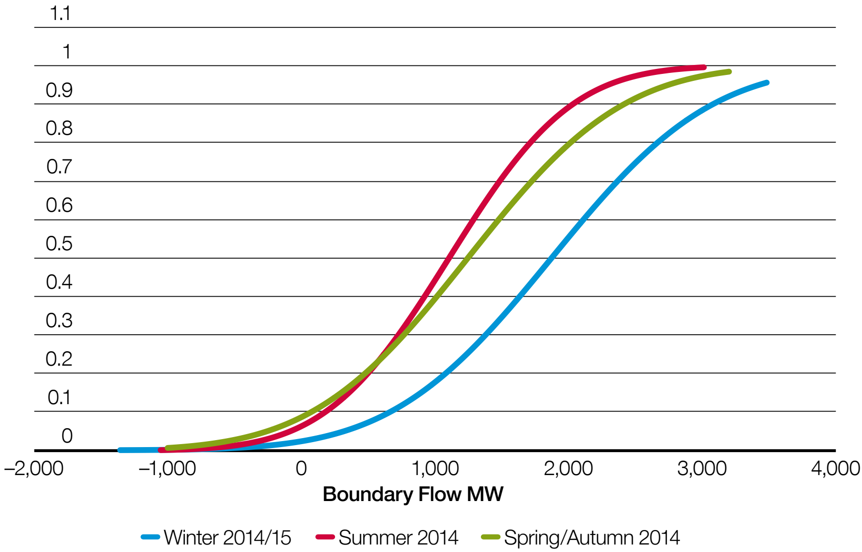


Figure 3.10 shows how the transmission system flows across the Anglo-Scottish boundary vary with the seasons and the differences even within season. The boundary flows above are constrained boundary flows, following actions by the system operator for constraints above the boundary.

For the majority of the time in 2014/15, power flows from Scotland to England across the Anglo-Scottish boundary. The highest flow in winter 2014/15 was around 3.5GW, Scotland to England, while the constrained spring peak flow was 3.2GW, and the constrained summer peak flow was 2.5GW, Scotland to England.

In addition to carrying power from Scotland to England, the system also has to be capable of carrying power in the opposite direction. The capability of the system at different times of the year is shown in Table 3.1 below.

Table 3.1
Anglo-Scottish boundary import limits (England to Scotland)

Year	Boundary	Summer capability	Winter capability
2015/16	Anglo-Scottish	2GW	2.55GW
2017/18	Anglo-Scottish	3.6GW	3.9GW

The current import (England to Scotland) capability of the system in summer and winter respectively is 2GW and 2.55GW, increasing to 3.6GW and 3.9GW in 2017/18, mainly because the Western Link will have been completed. The capability of the transmission system across the Anglo-Scottish boundary is expected to be sufficient to manage whole year-round importing condition in the near future, including times of low wind generation within Scotland. As with other boundaries, power flows will continue to be monitored for change and actions taken as appropriate to ensure system security is maintained.

Continuing the conversation

Email us with your views on ETYS at:
transmission.etys@nationalgrid.com
and we will get in touch.

Join our mailing list to receive ETYS email updates. You can register at:
http://www.nationalgrid.com/updates

Please see Chapter four for our stakeholder activities programme for 2015/16.

Overview of transmission solution options

3.5
Overview of transmission solution options

Transmission companies in England, Wales and Scotland identify a range of transmission solution options when we plan the development of the NETS for the future. This first stage of the process is to identify credible solutions that provide additional transmission network capability across the transmission boundaries being considered.

We consider commercial, operational and asset solutions (either onshore, offshore or a combination of both). In this section, we discuss the various categories of solutions we consider in transmission network planning; however we will not be representing details of potential reinforcement options to meet the network requirements. Those options will be represented in the new Network Options Assessment (NOA) report.

The range of solutions should include both small-scale reinforcements with short lead-times and large-scale reinforcements that may have longer lead-times. An important factor of the reinforcement considered is the increase in incremental network capability and cost. Transmission solutions are presented in Table 3.2 in order of increasing likely cost.

Table 3.2
Potential transmission solutions

Category	Transmission solution	Nature of constraint: Thermal	Nature of constraint: Voltage	Nature of constraint: Stability	Nature of constraint: Fault levels
Low cost investment	Automatic switching schemes for alternative running arrangements *(automatic schemes that open or close selected circuit breakers to reconfigure substations on a planned basis for recognised faults)*	✓	✓	✓	✓
	Coordinated quadrature booster (QB) schemes *(automatic schemes to optimise existing QBs)*	✓	✓		
	Dynamic ratings *(circuits monitored automatically for their thermal and hence rating capability)*	✓			
	Enhanced generator reactive range through reactive markets *(generators contracted to provide reactive capability beyond the range obliged under the codes)*		✓	✓	
	Addition to existing assets of fast switching equipment for reactive compensation *(a scheme that switches in/out compensation in response to voltage levels which are likely to change post-fault)*		✓	✓	
	Demand side services which could involve storage (contracted for certain boundary transfers and faults) *(these allow peak profiling which can be used to ease boundary flows)*	✓	✓		
	Protection changes *(faster protection can help stability limits while thermal capabilities might be raised by replacing protection apparatus such as current transformers (CTs))*	✓		✓	
Operational	Availability contract *(contract to make generation available, capped, more flexible and so on to suit constraint management)*	✓	✓	✓	
	Intertrip *(normally to trip generation for selected events but could be used for demand side services)*	✓	✓	✓	
	Reactive demand reduction *(this could ease voltage constraints)*		✓		
	Generation advanced control systems *(such as faster exciters which improve transient stability)*		✓	✓	
Investment	'Hot-wiring' overhead lines *(re-tensioning OHLs so that they sag less, insulator adjustment and ground works to allow greater loading which in effect increases their ratings)*	✓			
	Overhead line re-conductoring or cable replacement *(replacing the conductors on existing routes with ones with a higher rating)*	✓			
	Reactive compensation in shunt or series arrangements (MSC, SVC, reactors) (*shunt compensation improves voltage performance and relieves voltage constraint. Series compensation lowers series impedance which improves stability and reduces voltage drop)*		✓	✓	
	Switchgear replacement *(to improve thermal capability or fault level rating which in turn provides more flexibility in system operation and configuration. This would be used to optimise flows and hence boundary transfer capability)*	✓			✓
	New build (HVAC/HVDC) *(new plant on existing or new routes)*	✓	✓	✓	✓

Overview of transmission solution options

Operational and commercial options

Changes to operational policies and procedures may provide additional capability to the transmission system. An example would be a move to provide significantly increased quadrature booster actions following a fault. This would allow power to be redistributed more effectively after a fault to mitigate circuit overloading. Changes to operational policies and procedures will be developed in response to system requirements, taking into account operational practicality.

In order to provide a more economic and efficient electricity transmission system, National Grid, as the NETSO, also explores non-build transmission solutions to help resolve potential transmission system issues.

Examples of non-build transmission solutions include demand side management, inter-trips and reactive power services. These non-build options could negate the need for asset investment and construction. As we continue to develop opportunities in this area, we will discuss options with our stakeholders.

Onshore options

We could increase the capability of the transmission system by building major new infrastructure, by reinforcing existing routes, using new technologies or developing new routes. We carry out robust analysis of all options and the analysis is presented to the public and other stakeholders in the local communities.

In carrying out the options analysis, we apply two primary principles set out in the Electricity Act 1989 and the transmission licences:

- to develop an economic, efficient and coordinated transmission system;
- to have due regard to the environment.

With regard to the second of these principles, National Grid maintains a stakeholder, community and amenity policy[9] which defines the commitments when undertaking works.

In accordance with this policy, construction of electricity lines along new routes, or above-ground installations in new locations, will only be pursued as an option where:

- the existing infrastructure cannot be technically or economically upgraded to meet system security standards and regulatory obligations
- forecast increases in demand for electricity will not be satisfied by other means
- new customer connections are required.

All reinforcement needs are assessed using these criteria, which leads to the following approach for considering high-level network options.

[9] http://www2.nationalgrid.com/uk/services/land-and-development/planning-authority/community-consultation/

Figure 3.11
High-level network option considerations

Utilise existing assets	Upgrade existing assets	Replace existing assets	Construct new assets
	E.g. increase the thermal capability of an existing overhead line	E.g. reconductor an existing overhead line	E.g. construct a new transmission circuit

Figure 3.11, which presents our logic chain for the selection of network options, shows that the first option we consider is using existing assets to meet the needs of customers. If this is not possible, we consider upgrading existing assets, using techniques such as 'hot-wiring' circuits or employing innovative technologies. Beyond that, we consider replacing existing assets with assets of a higher capability, such as reconductoring an existing overhead line with a higher-rated conductor, or replacing a transformer with a higher-rated model. The construction of any major new infrastructure will be taken forward only if, after careful consideration, it is the most viable option to meet future network requirements.

Where there is a defined need case to improve the transmission system beyond the capability of existing assets, so new assets need to be installed, the various options for resolving the limitation are considered in detail. Stakeholders are consulted widely over what options have been considered as part of the planning process.

Offshore options

When considering the connection of offshore generation, particularly from the large offshore wind zones, two different design philosophies have been considered:

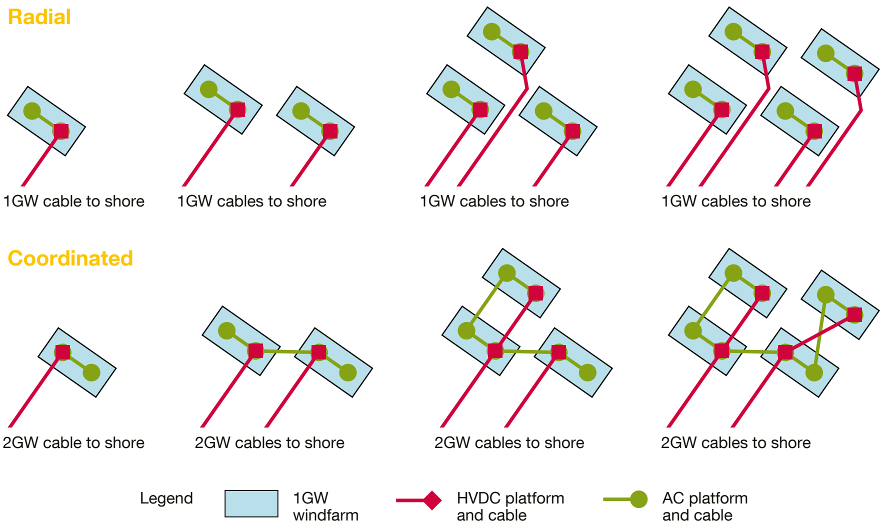
- Radial – a point-to-point connection from the offshore substation to a suitable onshore collector substation, using currently available transmission technology
- Coordinated – a coordinated onshore and offshore design approach, with AC cables and HVDC interconnection between offshore platforms and development zones.

This is optimised for an economic and efficient holistic design.

Figure 3.12 shows how the different design strategies affect the design of an illustrative 4GW offshore windfarm development. The network design is developed to be delivered in stages to aid timely investment and minimise stranding risk. Interconnection between the offshore platforms occurs at a later stage (shown as stage two in Figure 3.12) of the coordinated design strategy.

Overview of transmission solution options

Figure 3.12
Radial and coordinated offshore connections



In the event of the loss of any single offshore cable, the coordinated design strategy provides an alternative path for the power to the onshore collector substation. While there may not be sufficient transmission capacity to accommodate the full generation output following an outage, there should be sufficient capacity to cover the majority of the output. If the onshore connection points are separate, then interconnection offshore by the coordinated design provides a new transmission path between the two points. If at least one of the circuits is of HVDC construction then the flow of power is directly controllable. This capability is very useful for network operation as both onshore and offshore power flows can be operationally controlled by the influence of the HVDC circuits, thus providing additional resilience which is not catered for in radial designs.

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

HVDC systems, particularly the modern VSC designs, allow for direct active control of the power passing from one end to the other of DC circuits. When combined with offshore interconnection and the parallel operation with the onshore system, this can benefit the onshore power flows. By boosting or restricting power flow along the offshore HVDC circuits, power flow in the AC onshore system may be directed away from areas of electrical constraint. This active power control is a distinct advantage over more traditionally passive AC circuits.

Chapter four

The way forward

The way forward

4.1
Continuous development

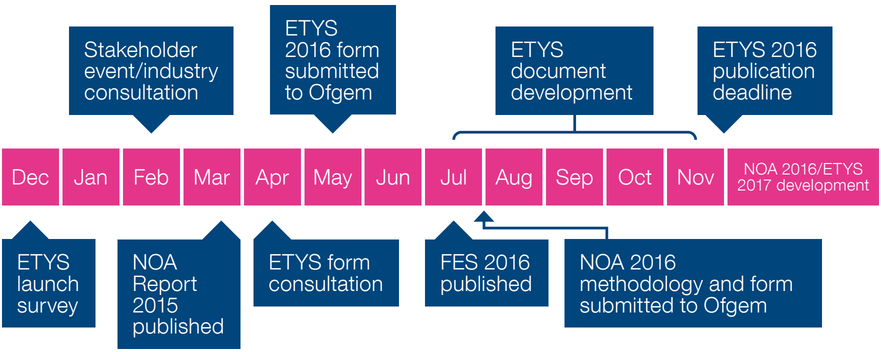
The ETYS is changing and so is our annual planning process. We welcome your feedback on these latest developments.

We have responded to the ITPR project by making some changes to our annual network development process.

The ETYS now focuses on communicating the transmission requirement of bulk power transfer to our stakeholders, while the NOA report (to be published in March 2016) will recommend the SO preferred options for network reinforcements. In the coming months we will discuss with our regulator, Ofgem, how best to use the ETYS and the NOA report as a way to communicate with our stakeholders about the future development, opportunities and challenges in the NETS.

We would like to hear your views on how we should shape both documents to meet your expectations – an indicative timetable for our 2016 ETYS/NOA stakeholder activities programme is shown in Figure 4.1.

Figure 4.1
ETYS/NOA stakeholder activities programme



Please complete our launch survey **https://www.surveymonkey.com/r/ETYS2015** and take part in our written consultation on the form of 2016 ETYS (planned for April 2016). Our various stakeholder activities are a great way for us to:

- identify and understand the views and opinions of all our stakeholders
- provide opportunities for constructive feedback and debate
- create open, two-way communication with our stakeholders about assumptions, drivers and outputs
- let stakeholders know how we have taken their views into consideration and the outcomes of our engagement activities.

We are always happy to listen to our stakeholders' views, including:

- at consultation events as part of the customer seminars
- at operational forums
- through responses to **transmission.etys@nationalgrid.com**
- at bilateral stakeholder meetings.

Continuing the conversation

Join our mailing list to receive ETYS email updates. You can register at **http://www.nationalgrid.com/updates**

The way forward

4.2
Improving your experience

We have created an interactive tool to help you access network information in a user-friendly way

You can use our Customer Connection Interface Tool (CCIT) to find out more about transmission sites, current and future generation connections and development times, and to understand the challenges we face in developing the NETS.

Since we introduced Connect and Manage in February 2011, we have been offering connection dates to our generation customers based on the time taken to complete a project's 'enabling works' – in other words, ahead of the completion of any wider transmission system reinforcements that are required under the NETS SQSS. The transmission requirement we present in the ETYS refers to the wider transmission system reinforcements only.

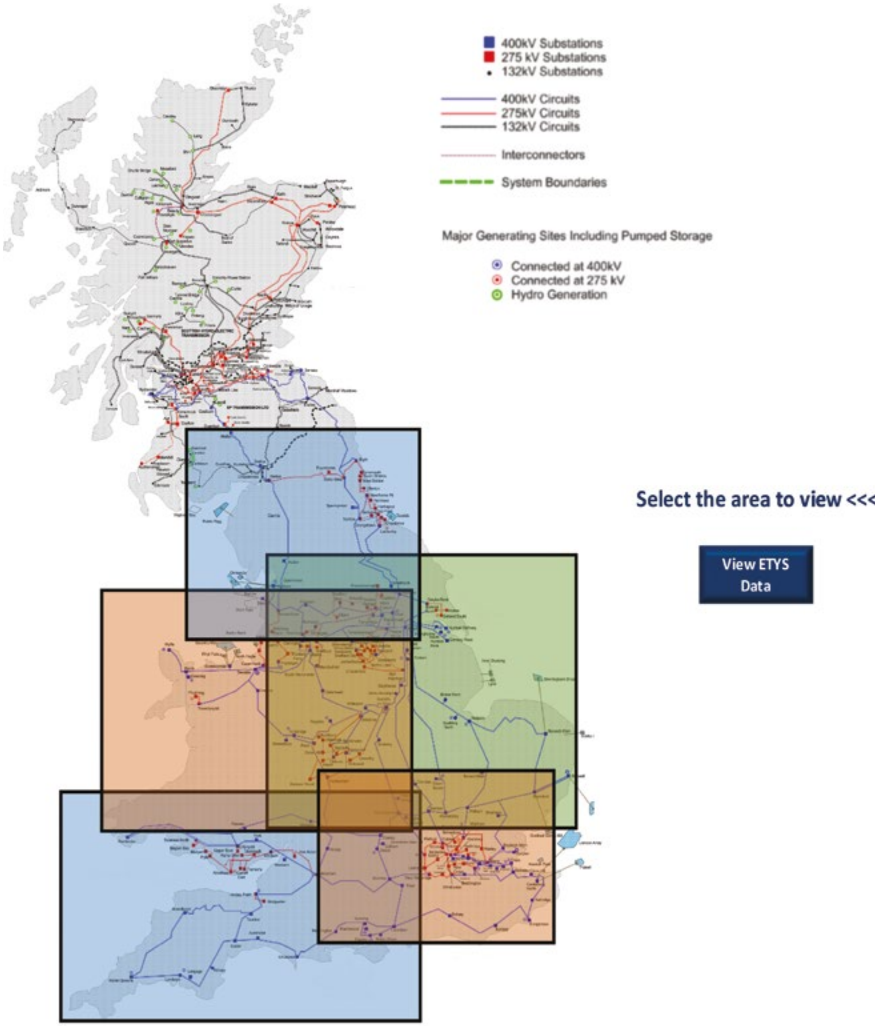
For more information on Connect and Manage visit: **http://www2.nationalgrid.com/UK/Services/Electricity-connections/Industry-products/connect-and-manage/**

A quick guide to the CCIT
We presented a CCIT prototype (showing information of East Anglia) at our London and Glasgow customer seminars in early 2015. We used feedback from these events to further develop the tool and expand it to include all of England and Wales. We then showcased it at our October 2015 customer seminar, where we received very positive comments.

The CCIT is not a complete decision-making tool; instead, it complements the current application process and provides user-friendly access to information so that customers are better informed before their initial discussions with National Grid. It does not replace the current application process and should not be used in isolation to assess connections.

Figure 4.2 shows the CCIT dashboard, where the user can select an area.

Figure 4.2
CCIT dashboard



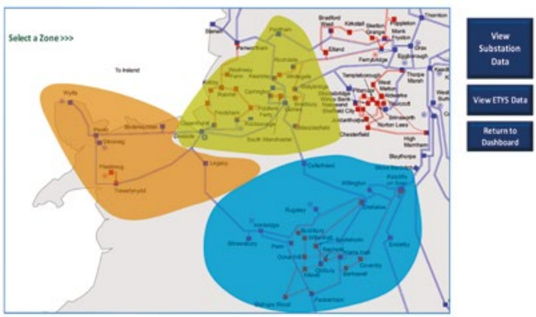
Chapter four

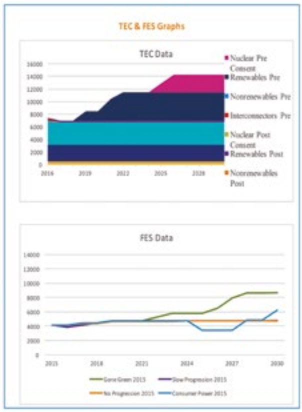
The way forward

The CCIT presents the following data:

- a graphical representation of capacity in the area – using the Transmission Entry Capacity (TEC) Register data (which represents contracted generation) and FES data to show plausible future scenarios (see Figure 4.3)
- information about substations in England and Wales
- a colour-coded heat map (see Figure 4.4) illustrating expected connection capacity and time frames
- data related to incremental wider works in various parts of the network.

Figure 4.3
TEC and FES data representation in the CCIT

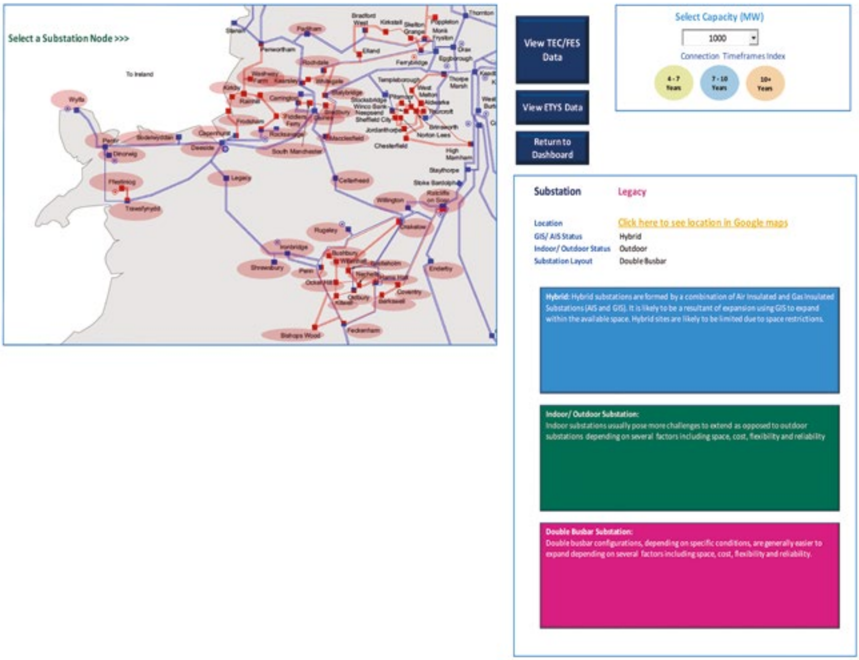




Transmission Entry Capacity (TEC) Report in selected area as on 11/5/2015
Interconnector Report as on 11/5/2015

Project Name	Connection Site	MW Connected	Increase/ Decrease	MW Effective Date	Project Status	Plant Type
Burbo Bank Extension Offshore Wind Farm	NGET Bodelwyddan 400kV Substation	0	254	31/05/2016	Under Construction/Com	Wind Offshore
Codling Park Wind Farm	Pentir Substation	0	1000	31/03/2021	Scoping	Wind Offshore
Connahs Quay	Deeside 400kV Substation	1380	0		Built	CCGT
Cwm Dyli	Trawfynydd	10	0		Built	Hydro
Deeside	Deeside 400kV Substation	260	-259	01/04/2016	Built	CCGT
Dinorwig	Dinorwig 400kV Substation	1644	0		Built	Pump Storage
Dolgarrog	Pentir	39	0		Built	Hydro
Ffestiniog	Ffestiniog 275kV Substation	360	0		Built	Pump Storage
Greenwire Wind Farm - Pembroke	Pembroke 400kV Substation	0	2000	31/10/2020	Scoping	Wind Offshore
Gwynt Y Mor Offshore Wind Farm	Gwynt y Mor 132/33kV Offshore Substation	574	0		Built	Wind Offshore
Marex	Connahs Quay 400kV	0	1500	31/10/2018	Scoping	Pump Storage
Pembroke Power Station	Pembroke 400kV Substation	2199	0		Built	CCGT
Shotton	Deeside 400kV Substation	0	0		Built	CHP
Wylfa	Wylfa 400kV Substation	450	-450	01/04/2016	Built	Nuclear
Wylfa Newydd	Wylfa 400kV Substation	0	1400	01/06/2024	Scoping	Nuclear
Wylfa Newydd	Wylfa 400kV Substation	0	1400	01/06/2025	Scoping	Nuclear
Wylfa Newydd	Wylfa 400kV Substation	0	1400	01/06/2025	Scoping	Nuclear
Wylfa Newydd	Wylfa 400kV Substation	0	1400	01/06/2025	Scoping	Nuclear
Wylfa Newydd	Wylfa 400kV Substation	0	1400	01/06/2024	Scoping	Nuclear
Wylfa Newydd	Wylfa 400kV Substation	0	1400	01/06/2025	Scoping	Nuclear
East West Interconnector	Deeside 400kV Substation	500	5		Built	Interconnector

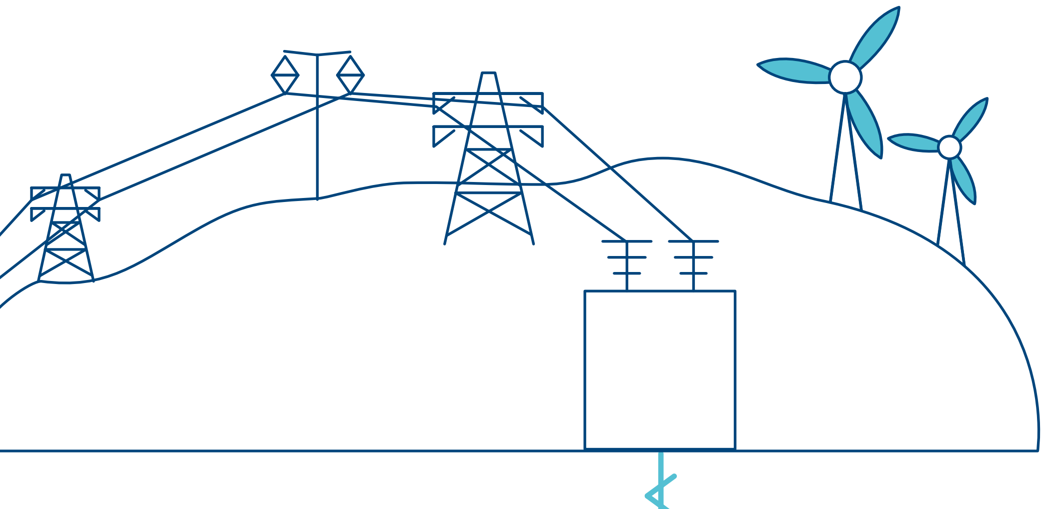
Figure 4.4
Substation data and heat map including Google Maps link (for illustration purposes only) in the CCIT



We are developing the CCIT in stages – this is a SO-supported tool that requires significant input from the TOs which currently only covers the England and Wales transmission network. We have started discussions with the Scottish TOs to review the potential benefits of extending the tool to include information of the Scottish transmission network. Based on stakeholders feedback, we will together explore the requirements to maintain the tool to provide GB-wide coverage.

You can find the latest version of the CCIT at: **http://www2.nationalgrid.com/WorkArea/DownloadAsset.aspx?id=43739**

You can also find the user guide at: **http://www2.nationalgrid.com/WorkArea/DownloadAsset.aspx?id=43759**



Chapter five

Appendices overview

Appendix A – System schematics and geographic drawings
Appendix A includes a set of system schematics and geographic drawings of the current NETS, with the approximate locations of existing power stations and reactive compensation plants shown. The schematics also show the NETS boundaries and ETYS zones we have used in our analysis.

You can view the system schematics and geographic drawings at:
http://www2.nationalgrid.com/WorkArea/DownloadAsset.aspx?id=43749

Appendix B – System technical data
To allow modelling of the transmission network, basic network parameters such as connectivity and impedances are provided in appendix B. The expected changes in the network based on the previous year's development decisions are also provided.

You can view the system technical data at:
http://www2.nationalgrid.com/WorkArea/DownloadAsset.aspx?id=43747

Appendix C – Power flow diagrams
To demonstrate the impact of future changes on the transmission network a set of winter peak power flow diagrams are presented in appendix C. These show snapshots of present and future power flows along major circuit routes for the Gone Green scenario. The expected changes in the network are based on the previous year's development decisions.

You can view the diagrams at:
http://www2.nationalgrid.com/WorkArea/DownloadAsset.aspx?id=43746

Appendix D – Fault levels
Appendix D gives indications of peak GB fault levels at nodal level for the current and future transmission network. The fault levels are at peak generation and demand conditions and can be used to investigate local area system strength.

You can find out more at:
http://www2.nationalgrid.com/WorkArea/DownloadAsset.aspx?id=43745
You can view the fault level data at:
http://www2.nationalgrid.com/WorkArea/DownloadAsset.aspx?id=43744

Appendix E – Technology
The transmission network is made of many different equipment types. Descriptions of the different equipment, its capabilities, usage, limitations and expectations for development are presented in appendix E.

You can find out more at:
http://www2.nationalgrid.com/WorkArea/DownloadAsset.aspx?id=43742

Appendix F – Generation data
Appendix F provides details of the GB contracted generation at the time of FES and ETYS production complete with future connection dates, capacities, transmission connection locations by zone and fuel types. A mapping table of ETYS transmission zones to boundaries is also provided.

You can view the generation data at:
http://www2.nationalgrid.com/WorkArea/DownloadAsset.aspx?id=43741

Appendix G – Demand data
Grid Supply Point winter peak demand data as supplied by the Distribution Networks Operators and Non-Embedded Customers is supplied in appendix G.

You can view the demand data at:
http://www2.nationalgrid.com/WorkArea/DownloadAsset.aspx?id=43761

Appendix H – Transmission losses
Appendix H gives expected transmission losses of the NETS at time of GB peak demand. The transmission losses come from both fixed losses and load related losses.

You can find out more at:
http://www2.nationalgrid.com/WorkArea/DownloadAsset.aspx?id=43740

Meet the ETYS team

Leadership team

Richard Smith
Head of Network Capability (Electricity)
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Julian Leslie
Electricity Network Development Manager
Julian.Leslie@nationalgrid.com

John West
Electricity Policy and Performance Manager
John.West@nationalgrid.com

Electricity Network Development

In addition to preparing the ETYS for publication we are responsible for developing a holistic strategy for the electricity transmission system. We use the FES and sensitivities around them for our analysis. We also:

- manage and implement the Network Development Policy which assesses the need to progress wider transmission system reinforcements
- recommend preferred options for GB transmission network investment under the new ITPR arrangements
- manage the technical activities relating to offshore electricity network design
- facilitate system access for development or maintenance activities while ensuring the system can be operated both securely and economically.

Contact Nick Harvey to discuss:

Network requirements
Network Options Assessment

Nick Harvey
Network Development Strategy Manager
Nicholas.Harvey@nationalgrid.com

Don't forget you can also email us with your views on ETYS at:
transmission.etys@nationalgrid.com

You can also join our mailing list to receive ETYS email updates at:
http://www.nationalgrid.com/updates

Electricity Policy and Performance

We are responsible for a variety of power system issues including generator and HVDC compliance. We also provide power system models and datasets for network analysis. Our works also includes managing the technical aspects of the GB and European electricity frameworks, codes and standards that are applicable to network development.

You can contact Xiaoyao Zhou to discuss:

Network data

Xiaoyao Zhou
Data and Modelling Manager
Xiaoyao.Zhou@nationalgrid.com

Meet the ETYS team

Supporting parties

Strategic network planning and producing the ETYS requires support and information from many people. Parties who provide the support and information that makes our work possible include:

- National Grid ETO
- SP Transmission
- SHE Transmission
- our customers.

Glossary

Acronym	Term	Definition
	Ancillary services	Services procured by a system operator to balance demand and supply and to ensure the security and quality of electricity supply across the transmission system. These services include reserve, frequency control and voltage control. In GB these are known as balancing services and each service has different parameters that a provider must meet.
ACS	Average cold spell	Average cold spell is defined as a particular combination of weather elements which gives rise to a level of winter peak demand which has a 50% chance of being exceeded as a result of weather variation alone. There are different definitions of ACS peak demand for different purposes.
	Boundary allowance	An allowance in MW to be added in whole or in part to transfers arising out of the NETS SQSS economy planned transfer condition to take some account of year-round variations in levels of generation and demand. This allowance is calculated by an empirical method described in Appendix F of the security and quality of supply standards (SQSS).
	Boundary transfer capacity	The maximum pre-fault power that the transmission system can carry from the region on one side of a boundary to the region on the other side of the boundary while ensuring acceptable transmission system operating conditions will exist following one of a range of different faults.
CCS	Carbon capture and storage	Carbon (CO_2) Capture and Storage (CCS) is a process by which the CO_2 produced in the combustion of fossil fuels is captured, transported to a storage location and isolated from the atmosphere. Capture of CO_2 can be applied to large emission sources like power plants used for electricity generation and industrial processes. The CO_2 is then compressed and transported for long-term storage in geological formations or for use in industrial processes.
	Climate change targets	Targets for share of energy use sourced from renewable sources. The 2020 UK targets are defined in the Directive 2009/28/EC of the European Parliament and of the Council of the European Union, see http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32009L0028&from=EN#ntc1-L_2009140EN.01004601-E0001
CCGT	Combined cycle gas turbine	Gas turbine that uses the combustion of natural gas or diesel to drive a gas turbine generator to generate electricity. The residual heat from this process is used to produce steam in a heat recovery boiler which in turn, drives a steam turbine generator to generate more electricity.
CHP	Combined heat and power	A system whereby both heat and electricity are generated simultaneously as part of one process. Covers a range of technologies that achieve this.
CP	Consumer Power	A Future Energy Scenario. Consumer Power is a world of relative wealth, fast-paced research and development and spending. Innovation is focused on meeting the needs of consumers, who focus on improving their quality of life.
	Contracted generation	A term used to reference any generator who has entered into a contract to connect with the National Electricity Transmission System (NETS) on a given date while having a transmission entry capacity (TEC) figure as a requirement of said contract.
CBA	Cost benefit analysis	A method of assessing the benfits of a given project in comparison to the costs. This tool can help to provide a comparative base for all projects to be considered.
DSR	Demand side response	A deliberate change to an industrial and commercial user's natural pattern of metered electricity or gas consumption, brought about by a signal from another party.
DECC	Department of Energy & Climate Change	A UK government department. The Department of Energy & Climate Change (DECC) works to make sure the UK has secure, clean, affordable energy supplies and promote international action to mitigate climate change.
DNO	Distribution Network Operator	Distribution network operators own and operate electricity distribution networks.

Glossary

Acronym	Term	Definition
	Double circuit overhead line	In the case of the onshore transmission system, this is a transmission line which consists of two circuits sharing the same towers for at least one span in SHE Transmission's system or NGET's transmission system or for at least two miles in SP Transmission system. In the case of an offshore transmission system, this is a transmission line which consists of two circuits sharing the same towers for at least one span.
	Embedded generation	Power generating stations/units that don't have a contractual agreement with the National Electricity Transmission System Operator (NETSO). They reduce electricity demand on the National Electricity Transmission System.
ENTSO-E	European Network of Transmission System Operators – Electricity	ENTSO-E is an association of European electricity TSOs. ENTSO-E was established and given legal mandates by the EU's Third Legislative Package for the Internal Energy Market in 2009, which aims at further liberalising electricity markets in the EU.
EU	European Union	A political and economic union of 28 member states that are located primarily in Europe.
FES	Future Energy Scenarios	The FES is a range of credible futures which has been developed in conjunction with the energy industry. They are a set of scenarios covering the period from now to 2050, and are used to frame discussions and perform stress tests. They form the starting point for all transmission network and investment planning, and are used to identify future operability challenges and potential solutions.
GTYS	Gas Ten Year Statement	The GTYS illustrates the potential future development of the (gas) National Transmission System (NTS) over a ten-year period and is published on an annual basis.
GW	Gigawatt	1,000,000,000 watts, a measure of power
GWh	Gigawatt hour	1,000,000,000 watt hours, a unit of energy
GG	Gone Green	A Future Energy Scenario. Gone Green is a world where green ambition is not restrained by financial limitations. New technologies are introduced and embraced by society, enabling all carbon and renewable targets to be met on time.
GB	Great Britain	A geographical, social and economic grouping of countries that contains England, Scotland and Wales.
GEP	Grid entry point	A point at which a generating unit directly connects to the national electricity transmission system. The default point of connection is taken to be the busbar clamp in the case of an air insulated substation, gas zone separator in the case of a gas insulated substation, or equivalent point as may be determined by the relevant transmission licensees for new types of substation. When offshore, the GEP is defined as the low voltage busbar on the platform substation.
GSP	Grid supply point	A point of supply from the GB transmission system to a distribution network or transmission-connected load. Typically only large industrial loads are directly connected to the transmission system.
HVAC	High voltage alternating current	Electric power transmission in which the voltage varies in a sinusoidal fashion, resulting in a current flow that periodically reverses direction. HVAC is presently the most common form of electricity transmission and distribution, since it allows the voltage level to be raised or lowered using a transformer.
HVDC	High voltage direct current	The transmission of power using continuous voltage and current as opposed to alternating current. HVDC is commonly used for point to point long-distance and/or subsea connections. HVDC offers various advantages over HVAC transmission, but requires the use of costly power electronic converters at each end to change the voltage level and convert it to/from AC.
IED	Industrial Emissions Directive	The Industrial Emissions Directive is a European Union directive which commits member states to control and reduce the impact of industrial emissions on the environment post-2015 when the Large Combustion Plant Directive (LCPD) expires.

Acronym	Term	Definition
ITPR	Integrated Transmission Planning and Regulation	Ofgem's Integrated Transmission Planning and Regulation (ITPR) project examined the arrangements for planning and delivering the onshore, offshore and cross-border electricity transmission networks. Ofgem published the final conclusions in March 2015.
	Interconnector	Electricity interconnectors are transmission assets that connect the GB market to Europe and allow suppliers to trade electricity between markets.
LCPD	Large Combustion Plant Directive	The Large Combustion Plant Directive is a European Union Directive which introduced measures to control the emissions of sulphur dioxide, oxides of nitrogen and dust from large combustion plant.
	Load factor	The average power output divided by the peak power output over a period of time.
MITS	Main Interconnected Transmission System	This comprises all the 400kV and 275kV elements of the onshore transmission system and, in Scotland, the132kV elements of the onshore transmission system operated in parallel with the supergrid, and any elements of an offshore transmission system operated in parallel with the supergrid, but excludes generation circuits, transformer connections to lower voltage systems, external interconnections between the onshore transmission system and external systems, and any offshore transmission systems radially connected to the onshore transmission system via single interface points.
	Marine technologies	Tidal streams, tidal lagoons and energy from wave technologies (see http://www.emec.org.uk/)
MW	Megawatt	1,000,000 Watts, a measure of power.
MWh	Megawatt hour	1,000,000 Watt hours, a measure of power usage or consumption in 1 hour.
	Merit order	An ordered list of generators, sorted by the marginal cost of generation.
NETS	National Electricity Transmission System	The National Electricity Transmission System comprises the onshore and offshore transmission systems of England, Wales and Scotland. It transmits high-voltage electricity from where it is produced to where it is needed throughout the country. The system is made up of high voltage electricity wires that extend across Britain and nearby offshore waters. It is owned and maintained by regional transmission companies, while the system as a whole is operated by a single system operator (SO).
NETSO	National Electricity Transmission System Operator	National Grid acts as the NETSO for the whole of Great Britain while owning the transmission assets in England and Wales. In Scotland, transmission assets are owned by Scottish Hydro Electricty Transmission Ltd (SHE Transmission) in the North of the country and Scottish Power Transmission (SP Transmission) in the South.
NETS SQSS	National Electricity Transmission System Security and Quality of Supply Standards	A set of standards used in the planning and operation of the national electricity transmission system of Great Britain. For the avoidance of doubt the national electricity transmission system is made up of both the onshore transmission system and the offshore transmission systems.
NGET	National Grid Electricity Transmission plc	National Grid Electricity Transmission plc (No. 2366977) whose registered office is 1-3 Strand, London, WC2N 5EH
NTS	National Transmission System	A high-pressure gas transportation system consisting of compressor stations, pipelines, multijunction sites and offtakes. NTS pipelines transport gas from terminals to NTS offtakes and are designed to operate up to pressures of 94 barg.
	Network access	Maintenance and system access is typically undertaken during the spring, summer and autumn seasons when the system is less heavily loaded and access is favourable. With circuits and equipment unavailable the integrity of the system is reduced. The planning of the system access is carefully controlled to ensure system security is maintained.
NOA	Network Options Assessment	The NOA is the process for assessing options for reinforcing the National Electricity Transmission System (NETS) to meet the requirements that the sytem operator (SO) finds from its analysis of the Future Energy Scenarios (FES).

Glossary

Acronym	Term	Definition
NP	No Progression	A Future Energy Scenario. No Progression is a world focused on achieving security of supply at the lowest possible cost. With low economic growth, traditional sources of gas and electricity dominate, with little innovation affecting how we use energy.
Ofgem	Office of Gas andElectricity Markets	The UK's independent National Regulatory Authority, a non-ministerial government department. Their principal objective is to protect the interests of existing and future electricity and gas consumers.
	Offshore	This term means wholly or partly in offshore waters.
	Offshore transmission circuit	Part of an offshore transmission system between two or more circuit breakers which includes, for example, transformers, reactors, cables, overhead lines and DC converters but excludes busbars and onshore transmission circuits.
	Onshore	This term refers to assets that are wholly on land.
	Onshore transmission circuit	Part of the onshore transmission system between two or more circuit breakers which includes, for example, transformers, reactors, cables and overhead lines but excludes busbars, generation circuits and offshore transmission circuits.
OCGT	Open cycle gas turbine	Gas turbines in which air is first compressed in the compressor element before fuel is injected and burned in the combustor.
	Peak demand	The maximum power demand in any one fiscal year: Peak demand typically occurs at around 5:30pm on a week-day between December and February. Different definitions of peak demand are used for different purposes.
pa	Per annum	Per year.
PV	Photovoltaic	A method of converting solar energy into direct current electricity using semi-conducting materials.
	Planned transfer	A term to describe a point at which demand is set to the National Peak when analysing boundary capability.
	Power supply background (aka generation background)	The sources of generation across Great Britain to meet the power demand.
	Ranking order	A list of generators sorted in order of likelihood of operation at time of winter peak and used by the NETS SQSS.
	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 power.
	Real power	This term (sometimes referred to as 'Active Power') provides the useful energy to a load. In an AC system, real power is accompanied by reactive power for any power factor other than 1.
	Seasonal circuit ratings	The current carrying capability of circuits. Typically, this reduces during the warmer seasons as the circuit's capability to dissipate heat is reduced. The rating of a typical 400kV overhead line may be 20% less in the summer than in winter.
	SHE Transmission	Scottish Hydro-Electric Transmission (No.SC213461) whose registered office is situated at Inveralmond HS, 200 Dunkeld Road, Perth, Perthshire PH1 3AQ.
SP	Slow Progression	A Future Energy Scenario. Slow Progression is a world where slower economic growth restricts market conditions. Money that is available is spent focusing on low cost long-term solutions to achieve decarbonisation, albeit it later than the target dates.
	SP Transmission	Scottish Power Transmission Limited (No. SC189126) whose registered office is situated at 1 Atlantic Quay, Robertson Street, Glasgow G2 8SP.

Acronym	Term	Definition
	Summer minimum	The minimum power demand off the transmission network in any one fiscal year: Minimum demand typically occurs at around 06:00am on a Sunday between May and September.
	Supergrid	That part of the national electricity transmission system operated at a nominal voltage of 275kV and above.
SGT	Supergrid transformer	A term used to describe transformers on the NETS that operate in the 275–400kV range.
	Switchgear	The term used to describe components of a substation that can be used to carry out switching activities. This can include, but is not limited to, isolators/disconnectors and circuit breakers.
	System inertia	The property of the system that resists changes. This is provided largely by the rotating synchronous generator inertia that is a function of the rotor mass, diameter and speed of rotation. Low system inertia increases the risk of rapid system changes.
	System operability	The ability to maintain system stability and all of the asset ratings and operational parameters within pre-defined limits safely, economically and sustainably.
SOF	System Operabiltiy Framework	The SOF identifies the challenges and opportunities which exist in the operation of future electricity networks and identifies measures to ensure the future operability.
SO	System Operator	An entity entrusted with transporting energy in the form of natural gas or power on a regional or national level, using fixed infrastructure. Unlike a TSO, the SO may not necessarily own the assets concerned. For example, National Grid operates the electricity transmission system in Scotland, which is owned by Scottish Hydro Electricity Transmission and Scottish Power.
	System stability	With reduced power demand and a tendency for higher system voltages during the summer months, fewer generators will operate and those that do run could be at reduced power factor output. This condition has a tendency to reduce the dynamic stability of the NETS. Therefore network stability analysis is usually performed for summer minimum demand conditions as this represents the limiting period.
TYNDP	Ten Year Network Development Plan	The TYNDP is published in accordance with Regulation (EC) 714/2009. The regulation requests the European Network of Transmission System Operators for Electricity (ENTSO-E) to produce the non-binding community-wide TYNDP every two years.
	Transmission circuit	This is either an onshore transmission circuit or an offshore transmission circuit.
TEC	Transmission entry capacity	The maximum amount of active power deliverable by a power station at its grid entry point (which can be either onshore or offshore). This will be the maximum power deliverable by all of the generating units within the power station, minus any auxiliary loads.
	Transmission losses	Power losses that are caused by the electrical resistance of the transmission system.
TO	Transmission Owners	A collective term used to describe the three transmission asset owners within Great Britain, namely National Grid Electricity Transmission, Scottish Hydro-Electric Transmission Limited and SP Transmission Limited.
TSO	Transmission System Operators	An entity entrusted with transporting energy in the form of natural gas or power on a regional or national level, using fixed infrastructure.

ETYS 2015 feedback form

Thank you for taking the time to complete our survey. We are really keen to capture your thoughts and comments on this year's ETYS so we can continue to develop the statement using your feedback.

You can return this questionnaire to us by:

Post
NDS, Electricity Network Development
National Grid House
Warwick Technology Park
Gallows Hill, Warwick
CV34 6DA

Email
Take a photo of the completed questionnaire, and email it to us at **transmission.etys@nationalgrid.com**

Online
Complete the questionnaire online at **www.surveymonkey.com/r/ETYS2015**

We may like to contact you further about your survey response to ensure we really understand your requirements. If you would prefer not to be contacted, please tick here ☐

Please tell us about yourself:

Name ____________________

Email address ____________________

Job title ____________________

Organisation ____________________

Have you read our Electricity Ten Year Statement before?

☐ Yes ☐ No

Have you read any of the following publications? (please tick all that apply)

☐ Gas Ten Year Statement
☐ System Operability Framework
☐ Future Energy Scenarios
☐ None of the above

Why are you interested in the ETYS? (please tick all that apply)

☐ To understand future requirements to develop the National Electricity Transmission System (NETS)
☐ To understand patterns of supply/demand
☐ To understand why/how transmission companies invest in the NETS
☐ To find data/facts/figures about the NETS
☐ For general interest
☐ Other

Please explain your choice

Which chapters/appendices of ETYS are of most value to you? (please tick up to 3)

☐ Executive summary
☐ Chapter 1: Introduction
☐ Chapter 2: The Future Energy Scenarios
☐ Chapter 3: The electricity transmission network
☐ Chapter 4: The way forward
☐ Appendix A: System schematics and geographic drawings
☐ Appendix B: System technical data
☐ Appendix C: Power flow diagrams
☐ Appendix D: Fault levels
☐ Appendix E: Technology
☐ Appendix F: Generation data
☐ Appendix G: Demand data
☐ Appendix H: Transmission losses

Please explain your choice

Which chapters/appendices of ETYS are of least value to you? (please tick up to 3)

- ☐ Executive summary
- ☐ Chapter 1: Introduction
- ☐ Chapter 2: The Future Energy Scenarios
- ☐ Chapter 3: The electricity transmission network
- ☐ Chapter 4: The way forward
- ☐ Appendix A: System schematics and geographic drawings
- ☐ Appendix B: System technical data
- ☐ Appendix C: Power flow diagrams
- ☐ Appendix D: Fault levels
- ☐ Appendix E: Technology
- ☐ Appendix F: Generation data
- ☐ Appendix G: Demand data
- ☐ Appendix H: Transmission losses

Please explain your choice

In your opinion, how user-friendly is the ETYS?

- ☐ Very easy to find what I needed
- ☐ Quite easy to find what I needed
- ☐ Neither easy nor difficult to find what I needed
- ☐ Difficult to find what I needed
- ☐ Very difficult to find what I needed

Please explain your choice

Does the ETYS clearly illustrate the future needs and development requirements of the NETS?

☐ Yes ☐ No

If you answered No please let us know which elements were unclear

Overall, how satisfied are you with this year's ETYS?

- ☐ Very satisfied
- ☐ Satisfied
- ☐ Neither satisfied nor dissatisfied
- ☐ Dissatisfied
- ☐ Very dissatisfied

Please explain your choice

How can we improve the ETYS?

Is there any additional information you would like to see in the ETYS?

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