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Chapter 8

GB Transmission System Capability

Introduction

This chapter describes the capability of the GB transmission system to transport power at the time of the system ACS peak. The power system analyses underlying many of the results discussed in this chapter have been conducted on the basis of the deterministic SYS background. The deterministic SYS background comprises the customer based demand forecasts of Chapter 2 (Electricity Demand), the existing and future transmission contracted generation of Chapter 3 (Generation) and the existing and planned transmission network described in Chapter 6 (GB Transmission System).

It should be noted that calculated system capabilities are a function of the generation, demand and transmission background against which they are assessed. Accordingly, the computed capabilities reported in this chapter are those which would arise should the SYS background be realised at the time of system peak. At other times and/or against other backgrounds different transmission capabilities may arise.

As explained in previous chapters, there is uncertainty associated with the demand forecasts and with future generation developments. Thus, it should be recognised that the SYS background does not necessarily represent the most likely outcome, nor should it be regarded as a 'forecast' of the outcome. Uncertainties in demand and generation developments will affect future power transfers, transmission system capabilities, the need or otherwise for transmission system reinforcements and the opportunities for making new or further use of the transmission system.

In view of this, the transfers and capabilities arising from the deterministic SYS background have been presented against the backdrop of a range of probabilistic transfers. These probabilistic transfers reflect, in part, our current views on a range of criteria, which influence the likely future outcome given the various generation and demand uncertainties. This presentation is intended to provide a more meaningful view of future transfers, promote a better appreciation of the future uncertainty we face in planning the system and enable the reader to make more informed judgements on the opportunities for making new or further use of the transmission system.

The chapter also identifies those reinforcements which could be required, in addition to the planned reinforcements presented in Chapter 6 (GB Transmission System), to achieve compliance with the Licence Standard on the basis of the SYS background. These additional reinforcements are subject to variation and should be regarded as indicative only.

In addition, a new section has been incorporated that refers to the work undertaken by the ENSG (Electricity Networks Strategy Group) in analysing what reinforcements would be required to meet the UK environmental targets, but in particular the electricity share of the renewable 2020 target.

The probabilistic range of transfers, which are presented in this chapter, have been derived using a National Grid program called the Generation Uncertainty Model (GUM). To provide a greater understanding of the probabilistic results presented and how they should be interpreted, the chapter includes a high level description of GUM.

System Boundaries

An understanding of the capability of the GB transmission system to transport power leads to an understanding of the ability of the GB transmission system to accommodate further generation and demand in different zones across the system. When considering the capability of the system, it is useful to consider the limits on the bulk transfer of power across certain system boundaries.

Accordingly, this chapter reports on a number of key boundary capabilities and, for this purpose, the 17 SYS boundaries described in "SYS Boundaries and SYS Study Zones" in Chapter 6 and shown graphically in Figure A.1.5. These boundaries are also shown in Figure A.2.3 for SHETL, Figure A.3.3 for SPT and Figure A.4.3 for NGET. These 17 boundaries have historically reflected some of the main weaknesses on the interconnected system. Such weaknesses can lead to the need to restrict power flows across the system; possibly through the potentially uneconomic constrained operation of generating plant. Alternatively, weaknesses in transmission may be removed by transmission reinforcement. Although the most critical boundaries may not be precisely the same as those studied, the 17 boundaries which have been used remain relevant for illustrating system trends and limitations.

Consideration of the range of possible future transfers across each of the 17 boundaries enables us to describe the type of reinforcement schemes, which may be required in order to ensure continued compliance with the Licence Standard.

Boundary Capabilities and Required Capabilities

Two types of system limitation, relating to the transfer of power across a boundary, have been considered. The first relates to thermal capability and the second to voltage capability. The boundary capabilities have been evaluated for the time of the system winter peak demand in 2011/12, 2013/14, 2015/16 and 2017/18 and are on the basis of the SYS background. These capabilities will, of course, potentially change at off-peak times but, as explained in "Off-Peak Power Flows" in Chapter 7, in the 'real time' operational time-phase, the system is managed such that it complies at all times with operational criteria of the Licence Standard.

As mentioned above, the Licence Standard defines certain unacceptable conditions, which shall not occur as a result of specific secured events. The unacceptable conditions referred to include:

- loss of supply capacity (except as permitted by specific demand connection criteria);
- unacceptable overloading of any primary transmission equipment;
- unacceptable voltage conditions or insufficient voltage performance margins; and
- system instability.

For example, in the case of planning the development of the Main Interconnected Transmission System, a boundary in which a single circuit is out of service due to a fault, must be capable of transferring the Planned Transfer (as defined in the Licence Standard) plus an allowance (also specified in the Licence Standard) to take account of non-average conditions (e.g. relating to power station availability, weather and demand) without any of the above unacceptable conditions arising. The allowance, referred to, is calculated by an empirical method described in the Licence Standard and is called the "Interconnection Allowance".

Similarly, the Licence Standard also requires that a boundary, in which two circuits are out of service (i.e. N-2 or N-D as appropriate), must be able to transfer the Planned Transfer plus half the calculated Interconnection Allowance without any unacceptable conditions arising.

The boundary thermal capability is the power flow that can be transferred across the boundary without causing any unacceptable conditions following the outage of two circuits (i.e. N-2 or N-D) as defined in the Licence Standard. The overall boundary capability is the lower of the thermal and voltage capabilities. Known stability limitations are also reported in the Boundary Commentary section which is presented later in this chapter. The required capability is simply the Planned Transfer plus half the Interconnection Allowance.

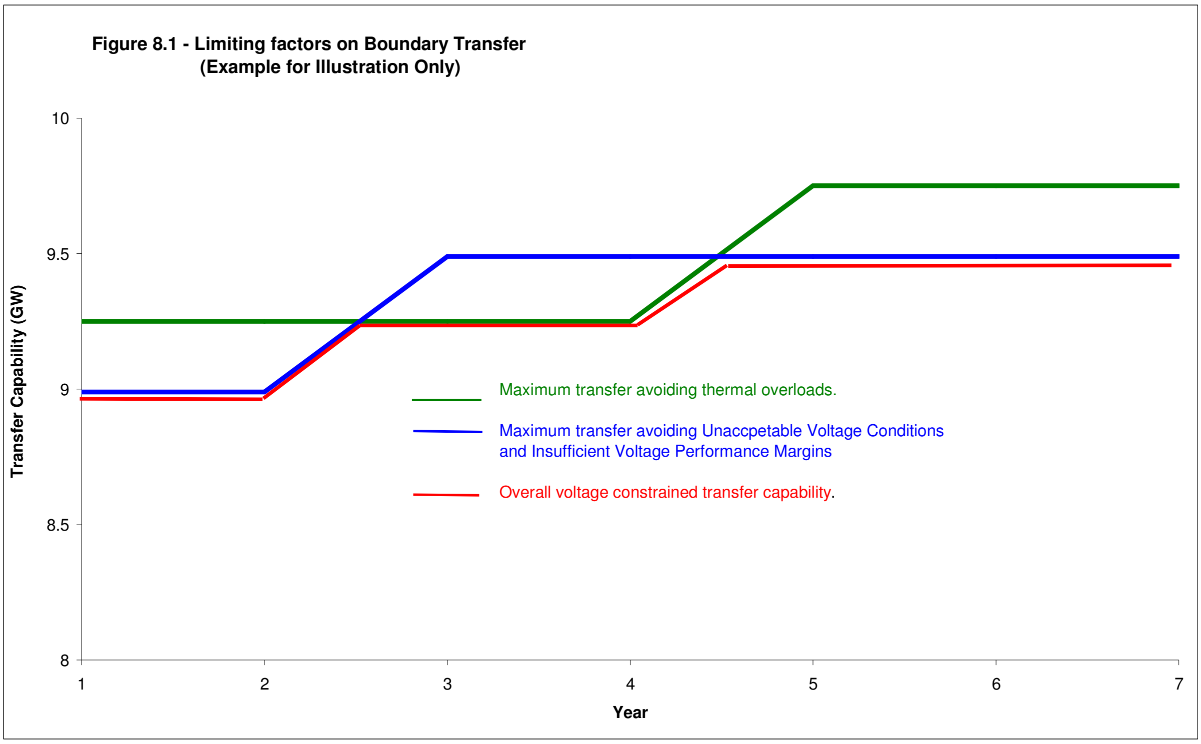
Please note, however, that application of the Interconnection Allowance (or part thereof) relates only to those boundaries, which divide the system into two contiguous parts, the smaller of which contains more than 1500MW of demand. In the case of the boundaries, which have been defined for the NGET and SPT systems, this is always the case. However, for a number of boundaries in the SHETL system (namely: boundaries B1, B2 and B3), this is not the case and, in these instances, the required capability quoted is simply the Planned Transfer.

The boundary capabilities reported in this chapter give an indication of the maximum boundary transfer that can be supported without contravening any of the above unacceptable conditions following a secured event. A boundary capability that is less than the required capability indicates a need for transmission reinforcement. A boundary capability that is greater than the required capability shows only that the security criteria are satisfied for the particular transfer conditions and background studied.

While not identical (particularly for voltage control and fault levels), in terms of flows on the system, the withdrawal of generation will have a broadly similar effect to the addition of demand and vice versa. The amount by which a boundary capability exceeds the required capability gives an indication of the approximate extent of 'spare' transfer capacity on that boundary. However, this does not necessarily mean that an equivalent volume of additional generation on the exporting side of the boundary (or an equivalent volume of additional demand on the importing side) can be readily accommodated. This can be due to a number of reasons including:

- there may be a need for 'local' reinforcements not directly related to the boundary;
- as additional generation or demand is connected to the system, the background against which both the required capability and boundary capability are assessed changes; and
- the security criteria must be satisfied for all system boundaries indicated by the Licence Standard, i.e. while a particular connection may satisfy conditions for one boundary, it may fail to do so for another.

The nature of a boundary capability can be illustrated by separately establishing the voltage capability and the thermal capability. The way in which voltage or thermal considerations might be the limiting factor in different years is illustrated in Figure 8.1. The voltage capability is shown as a blue line (this may arise either because of unacceptable voltage conditions or insufficient voltage performance margin, whichever limit arises first), and the thermal capability as a green line. The net boundary capability is shown by the red line.



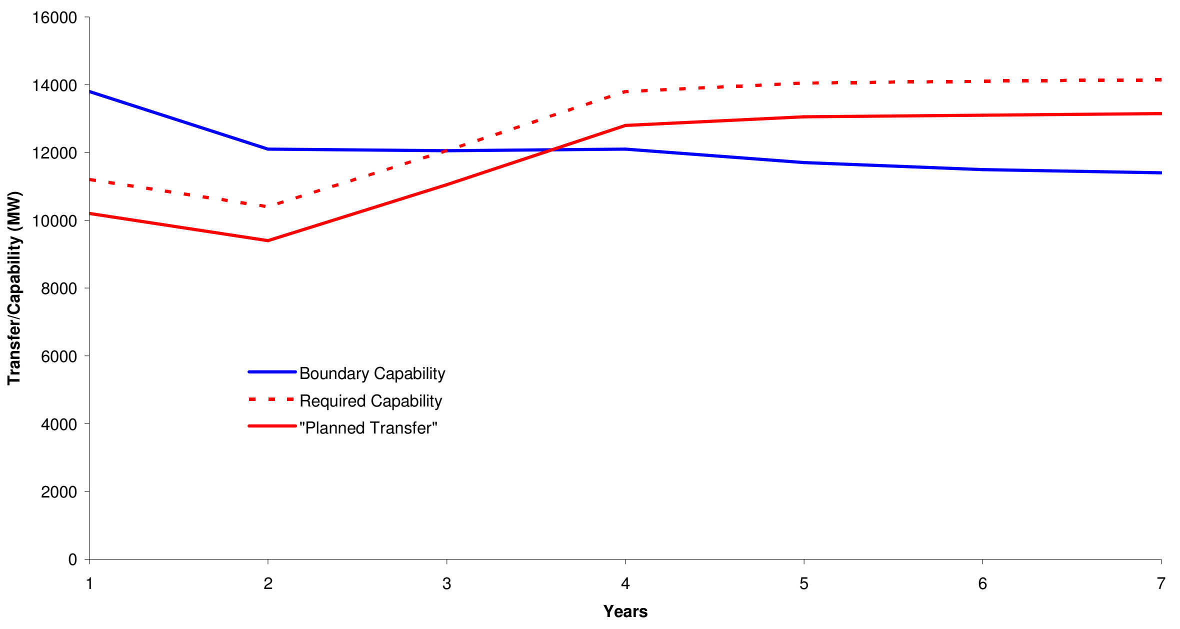
Deterministic Transfers

The power flows presented in this chapter are based on the deterministic SYS background. There is inherent uncertainty associated with the assumptions underlying any deterministic background. For example demand and generation may, in the event, deviate from any of the deterministic assumptions underlying the background. Uncertainty must also therefore be attributed to both the resultant deterministic power flows and any consequent perceived need for transmission reinforcement. The SYS background is no exception and, while it has been selected as the most reasonable deterministic background for the purposes of Chapter 7, it should not be assumed that it represents the most likely future outcome.

For ease of explanation, the boundary commentaries presented later in this chapter include a series of figures from Figure 8.B1 to Figure 8.B17. Amongst other things, each of these figures shows the planned transfer, the required capability and the actual calculated capability for the relevant boundary. These values are all calculated on the basis of the deterministic SYS background and, in view of this, they are often referred to as the “SYS Transfer”, the “SYS Required Transfer" and the "SYS Capability" respectively.

As specified by the Licence Standard, for a particular generation and demand background, the required capability is simply the planned transfer enhanced by the appropriate Interconnection Allowance for a boundary. Where the required capability is less than the actual boundary capability, there is no need for further reinforcement in respect of that particular boundary. An example of this is given in Figure 8.2, which illustrates that the required capability exceeds the actual capability from around year 3 onwards indicating a potential need for further reinforcement on the basis of the SYS background.

Figure 8.2 - Constraints on Boundary Transfer
(Example for Illustration Only)



The boundary capabilities quoted in this chapter relate to planning the medium to long term future development of the system and are not necessarily appropriate to the real time operation of the system. Operational boundary capabilities are a function of the real time transfer, which can be achieved within operational timescales for a given pattern of system outages, demand and generation availability. In operational timescales each of these factors is known with a relatively high degree of certainty, unlike in the planning time phase where there is a need to consider a great many more uncertainties.

The boundary capabilities reported in this chapter do, nevertheless, provide a good broad appreciation of the overall capability of the GB transmission system to transport power. An apparent surplus of boundary capability over the required capability generally shows the exporting side to have at least some potential for additional generation and the importing side to have some potential for additional demand. A deficit of boundary capability against the required capability provides an indication that, were the SYS background to be realised, either investment to reinforce the system and thereby enhance the capability may be appropriate, or alternatively constrained operation of generation is required in order to limit the boundary transfers to within acceptable levels.

The possible need, or otherwise, for transmission reinforcement is discussed under "Boundary Commentary" later in this chapter.

Finally, for the purpose of providing the power flow information reported in this chapter and in Chapter 7, it is first necessary to be able to obtain a converged AC power flow study at least for the intact system and for the Planned Transfer Condition. Under the SYS background there are a number of boundaries for which the boundary capability is substantially lower than the planned transfer in a number of years. In those cases where such deficits are large, convergence of the AC power flow program may be inhibited. In such cases it may be necessary to add a minimum number of indicative system reinforcements solely for the purpose of obtaining convergence of the Planned Transfer Condition. These ‘indicative convergence works’ (e.g. reactive compensation to achieve acceptable voltage conditions) are not necessarily sufficient for compliance with the Licence Standard, and the boundary capabilities have been quoted with them included.

Probabilistic Transfers

The Generation Uncertainty Model (GUM)

Deterministically derived boundary transfers are useful but have limited value since they do not consider the uncertainties associated with projected future demand and generation developments. It is important to take account of the potential impact of these uncertainties on power transfers across key transmission boundaries when considering the merits of transmission reinforcements.

For a given set of assumptions relating to demand and generation, the Generation Uncertainty Model (GUM) provides a probabilistic representation of the electricity market. GUM employs a Monte Carlo model in which openings of new generating stations and closures of existing stations are randomly selected (subject to the influence of the input assumptions) against a background of uncertain demand growth. The resultant probabilistic transfers reflect our current view of how the planned transfers across each of the 17 boundaries at the time of system peak are likely to develop over the next seven years.

Factors which have been taken into account in compiling the input data for GUM include but are not limited to the possible:

- variations in demand growth;
- variations in Plant Margin;
- generation closure and placing in reserve (station CEC=TEC=0 or TEC < station CEC). Within GUM these are referred to as "closures";
- return to service of plant currently held in reserve. Within GUM these are referred to as "re-openings";
- new power stations, which have received approval, proceeding to completion. Within GUM these are referred to as "openings";
- additional proposed new power stations receiving approval and proceeding to completion. Within GUM these are again referred to as "openings";
- termination or modification to current generation connection agreements; and
- variations (including exports) in transfers over the External Interconnections with External Utilities.

It is not possible to provide the detail of the input assumptions we have made since this would breach our obligations on commercial confidentiality. The probabilistic transfer information is provided without prejudice and reflects our current view of future uncertainty. Clearly, this view may change as developments in the electricity market in Great Britain unfold, but nevertheless it should prove a useful complement to the simple deterministic SYS background approach.

The purpose of presenting this additional information is to:

- provide a more meaningful view of the possible range of future boundary transfers given an unconstrained transmission system;
- place the deterministic SYS background based boundary transfers and capabilities in the context of what we currently believe to be the likely range of future transfers;
- promote an appreciation of the future uncertainty in relation to planning the development of the transmission system; and
- enable the reader to make more informed judgements on the opportunities for making new or further use of the transmission system without incurring the need for major inter-zonal transmission reinforcement.

Overview of GUM Analyses

For each year within the period of study, GUM models the system at the time of peak demand on the GB transmission system. This is consistent with the deterministic boundary transfer and capability analyses. The program does not simulate the system year-round; its purpose is to model the generating capacity that might be available to meet the likely peak demand.

The input information provided to GUM reflects our current views on the various generation and demand uncertainties. Our market intelligence in this area is largely based on material in the public domain. In compiling the input assumptions we have tried to avoid introducing any bias. Clearly, our views may change as developments in the electricity market in Great Britain unfold. Nevertheless, the results obtained from GUM analyses should prove more stable than a simple deterministic approach.

There are currently more generation projects proposed than are essential to meet forecast demand. From experience, we consider it unlikely that all of these projects will be completed as planned. Some may slip from their planned commissioning dates while others will be terminated. At the same time, some existing plant can be expected to close down due to age alone while some may close due to competitive pressure from more efficient new market entrants or due to increasing pressure due to environmental constraints. We are not attempting to predict specific generation openings and closures, yet we need to know their probable effects on the power flows on the transmission system. GUM can be used to provide us with this information.

To estimate the probable ranges of power transfer, GUM randomly selects generator openings and closures, balancing the probable generation capacity against probable peak demand and probable plant margin. The random selections are weighted according to a range of input information and criteria, which influence the likelihood of the station opening or closing. Weightings for station openings consider, but are not limited to, the stage of development activity for the stations (which includes issues such as consents status), environmental impact, thermal efficiency, fuel type, and availability of fuel, water, and transmission. Weightings for station closure include, but are not limited to, age, thermal efficiency, fuel delivery, fuel type, availability and environmental impact.

By making random selections of demand and generation according to the given probability functions and weightings, GUM generates up to 10,000 demand/generation permutations or backgrounds. Each single background represents a time sequence of demand growth, plant openings and plant closures running from 2010/11 to 2017/18.

However, a typical GUM analysis does not model every possible future; rather it represents a possible range of variations around the overall demand growth forecast and range of possibilities within the current list of generation projects. Changing the underlying assumptions (for example, a major change in relative fuel costs, or changes in the location and timing of new generation projects) would have some effect on the power transfer ranges.

GUM Boundaries and Zones

For each of the 10,000 backgrounds, GUM calculates the net generation capacity surplus or deficit for each specified GUM zone or group of GUM zones. This surplus or deficit then permits the calculation of the range of possible transfers out of or into each specified zone or group of zones for each sampled generation background. By calculating the net transfer for each of the 10,000 backgrounds within each year of the study period, it is possible to show probabilistic ranges of net transfers into or out of each specified zone, or group of zones, year by year. The program only considers net transfers. Since GUM does not incorporate a network model, it does not in itself calculate power flows across individual circuits.

As with the deterministic analyses, it is useful to consider probabilistic power transfers across certain critical boundaries. The GUM analyses presented in this chapter are based around the SYS Boundaries and SYS Study Zones introduced in Chapter "6_8","SYS Boundaries and SYS Study Zones". Since GUM calculates net imports and exports for zones and groups of zones, all

GUM boundaries are defined in terms of the complete boundary surrounding specified single zones or groups of zones.

Accordingly, each boundary under study is defined in terms of the zones on one side of that boundary. Table 8.1 lists the defining zones on one side of each of the main SYS boundaries. For boundaries B10 & B12 the defining zones are south of the boundary. For boundaries B1, B3, B13, B14, B15 & B17 the defining zones are those encompassed by the boundary. For all other boundaries, the defining zones are north of the boundary.

Presentation of Results

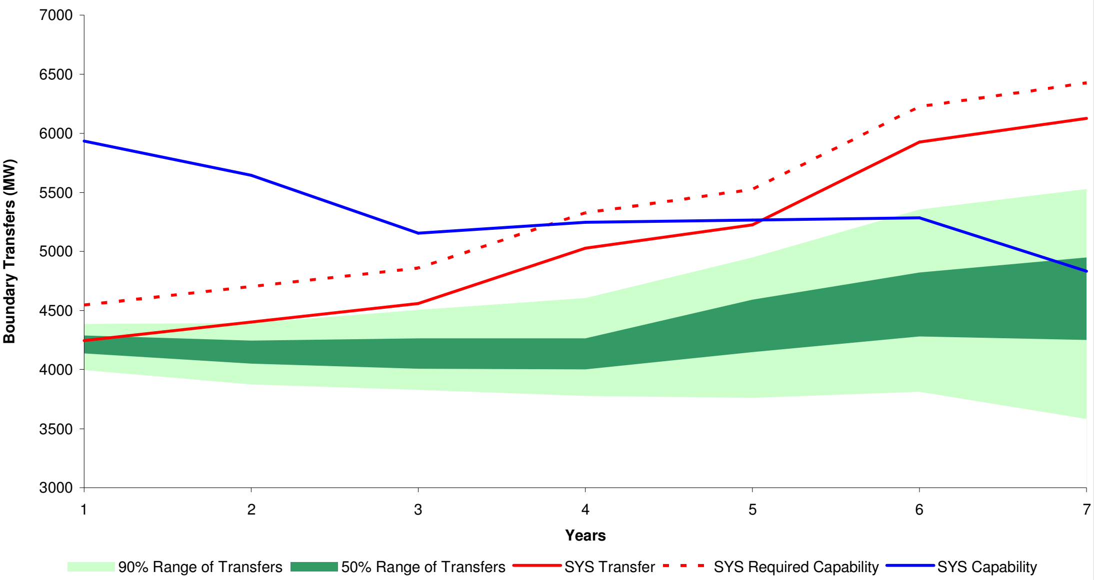
The Fan Diagram

A key output of GUM is the probabilistic range of transfers over a given period for each defined boundary. For each year of the study, GUM calculates probabilistic distributions of power transfers for each boundary under peak load conditions. These distributions could be plotted as separate charts for each boundary for each year. However, a concise and convenient method of presenting the results is to plot percentiles of the distributions to show how the range of probable transfers varies year by year for each boundary.

The resultant plots typically display a narrower range of transfers in the earlier years than in the later years, since there is greater certainty associated with the earlier years. The characteristic shape is therefore generally in the form of a fan and, in view of this, the diagrams are often referred to as "fan diagrams".

An illustrative example is given in Figure 8.3. The green shaded area shows the range of probabilistically derived transfers arising out of the GUM analyses. The deterministic SYS planned transfer, the deterministic SYS required capability and the deterministic SYS capability have been superimposed on top of the fan of probabilistic transfers for comparison.

Figure 8.3 Boundary Transfers and Capability (Illustrative Example)



In Figure 8.3, the darker shaded central band extends (on the vertical axis) from the 25th to the 75th percentiles of the range of probabilistically derived transfers, and thus includes 50% of all such transfers across the boundary at the time of system peak. The wider area, encompassed by the lighter shaded bands runs from the 5th to the 95th percentile and thus, together with the dark band, includes 90% of transfers. The remaining 10% lie outside the shaded range.

The fan of probabilistically derived transfers can be compared with the deterministic planned transfer for the single deterministic SYS background.

It does not follow that the probabilistic transfer arising from a background considered to be likely will necessarily be captured within the envelope range shown on the diagram. Nor does it follow that all the most commonly occurring transfers have highly probable backgrounds. In GUM, all backgrounds are equally probable. Nevertheless, the range of transfers displayed in the fan diagram does provide a very useful indicator of the most probable future planned transfer across the boundary given the possible combined effects of the various sources of generation and demand uncertainty. GUM can then be interrogated to reveal the details of any background underlying any transfer (point on the fan diagram) for further detailed analysis.

GUM takes as its starting point the existing pattern of zonal demand and generation at the time of the 2010/11 winter peak. Conditions in the following year should be fairly predictable; nevertheless there are uncertainties that are represented in GUM's probabilistic analysis. For example, a power station may be scheduled to commission by the 2011/12 winter peak, but construction may slip such that it is unable to contribute to the system peak demand until 2012/13. Variations and uncertainties relating to transfers across the external interconnections with external systems are included in the probabilistic analyses. This can account for a significant part of the range of uncertainty displayed in the fan diagrams.

Interpretation

In the arbitrary example given in Figure 8.3 the deterministic SYS required capability exceeds the SYS boundary capability by year four, which implies that there are no opportunities for additional generation on the exporting side of the boundary from that year without reinforcement. The probabilistic transfers, indicated by the fan, imply that the need for reinforcement is unlikely until the later years, if at all. Any reinforcement can therefore be delayed until the later years when the need becomes more certain.

However, as noted previously, these kinds of conclusions must be qualified by recognition that the boundary capability is dependent on the exact disposition of generation and demand in the background against which it is assessed. For example, interactions of generation openings and closures and changes in demand all on the same side of a boundary, or on opposite sides, can lead to little or no change in the ‘Planned’ boundary transfer but, nevertheless could give rise to a need for significant reinforcements in order to maintain system security. Nor would two backgrounds, which, result in similar transfers across a particular boundary necessarily, give rise to the need for the same transmission reinforcement across that boundary since the boundary capability is a function of how the boundary transfer is shared between the boundary circuits, which is in turn a function of the particular background under consideration.

An important message is that the requirement for transmission system reinforcement does not simply correspond to a given boundary transfer. The need for system reinforcement can still arise at transfers below the ‘SYS capability’ levels displayed in the series of figures (i.e. Figure 8.B1 to Figure 8.B17) included in the next section of this chapter.

Boundary Commentary

Background

For a better understanding of the results presented in this section the reader is advised to first read the previous sections of this chapter. In particular the format of the figures used is as presented in Figure 8.3. The SYS background transfers presented are consistent with the power flow studies discussed in Chapter 7 (GB Transmission System Performance) which were also based on the generation ranking order of operation given in Table 7.1.

Please note that the transfers displayed in the series of figures which follow (i.e. Figure 8.B1 to Figure 8.B17) relate to the time of system peak demand. The capabilities shown are the transfer levels beyond which either thermal or voltage limitations become apparent on the Main Interconnected Transmission System. These SYS capabilities have been evaluated for the spot years 2011/12, 2013/14, 2015/16 and 2017/18 only. It is stressed that the SYS capabilities are appropriate for the SYS background and do not necessarily correspond to any of the many backgrounds appropriate to the probabilistic transfer range. The SYS capability does nevertheless provide a useful reference and initial indicator of overall capability.

The probabilistic transfer ranges shown are considered to be a more realistic representation of the likely transfer range than the single deterministic SYS background transfers and naturally receive attention in the commentary that follows. However, apart from a high level comparison, it is not possible to provide a detailed commentary on the probabilistic ranges since to do so could breach our obligations to our customers on commercial confidentiality. For the single deterministic SYS background transfers this is not a concern and accordingly greater detail has been included in the commentary.

In considering each of the following boundary commentaries it is useful to cross reference a number of tables presented elsewhere which are relevant to the SYS background transfers. Table 7.3 presents the SYS background studied generation, demand and transfer for each boundary. For ease of reference, each of the following boundary commentaries includes the relevant extract of Table 7.3. Please refer to the tables shown in Appendix F for details of generation capacity changes under the SYS background over the period from 2011/12 to 2017/18 inclusive and also chapter 3 Table 3.5 and Table 3.6 for generation disconnections and generating units declared unavailable.

Overview

As explained in Chapter 3, access to the GB transmission system is provided through arrangements with National Grid, acting as GBSO, under the Connection and Use of System Code (CUSC). The CUSC sets out the contractual framework for connection to, and use of, the GB transmission system. The CUSC has applied across the whole of Great Britain since BETTA "go-live" (1 April 2005).

The removal, under BETTA, of the previous commercial arrangements for the use of the circuits connecting Scotland and England has given wider rights of GB system access than previously was the case. However, the volume of requirements for connection to and use the GB transmission system has meant that:

- there is a potential shortage of transmission system capacity, and
- transmission reinforcement is required to maintain compliance with the Licence Standard.

The results reported in this chapter demonstrate this potential transmission capacity shortage under the SYS background. As a consequence, there is a potential need for significant reinforcement of the system in addition to those identified in Table 6.2.

After the introduction of BETTA an extensive reinforcement programme is required to accommodate the required capabilities determined by the SYS background for boundaries in the border area. The projected commissioning of more than 2GW of new transmission contracted generation in Scotland, substantially made up of wind farms, is dependent on the completion of the schemes which make up the planned Beauly/Denny transmission reinforcement and strategic reinforcements as planned through ENSG. The Beauly/Denny reinforcements are included as part of the SYS background for commissioning by 2013/14. In addition the first stages of the strategic ENSG reinforcements are also included.

Examination of the boundary transfer levels over the seven year period for the SYS background indicates that:

- The major Northern boundaries B1 (SHETL North West Export), B2 (North to South SHETL), B4 (SHETL to SPT), B5 (North to South SPT), B6 (SPT – NGET), B7 (Upper North) all show steady growth in power transfers over the SYS period due primarily to contracted renewable energy developments throughout Scotland. A sudden drop in power flow to the South happens in 2016 when some LCPD closures are expected. Further increase in new renewable generation in the North will push the boundary transfers higher.

- Boundaries B8 (North to Midlands) and B9 (Midlands to South), B11 (Northeast & Yorkshire), B12 (South & Southwest import), B16 (Northeast, Trent & Yorkshire) and B17 (West Midlands import) show mostly constant power flows with some fluctuation due to new generation connections and older generation closures.

- B14 (Central London import) shows a trend of a steady increase in transfers reflecting gradually increasing demands and the lack of new generation projects within this zone;

- There is a general trend with reducing transfers across the B10 (South Coast import), and B13 (South West import) reflecting new plant that might be expected to commission in the South and Southwest in line with present contractual positions.

Comparison of the SYS Planned Transfers with the probabilistic ranges reveals that for most boundaries the SYS transfers lie very close the probabilistic range with only limited deviation which can be explained by the effect of some large individual generators pushing the transfer points.

Examination of Figures 8.B1 to Figure 8.B17 reveals a wide range in the width of the probabilistic transfer envelope across the various boundaries. For boundaries cutting large importing or exporting areas such as B8 (North to Midlands) and B9 (Midlands to South), the width of the probabilistic transfer envelope reflects, inter alia, the higher uncertainty associated with the larger tranche of generating plant on the exporting side. For other boundaries, such as B14 (London) which is an importing boundary dominated by a large demand with little generation, the width of the probabilistic transfer envelope is relatively narrow reflecting a higher degree of certainty.

The planned contracted and strategic reinforcements listed in Table 8.2 provide the transmission capability to cover the majority of the system boundary requirements. Some non-compliance for the major northern boundaries may be experienced for the early years until the necessary reinforcements are constructed or the power flow decreases enough to lie within capability.

Boundary 1: SHETL North West

Figure 8.B1 Boundary Transfers and Capability
Boundary 1: North West Export

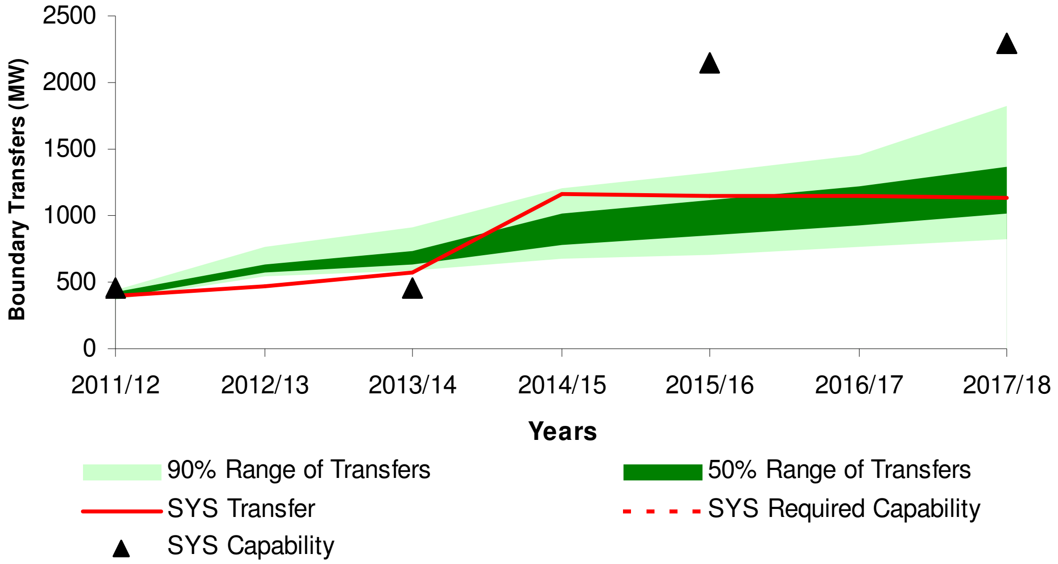


Table 8-T1 - Boundary B1 SHETL North West							
Quantity (MW)	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**
B6E - EXPORT							
Effective Generation	915	992	1100	1675	1655	1646	1638
Demand	511	515	520	509	507	506	506
Required Transfer	404	477	580	1166	1148	1140	1132
B6I - IMPORT							
Effective Generation	57927	57850	57742	57167	57197	57193	57202
Demand	58321	58318	58313	58312	58315	58313	58314
Required Transfer	-404	-477	-580	-116	-1148	-1140	-1132

Generation to the north of this boundary is increasing at a significant rate due to the high volume of contracted wind based generation seeking connection to the grid in the area. Consequently, the boundary transfers are also increasing at a similar rate. Further renewable generation is expected in this area as a result of onshore and offshore wind and marine generation in the waters around Orkney and in the Pentland Firth.

It should be noted that application of the Interconnection Allowance (or part thereof) relates only to those boundaries which divide the system into two contiguous parts, the smaller of which contains more than 1500MW of demand. For this boundary (as with boundaries B2 and B3), this is not the case and accordingly the Required Transfer capability is equal to the Planned Transfer.

The first of the proposed reinforcements for this boundary is scheduled for completion by 2011/2012 and comprises the creation of a new 275/132kV substation at Knocknagael. This is located to the south of Inverness at the existing Foyers connection tee point on the Beauly-Blackhillock line. The existing Inverness demand is relocated onto this new substation using new 132kV cable circuits, thus reducing the load on the Beauly-Keith 132kV circuits and thereby increasing the B1 capacity to around 450MW.

The second proposed reinforcement is the Beauly-Denny project comprising the replacement of the existing 132kV double circuit tower line between Beauly, Fort Augustus, Errochty and Bonnybridge by a new 400kV double circuit tower line terminating at Denny near Bonnybridge. The Beauly-Denny project was the subject of an extensive Public Inquiry which started in January 2007 and concluded successfully in January 2010 with consent from the Scottish Government to build the line, subject to mitigation measures being undertaken. Currently the project completion date is predicted to be the end of 2014. The completion of Beauly-Denny will increase this boundary capability from 450MW to around 1300MW.

The additional generation connecting to the north of this boundary means that further reinforcement of this boundary will be required. The next proposed reinforcement is strengthening of the transmission infrastructure between Beauly (near Inverness), Keith/Blackhillock and Kintore. The boundary capability can be raised to around 1600MW by replacing the conductor on the existing 275kV transmission line between Beauly, Blackhillock and Kintore with a new conductor of higher capacity. SHETL obtained regulatory approval to proceed to the construction phase of this reinforcement in March 2010.

Within the B1 North West boundary, additional transmission reinforcement is required to connect the contracted and expected new generation. For example, to the north of Beauly additional works between Beauly and Dounreay will be required. The first phase of this work comprises installation of a new conductor on the spare side of the existing 275kV double circuit line between Beauly and Dounreay, installation of a 275kV busbar and a second 275/132kV transformer at Dounreay. Phase shifting transformers will also be required on the 132kV lines between Beauly and Shin. SHETL obtained regulatory approval to proceed to the construction phase of this reinforcement in March 2010 and the work is expected to be completed by the end of 2012.

A second phase of reinforcement for the Caithness area will also be required as a result of contracted generation north of Beauly. The proposed reinforcement, due to complete by spring 2016, comprises the installation of an HVDC link between Caithness and the Moray coast and some associated works on the mainland network. This has the effect of providing an additional circuit across B1 and therefore increases the capacity of the boundary. The installation of an offshore HVDC switching Hub within the proposed HVDC link is being investigated with the aim to provide economic connection options for the generation on Shetland and the offshore windfarms in the Moray Firth.

The significant interest from generation developers on the large island groups of the Western Isles, Orkney and Shetland means that new transmission infrastructure will be required to connect these to the mainland transmission network. Current proposals are for the Western Isles to be connected using an HVDC transmission link to Beauly substation. It is also proposed to use an HVDC link to connect Shetland to the mainland at Blackhillock or to the offshore Hub mentioned above. The growth of onshore renewable generation on mainland Orkney is more gradual, however significant growth in marine generation around Orkney and the Pentland Firth is likely following the announcement by the Crown Estate to grant exclusive development rights to companies in these areas. Consequently, the extent to which reinforcement to Orkney is required is under review.

The proposed routes for new transmission tower lines and subsea cables will undergo detailed environmental impact assessment and will be subject to consents and planning approval.

Boundary 2: SHETL North – South

Figure 8.B2 Boundary Transfers and Capability
Boundary 2: North to South SHETL

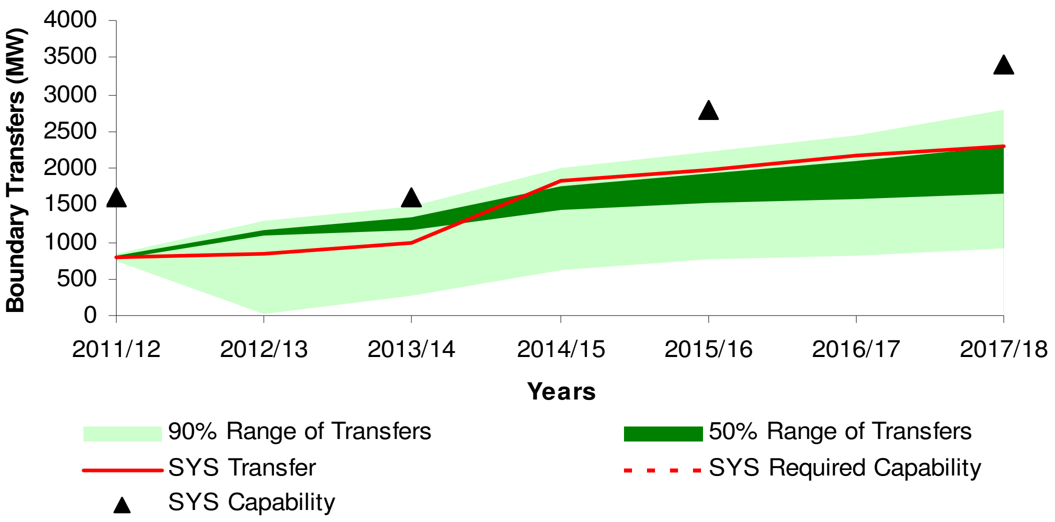


Table 8-T2 - Boundary B2 SHETL North–South							
Quantity (MW)	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**
B6E - EXPORT							
Effective Generation	1905	1977	2119	2961	3095	3289	3413
Demand	1120	1126	1136	1127	1117	1115	1115
Required Transfer	785	851	983	1834	1978	2174	2298
B6I - IMPORT							
Effective Generation	56926	56854	56712	55870	55756	55539	55415
Demand	57722	57715	57704	57701	57708	57704	57706
Required Transfer	-785	-851	-983	-1834	-1978	-2174	-2298

Generation to the north of this boundary is increasing at a significant rate due to the high volume of contracted renewable generation seeking connection to the north of this boundary. Consequently, the boundary transfers are also increasing at a similar rate. It should be noted that application of the Interconnection Allowance (or part thereof) relates only to those boundaries, which divide the system into two contiguous parts, the smaller of which contains more than 1500MW of demand. For this boundary (as with boundaries B1 and B3), this is not the case and accordingly the required transfer capability is equal to the Planned Transfer.

The increase in required transfer capability of this boundary over the seven year period indicates the need to reinforce the transmission system in this location. The proposed Beauly to Denny reinforcement required for the North West boundary also provides the necessary increased capacity for this boundary. The reinforcement comprises the replacement of the existing 132kV double circuit tower line between Beauly, Fort Augustus, Errochty and Bonnybridge, by a new 400kV double circuit tower line terminating at Denny near Bonnybridge. The Beauly-Denny reinforcement is due to be completed by the end of 2014 and will increase the North South boundary capability from 1600MW to 2650MW in 2014/15.

It is expected that additional reinforcement of this boundary will be required based on the contracted generation volumes. This is likely to comprise an upgrade of the existing east coast route, between Blackhillock and Kincardine, to 400kV using existing infrastructure that is currently operated at 275kV but which is constructed at 400kV. Currently SHETL are undertaking pre-construction design and engineering of the 400kV east coast project with a view to completion in 2015 subject to regulatory approval.

Boundary 3: SHETL Sloy

Figure 8.B3 Boundary Transfers and Capability
Boundary 3: Sloy Export

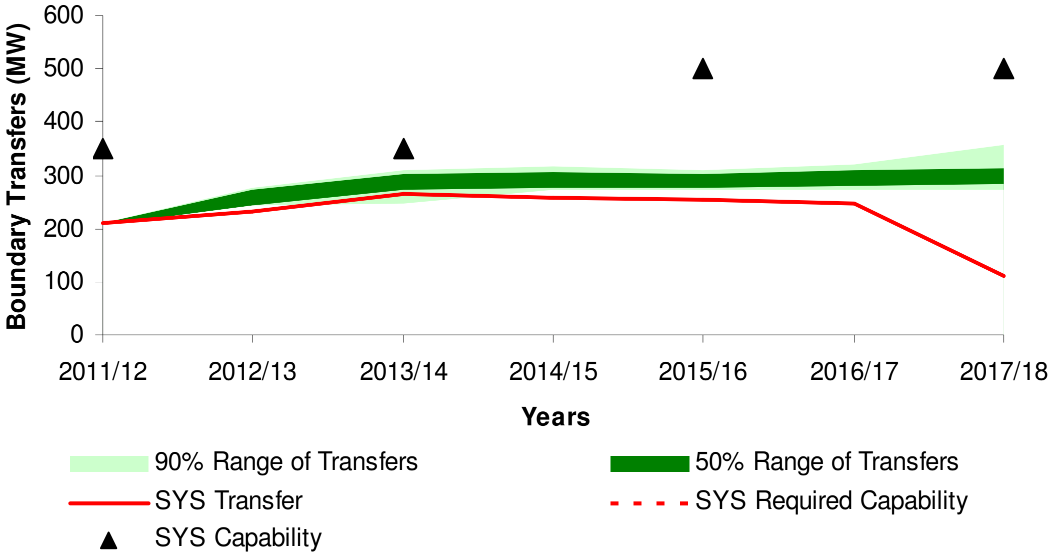


Table 8-T3 - Boundary B3 SHETL Sloy							
Quantity (MW)	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**
B6E - EXPORT							
Effective Generation	273	299	333	325	322	316	177
Demand	65	66	67	66	68	70	67
Required Transfer	208	233	266	259	254	246	110
B6I - IMPORT							
Effective Generation	58560	58535	58503	58511	58516	58520	58659
Demand	58782	58782	58781	58781	58782	58781	58782
Required Transfer	-208	-233	-266	-259	-254	-246	-110

The application of the Interconnection Allowance (or part thereof) relates only to those boundaries, which divide the system into two contiguous parts, the smaller of which contains more than 1500MW of demand. For this boundary (as with boundaries B1 and B2), this is not the case and accordingly the required transfer capability is equal to the Planned Transfer. The new 275/132kV Inverarnan substation, which links the existing Killin to Sloy 132kV line with the existing 275kV line between Windyhill and Dalmally, was completed in 2010/11 and the increase in boundary capability is reflected in the above table.

The sudden decrease in Planned Transfer across B3 in 2017/18 is a result of Sloy hydro generation falling out of merit in the Seven Year Statement ranking order and is not representative. The removal of generation at Sloy has a significant impact on B3 transfers which is a very small boundary in the GB context. For this boundary, the range of transfers indicated in the Fan diagram gives a better indication of the required transfer levels for this region.

Renewable generation continues to increase in the Kintyre and Argyll area and further reinforcement will be required to address both the Zonal boundary capacity and the capability of the internal network, particularly between Carradale and Inveraray. The proposed reinforcement for this area is the installation of two subsea cable links from Crossaig, north of Carradale, to Hunterston in Ayrshire. Currently SHETL are undertaking pre-construction design and engineering of the subsea link with a view to completion in 2015/16 subject to regulatory approval.

Boundary 4: SHETL – SPT

Figure 8.B4 Boundary Transfers and Capability
Boundary 4: SHETL to SPT

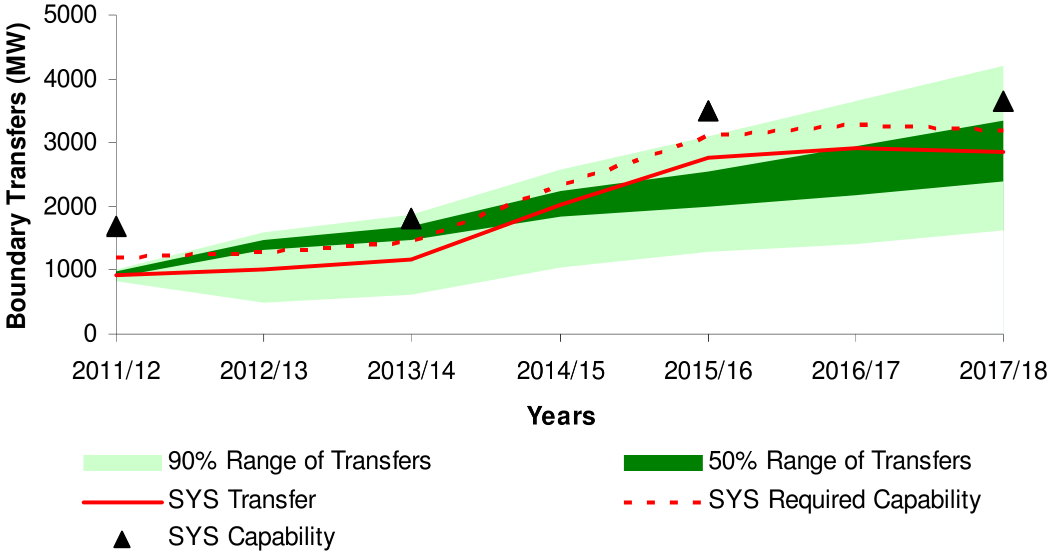


Table 8-T4 - Boundary B4 SHETL – SPT							
Quantity (MW)	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**
B6E - EXPORT							
Effective Generation	2634	2729	2901	3760	4488	4655	4565
Demand	1702	1712	1730	1733	1726	1733	1727
Required Transfer	1192	1283	1446	2343	3107	3275	3187
B6I - IMPORT							
Effective Generation	56206	56111	55941	55082	54384	54183	54273
Demand	57132	57121	57105	57101	57112	57105	57108
Required Transfer	-1192	-1283	-1446	-2343	-3107	-3275	-3187

The SHETL to SPT boundary defines the asset ownership boundary between SHETL and SPT and runs from the Firth of Tay in the east to near the head of Loch Long in the west. This boundary encompasses all the generation and demand (except for Dunoon and Strathleven) in the SHETL area and is normally an exporting boundary.

Generation to the north of this boundary is increasing over time due to the high volume of new contracted renewable generation seeking connection in the SHETL area. Consequently, the boundary transfers are also increasing with time.

The application of the Interconnection Allowance (or part thereof) relates only to those boundaries which divide the system into two contiguous parts, the smaller of which contains more than 1500MW of demand. For this boundary, Interconnection allowance is applicable and is added to the Planned Transfer to give the required transfer capability for the boundary.

The increase in the required transfer capability over the seven year period clearly indicates the need to reinforce the transmission system across Boundary 4. The proposed Beauly to Denny reinforcement, due to be completed by the end of 2014, will increase the capacity of the B4 boundary significantly from 1700MW to around 3000MW by the end of 2014. The Beauly to Denny reinforcement comprises the replacement of the existing 132kV double circuit tower line between Beauly, Fort Augustus, Errochty and Bonnybridge, by a new 400kV double circuit tower line terminating at Denny near Bonnybridge.

It is expected that additional reinforcement of this boundary will be required based on the contracted generation volumes. This is likely to comprise an upgrade of the existing east coast route, between Blackhillock and Kincardine, to 400kV using existing infrastructure that is currently operated at 275kV but which is constructed at 400kV. This reinforcement will increase the B4 boundary capability from 3000MW to around 3500MW in 2015/16. Currently SHETL are undertaking pre-construction design and engineering of the 400kV east coast project with a view to completion in 2015/16 subject to regulatory approval.

Smaller upgrades to the SHETL network including the installation of Quadrature Boosters at Blackhillock in 2016/17 and the split of the Errochty 132kV busbar in 2017/18 allow optimisation of power flows though the network and provide small but very cost effective increases in B1, B2 and B4 boundary capacities.

Boundary B4 capability from 2015/16 onwards is restricted by the thermal rating of two short sections of 275kV cable at Longannet on the circuits east to Westfield. Increasing the rating of these cables, together with the removal of protection limitations, may further increase boundary capability in these years by up to 300MW.

Beyond this, taking account of the potential generation in the period up to and beyond 2020, SHETL, SPT and NGET are carrying out pre-construction design and engineering of an offshore multi-terminal HVDC link between Peterhead, Torness and the north of England. An estimated completion date for this scheme is 2018, subject to regulatory approval.

The undertaking of pre-construction design and engineering work positions the delivery of a project such that construction can commence at the appropriate time when there is confidence that the reinforcement will be required.

Boundary 5: SPT North – South

Figure 8.B5 Boundary Transfers and Capability
Boundary 5: North to South SPT

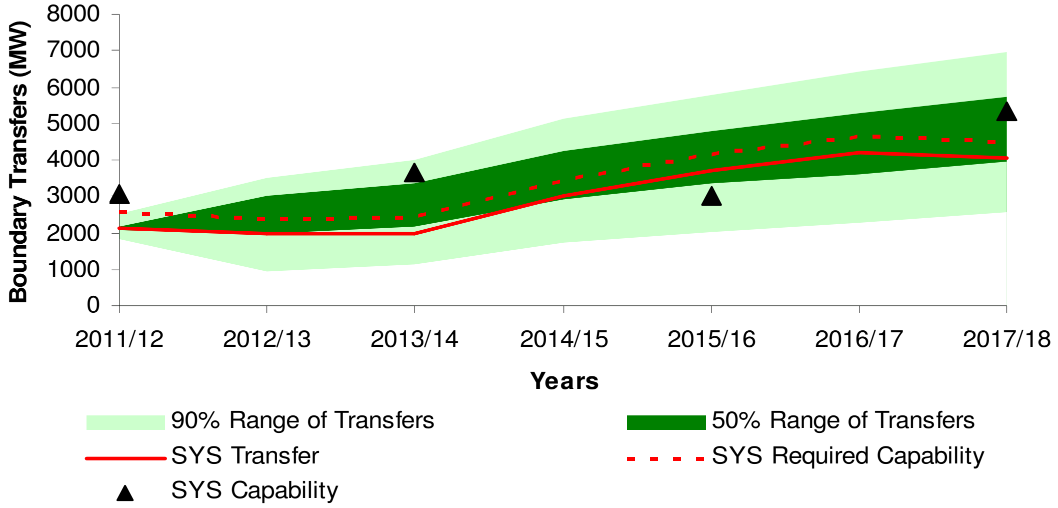


Table 8-T5 - Boundary B5 SPT North – South							
Quantity (MW)	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**
B6E - EXPORT							
Effective Generation	5033	4884	4937	5929	6654	7156	6971
Demand	2778	2803	2801	2783	2797	2790	2786
Required Transfer	2546	2370	2404	3434	4171	4664	4505
B6I - IMPORT							
Effective Generation	54048	53947	54027	53132	52469	52073	51984
Demand	55939	55938	55935	55931	55937	55938	55939
Required Transfer	-2546	-2370	-2404	-3434	-4171	-4664	-4505

The north to south transfer across this boundary in the central belt of Scotland rises through the years of this statement due to contracted renewable energy developments in the north of Scotland.

The base boundary capability is adversely impacted by the increased transfer assumption on the Moyle Interconnector in all years compared to that in the 2010 GB SYS. The installation of a second 400/275kV transformer at Strathaven, together with reactive compensation equipment in the SPT area, will enhance B5 capability to approximately 3650MW by winter 2012/13.

Taking into account the significant changes anticipated in the generation mix in the period to 2020 and beyond, SPT is undertaking pre-construction design and engineering work on further upgrades to Boundary B5. Undertaking pre-construction engineering work positions the delivery of any project such that construction can commence when there is sufficient confidence that the reinforcement will be required. The commissioning of a significant volume of generation in the south east of the SHETL area in 2015/16 has the effect of reducing the boundary capability due to the redistribution of power flows. Boundary capability may be restored by modifying connections at Denny North 275kV Substation, increasing the thermal rating of the 275kV circuits west from Denny and / or modifying the transfer level on the Western HVDC Link.

Indicative reinforcement, included in SYS Year 7, delivers a boundary capability approaching 5350MW.

Boundary 6: SPT – NGET

Figure 8.B6 Boundary Transfers and Capability
Boundary 6: SPT to NGET

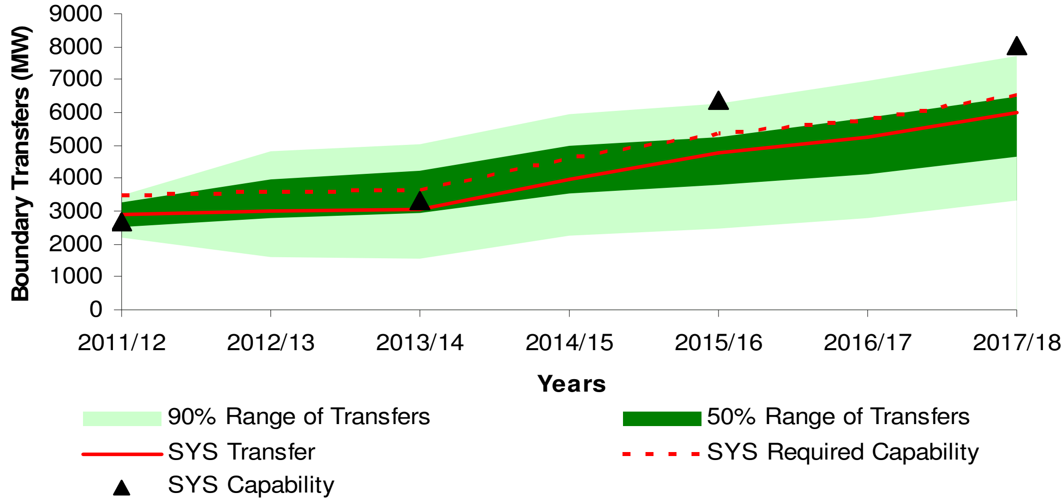


Table 8-T6 - Boundary B6 SPT – NGET							
Quantity (MW)	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**
B6E - EXPORT							
Effective Generation	8954	9060	9143	10104	10573	11424	12132
Demand	5486	5490	5497	5470	5504	5487	5484
Required Transfer	3496	3602	3656	4611	5340	5806	6526
B6I - IMPORT							
Effective Generation	50106	49664	49610	48521	48302	47959	46811
Demand	52809	52805	52799	52790	52802	52805	52808
Required Transfer	-3496	-3602	-3656	-4611	-5340	-5806	-6526

The north to south transfer across the boundary between SPT and NGET rises through the years of this statement, due to contracted renewable energy developments throughout Scotland. As a consequence, the required capability is significantly in excess of the current capability, indicating a strong need for reinforcement.

Due to the fact that the required capability currently exceeds the actual capability, SPT and NGET have been granted relief from Licence Condition D3 in respect of the circuits connecting the SPT system to that of NGET.

To achieve a capability of approximately 3,300MW by 2012/13, SPT and NGET are undertaking an extensive reinforcement programme. Upon completion of these works, this boundary continues to show insufficient transfer capability for the given SYS Background, indicating further reinforcement is required.

Taking into account the significant changes anticipated in the generation mix in the period to 2020, SPT and NGET are undertaking pre-construction design and engineering work on further upgrades to Boundary B6. These include series compensation and offshore HVDC schemes. Undertaking pre-construction engineering work positions the delivery of any project such that construction can commence when there is sufficient confidence that the reinforcement will be required.

Incorporating series compensation and the Western HVDC Link (with assumed 2000MW capacity) into the SYS background in 2015/16, together deliver a boundary capability of 6400MW.

Incorporating an Eastern HVDC Link from the Torness area (with assumed 2000MW capacity) into the SYS background in 2017/18, coincident with the commissioning of a significant volume of generation in the south east of the SPT area, increases boundary capability to approximately 8000MW.

Boundary 7: NGET Upper North

Figure 8.B7 Boundary Transfers and Capability
Boundary 7: Upper North to North

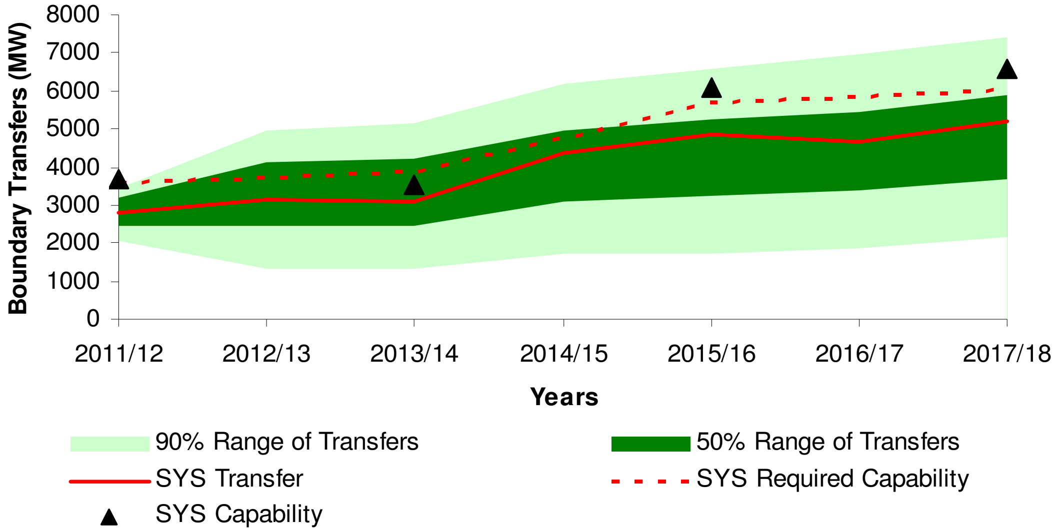


Table 8-T7 - Boundary B7 NGET Upper North							
Quantity (MW)	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**
B7E - EXPORT							
Effective Generation	11698	12131	12200	13494	13978	13868	14507
Demand	8886	8993	9102	9122	9123	9225	9329
Required Transfer	3587	3917	3880	5175	5678	5489	6048
B7I - IMPORT							
Effective Generation	47136	46703	46634	45340	44856	44966	44327
Demand	49948	49841	49732	49712	49711	49609	49505
Required Transfer	-3587	-3917	-3880	-5175	-5678	-5489	-6048

Boundary B7 is one of the Anglo Scottish boundaries which is strongly affected by the flow of B6, as it is characterised by six 400kV primary AC circuits in close proximity to boundary B6. The reinforcements for B7 are the uprating of Harker-Hutton double circuit to 3100 MVA, and the West Coast HVDC link. This is demonstrated in 2015 which increases the SYS capability from 3,500 to 6,100 MW and is essential to meet compliance as flows increase. In later years (post 2015) the transfer increases further as more wind farms connect in Scotland. It is important to note that B7 can become highly constrained, if power flows increase from the North.

Boundary 8: NGET North to Midlands

Figure 8.B8 Boundary Transfers and Capability
Boundary 8: North to Midlands

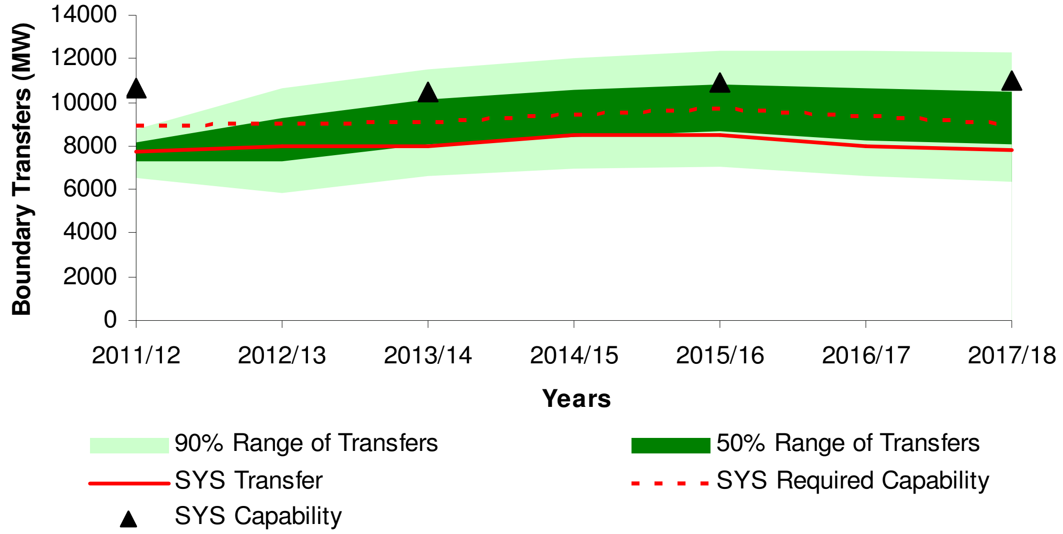


Table 8-T8 - Boundary B8 NGET North - Midlands							
Quantity (MW)	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**
B8E - EXPORT							
Effective Generation	29192	29343	29265	29772	29750	29582	29906
Demand	21434	21346	21260	21240	21206	21624	22049
Required Transfer	8890	9131	9140	9674	9695	9118	9027
B8I - IMPORT							
Effective Generation	29642	29491	29569	29062	29084	29252	28928
Demand	37400	37488	37574	37594	37628	37210	36785
Required Transfer	-8890	-9131	-9140	-9674	-9695	-9118	-9027

Boundary B8 is the North to Midlands boundary, and is part of the wider group of system boundaries which separate England and Wales generation approximately midway throughout the country. The B8 boundary has an average capability of 10,500 MW throughout the years as the generation pattern across the country changes. A drop in transfers can be seen in comparison to previous year's statements due to generation closures north of the boundary and new generation south of the boundary.

The boundary capability is sufficient for the range of transfer under the SYS background. The required transfers range from 8,800 MW to 9,600 MW. Two distinctive points can be identified on the boundary graphs: An increase in transfer from 2011/12 to 2015/16 and a drop in transfer from 2015/16 to 2017/18. An increase in transfer can be explained by offshore windfarms such as Hornsea being connected, which leads to a net increase in transfer, as it compensates a number of coal units falling out of merit. The drop in transfer from 2015/16 to 2017/18 can also be explained by a number of CCGT plants falling out of merit and LCPD closures, which occur more on the north side of the boundary.

Boundary 9: NGET Midlands to South

Figure 8.B9 Boundary Transfers and Capability
Boundary 9: Midlands to South

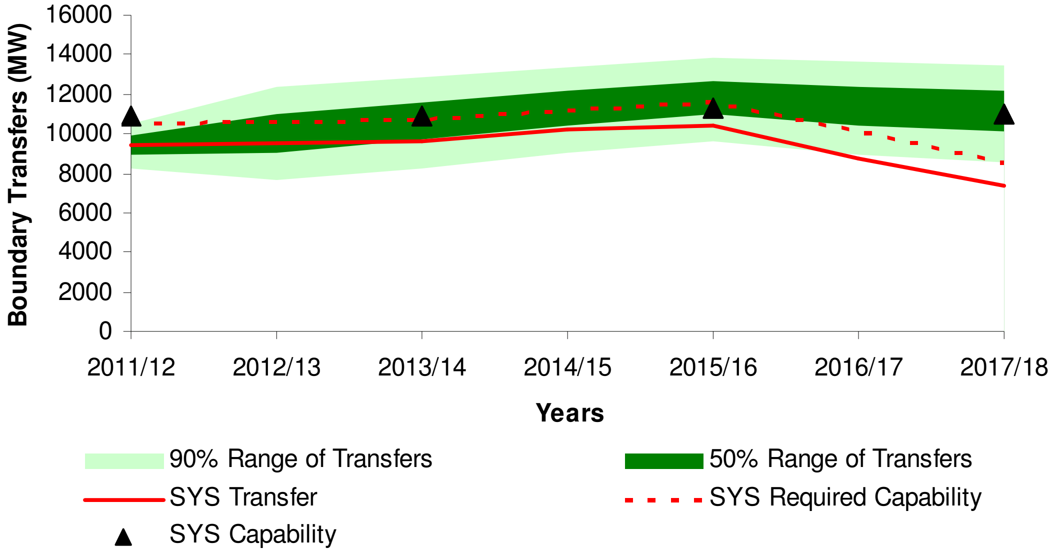


Table 8-T9 - Boundary B9 Midlands – South							
Quantity (MW)	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**
B9E - EXPORT							
Effective Generation	39219	39212	39052	39645	39887	38577	37599
Demand	29832	29642	29452	29454	29444	29821	30202
Required Transfer	10515	10705	10741	11333	11586	9910	8560
B9I - IMPORT							
Effective Generation	19615	19622	19782	19189	18947	20257	21235
Demand	29002	29192	29382	29380	29390	29013	28632
Required Transfer	-10515	-10705	-10741	-11333	-11586	-9910	-8560

Boundary B9 has a similar required transfer capability trend to that of B8, and is more sensitive to generation change on either side of the boundary in later years. In the early years the boundary remains compliant, with a SYS Capability of around 11,000 MW. As generation increases from the north a thermal and voltage limitation occurs around the Cottam region. Already planned network reinforcements around Cottam, Keadby and West Burton, are required to increase the thermal capability of the region. In 2015/16, the boundary goes marginally non-compliant. However, as generation increases south of the boundary, a significant drop in transfer is shown between the years of 2015/16 to 2017/18 which eventually leads to the SYS boundary capability being compliant again.

Boundary 10: NGET South Coast

Figure 8.B10 Boundary Transfers and Capability
Boundary 10: South Coast

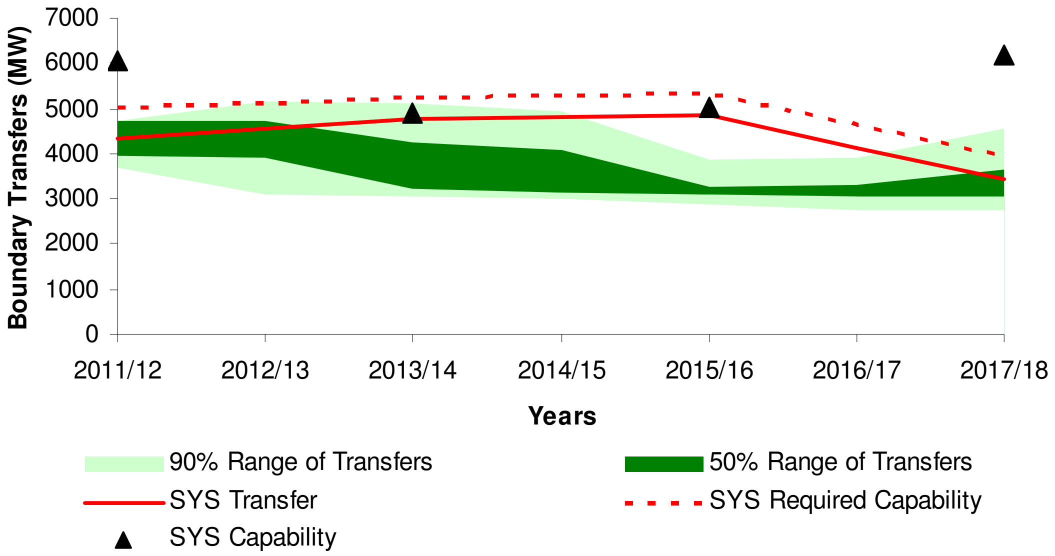


Table 8-T10 - Boundary B10 NGET South Coast							
Quantity (MW)	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**
B10E - EXPORT							
Effective Generation	3045	2831	2641	2589	2582	3251	3875
Demand	7384	7387	7389	7402	7418	7355	7290
Required Transfer	-5011	-5131	-5228	-5299	-5327	-4622	-3960
B10I - IMPORT							
Effective Generation	55789	56003	56193	56245	56252	55583	54959
Demand	51450	51447	51445	51432	51416	51479	51544
Required Transfer	5011	5131	5228	5299	5327	4622	3960

The South Coast boundary is characterised by a high demand region with a sensitive voltage stability profile which is primarily due to lack of generation in and around the area. Boundary B10 is reliant on importing power from the Midlands and Thames Estuary. The required transfer ranges from approximately 4,600 MW to 4,000 MW in the later years, with the probability of the boundary falling out of compliance around 2013/14 to 2015/16 due to diminishing support from local generation. However the non-compliance is short lived as more generation is connected in the South Coast such as Hinkley Point C and the Atlantic Array windfarms, which restores local voltage support. The probabilistic range of transfers sits below the required transfers in the early years due to an assumed output from normally non-contributory generation.

Boundary 11: NGET North East and Yorkshire

Figure 8.B11 Boundary Transfers and Capability
Boundary 11: North East & Yorkshire

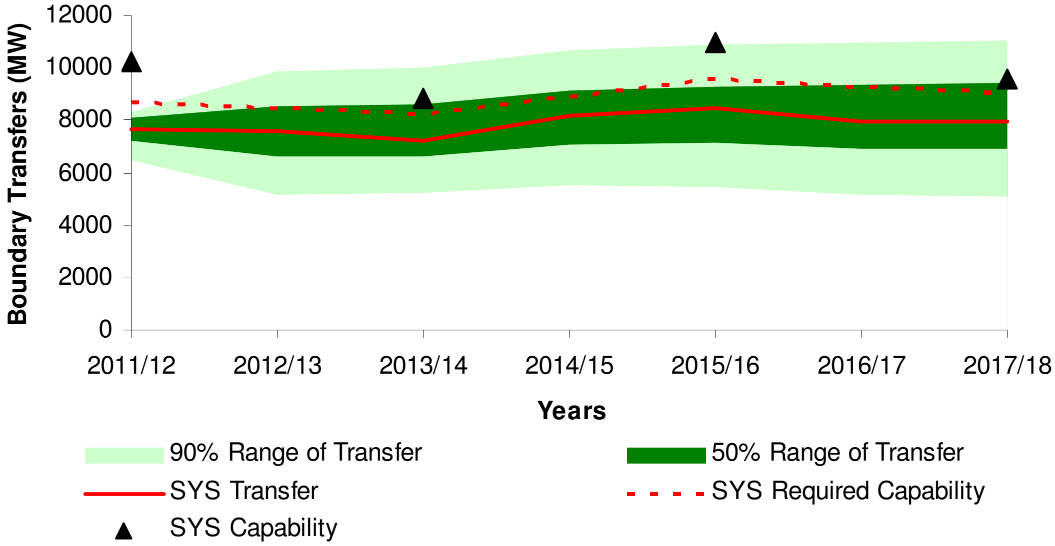


Table 8-T11 - Boundary B11 NGET North East & Yorkshire							
Quantity (MW)	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**
B11E - EXPORT							
Effective Generation	21835	21863	21605	22503	22746	22263	22387
Demand	14176	14276	14378	14323	14249	14336	14423
Required Transfer	8686	8614	8254	9219	9548	8983	9024
B11I - IMPORT							
Effective Generation	36999	36971	37229	36331	36088	36571	36447
Demand	44658	44558	44456	44511	44585	44498	44411
Required Transfer	-8686	-8614	-8254	-9219	-9548	-8983	-9024

Boundary B11 is the North East and Yorkshire boundary and transfers the bulk of the power from the Anglo Scottish boundaries to Central and North West. The required transfer increases steadily throughout the period of 2011/12 to 2015/16, indicating the lack of net generation in the south of England and some conventional generating units coming out of merit. In 2016/17 the transfers decrease due to an increase in generation south of the boundary. It can be seen from the figure that the SYS capability is higher than the required capability throughout the seven years, and increases to its maximum in 2015/17 of 10,995 MW; due to the West Coast HVDC link and other associated TIRG works which results in a thermal increase of the boundary circuits.

Boundary 12: NGET South & South West

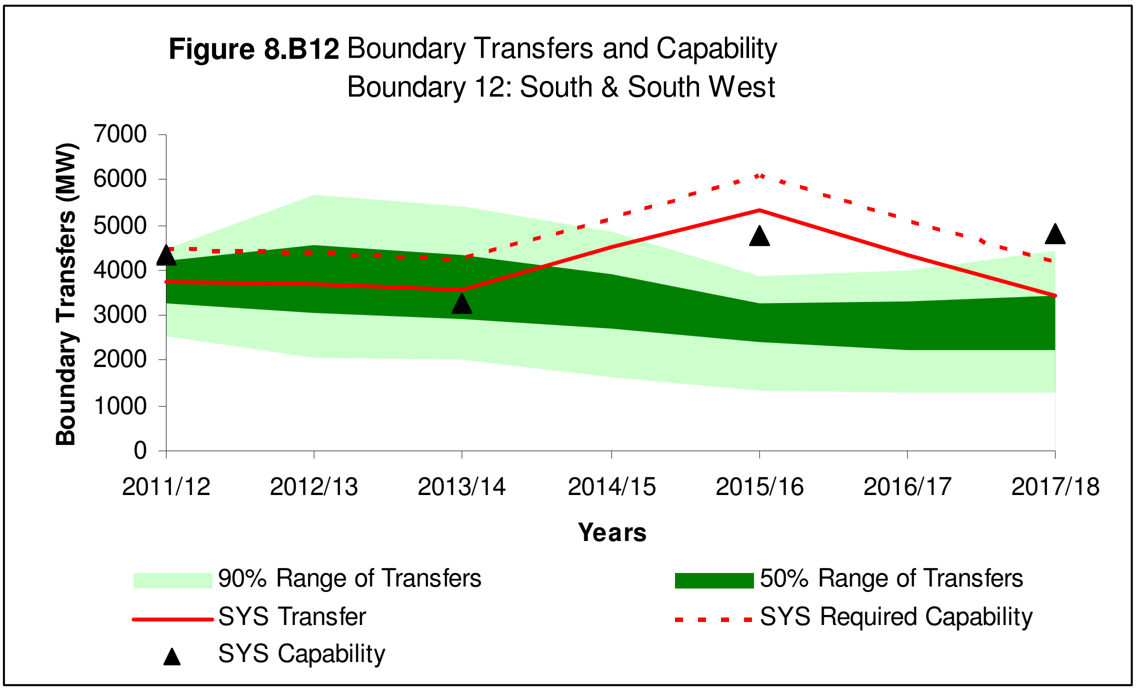


Table 8-T12 - Boundary B12 NGET South & South West							
Quantity (MW)	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**
B12E - EXPORT							
Effective Generation	8877	8927	9045	8105	7298	8177	8933
Demand	12605	12603	12600	12608	12620	12498	12373
Required Transfer	-4470	-4398	-4257	-5235	-6084	-5060	-4157
B12I - IMPORT							
Effective Generation	49957	49907	49789	50729	51536	50657	49901
Demand	46229	46231	46234	46226	46214	46336	46461
Required Transfer	4470	4398	4257	5235	6084	5060	4157

Boundary B12 is the South and South West boundary, which transfers power from the Midlands to the South Coast. In 2015/16 the required transfer spikes due to particular plant in the boundary falling out of merit. This can be overcome by a combination of operational measures and applied reinforcements. As Hinkley Point C and the Atlantic Array connect in 2017/18 a drop in planned transfer is encountered as the local generation within the zones feeds the local demand, a net decrease in transfer is encountered; thus minimising its reliance on importing power from the boundary.

Boundary 13: NGET South West

Figure 8.B13 Boundary Transfers and Capability
Boundary 13: South West

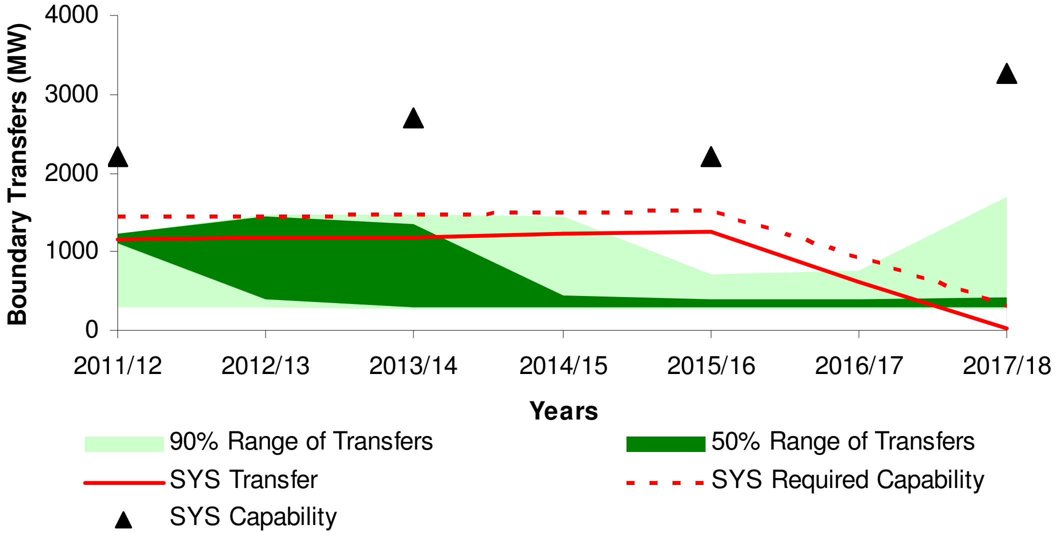


Table 8-T13 - Boundary B13 NGET South West							
Quantity (MW)	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**
B13E - EXPORT							
Effective Generation	1786	1760	1748	1713	1708	2382	3024
Demand	2950	2944	2937	2944	2951	3002	3053
Required Transfer	-1444	-1462	-1466	-1513	-1530	-911	-324
B13I - IMPORT							
Effective Generation	57048	57074	57086	57121	57126	56452	55810
Demand	55884	55890	55897	55890	55883	55832	55781
Required Transfer	1444	1462	1466	1513	1530	911	324

Boundary B13 is located at the southern most tip of the UK, running from the Severn Estuary to the South Coast, East of Mannington. It is characterised with high zonal demand. As the generation increases throughout the SYS period, and begins to exceed the local demand, the boundary becomes an exporting boundary during the summer period due to light loads within the region.

The SYS transfer remain fairly constant throughout the early SYS periods fluctuating around 1,100MW; but with the connection of new offshore windfarms within the South West, an increase in generation leads to reduction in transfer. The SYS capability of boundary B13 exceeds the boundary transfers significantly throughout the years, and the addition of the new overhead line from Hinckley Point to Seabank increases the thermal capability of the boundary in later years. Thus in 2017/18 the SYS capability increases from approximately 2,200 MW to 3,200 MW.

Boundary 14: NGET London

Figure 8.B14 Boundary Transfers and Capability
Boundary 14: London

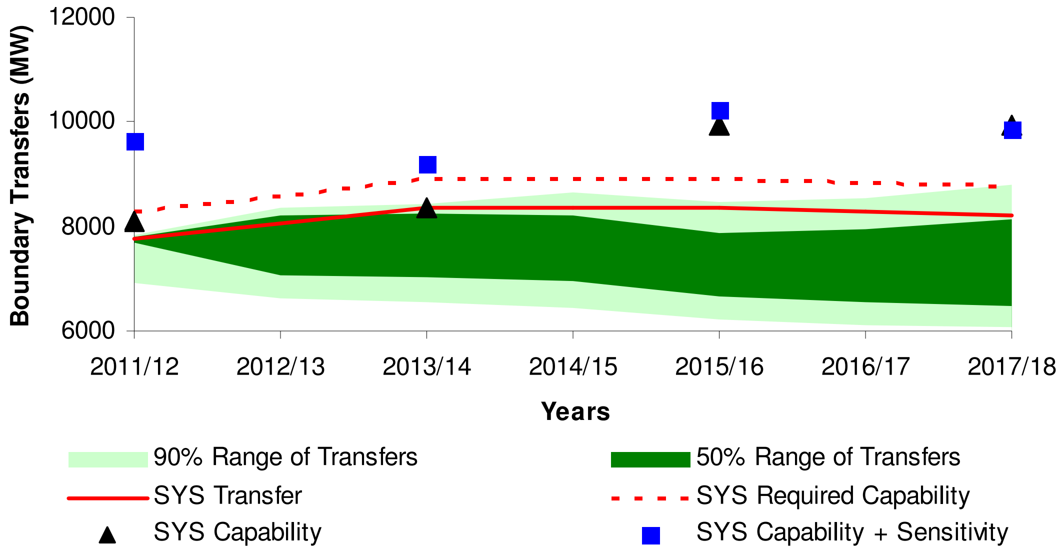


Table 8-T14 - Boundary B14 NGET London							
Quantity (MW)	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**
B14E - EXPORT							
Effective Generation	1750	1724	1712	1861	2044	2035	1992
Demand	9504	9791	10078	10234	10395	10301	10205
Required Transfer	-8268	-8595	-8909	-8927	-8915	-8827	-8769
B14I - IMPORT							
Effective Generation	57084	57110	57122	56973	56790	56799	56842
Demand	49330	49043	48756	48600	48439	48533	48629
Required Transfer	8268	8595	8909	8927	8915	8827	8769

B14 covers Central London and the surrounding outer London areas. It relies on importing power from generators outside the boundary, namely the Thames Estuary region to feed the London demand of approximately 10,000 MW. As the Seven Year Statement assumes that approximately 1,800 MW on average is being generated in London, approximately 8,200 MW is assumed to be imported from other generators outside of the boundary. Boundary B14 is characterised with high local demand and minimal generation in comparison to the other boundaries. London's energy import relies heavily on a number of 400 and 275kV circuits such as the 275 kV Tilbury-Warley-Elstree circuits and the Littlebrook-West Thurrock circuits bringing power from the surrounding areas. Additional stress can be placed on the surrounding circuits if the European interconnectors in the Thames Estuary export to the continent causing increased power flows through London and across B14. This can be seen in figure 8. B14 by a low SYS capability. However, when the links are at float shown as a sensitivity, the capabilities are higher and achieve compliance in all years. Reinforcement schemes are adopted around the London region to ensure that the boundary is compliant against a number of credible conditions.

Boundary 15: NGET Thames Estuary

Figure 8.B15 Boundary Transfers and Capability
Boundary 15: Thames Estuary

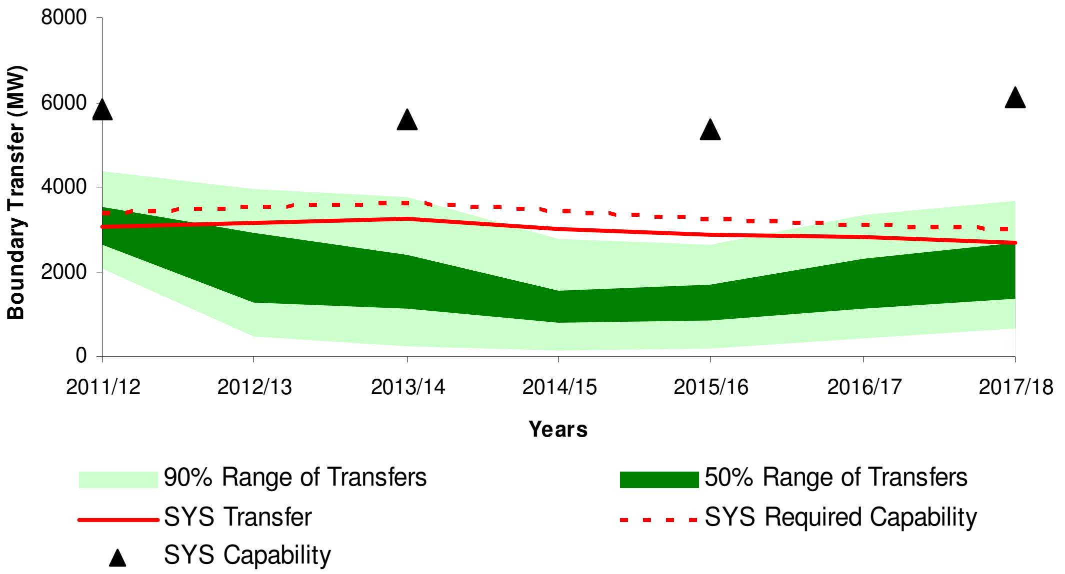


Table 8-T15 - Boundary B15 NGET Thames Estuary							
Quantity (MW)	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**
B15E - EXPORT							
Effective Generation	5214	5285	5395	5189	5073	5073	4990
Demand	2150	2155	2161	2193	2226	2273	2322
Required Transfer	3384	3489	3634	3395	3244	3168	3008
B15I - IMPORT							
Effective Generation	53620	53549	53439	53645	53761	53761	53844
Demand	56684	56679	56673	56641	56608	56561	56512
Required Transfer	-3384	-3489	-3634	-3395	-3244	-3168	-3008

B15 is referred to the Thames Estuary boundary with significant generation in Dungeness (nuclear), Damhead Creek (CCGT) and Kingsnorth (coal) with future wind power entering from the east generated by Rounds 1 and 2 windfarms such as the London Array wind farms. However even though generation is high within this zone, a drop in transfer is encountered in later years, as numerous LCPD and coal fired power station close or fall out of merit. This is somewhat counter balanced by new renewable generation and new CCGT plants. In essence the required transfer remains fairly constant throughout the SYS years, with a SYS capability exceeding the transfers. Against the SYS background the capability of this boundary exceeds the required transfers of this boundary for all the years, however the interconnectors to France and the Netherlands can change the boundary requirements by up to 6GW dependant on whether they import or export power. To manage this large range of potential transfers it is necessary to keep a high boundary capability to avoid possible restrictions.

Boundary 16: NGET North East, Trent & Yorkshire

Figure 8.B16 Boundary Transfers and Capability
Boundary 16: North East, Trent & Yorkshire

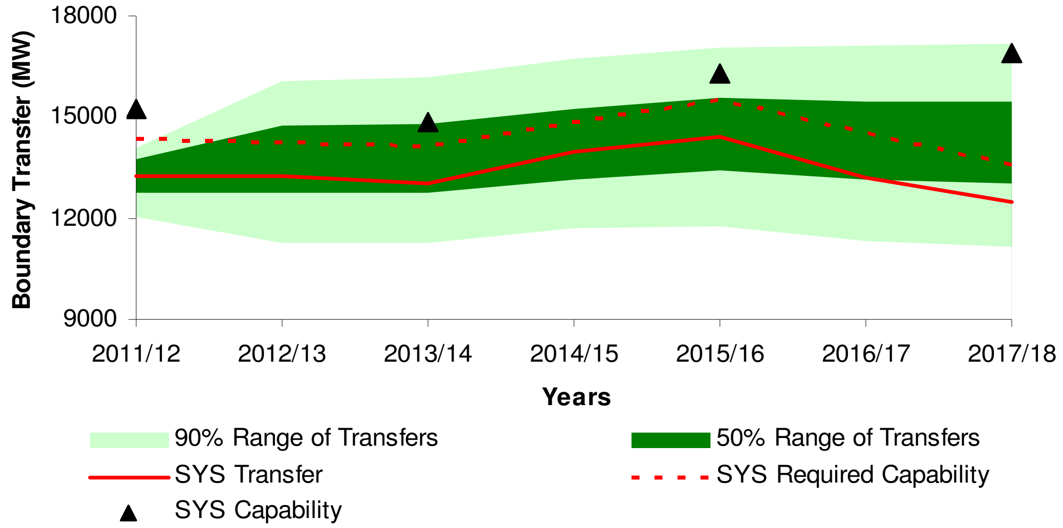


Table 8-T16 - Boundary B16 NGET North East, Trent & Yorkshire							
Quantity (MW)	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**
B16E - EXPORT							
Effective Generation	28376	28491	28370	29284	29666	28445	27721
Demand	15133	15242	15352	15309	15248	15250	15252
Required Transfer	14341	14349	14120	15087	15539	14299	13558
B16I - IMPORT							
Effective Generation	30458	30343	30464	29550	29168	30389	31113
Demand	43701	43592	43482	43525	43586	43584	43582
Required Transfer	-14341	-14349	-14120	-15087	-15539	-14299	-13558

Boundary B16 is the North East, Trent and Yorkshire boundary which cuts across from western side of Scottish border to the east coast of central England. The transfer trend characteristics follow similar to that of B8, B9 and B11, with the range of required transfer varying from approximately 13,500 MW to 15,500 MW. The SYS capability is sufficient for boundary compliance through out all years. The critical limitation of this boundary is a thermal overload on the West Burton to High Marnham circuit, and West Burton to Cottam circuit. The already planned uprating of these circuits and the addition of the West Coast HVDC link, ensures that the boundary is compliant in later years.

Boundary 17: NGET West Midlands

Figure 8.B17 Boundary Transfers and Capability
Boundary 17: West Midlands

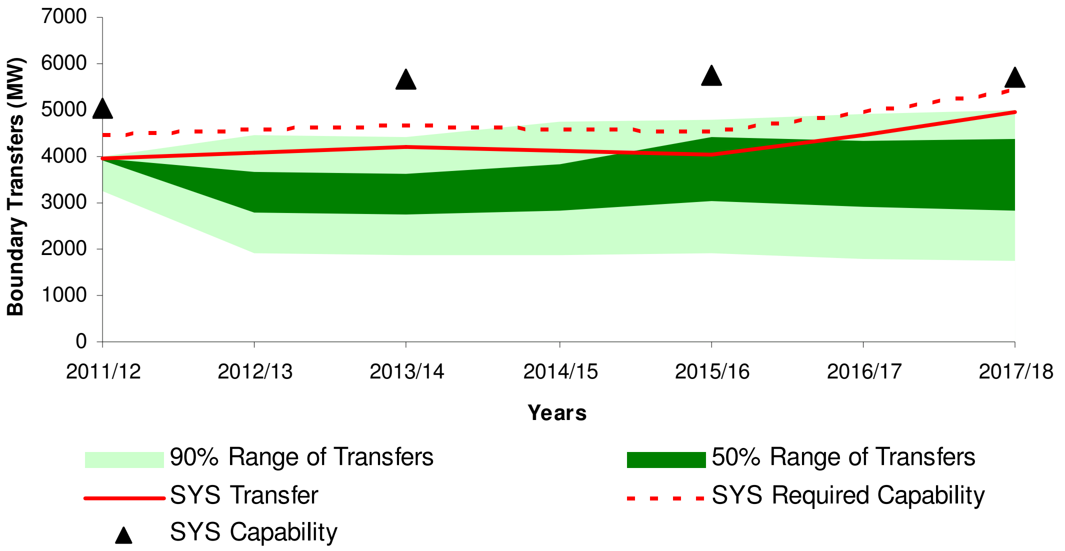


Table 8-T17 - Boundary B17 NGET West Midlands							
Quantity (MW)	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**
B17E - EXPORT							
Effective Generation	3486	3241	3023	3092	3217	2814	2359
Demand	7441	7330	7217	7227	7240	7282	7325
Required Transfer	-4465	-4588	-4684	-4630	-4523	-4952	-5431
B17I - IMPORT							
Effective Generation	55348	55593	55811	55742	55617	56020	56475
Demand	51393	51504	51617	51607	51594	51552	51509
Required Transfer	4465	4588	4684	4630	4523	4952	5431

Boundary B17 is classified as the West Midlands boundary and historically suffers from a lack of local generation as well as having a high dependency of importing power from Northern zones to meet its demands. The thermal capability of the boundary under SQSS standards is in the region of 5,500 MW, but suffers from voltage violations in later years as conventional plant fall out of merit or close which reduces reactive support to the region. Throughout the SYS period the boundary capability is sufficient to meet the boundary requirements.

Indicative Reinforcements for licence compliance

The list of reinforcement schemes presented in Table 8.2 provides an indication of those reinforcements that may be required to ensure continued compliance with the Licence Standard across the 17 major SYS boundaries at the time of peak for the given SYS background, i.e. to remedy capability deficits.

These indicative schemes would be additional to the currently planned transmission reinforcements listed in Table 6.2, and which already form part of the SYS background.
The additional schemes would be required, not only for compliance across the 17 SYS boundaries ('inter-zonal' reinforcements), but also for compliance across a number of boundaries internal to the zones delineated by the 17 SYS boundaries ('intra-zonal' reinforcements). The developments listed are those required for the specific SYS background. The additional indicative schemes would be varied to meet the changing needs of the system as it evolves.

Once the need for a particular reinforcement is established the detailed specification will be considered. By way of example, for reactive compensation plant, the optimal location, size and desired performance will be the subject of detailed analyses nearer the time when there is a need to commit to the work.

Some of the works listed in Table 8.2 will have been made a condition of particular 'GB Agreements' for connection to and use of the GB system. That is, a condition will have been included in certain agreements stipulating that the works would have to be completed before connection to or use of the GB Transmission System is permitted. This is in order to ensure continued compliance of the system with the Licence Standard and to safeguard the interests of all Users of the GB Transmission System in respect of security of supply.

Indicative Reinforcements required to meet Environmental Targets

In June 2008, the Government published its consultation on a UK Renewable Energy Strategy. Following on from this, the Electricity Networks Strategy Group (ENSG), a cross industry group jointly chaired by the Department of Energy and Climate Change and Ofgem, asked the three GB Transmission Licensees, National Grid, Scottish Hydro Electric Transmission and Scottish Power Transmission with the support of an Industry Working Group to take forward a study to:

- Develop electricity generation and demand scenarios consistent with the EU target for 15% of the UK's energy to be produced from renewable sources by 2020; and
- Identify and evaluate a range of potential electricity transmission network solutions that would be required to accommodate these scenarios.

In March 2009, ENSG published a report 'Our Electricity Transmission Network: A Vision For 2020':

http://www.ensg.gov.uk/assets/1696-01-ensg_vision2020.pdf

which discharged the action placed on the Transmission Licensees. The reinforcements identified in this report are based on a range of scenarios that take account the significant changes anticipated in the generation mix between now and 2020. In particular, the scenarios examined the potential transmission investments with the connection of large volumes of onshore and offshore wind generation required to meet the 2020 renewables target, whilst, at the same time, facilitating the connection of other essential new generation, such as new nuclear that will be needed to reduce carbon emissions and maintain continued security of supply.

The study concluded that, provided the identified reinforcements are taken forward in a timely manner, they can be delivered to required timescales. It should also be noted that the reinforcements identified in this report are designed to facilitate connection of a large volume of different types of generation in a given area, not dependent on a single generation project proceeding, and where the lead time for the combined transmission reinforcements in a given area would exceed the time taken to construct the generation, i.e. lack of transmission capacity would have a potential negative impact in meeting renewable targets and/or accommodating generation required to maintain continued security of supply.

The development of the potential reinforcements are phased to achieve a 2020 delivery date with the initial phase being delivered in 2015 based on the prospective growth of renewables in each region. It is recognised that there will continue to be a degree of uncertainty about the volume and timing of generation growth in any given area. It is therefore proposed to continue to monitor the development of the market and update the scenarios accordingly. The proposed transmission reinforcements will be developed in such a manner as to ensure that the options are maintained at minimum costs. By undertaking pre-construction engineering work positions the delivery of each project such that construction can be commenced when there is sufficient confidence that the proposed reinforcements will be required. This is the least regrets solution, i.e. the minimum commitment to secure the ability to deliver to required timescales.

Following Ofgem initial consultation phase on Strategic investments, funds have been made available to undertake the pre-construction engineering for reinforcements identified by the study and these are being developed without requirements for User commitment. It is anticipated that Ofgem will undertake further consultation with regard establishing a regulatory framework which will facilitate taking forward the reinforcements identified by the report and any additional anticipatory reinforcement which may be required to facilitate the objectives identified in the report.

Table 8.1 - GUM Boundaries Defined by SYS Study Zone

Boundary Number	Boundary Name	SYS Study Zone/s (one side of boundary)
B1	North West Export	Z1
B2	North-South	Z1, Z2
B3	Sloy Export	Z3
B4	SHETL-SPT Boundary	Z1, Z2, Z3, Z4
B5	North-South	Z1, Z2, Z3, Z4, Z5
B6	SPT-NGET Boundary	Z1, Z2, Z3, Z4, Z5, Z6
B7	Upper North-North	Z1, Z2, Z3, Z4, Z5, Z6, Z7
B8	North to Midlands	Z1, Z2, Z3, Z4, Z5, Z6, Z7, Z8, Z9
B9	Midlands to South	Z1, Z2, Z3, Z4, Z5, Z6, Z7, Z8, Z9, Z10, Z11
B10	South Coast	Z16, Z17
B11	North East & Yorkshire	Z1, Z2, Z3, Z4, Z5, Z6, Z7,Z8
B12	South & South West	Z13, Z16, Z17
B13	South West	Z17
B14	London	Z14
B15	Thames Estuary	Z15
B16	North East, Trent & Yorkshire	Z1, Z2, Z3, Z4, Z5, Z6, Z7, Z8, Z10
B17	West Midlands	Z11

Table 8.2 Indicative Developments		
Location	**Works**	**Affected Boundaries/Licensee**
Higm Marnham - Ratcliffe	Uprating on the High Marnham to Ratcliffe circuits	NGET
Ratcliffe - Staythorpe	Uprating of the Ratcliffe to Staythorpe circuit	NGET
Grendon – West Burton	Uprating of the Grendon to West Burton circuit	NGET
Ninfield	Install reactive compensation (1MSC)	NGET
Feckenham	Install reactive compensation (1MSC)	NGET
Cottam	Install reactive compensation (1MSC)	NGET
Staythorpe	Install reactive compensation (1MSC)	NGET
Ratcliffe on Soar	Install reactive compensation (1MSC)	NGET
Pelham	Install reactive compensation (1MSC)	NGET