Network Options Assessment Methodology

System Operator

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nationalgrid

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About this document

This document contains National Grid's Network Options Assessment (NOA) methodology established under NGET Licence, Licence Condition C27 in respect of the financial year 2015/16. It covers the three methodology documents on which NGET in its role as SO will base the initial NOA processes in 2015/16.

Network Options Assessment Methodology

Foreword

This document contains National Grid's Network Options Assessment (NOA) methodology established under NGET Licence, Licence Condition C27 in respect of the financial year 2015/16. It describes how the System Operator (SO) meets these obligations which are broken down into the three components below:

- Network Options Assessment Report methodology
- Network Options Assessment for Interconnectors
- SO Process for Input into Transmission Owner (TO) Led Strategic Wider Works (SWW) Needs Case Submissions.

NOA Report methodology describes how we assess options for reinforcing the National Electricity Transmission System to meet the requirements that the SO finds from its analysis of the Future Energy Scenarios. This methodology includes the proposed form of the NOA report.

NOA for Interconnectors details the methodology for the analysis and publication of the NOA for Interconnectors report, It includes an introduction to social and economic welfare benefits and analysis.

SO Process for Input into TO Led SWW Needs Case Submissions documents how the SO supports the Transmission Owners (TO) in their creation and development of Needs Cases through to the submission to Ofgem.

We have taken the approach of three component documents for the first year of the NOA process to ease the transition and evolution of existing processes into new ones. While we have written the three component documents so that they can be read in isolation, we expect that in future years these component parts will be brought together into a single NOA methodology.

Network Options Assessment Report Methodology

System Operator

September 2015

Version	**FINAL 1.2**
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About this document

This document contains National Grid's Network Options Assessment (NOA) Report methodology established under NGET Licence, Licence Condition C27 in respect of the financial year 2015/16. It covers the methodology on which NGET in its role as SO will base the initial NOA report which will be published by 31 March 2016. As the methodology evolves due to experience and stakeholder feedback, the methodology statement will be revised for the second NOA and on an enduring basis as required by Licence Condition C27.

Network Options Assessment Report Methodology

Contents

Network Options Assessment Report Methodology 2
Introduction 4
Overview 4
Differences between NOA and ETYS 4
Appendix A: Network Options Assessment Report Methodology 5
Introduction 5
Collect Input 7
Updated Future Energy Scenarios 7
Sensitivities 9
Interconnectors 10
Latest version of National Electricity Transmission System Security and Quality of Supply Standard (NETS SQSS) 10
Identify future transmission capability requirements 10
National generation and demand scenarios 10
Identify future transmission solutions 11
Build GB Model 14
Boundary capability assessment for options 15
Cost Benefit Analysis (CBA) 17
Introduction 17
CBA Methodology 17
Electricity Scenario Illustrator (ELSI) 20
Selection of preferred option 20
Single Year Least Regret Decision Making 20
Process Output 23
Report drafting 23
Report publication 24
Stakeholder consultation 25
Methodology 25
Report output 25
Area for further development 26
Provision of Information 26

Appendix B: System Requirements Form Template 28
Appendix C: NOA Study Matrix 32
Appendix D: NOA Process Flow Diagram 33
Appendix E: Summary of Stakeholder feedback 38
Appendix F: Form of the Report 40

Introduction

Overview

1 The purpose of the Network Options Assessment (NOA) is to facilitate the development of an efficient, coordinated and economical system of electricity transmission consistent with the National Electricity Transmission System Security and Quality of Supply Standard and the development of efficient interconnector capacity.

2 This document provides an overview of the aims of the NOA and details the methodology which describes how the System Operator (SO) assesses the required levels of network capability, the options available to meet this capability and the SO's preferred options for further development. It is important to note that whilst the SO identifies its preferred options to progress to meet system needs, any investment decisions remain with the Transmission Owners (TOs) or other relevant parties as appropriate.

3 This methodology document describes the end to end process for the analysis and publication of the initial NOA report (to be published by 31 March 2016) and clearly identifies the roles and responsibilities of the SO and TOs.

4 Where this methodology refers to 'TOs', it means onshore TOs.

5 Appendix A describes the process and the headers used follow the flow diagram in Appendix D for clarity. Appendices B and C contain supporting information.

6 In accordance with Standard Licence Condition C27, the SO has sought the input of stakeholders. Appendix E summarises any views that the SO has not accommodated in producing this NOA report methodology.

Differences between NOA and ETYS

7 The NOA process is an obligation under NGET Licence, Standard Licence Condition C27 (The Network Options Assessment process and reporting requirements). Specifically, paragraph 14 defines the required contents of the NOA report which are the SO's best view of options for reinforcements for the national electricity transmission system together with alternatives and preferred options.

8 The Electricity Ten Year Statement (ETYS) is an obligation under NGET Licence, Standard Licence Condition C11 (Production of information about the national electricity transmission system). Paragraph 3 defines ETYS' required contents which are the SO's best view of the design and technical characteristics of the development of the national electricity transmission system and the system boundary transfer requirements.

9 In summary, ETYS describes technical aspects of the system and the system's development while NOA describes options for reinforcement to meet system needs.

Appendix A: Network Options Assessment Report Methodology

Introduction

A1 The Network Options Assessment (NOA) process set out in Standard Licence Condition C27 of the NGET Licence facilitates the development of an efficient, coordinated and economical system of electricity transmission and the development of efficient interconnection capacity. This NOA report methodology has been developed in accordance with Standard Licence Condition C27 of the NGET licence.

A2 This document defines the process by which the NOA is applied to the onshore and offshore electricity transmission system in GB. The process runs from identifying a future reinforcement need, through assessing available solutions, to selecting and documenting the recommended option/s for further development. The SO has engaged with the onshore TOs to develop this initial methodology statement. The Offshore TOs declined to be involved in formulating the initial NOA methodology but the SO will continue to offer the opportunity for consultation. Following publication of the NOA report further stakeholder engagement is undertaken to inform the methodology statement for supporting further NOA reports.

A3 As background information changes and new data is gained, for example in response to changing customer requirements, both the recommended options and their timing will be updated, driving timely progression of investment in the electricity transmission system.

A4 The SO engages stakeholders on the annual updates to the key forecast data used in this decision-making process, and shares the outputs from this process through the publication of the NOA report.

A5 NGET Licence Condition C27 Paragraph 15 sets out the contents of the NOA report:

> Each NOA report (including the initial NOA report) must, in respect of the current financial year and each of the nine succeeding financial years:
>
> (a) set out:
>
> (i) the licensee’s best view of the options for Major National Electricity Transmission System Reinforcements (including any Non Developer-Associated Offshore Wider Works that the licensee is undertaking early development work for under Part D), and additional interconnector capacity that could meet the needs identified in the electricity ten year statement (ETYS) and facilitate the development of an efficient, co-ordinated and economical system of electricity transmission;
>
> (ii) the licensee’s best view of alternative options, where these exist, for meeting the identified system need. This should include options that do not involve, or involve minimal, construction of new transmission capacity; options based on commercial arrangements with users to provide transmission services and balancing services; and, where appropriate, liaison with distribution licensees on possible distribution system solutions;
>
> (iii) the licensee’s best view of the relative suitability of each option, or combination of options, identified in accordance with paragraph 15(a)(i) or (ii), for facilitating the

> development of an efficient, co-ordinated and economical system of electricity transmission. This must be based on the latest available data, and must include, but need not be limited to, the licensee's assessment of the impact of different options on the national electricity transmission system and the licensee's ability to co-ordinate and direct the flow of electricity onto and over the national electricity transmission system in an efficient, economic and co-ordinated manner; and
>
> (iv) the licensee's recommendations on which option(s) should be developed further to facilitate the development of an efficient, co-ordinated and economical system of electricity transmission;
>
> (b) be consistent with the ETYS and where possible align with the Ten Year Network Development Plan as defined in standard condition C11 (Production of information about the national electricity transmission system), in the event of any material differences between the Ten Year Network Development plan and the NOA report an explanation of the difference and any associated implications must be provided; and
>
> (c) have regard to interactions with existing agreements with parties in respect of developing the national electricity transmission system and changes in system requirements.

A6 References to 'weeks' in the NOA report methodology are to calendar weeks as defined in ISO 8601. Week 1 is at the start of January and is the same as the system used the Grid Code OC2.

Major National Electricity Transmission System Reinforcements

A7 Standard Licence Condition Section C refers to the term Major National Electricity System Reinforcements for the purpose of this NOA report methodology statement. The definition has been agreed from consultation with the onshore TOs and the Authority (Ofgem) as:

Major National Electricity Transmission System Reinforcements are defined by the SO to consist of a *project or projects in development to deliver additional boundary capacity or alternative system benefits as identified in the Electricity Ten Year Statement or equivalent document.*

A8 The intention of this definition is to maximise transparency in the investment decisions affecting the National Electricity Transmission System while omitting schemes that do not provide wider system benefits. Such system benefits might be a user connection or improved system reliability.

Eligibility criteria for projects for inclusion / exclusion

A9 The NOA report presents projects that are defined by Major National Electricity System Reinforcements (see definition above).

A10 The SO provides a summary justification for any projects that are excluded from detailed NOA analysis.

A11 Once a Strategic Wider Works (SWW) Needs Case has been approved by Ofgem, the option is excluded from the NOA analysis although the report refers to it and it is included in the baseline. This is because it is managed through the SWW process. Ofgem have agreed the approach of excluding options where they have agreed the SWW Needs Case. The NOA Report will include analysis of options under construction that are funded through the Incremental Wider Works mechanism.

Roles and responsibilities of SO and TOs

A12 The roles and responsibilities of the SO and TOs are described below. However, as the NOA process evolves and matures, these roles and responsibilities will also develop and change.

A13 The SO role and responsibilities are based around its overview of the network requirements. Specific role areas are:

- Analysis of UK Future Energy Scenarios (UK FES) data
- Technical analysis of boundary capabilities for England and Wales
- Running Cost Benefit Analysis (CBA) studies
- Production and publication of NOA report
- Recommending options for further development
- Devising and developing options for non-build and Offshore Wider Works.

A14 The TOs' roles and responsibilities include:

- Technical analysis of boundary capabilities by SPT and SHE Transmission in and affecting their areas[1]
- Cost information
- Environmental information
- Consents and deliverability information
- Capability improvements
- Earliest in Service Date (EISD)
- Stakeholder engagement (following review of draft outputs)
- Community engagement.

The headers in this methodology follow the stage names in the process diagram in Appendix D.

Collect Input

Updated Future Energy Scenarios

A15 The relevant set of UK Future Energy Scenarios (UK FES) as required by NGET Licence, Licence Condition C11, is used as the basis for each annual round of analysis. These provide self-consistent generation and demand scenarios which extend to 2035 in detail and at a higher level to 2050. The UK FES document is consulted upon widely and published each year as part of a parallel process.

A16 The NOA process utilises the main UK FES as well as the contracted position to form the background for which studies and analysis is carried out. The total number of scenarios is subject to change depending on stakeholder feedback received through the UK FES consultation process. In the event of any change, the rationale is described and presented within the UK FES consultation report that is published each year.

[1] This is anticipated for the initial NOA report.

A17 In 2015, the four main scenarios are:

- Gone Green – The Gone Green scenario represents a potential generation and demand background which meets the environmental targets in 2020 and maintains progress towards the UK's 2050 carbon emissions reduction target. The achievement of the climate change targets requires the deployment of renewable and low carbon technologies. EU aspirations regarding interconnector capacity for each member country remain applicable.

- Slow Progression – Slow Progression is a scenario where secure, affordable and sustainable energy sources are the political objectives, but the economic conditions are less favourable than under Gone Green and so carbon reduction policies cannot be implemented as quickly as under that scenario. The focus on the green agenda ensures that the generation landscape is shaped by renewable technology. Ambition for innovation is constrained by financial limitations, which, in comparison to Gone Green, leads to a slower uptake of renewables.

- No Progression – No Progression is a scenario where secure and affordable energy sources are the major political objective, because the economic conditions are less favourable than other scenarios and there is less of a political focus on sustainability. This means that ambitious carbon reduction policies are not expected to be implemented. Gas and existing coal feature in the generation mix over renewables and nuclear, with focus being on the cheapest sources of energy. The lack of focus on the green agenda and limited financial support available for low carbon results in a limited new build programme for nuclear and minimal deployment of less established technology.

- Consumer Power - Consumer Power is a scenario where there is more future economic prosperity but less political emphasis on sustainable energy policy. There is more money available in the economy to both consumers and Government, but there is a lack of political will for centralised carbon reduction policy. The favourable economic conditions encourage development of generation at all levels. There is high renewable generation at a local level and high volumes of nuclear and gas generation at a national level. There is minimal deployment of new low carbon technologies, with the technology not achieving commercial scalability e.g. Carbon Capture and Storage (CCS), marine.

A18 The demand scenarios are created by using a mix of data sources, including feedback from the UK FES consultation process. The overall scenarios are a composite of a number of sub-scenarios: inputs; the key scenarios being the economic growth projections, fuel prices, domestic heat/light/appliance demand, and projections of manufacturing and non-manufacturing output. Other inputs include (but are not limited to) small scale generation, consumer behaviour and the effect of smart meters/time of use tariffs and new technologies (e.g. electric vehicles, heat pumps. LED light bulbs). The scenario demands are then adjusted to match the metered Average Cold Spell (ACS)[2] corrected actual outturns.

A19 Using regionally metered data, the "ACS adjusted scenario demands" are split proportionally around GB.

[2] The Average Cold Spell (ACS) is defined as a particular combination of weather elements which give rise to a level of peak demand within a financial year (1 April to 31 March) which has a 50% chance of being exceeded as a result of weather variation alone.

A20 Annual demand submissions are made by transmission system users, which are obtained between June and November each year. The regionally split “ACS adjusted demand scenarios” are then converted into demand by Grid Supply Point using the same proportions as specified in the ‘User’ submissions.

Sensitivities

A21 Sensitivities are used to enrich the analysis for particular boundaries to ensure that issues, such as the sensitivity of boundary capability to the connection of particular generation projects, are adequately addressed. The SO leads on the sensitivities in conjunction with the TOs and any feedback from stakeholders sought through the FES consultation process. This allows regional variations in generation connections and anticipated demand levels that still meet the scenario objectives to be appropriately considered.

A22 For example, the contracted generation background on a national basis far exceeds the requirements for credible scenarios, but on a local basis, the possibility of the contracted generation occurring is credible and there is a need to ensure that we are able to meet customer requirements. A “one in, one out” rule is applied: any generation added in a region of concern is counter-balanced by the removal of a generation project of similar fuel type elsewhere to ensure that the scenario is kept whole in terms of the proportion of each generation type. This effectively creates sensitivities that still meet the underlying assumptions of the main scenarios but accounts for local sensitivities to the location of generation.

A23 The inclusion of a local contracted scenario generally forms a high local generation case and allows the maximum regret associated with inefficient congestion costs to be assessed. In order to ensure that the maximum regret associated with inefficient financing costs and increased risk of asset stranding is assessed; a low generation scenario where no new local generation connects is also considered. This is particularly important where the breadth of scenarios considered do not include a low generation case.

A24 Interconnectors to Europe give rise to significant swings of power flows on the network due to their size and because they can act as both a generator (when importing into GB) and demand (when exporting to Europe). For example, when interconnectors in the South East are exporting to Europe, this changes the loading on the transmission circuits in and around London and hence creates different limits on the amount of power that can be transferred.

A25 The modelling of interconnector flows during winter peak condition is based on an economic simulation driven by forecast energy prices for GB and remote markets in Europe. However, the modelling of interconnector flows during summer demand condition is based on historical precedent. In future, the modelling of interconnector flows during summer demand condition will be based on economic simulation. Therefore, we continue to work closely with stakeholders in developing our models of interconnector flows.

A26 The SO extends sensitivities studies further to test import or security constraints. UK FES tends to produce export type flows such as north to south. In some circumstances, flows are reversed. The SO develops these sensitivities in consultation with stakeholders to produce transfer requirements for import cases.

Interconnectors

A27 The SO undertakes analysis to assess the optimum level of interconnectors capacity. Interconnectors are recognised in the background for the NOA report. Network capacity and welfare benefit are the key drivers for determining the optimum level of interconnection for GB consumers. The SO anticipates the market will respond to this intelligence with potential projects aligned with the optimum level of interconnectors recommended by the SO. This output is expected as part of ETYS 2016 (produced in November 2016) or the NOA report 2016 (produced March 2017). In order to facilitate the above, the SO is developing a new market model. As a result for 2015/16, the proposed methodology only seeks to forecast the consumer surplus which could be derived from interconnectors proposed across the four Future Energy Scenarios (FES) published in 2015. The details of the proposed approach for 2015/16 are presented in the NOA for Interconnectors methodology.

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

A28 The existing version of the National Electricity Transmission System Security and Quality of Supply Standard (NETS SQSS) is used for each annual update. If amendments are active, the potential impacts of these amendments are also considered as part of this process.

Identify future transmission capability requirements

National generation and demand scenarios

A29 For every boundary, the future capability required under each scenario and sensitivity is calculated by the application of the NETS SQSS. The network at peak system demand and other seasonal demands (spring/autumn and summer) is used to outline the minimum required transmission capability for both the Security and Economy criteria set out in the NETS SQSS.

A30 The Security criterion is intended to ensure that demand can be supplied securely, without reliance on intermittent generators or imports from interconnectors. The level of contribution from the remaining generators is established in accordance with the NETS SQSS for assessing the Average Cold Spell (ACS) peak demand[3]. Further explanation can be found in Appendices C and D of the NETS SQSS.

A31 The Economy criterion is a pseudo cost benefit study and ensures sufficient capability is built to allow the transmission of intermittent generation to main load centres. Generation is scaled to meet the required demand level. Further details can be found in Appendix E and F of the NETS SQSS.

A32 The NETS SQSS also includes a number of other areas which have to be considered to ensure the development of an economic and efficient transmission system. Beyond the criteria above, it is necessary to:

[3] ACS Peak Demand is defined as unrestricted transmission peak demand including losses, excluding station demand and exports. No pumping demand at pumped storage stations is assumed to occur at peak times. Please note that other related documents may have different definitions of peak demand, e.g. National Grid's 'Winter Outlook Report' quotes restricted demands and 'Future Energy Scenarios' quotes GB peak demand (end-users) demands.

- Ensure adequate voltage and stability margins for year-round operation
- Ensure reasonable access to the transmission system for essential maintenance outages.

A33 The SO uses the UK FES scenarios and the criteria stated in the NETS SQSS to produce the future transmission capability requirements by using an in-house tool called Peak Y. The SO then passes this information to TOs for identification of the future transmission solutions which are described in the following section.

Identify future transmission solutions

A34 At this stage all high level potential transmission solutions that could provide additional capability across a system boundary found to be requiring reinforcement are identified (for economic and security criteria), including a review of any solutions previously considered. The NOA report presents a high level view of options, with key choices to be taken for further evaluation as outlined on a non-exhaustive basis below. The NOA options are based around choices for example:

- An onshore route of conventional AC overhead line (OHL) or cable
- An onshore route of HVDC
- Offshore options whether ‘bootstrap’ or integration between offshore generation stations (Offshore Wider Works).

A35 Variations on each of these choices may be presented where there are significant differences in options, for instance between different OHL routes where they could provide very different risks and costs.

A36 In response to the SO data on boundary capabilities and requirements, TOs identify and develop multiple credible options that deliver the potentially required reinforcements of boundaries. The SO produces and circulates the System Requirement Forms (SRF) to the TOs and in return, TOs provide high level details of credible onshore reinforcement options that are expected to satisfy the requirement. Appendix B of this document provides detailed information about the SRF template. The SO can suggest ideas for options to the TOs.

A37 The SO considers options for Non Developer-Associated Offshore Wider Works (NDAOWW) which would deliver offshore reinforcements where such an investment could achieve the desired improvement in a boundary capability. The SO continues with the early development of NDAOWW in accordance with NGET Licence, Standard Licence Condition C27 Part D.

A38 The options that the TOs provide are listed and described in the NOA report along with ‘non-build’ options such as commercial or ‘minimal-build’ options that the SO develops. The non-build solutions might include liaison with distribution licencees. The SO produces the description of the ‘non-build’ option in conjunction with the relevant TOs. The description includes the boundary that the option relieves, categorising the option into ‘build’, ‘non-build’ etc and a technical outline such as an overhead line route connecting substation ‘X’ to substation ‘Y’. The option description includes any associated aspects such as the nature of the area affected, related network changes for example substation rebuilds etc.

A39 It is recognised that as solutions develop, their level of detail increases. Solutions at a very early development stage might lack detail due to emerging drivers such as a changing generation background.

A40 The NOA process includes a window during which the TOs respond to the SO with completed SRFs.

A41 By Week 46 the Scottish TOs return the completed SRF after they have performed the technical assessment of the credible reinforcement options for their respective areas. The England and Wales TO returns the SRF earlier in June for the SO to perform the boundary capability assessment. The Scottish TOs perform the boundary capability assessment before returning the SRF.

A42 Where a boundary reinforcement affects an adjacent TO, the TOs and SO coordinate their views on the reinforcement options and produce an agreed set of options by Week 43. The SO then uses the agreed set of options in its boundary capability analysis (for England and Wales) and for the economic analysis. If there is no agreement, the SO forms a view on which options it assesses.

A43 Potential transmission solutions are presented in Table A1.

Table A1: Potential transmission solutions

Category	Transmission solution	Nature of constraint: Thermal	Voltage	Stability	Fault Levels
Low cost-investment	Co-ordinated Quadrature Booster (QB) Schemes *(automatic schemes to optimise existing QBs)*	✓	✓		
	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)*	✓	✓	✓	✓
	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 improves 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 that type of 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.*	✓	✓	✓	✓

A44 It is intended that the range of solutions identified has some breadth and includes both small-scale reinforcements with short lead-times as well as larger-scale alternative reinforcements which are likely to have longer lead-times. The SO applies a sense check in conjunction with the TOs and builds an understanding of the options and their practicalities. In this way, the SO narrows down the options while it allows the SO to assess the most beneficial solution for customers. Other than the application of economic tools and techniques, to refine a shortlist of options or identify a potential preferred solution, we rely on the TO for deliverability, planning and environmental factors. We offer a lead on operability, non-build and offshore integration matters ahead of the Cost Benefit Analysis (CBA).

A45 In checking for the suitability of an option, the SO reviews options for their operability and their effect on the wider system. As a result the SO checks for system access, ease of operation and the ability to adhere to operation policy and national standards. For system access, this means delivery of the option and the ability to manage outages to deliver future capital works and maintenance activities. In and affecting their areas, SPT and SHE Transmission undertake part of this review of options in conjunction with the SO. Because of their scale and complexity, some options may need more in-depth study work and involve an iterative approach with increasing detail added between NOA Reports.

Environmental impacts and risks of options

A46 Using the SRF the TOs provide views on the environmental impact of the options that they have proposed. They include in their views the environmental impact on the practicality of implementing each option.

A47 Different planning legislation and frameworks apply in Scotland from those in England and Wales. Where reinforcements cross more than one planning framework, this is highlighted in the NOA report together with any implications. The TOs hold the specialist knowledge for planning and consents and provide the commentary.

Basis for the cost estimate provided for each option

A48 The forecast total cost for delivering the project is split to reflect the pre-construction and construction phases. The forecast cost is a central best view.

A49 By Week 36, the TOs and SO agree each year the cost basis to be used for NOA analysis.

A50 The TOs provide the individual elements of the investments that provide incremental capability.

A51 For consistency of assessment across all options, the TOs provide all relevant costs information in the current price base.

Build GB Model

A52 The TOs submit a yearly power system model to the SO. The SO then creates the GB power system models and publishes the model for studies. Additional power system model/modelling information for network options should also be submitted from TOs such that SO have adequate models to carry out the necessary option analysis.

Boundary capability assessment for options

A53 By Week 46, the SO has completed boundary capability assessment studies for England and Wales while the Scottish TOs have completed these studies for the own areas.

A54 The boundary capability that is assessed is the lowest of the thermal, voltage and stability (where required) capability. Each of these capabilities are assessed at relevant points of the year to ensure that both the peak and off-peak capabilities are considered during the NOA process. In reporting the boundary capability each year, only the most restrictive of the capability values are published and the criteria for its definition provided in any accompanying narrative.

A55 The boundary capabilities are assessed using the Gone Green scenario for the winter peak demand condition. For the purposes of any stability analysis (where required), year round demand condition is considered. The secured events that are considered for these assessments are N-1-1, N-1 and N-D as appropriate in accordance with the NETS SQSS Chapter 5.

A56 The analysis is done in accordance with the NOA study matrix which describes the constraint type, FES scenario, season and the years for the network assessment. Selected 'Spot' years (7 and 10) are used as adjacent years would be too similar. The detailed NOA study matrix is populated in Appendix C of this document.

A57 For the purpose of the boundary capability assessment, the baseline boundary conditions need to be altered to identify the maximum capability across the boundary. To make these changes, the generation and demand on either side of the boundary is scaled until the network cannot operate within the defined limits. The steady state flows across each of the boundary circuits prior to the secured event are summed to determine the maximum boundary capability.

A58 The factors shown in Table A2 below are identified for each transmission solution to provide a basis on which to perform cost benefit analysis at the next stage.

Table A2: Transmission solution factors

Factor	Definition		
Output(s)	The calculated impact of the transmission solution on the boundary capabilities of all boundaries, the impact on network security		
Lead-time	An assessment of the time required developing and delivering each transmission solution; this comprises an initial consideration of planning and deliverability issues, including dependencies on other projects. An assessment of the opportunity to advance and the risks of delay is incorporated.		
Cost	The forecast total cost for delivering the project, split to reflect the pre-construction and construction phases.		
Stage[4]	The progress of the transmission solution through the development and delivery process. The stages are as follows:		
	Pre-construction	*Scoping*	Identification of broad need case and consideration of number of design and reinforcement options to solve boundary constraint issues.
		Optioneering	The need case is firm; a number of design options provided for public consultation so that a preferred design solution can be identified.
		Design	Designing the preferred solution into greater levels of detail and preparing for the planning process.
		Planning	Continuing with public consultation and adjusting the design as required all the way through the planning application process.
	Construction		Planning consent has been granted and the solution is under construction.

A59 In order to assess the lead-time risk described in Table A2, new overhead line solutions for example with significant consents and deliverability risks are considered with both ‘best view’ and ‘worst case’ lead-times to establish the least regret for each likely project lead-time.

A60 It is possible that alternative solutions are identified during each year and that the next iteration of the NOA process will need to consider these new developments alongside any updates to known transmission solutions, the scenarios or commercial assumptions.

A61 If the SO or the Scottish TOs (who conduct boundary capability studies) decide that there are not sufficient options to cover all scenarios, they initiate further work to

[4] These project categorisations are consistent with definitions defined as part of the ENSG process and published by DECC.

identify reinforcement options. The TOs and SO aim for at least three options for each reinforcement requirement.

A62 Where there are boundaries affecting more than one TO, the TOs and SO arrange challenge and review meetings to determine the preferred options for inclusion in the economic analysis and in the NOA report.

A63 The Scottish TOs use their boundary capability results in the SRFs that they submit back to the SO.

A64 The SO leads on non-build options in cooperation with the TOs. The economic analysis tool needs a MW value for the boundary capability which this analysis of non-build options must provide. In addition the SO must provide ongoing costs for the economic analysis such as intertrip arming fees as well as any capital outlay such as the cost of designing/installing the intertrip.

Cost Benefit Analysis (CBA)

Introduction

A65 Cost Benefit Analysis (CBA) is the best practice approach to inform an investment recommendation for a project. In particular, the approach compares forecast capital costs and monetised benefits over the project's life to inform this investment recommendation.

A66 The NOA provides investment signals based on the Single Year Regret Decision Making process. If the investment signal triggers the TO's Needs Case, the SO will assist the TO in undertaking a more detailed CBA.

A67 The purpose of the Single Year Regret Decision Making process is to inform investment recommendations regarding wider transmission works for the coming year. The main output of the process is a list of recommendations of which wider works reinforcement projects to proceed with in the next year and which to delay, a secondary output is an indicative list of which reinforcements would be proposed at present if each of the scenarios were to turn out.

A68 The methodology follows the **Guidance on the Strategic Wider Works arrangements in the electricity transmission price control, RIIO-T1** document published by Ofgem[5]. A needs case is submitted by the TO that is proposing the project to the regulator, the needs case includes a CBA section that outlines the financial case for the project. The output of this process is a recommendation of the project that is to be proceeded with.

CBA Methodology

A69 Since the number of reinforcements planned for the transmission system is quite large the country is split into regions and each reinforcement is determined to be in one of the regions. The CBA process for each region is conducted in isolation. The

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[5] See https://www.ofgem.gov.uk/ofgem-publications/83945/guidanceonthestategicwiderworksarrangementsinriiot1.pdf

year in which each of the reinforcements outside the region that is being studied will be commissioned is fixed to a pre-determined value, which may vary by scenario, This is usually based upon the recommendations of the most recent Electricity Ten Year Statement. The definition of a region is fluid and may change from year to year. The criterion by which a region is defined is that a reinforcement may not appear in more than one region (this is to prevent a reinforcement being evaluated more than once, with the risk of two different answers).

A70 All of the UK FES scenarios are considered; furthermore it is usual for sensitivities to be considered as described previously. Each scenario is also studied in isolation; the following description refers to the study of one scenario, the process is repeated (in parallel since there is no dependency) for the other scenarios. The process is an iterative process that involves adding a single reinforcement at a time and then evaluating the effect that this change has had on the constraint cost forecast.

A71 To begin the process all proposed reinforcements within the region are disabled, the output of the model is analysed to determine which boundaries within the region require reinforcement and when the reinforcement is required, this simulation is referred to as the base case. This information is used to determine which reinforcement(s) should be evaluated first. The reinforcement that has been selected to be evaluated next is then activated in the Electricity Scenario Illustrator (ELSI) (see the box on page 20 for a description) at its Earliest In Service Date (EISD), if a number of potential reinforcements have been identified as being candidates for the next reinforcement then this process must be repeated with each reinforcement in turn. There are now two sets of constraint cost forecasts, the base case and the reinforced case, which are compared using the Spackman[6] methodology.

A72 It is assumed that each transmission asset is to have a 40 year asset life, since ELSI only forecasts 20 years the constraint costs for each year of the second half of the 40 year asset life are assumed to be identical to the final simulated year (note that this limitation occurs because the UK FES scenarios do not contain detailed ranking orders beyond 20 years). Both constraint cost forecasts are discounted using HM Treasury's Social Time Preferential Rate (STPR) to convert the forecasts into present values. The capital cost for the reinforcement is amortised over the asset life using the prevalent Weighted Average Cost of Capital (WACC) and discounted using the STPR. This value is added to the constraint cost forecast for the reinforced case. The present value of the base case is then compared to the present value of the reinforced case plus the amortised present value of the capital costs to give the net present value (NPV) for this reinforcement.

A73 This CBA process is carried out in a separate comparison tool which also automatically calculates the NPVs if the reinforcement being evaluated were to be delayed by a number of years. This list of NPVs allows the optimum year for the reinforcement, for the current scenario, to be calculated. If a number of alternative candidate reinforcements have been identified then the reinforcement that has the

[6] The Joint Regulators Group on behalf of UK's economic and competition regulators recommend a discounting approach that discounts all costs (including financing costs as calculated based on a Weighted Average Cost of Capital or WACC) and benefits at HM Treasury's Social Time Preference Rate (STPR). This is known as the Spackman approach.

earliest optimum year should be chosen. The chosen reinforcement is then added to the base case and another reinforcement is chosen for evaluation. The process is then repeated until no further reinforcements produce a negative NPV (which would indicate that the capital cost of the reinforcement exceeds the saving in constraint costs). There may be an element of branching if it is not immediately obvious during the process which reinforcement should be chosen to be added to the base case at any given point.

A74 The outcome of this process is a list of reinforcements, for the current region and scenario, and the optimum year for each. This is referred to as a 'reinforcement profile'.

A75 Once the reinforcement profile for each scenario within a region has been determined the 'critical' reinforcements for that region may be chosen. The definition of a 'critical' reinforcement has some flexibility but the definition below must be considered.

A76 A reinforcement is critical if, in any scenario or sensitivity the optimum year for the reinforcement is such that if a delay decision were made then the optimum year, for that scenario or sensitivity, could no longer be met (note that outage availability may play a part in this decision).

Electricity Scenario Illustrator (ELSI)

A77 The constraint modelling tool currently used by the SO is called ELSI; it is used to forecast the constraint costs for different network states and scenarios. It is an open source tool developed in house and made available for stakeholders to conduct their own constraint forecasting. The tool is an Excel based model. The high-level assumptions and inputs used in ELSI are outlined in table A3.

Table A3: Assumptions and input data for ELSI.

Input Data	Current Source	Description
Fuel price forecasts	FES	20 year forecast, varies by scenario
CO_2 forecasts	FES	20 year forecast
Plant efficiencies and season availabilities	Historic data	
Plant bid and offer costs	Historic data	
Forecast system marginal prices for overseas markets	Baringa	20 year forecast, varies by scenario and market
Wind data	Poyry (historic)	Wind load factors for various zones around the UK
Demand data	FES	Annual peak and zonal distribution
Load duration curve	Historic data	2012/13 outturn data converted into ELSI periods
Maintenance outage patterns	Historic data	Maintenance outage durations by boundary
System boundary capabilities	Power Factory studies	See text
Reinforcement incremental capabilities	Power Factory studies	See text

A78 The model simulates 4 periods per day for 365 days per year and is set to simulate 20 years into the future. The year in which a reinforcement is commissioned can be varied. The primary output from ELSI for the CBA process is the annual constraint forecast; there are further outputs that help the user identify which parts of the network require reinforcement.

Selection of preferred option

A79 At this point all of the economic information available to assess the options is in place. The SO then uses the Single Year Least Regret analysis methodology to identify the preferred option.

Single Year Least Regret Decision Making

A80 The single year least regret methodology involves evaluating every permutation of the critical options in the first year and then assuming that information will be revealed such that the optimal steps for a given scenario can be taken from year two onwards. For each critical reinforcement the permutations are either to proceed with the project for the next year or to delay the project for the next year. If there is more than one critical reinforcement in the region then the permutations increase; the number of permutations is equal to 2^n, where n is the number of critical reinforcements.

A81 Each of the permutations have a series of cost implications, these are either additional capital costs if the project were delayed (and further additional costs if the project were to be restarted at a later date) or inefficient financing costs if the project is proceeded with too early.

A82 For each permutation and scenario combination the present value is calculated, taking into account operational and capital costs. For each scenario one of the permutations will have the lowest present value cost, this is set as a reference point against which all the other permutations for that scenario are compared. The regret cost for each permutation and scenario is calculated as the difference between the present value of the current permutation for the current scenario and the present value that is lowest of all permutations for the current scenario. This results in one permutation having a zero regret cost for each scenario.

A83 The following section is a worked example of the least regret decision making process. Two projects have been determined to be 'critical' in this region, the EISD for reinforcement 1 is 2018 and the EISD for reinforcement 2 is 2019. The optimum years for scenarios A, B and C are shown in table A4. Note that the scenarios are colour-coded; this is used for clarity in following tables.

Table A4: Example of optimum years for two critical reinforcements.

Scenario	Reinforcement 1	Reinforcement 2
A	2018	2019
B	2018	2022
C	2025	N/A

Table A5: Example decision tree

Permutation	Year 1 Options	Year 1 Capital Costs	Completion Date	Regrets	Worst regret for each permutation
i	Proceed reinforcement 1	£20m	Reinforcement 1: 2018 Reinforcement 2: 2020	£51m	£51m
	Delay Reinforcement 2	£1m	Reinforcement 1: 2018 Reinforcement 2: 2022	£0m	
			Reinforcement 1: 2025 Reinforcement 2: Cancel	£5m	
ii	Delay Reinforcement 1	£2m	Reinforcement 1: 2019 Reinforcement 2: 2019	£102m	£102m
	Proceed reinforcement 2	£10m	Reinforcement 1: 2019 Reinforcement 2: 2022	£35m	
			Reinforcement 1: 2025 Reinforcement 2: Cancel	£10m	
iii	Proceed reinforcement 1	£20m	Reinforcement 1: 2018 Reinforcement 2: 2019	£0m	£15m
	Proceed reinforcement 2	£10m	Reinforcement 1: 2018 Reinforcement 2: 2022	£2m	
			Reinforcement 1: 2025 Reinforcement 2: Cancel	£15m	
iv	Delay Reinforcement 1	£2m	Reinforcement 1: 2019 Reinforcement 2: 2020	£153m	£153m
	Delay Reinforcement 2	£1m	Reinforcement 1: 2019 Reinforcement 2: 2022	£32m	
			Reinforcement 1: 2025 Reinforcement 2: Cancel	£0m	

A84 Table A5 is an example of a least regret decision tree, since there are two 'critical' reinforcements there are therefore four permutations. From Year 2 onwards for each of the permutations the reinforcements are commissioned in as close to the optimum year for each reinforcement for each scenario. For each scenario one of the four permutations is the optimum and therefore there is one £0m value of regret for each scenario. The table's Year 1 Capital Costs column indicates the expenditure needed in Year 1 and which is key in the Single Year Least Regret analysis. This might include delay costs.

A85 The causes of the regret costs vary depending upon what the optimum year is for the reinforcement and scenario:

- If the reinforcement is delayed and therefore cannot meet the optimum year then additional constraint costs will be incurred
- If the reinforcement is delayed unnecessarily then there will be additional delay costs

- If the reinforcement is proceeded with too early then there will be inefficient financing costs
- If the reinforcement is proceeded with and is not need then the investment will have been wasted.

A86 The regret costs for each permutation are then compared to find the greatest regret cost for each permutation. This is referred to as the worst regret cost. The permutation with the least worst regret cost is chosen as the investment recommendation output. In the example shown above the least regret permutation is to proceed with both reinforcements 1 and 2 which has a regret of £15m and is the least of the four permutations.

Process Output

A87 Following Single Year Regret analysis, for each region in the country a list of 'critical' reinforcements for the region is presented with the investment recommendation for each. If the investment signal triggers the TO's Needs Case, the SO will assist the TO in undertaking a more detailed CBA. The SO reconciles the economy and security results (in accordance with NETS SQSS Chapter 4) as mentioned previously in the section on sensitivities before making a final recommendation on a preferred option.

Report drafting

A88 The SO drafts the NOA report but the responsibility for the contents varies between the SO and TOs. The form of the report is subject to consultation and also to Ofgem approval. The NOA report covers the areas in the table below which shows responsibilities also.

Table A6: Overview of the NOA report contents

Report chapter	NOA report topic	Scotland	E&W	Comments
1	Aim of report	SO	SO	
2	Methodology description including definition of Major National Electricity Transmission System Reinforcements	SO	SO	SO consults with TOs
3	Project exclusions	TO	TO	TO makes the justification
4	Options	-	-	See table A7 below
5	Stakeholder engagement and feedback	SO	SO	

A89 The options are within a single chapter (4) and the component parts of the chapter and the responsibilities for producing the material are in the table below. Appendix F gives more detail on the form of the NOA Report.

Table A7: Topics in the Options chapter in the NOA report

NOA report Options topic	Scotland	E&W	Non-build/ min-build	Offshore	Comments
The Options					
Options: Status of the option (scoping, optioneering, design, planning, construction)	TO	TO	SO / TO	SO	
Options: Technical aspects – assets and equipment	TO	TO	SO / TO	SO	
Options: Technical aspects – boundary capabilities	TO	SO	SO / TO	SO / TO	
Options: Economic appraisal	SO	SO	SO	SO	Leads to preferred options for TOs
Options: Environmental impacts and risks	TO	TO	TO	SO	
Options: Comparison of the options	SO	SO	SO	SO	
Table overview of boundaries and options	SO				

A90 The report is transparent where possible whilst maintaining appropriate commercial confidentiality. Information is therefore presented to demonstrate the relative benefits of options while protecting commercial confidentiality. This is in consultation with stakeholders. The SO passes outputs to the TOs to support its view of preferred options.

A91 Report drafting is undertaken in the period late November to mid-February.

Report publication

A92 The SO publishes the initial NOA report by 31 March 2016.

A93 On publication the report is placed on the National Grid website in a PDF form that is widely readable by readily available software. The SO also prints copies such that it can provide on request and free of charge a copy of the report to anyone who asks for one.

A94 Standard Licence Condition C27 Paragraph 10 provides for delaying publication if the Authority (Ofgem) delay their approval of the NOA report methodology or form of NOA report.

A95 The Licence Condition allows for the omission of sensitive information.

Stakeholder consultation

A96 The SO has consulted with the TOs and Ofgem whilst preparing this NOA report methodology.

A97 The key consultation areas are the NOA methodology, form of the NOA report and the NOA report outputs and contents.

A98 This section shows the timescales for the SO's consultation of stakeholders during the period of writing the NOA report.

Methodology

A99 The SO seeks stakeholder views annually for consideration and where appropriate implementation before the NOA process starts its annual cycle.

A100 Following the final publication of the NOA report, the SO undertakes an internal review of the NOA process. This is completed within eight weeks of NOA report publication with the publication of an updated NOA methodology that consults stakeholders and invites comments/feedback. The deadline for comments is 14 weeks from NOA report publication. The SO considers these comments for a revised NOA methodology that is published 18 weeks from NOA report publication and submitted to Ofgem by 1 August 2016.

Report output

A101 The SO makes available selected parts of the pre-release NOA report to key stakeholders particularly the relevant TOs based on discussions with those stakeholders while respecting confidentiality obligations. This is as the NOA report is being written based on assessment data, particularly economic data, becoming available.

A102 Further engagement happens with stakeholders with the draft NOA report being circulated to them three weeks before the NOA report is due to be formally published. This gives them the opportunity to comment on the NOA report and raise any significant concerns. When a stakeholder expresses concern with the conclusions of the report, a comment is incorporated in the relevant section/s.

A103 The SO seeks approval from the Authority (Ofgem) on the NOA report methodology and form of the NOA report as part of the annual stakeholder engagement process.

Area for further development

A104 Licence Condition C27 Paragraph 6 (a) requires NGET to explain where it has not been possible for the NOA methodology to meet the information required by Paragraph 8 and how it will progress the outstanding issues. This section covers these matters.

A105 This NOA methodology is written for the NOA report which is to be published by 31 March 2016. The NOA methodology will be updated annually as the NOA process and report are modified following experience and stakeholder feedback.

A106 Expected areas for further development for the annual NOA report are:

- SO to conduct boundary capability studies for all of the national electricity transmission system
- Interconnector modelling (see below)
- Provision of Information to electricity transmission licensees and interconnector developers (C27 Part C)
- Review of NOA study matrix
- Consistent costing basis across all TOs and the SO
- Security assessment and refining the analysis steps for cases where boundary capability is not the key deliverable
- Refinement to support competition
- Development of analysis processes for options where boundary capability is not the key deliverable.

We will use feedback from stakeholders to help us with further development areas for the 2017 NOA.

A107 The SO's interconnector evaluation output is limited for the initial NOA report. The optimum level of interconnectors recommended by the SO is expected as part of ETYS 2016 (produced in November 2016) or the NOA report 2016 (produced March 2017). Interconnectors will be excluded from the ETYS 2015 and from the NOA report to be produced in March 2016. Interconnectors are recognised in the background for the NOA report.

Provision of Information

Engagement with interested parties to share relevant information and how that information will be used to review and revise the NOA methodology

A108 The NOA methodology and NOA report adequately protects any confidential information provided by stakeholders or service providers, for example, balancing services contracts. For this reason, this methodology seeks to be as open and transparent as possible to withstand scrutiny and provide confidence in its outcomes, while maintaining confidentiality where necessary.

A109 In accordance with Licence Condition C27 Part C, the SO provides information to electricity transmission licensees, interconnector developers and to the Authority

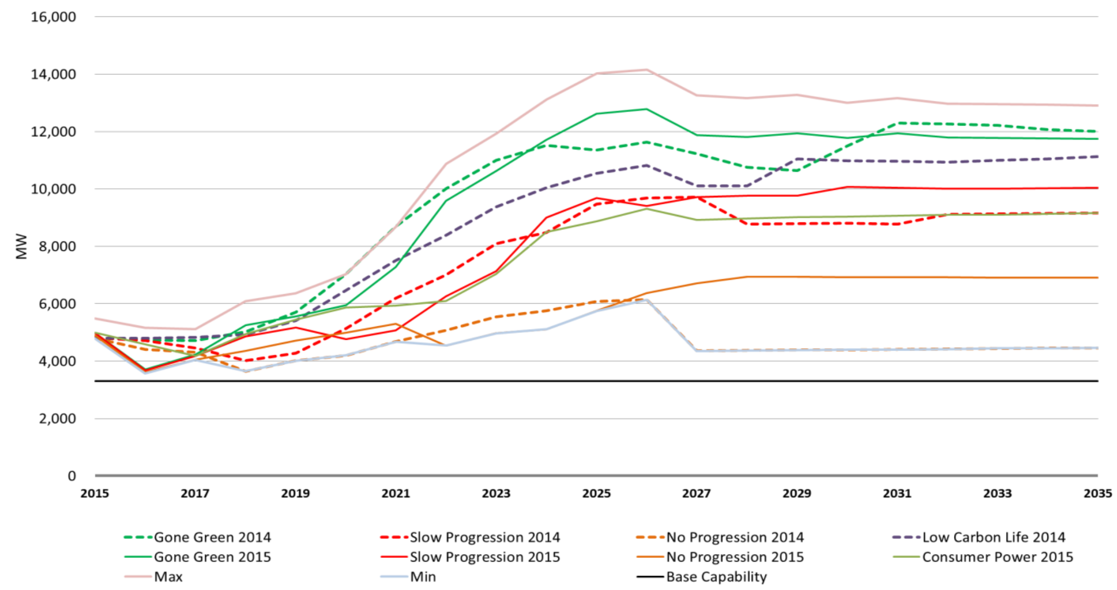
(Ofgem) if requested to do so. The SO will assist TOs with CBA for SWW Needs Cases.

Appendix B: System Requirements Form Template

Boundary B6

Requirement proposer:
Passed To / Date: -
Boundary under Analysis: B6

Boundary Required Transfer Summary:



	Economy / Export	Secured event	2015/ 16	2016/ 17	2017/ 18	2018/ 19	2019/ 20	2020/ 21	2021/ 22	2022/ 23	2023/ 24	2024/ 25	2025/ 26
See Note 1	Gone Green Winter Peak Required Transfer (MW)												
	Slow Progression Winter Peak Required Transfer (MW)												
	No Progression Winter Peak Required Transfer (MW)												
	Consumer Power Winter Peak Required Transfer (MW)												
See Note 2	Gone Green Winter Peak Intact Boundary Capability (MW)												
	Gone Green Spring / Autumn Intact Boundary Capability (MW)												
	Gone Green Summer-max Intact Boundary Capability (MW)												
	Gone Green Summer-max Outage Boundary Capability (MW)												

Note 1: Required Transfers in accordance with NETS SQSS Chapter 4 Economy Background.
Note 2: Boundary Capabilities derived from modification of the Economy Background, with secured events as per NETS SQSS Chapter 5.

Assumed Annual Duration of Planned Boundary Outage: *TBC* boundary outage days per annum

Security / Import		Secured event	2015/ 16	2016/ 17	2017/ 18	2018/ 19	2019/ 20	2020/ 21	2021/ 22	2022/ 23	2023/ 24	2024/ 25	2025/ 26
See Note 3	Gone Green Winter Peak Required Transfer (MW)												
	Slow Progression Winter Peak Required Transfer (MW)												
	No Progression Winter Peak Required Transfer (MW)												
	Consumer Power Winter Peak Required Transfer (MW)												
See Note 4	Gone Green Winter Peak Boundary Capability (MW)												
	Gone Green Spring / Autumn Boundary Capability (MW)												
	Gone Green Summer-max Boundary Capability (MW)												

Note 3: Required Transfers in accordance with NETS SQSS Chapter 4 Security Background
Note 4: Boundary Capabilities derived from modification of the Security Background, with secured events as per NETS SQSS Chapter 4.

Boundary Power System Analysis Summary:

Reinforcement options:

To satisfy the indicated future system requirement the following reinforcement options are suggested:

Option 1:	Status: Same/Changed/New
Option Name: *Insert the name of the proposed reinforcement.*	
Description: *Provide a description of the physical nature of the reinforcement sufficient to allow power system modelling and costs to be developed.*	
NOA Description: *Description of the option suitable for public presentation*	
Diagram: *Put diagrams here of how the new configuration will look including circuits and substation layouts.*	
Boundary Capability Estimate: *Provide an estimate of the boundary capability (MW) offered by this reinforcement.*	
Solution: *Describe how the proposed solution is intended to increase capability and under what conditions.*	
Environmental impacts and risks: *Provide views on the environmental impact of the options*	
EISD: *Year*	Current Status: *Scoping, Delivery, etc…*
Cost Estimate: *£m for the option*	Scheme #: *All relevant or create a new reference if none already exist*

Red is required text.

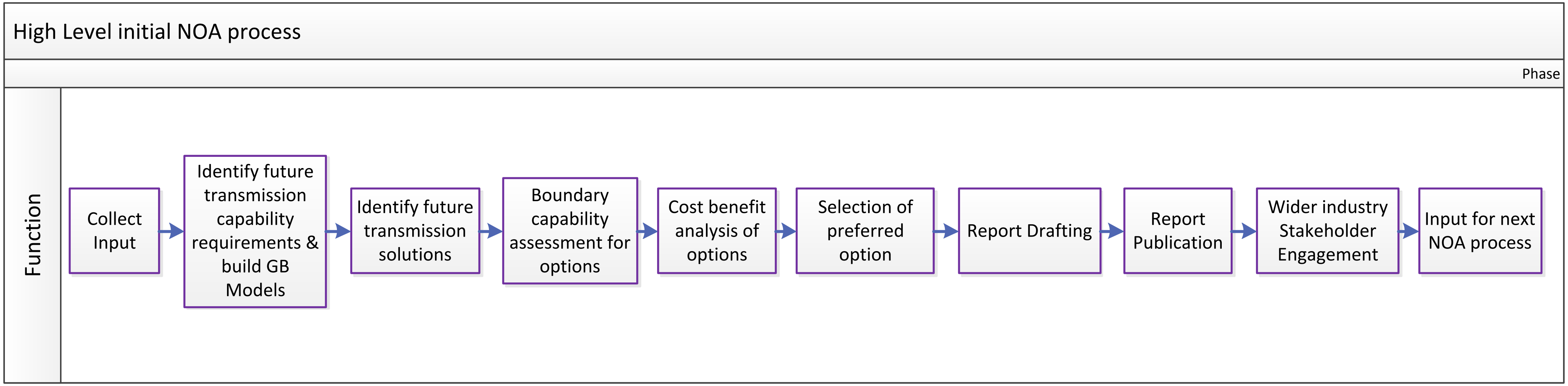
Option 1 costs profile (based on current year costs)

	2015 /16	2016 /17	2017 /18	2018 /19	2019 /20	2020 /21	2021 /22	2022 /23	2023 /24	2024 /25	2025 /26	2026 /27	2027 /28	2028 /29	2029 30	2030 /31
Pre-construction																
Construction																
Total																

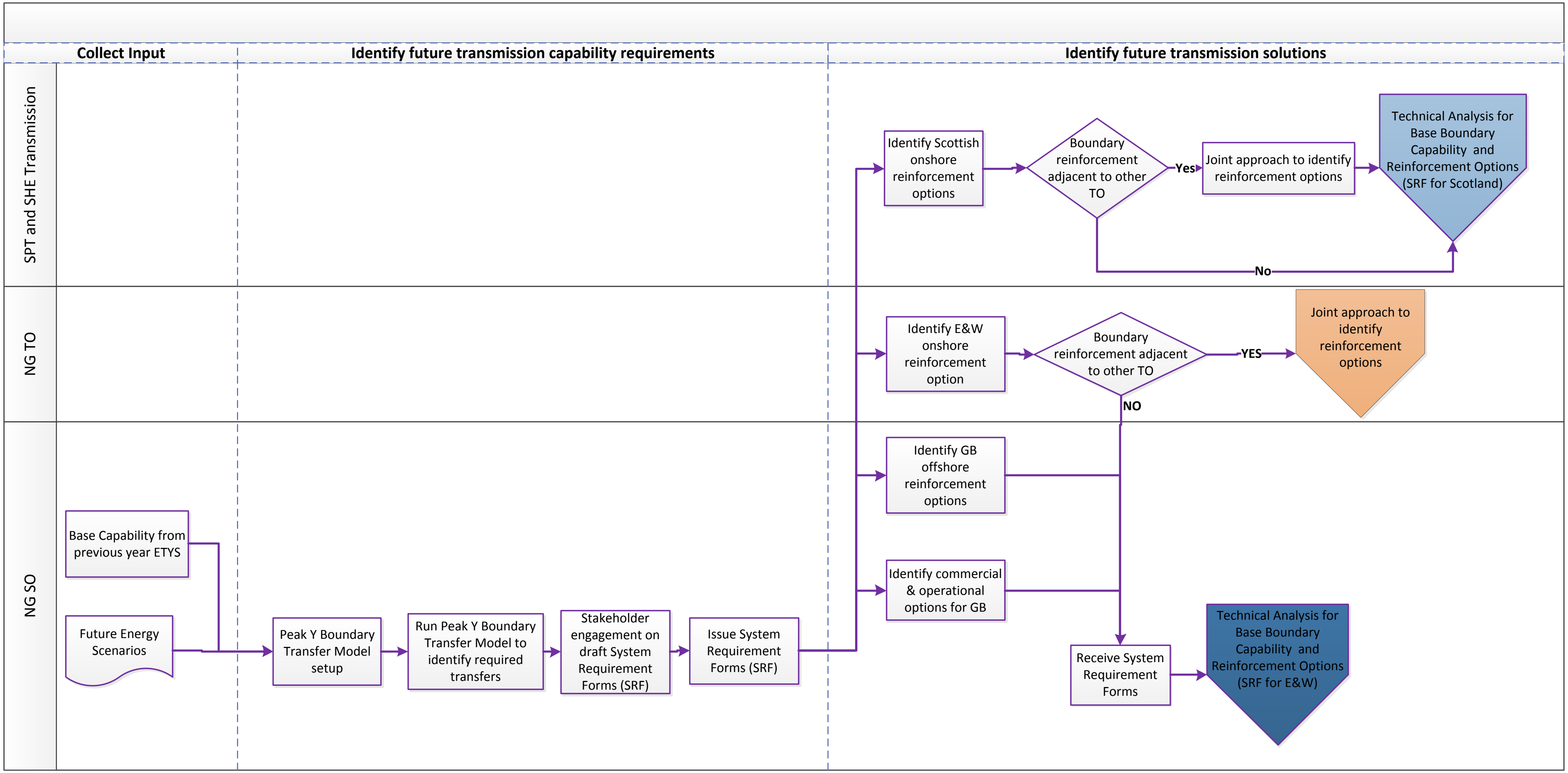
Appendix C: NOA Study Matrix

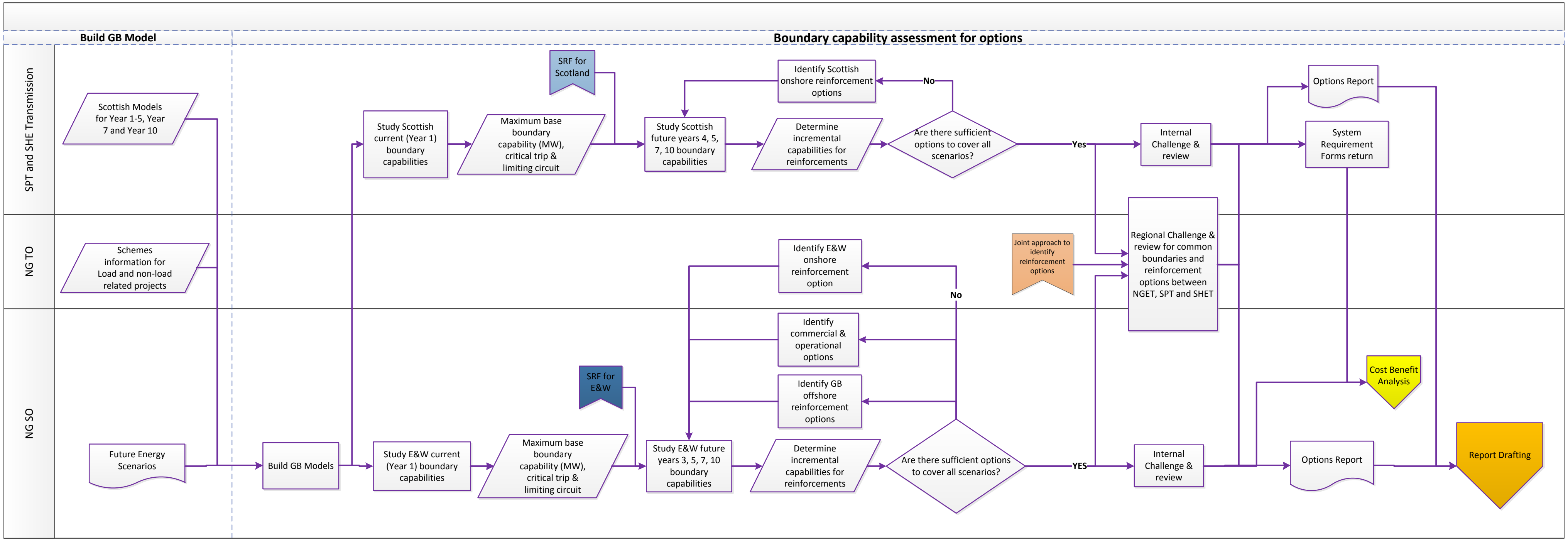
Assumption/Condition		Initial NOA (March 2016)	Comments
Generation Scenarios	Gone Green	✓	Technical and economic assessment of the reinforcement options; sensitivity studies where appropriate
	Slow Progression	✓	Economic assessment only of the reinforcement options; sensitivity studies where appropriate
	Consumer Power	✓	Economic assessment only of the reinforcement options; sensitivity studies where appropriate
	No Progression	✓	Economic assessment only of the reinforcement options; sensitivity studies where appropriate
Demand	Winter Peak	✓	Technical and economic assessment of the reinforcement options
	Spring/Autumn	✓	Economic assessment, boundary capabilities in NOA will be calculated based on agreed scaling factors from winter peak capabilities which are validated against benchmarked results. Benchmarking is subject to availability of the model and agreement on generation despatch
	Summer	✓	Economic assessment, boundary capabilities in NOA will be calculated based on agreed scaling factors from winter peak capabilities which are validated against benchmarked results. Benchmarking is subject to availability of the model and agreement on generation despatch
Boundary Capability Study Type	Voltage Compliance	✓	
	Thermal	✓	
Contingencies	N-1-1	✓	
	N-1	✓	
	N-D	✓	
Network Reinforcements	Transmission Based reinforcements	✓	
	Alternative non-build reinforcements	✓	Assessment of non-build reinforcement options
Study Years	Year 1		Year 1 analysis in NOA is not relevant due to the publication date in March 2016
	Year 2	✓	Assessment of non-build reinforcement options subject to availability
	Year 3	✓	Assessment of non-build reinforcement options subject to availability
	Year 4	✓	Assessment of build and non-build reinforcements options excluding those are subject to Ofgem agreement
	Year 5	✓	Assessment of build and non-build reinforcements options excluding those are subject to Ofgem agreement
	Year 7	✓	Assessment of build and non-build reinforcements options excluding those are subject to Ofgem agreement
	Year 10	✓	Assessment of build and non-build reinforcements options excluding those are subject to Ofgem agreement

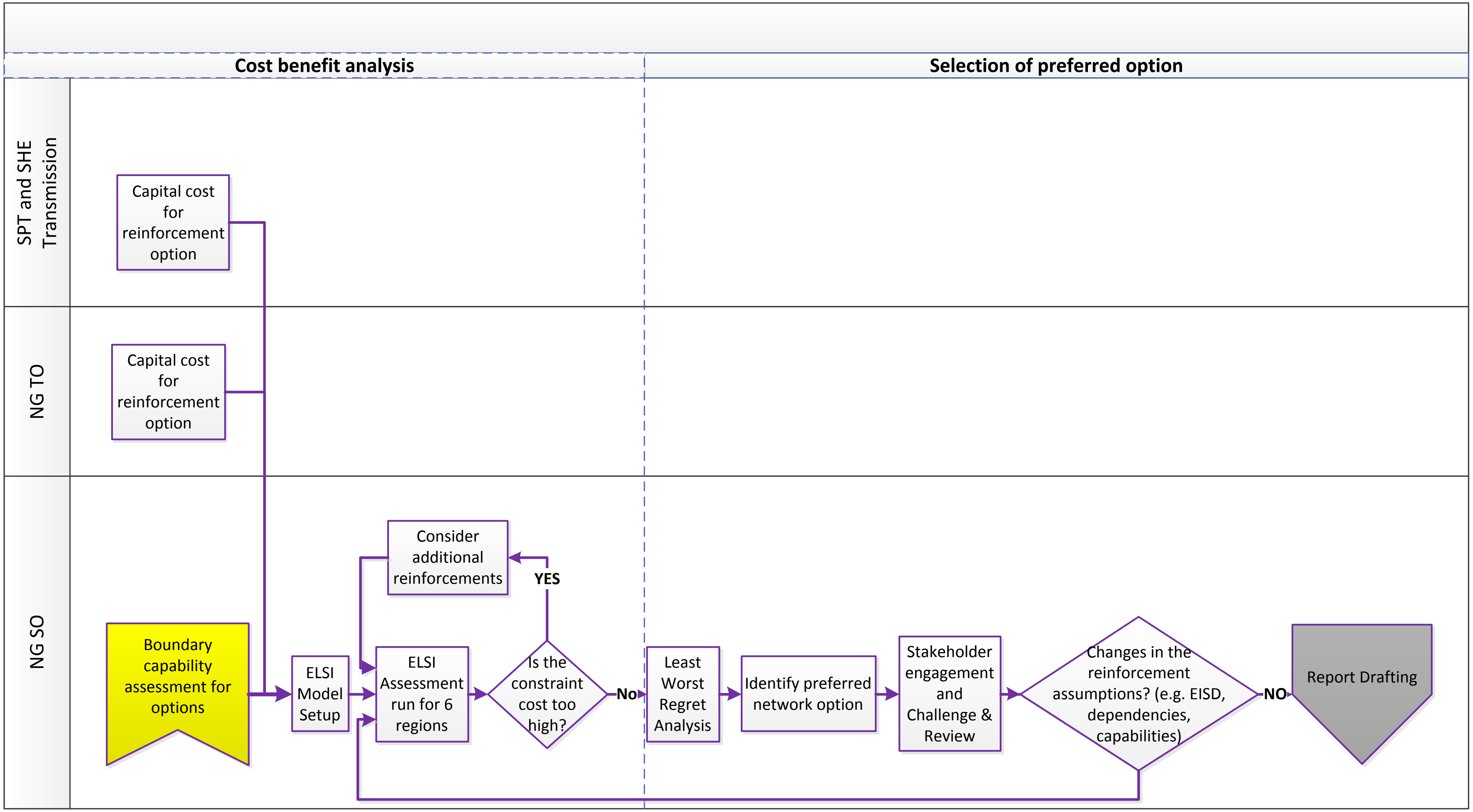
Appendix D: NOA Process Flow Diagram

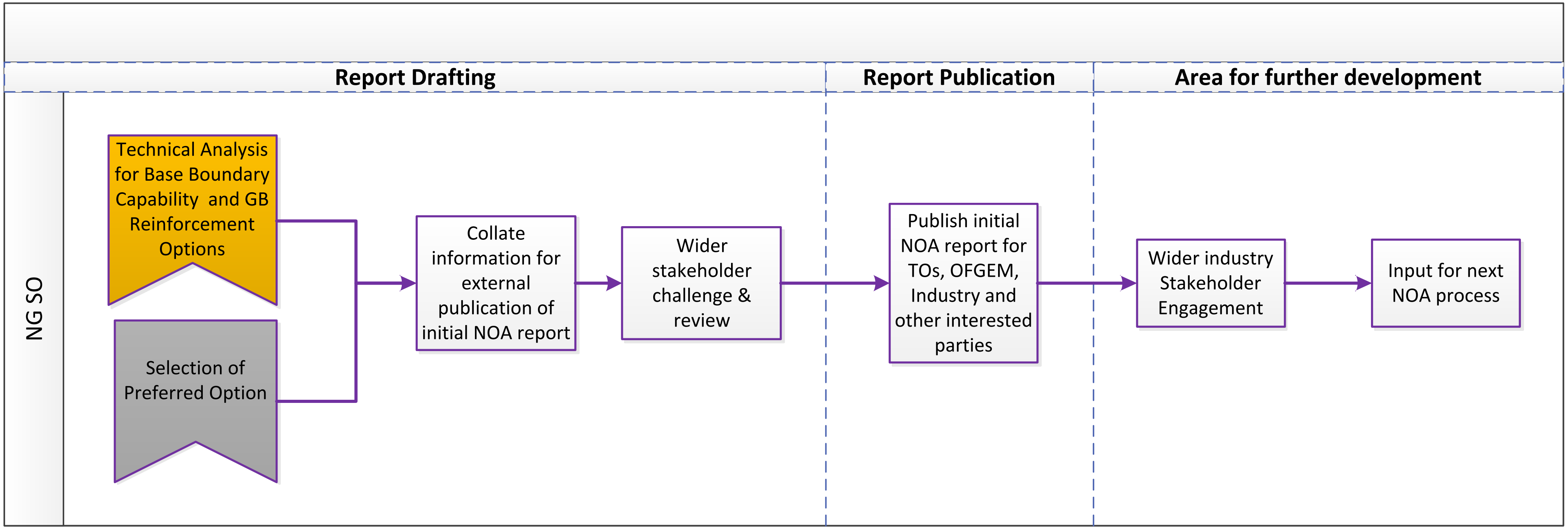


This diagram shows the overall NOA process. The text in each box corresponds to the descriptions of the stages at the top of the diagrams on the next pages. The process headings can also be found in Appendix A.


Collect Input
Identify future transmission capability requirements
Identify future transmission solutions
SPT and SHE Transmission
NG TO
NG SO
Identify Scottish onshore reinforcement options
Boundary reinforcement adjacent to other TO
Yes
Joint approach to identify reinforcement options
Technical Analysis for Base Boundary Capability and Reinforcement Options (SRF for Scotland)
No
Identify E&W onshore reinforcement option
Boundary reinforcement adjacent to other TO
YES
Joint approach to identify reinforcement options
NO
Identify GB offshore reinforcement options
Identify commercial & operational options for GB
Base Capability from previous year ETYS
Future Energy Scenarios
Peak Y Boundary Transfer Model setup
Run Peak Y Boundary Transfer Model to identify required transfers
Stakeholder engagement on draft System Requirement Forms (SRF)
Issue System Requirement Forms (SRF)
Receive System Requirement Forms
Technical Analysis for Base Boundary Capability and Reinforcement Options (SRF for E&W)


Build GB Model
Boundary capability assessment for options
SPT and SHE Transmission
NG TO
NG SO
Scottish Models for Year 1-5, Year 7 and Year 10
Schemes information for Load and non-load related projects
Future Energy Scenarios
Build GB Models
Study Scottish current (Year 1) boundary capabilities
Maximum base boundary capability (MW), critical trip & limiting circuit
SRF for Scotland
Study Scottish future years 4, 5, 7, 10 boundary capabilities
Determine incremental capabilities for reinforcements
Are there sufficient options to cover all scenarios?
Identify Scottish onshore reinforcement options
No
Yes
Internal Challenge & review
Options Report
System Requirement Forms return
Joint approach to identify reinforcement options
Regional Challenge & review for common boundaries and reinforcement options between NGET, SPT and SHET
Identify E&W onshore reinforcement option
Identify commercial & operational options
Identify GB offshore reinforcement options
No
Study E&W current (Year 1) boundary capabilities
Maximum base boundary capability (MW), critical trip & limiting circuit
SRF for E&W
Study E&W future years 3, 5, 7, 10 boundary capabilities
Determine incremental capabilities for reinforcements
Are there sufficient options to cover all scenarios?
YES
Internal Challenge & review
Options Report
Cost Benefit Analysis
Report Drafting


Cost benefit analysis
Selection of preferred option
SPT and SHE Transmission
NG TO
NG SO
Capital cost for reinforcement option
Capital cost for reinforcement option
Boundary capability assessment for options
ELSI Model Setup
ELSI Assessment run for 6 regions
Consider additional reinforcements
YES
Is the constraint cost too high?
No
Least Worst Regret Analysis
Identify preferred network option
Stakeholder engagement and Challenge & Review
Changes in the reinforcement assumptions? (e.g. EISD, dependencies, capabilities)
NO
Report Drafting


Report Drafting
Report Publication
Area for further development
NG SO
Technical Analysis for Base Boundary Capability and GB Reinforcement Options
Selection of Preferred Option
Collate information for external publication of initial NOA report
Wider stakeholder challenge & review
Publish initial NOA report for TOs, OFGEM, Industry and other interested parties
Wider industry Stakeholder Engagement
Input for next NOA process

Appendix E: Summary of Stakeholder feedback

Letter from SHE Transmission

Scottish and Southern Energy
Power Distribution

Inveralmond House
200 Dunkeld Road
Perth PH1 3AQ
email: jen.carter@sse.com

Julian Leslie
Electricity Network Development Manager
National Grid Electricity Transmission
Warwick Technology Park, Gallows Hills
Warwick
CV34 6DA

26 June 2015

Dear Julian,

Re: Development of the Network Options Assessment methodology

On behalf of Scottish Hydro Electric Transmission (SHE Transmission), I would like to express our appreciation for the opportunity to participate in the Network Options Assessment (NOA) working group and to contribute our views to the development of the proposed methodology.

Whilst we recognise the licence obligation sits with National Grid Electricity Transmission (NGET) as the System Operator (SO), we see the annual publication of a NOA report as a significant undertaking for all of the onshore Transmission Owners (TOs). As with similar documents like the Electricity Ten Year Statement and the National Electricity Transmission System Performance Report, we will support the SO in the collation of data relevant to our licensed area and associated analysis. To that end, we support the split of roles and responsibilities for the 2015/16 NOA report.

As per previous discussions, we remain concerned with proposals to bring forward the publication date in subsequent years, given the extent of data exchange that is required between parties.

We appreciate that further work is required to develop the methodology in relation to SO support to TOs during the development and assessment of Strategic Wider Works Needs Cases and look forward to discussion of this aspect over the summer.

Yours sincerely,

Jen Carter

Networks Regulation, Transmission

Scottish and Southern Energy Power Distribution is a trading name of: Scottish and Southern Energy Power Distribution Limited Registered in Scotland No. SC213459; Scottish Hydro Electric Transmission plc Registered in Scotland No. SC213461; Scottish Hydro Electric Power Distribution plc Registered in Scotland No. SC213460; S+S Limited Registered in Scotland No. SC214382 (all having their Registered Offices at Inveralmond House 200 Dunkeld Road Perth PH1 3AQ); and Southern Electric Power Distribution plc Registered in England & Wales No. 04094290 having its Registered Office at 55 Vastern Road Reading Berkshire RG1 8BU which are members of the SSE Group

www.ssepd.co.uk

Letter from SP Transmission

SP ENERGY NETWORKS

Network Planning & Regulation

Julian Leslie
Electricity Network Development Manager
National Grid House,
Gallows Hill,
Warwick
CV34 6DA

Your ref

Our Ref

Date
30th June 2015

Contact / Extension
Alan Kelly/0141 614 1736

Dear Julian,

Re: Development of the Network Options Assessment methodology

On behalf of SP Transmission plc (SPT), I would like to acknowledge the effectiveness of the stakeholder engagement provided through the Network Options Assessment (NOA) working group. Our involvement with this group has allowed us to fully contribute to the development of the proposed process and methodology. This has been another good example of coordination and co-operation between the System Operator (SO) and all there onshore Transmission Owners (TO's).

Whilst we recognise the licence obligation sits with National Grid Electricity Transmission (NGET) as the SO, we recognise the annual publication of a NOA report will be a significant undertaking for all of the onshore TOs. To that end, we support the proposed timetable and delegation of roles and responsibilities for the 2015/16 NOA report.

As the working group has developed the scope of the methodology and report, we consider the ability for us to contribute effectively if the report is earlier than March in subsequent years will be a significant challenge. However, we are committed to providing the required data as best we can.

We look forward to continuing the engagement with you on the further development and delivery of the NOA process.

Kind regards

Alan Kelly
Transmission Commercial and Policy Manager
SP Energy Networks

Ochil House, 10 Technology Avenue, Hamilton International Technology Park, Blantyre, G72 0HT
Telephone: 0141 614 0008
www.scottishpower.com

Appendix F: Form of the Report

The System Operator (SO) will produce two versions of the NOA Report. One version will contain full cost details of options and will have very limited circulation that will include Ofgem. Extracts of this report will go to the relevant Transmission Owners (TO). The second version will omit commercially confidential information and will be available publicly. We will provide Ofgem with justification for the redactions. This appendix describes the contents and chapters of the report.

Foreword

Executive Summary

Contents Page

Chapter 1: Introduction and Aim of the Report

This chapter will describe the aim of the NOA Report, provide the reader with clear guidance on its relationship with the Electricity Ten Year Statement (ETYS) and give guidance on how to navigate the NOA Report.

The chapter will give stakeholders an overview of options to meet electricity transmission system reinforcement needs and the SO's view of the preferred options. It will reiterate that the final investment decision rests with the TO.

Chapter 2: Methodology description

This chapter will describe the assessment methodology used at a high level and refer the reader to the NOA Report Methodology statement published on National Grid's public website.

The chapter will also include the definition of and commentary on Major National Electricity Transmission System Reinforcements. We will include a description of how the SO treats Strategic Wider Works (SWW).

Chapter 3: Methodology variations

We expect options to improve boundary capabilities will fall broadly into three categories:

- SWW that have Ofgem approval. The NOA Report will refer to these options which will be included in the baseline while presenting no analysis. The Report will justify why these options are treated as such.
- Options that have SWW analysis underway. This analysis and available results will be used in the NOA Report.
- Options analysed using the Single Year Regret Cost Benefit Analysis. This analysis will appear in the NOA Report.

Should any options fall outside of these three categories, the chapter will list them with an explanation as to how and why they are treated differently.

We might merge chapters 2 and 3 if there are no or few options to be excluded.

Chapter 4: Options

The purpose of this chapter is to describe the options that the SO has assessed and set out the analysis and recommendations of the SO for reinforcement of the electricity transmission system.

The chapter will introduce each boundary with a short description and a map. It will refer the reader to the ETYS Chapter 3 Network Capacity and Requirements for details of the system needs for each boundary. For each boundary, the report will present reinforcement options and include any under construction. However, due to differences in funding mechanisms, options under construction in England and Wales will be included with analysis. Options under construction in Scotland will be presented without further analysis.

For each boundary, the chapter will describe each option assessed. This description will identify each option as build or non-build and include summaries of the technical, environmental, operability and deliverability aspects of the work. The emphasis on technical and environment content as opposed to commercial content will differ depending on whether an option is build or non-build. The description will also include the status of an option (under scoping, optioneering, design, planning, construction) and a general overview. Where there are system security requirements for the boundary (in addition to economic), the chapter will include a description of the benefit that each option will provide.

The chapter will move onto the relative economic benefits of each option. This will be tabulated and to support the comparison include earliest in service (EISD) and optimum dates.

To protect the confidentiality as per licence requirements of those organisations that have provided options, in the public version the costs and benefits are put on a relative basis to compare with a reference option. The information will include an SO recommendation whether or not to proceed with each option. In some instances, there might be a recommendation to proceed with more than one option. Such an instance could be at an early stage when two options are closely ranked but there is uncertainty about key factors for example deliverability. The full version will include the relevant costs and benefits in full monetary detail.

The chapter will finish with a summary of the options for the boundary. It will provide:

- Any differences in preferred options between annual NOA Reports where the SO has carried out similar analysis in the past.
- How the scenarios have different requirements and how they affect the options
- A comparative view of each option’s deliverability and how it affects the choice of the preferred options.

The SO will include the Network Development Policy output for Incremental Wider Works in an appendix to the NOA Report.

Chapter 5: Stakeholder engagement and feedback

To help our understanding of stakeholder views, through the document we will include feedback questions. We will use this feedback to refine the NOA Report process and methodology for the next report.

Having used the spring 2015 customer seminars to start to talk with stakeholders, onshore TOs have engaged with us and assisted in developing the NOA Report methodology. We want to extend our engagement further and starting with the email circulation lists for ETYS, we have started to build a contact list for the NOA Report methodology which we will extend to NOA in general.

Glossary

Network Options Assessment for Interconnectors

Interconnectors Welfare Benefit Assessment Methodology for ITPR Year 1

December 2015

nationalgrid

Version	**FINAL 1.1**
Date	**1 December 2015**

About this document

This document contains National Grid's Network Options Assessment (NOA) methodology for assessment of interconnectors established under NGET Licence, Licence Condition C27 in respect of the financial year 2015/16. It covers the methodology on which NGET in its role as SO will base the initial NOA for Interconnectors report which will be published by 31 March 2016. National Grid's experience and stakeholder feedback will evolve over the next twelve months. Based upon this initial experience the methodology will be fully consulted with industry stakeholders for NOA year 2. Furthermore, National Grid seeks to acquire a new market model in this time period. Hence, the methodology statement will be revised for the second NOA for Interconnectors and on an enduring basis as required by Licence Condition C27.

Network Options Assessment for Interconnectors

Contents

Network Options Assessment for Interconnectors 2
Introduction 3
Overview 3
Structure of the Document 3
Appendix A: Components of Welfare Benefits of Interconnectors 4
Introduction 4
Social and Economic Welfare 4
Effects on Interconnected Markets 4
Appendix B: NOA for Interconnectors Methodology for 2015/16 7
Introduction 7
Pre-Requisite Study Work 7
Electricity Scenario Illustrator (ELSI) 7
Interconnector Welfare Benefit Process 8
Process Output 10

Introduction

Overview

1 The purpose of the Network Options Assessment (NOA) is to facilitate the development of an efficient, coordinated and economical system of electricity transmission consistent with the National Electricity Transmission System Security and Quality of Supply Standard and the development of efficient interconnector capacity. Interconnectors with other European markets will increasingly play an important role to achieve this goal.

2 This document provides an overview of the aims of the NOA for Interconnectors and details the methodology which the System Operator (SO) will adopt for the analysis and publication of the initial NOA for Interconnectors report (to be published by 31 March 2016). This methodology is limited by the modelling tools currently available to the SO. As the SO acquires a new Pan-European Market Model, which can optimise interconnector flows across modelled European markets as well as forecast operational costs for the GB market, the methodology statement will be revised for the second NOA for Interconnectors and on an enduring basis as required by Licence Condition C27.

Structure of the Document

3 This document includes the following:

a. Appendix A: Components of Welfare Benefits of Interconnectors

b. Appendix B: Methodology for 2015/16.

Appendix A: Components of Welfare Benefits of Interconnectors

Introduction

A1 This section outlines the definition of Social Economic Welfare. The purpose of this section is to give the theoretical background of assessing the impact of connected importing and exporting markets on consumers, producers and interconnectors triggered by an interconnector.

Social and Economic Welfare

A2 Social and Economic Welfare (SEW) benefits of an interconnector includes the following three components:

a. Consumer surplus, derived as an impact of market prices borne by the electricity consumers

b. Producer surplus, derived as an the impact of market prices borne by the electricity producers

c. Interconnector revenue or congestion rents, derived as the impact on revenues of interconnectors between different markets.

A3 Interconnectors could help to provide ancillary services (including black start capability, frequency response or reserve response), facilitate deployment of renewables, reduction in carbon emissions and displace network reinforcements.

A4 Interconnectors also provide benefits of being connected to more networks giving access to a more diverse range of generation which could lead to reduction in carbon emissions.

Effects on Interconnected Markets

A5 Power flows between two connected markets is driven by price differentials. Figure 1 shows the effects of such price differentials for two markets, A and B with variable prices over time. When the price is higher in market A, power will be transferred from B to A. When the price in A is lower than in B power will be transferred from A to B.

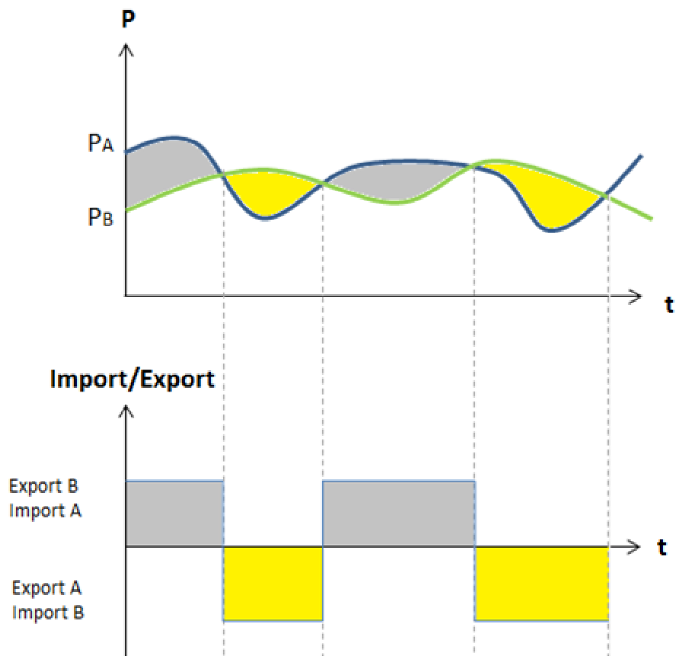


Figure 1 Price difference as import and export driver

A6 Figure 2 shows the impact of an interconnector (+IC) linking two markets on consumer (Demand D) and producer (Supply S) costs. When two competitive markets with different price profiles are interconnected, price arbitrage drives power flow from the low price market (B) to the high price market (A). Consumers in market A are likely to gain (a + b) as they benefit from access to cheaper power. Consumers in market B are likely to lose (d). Generators in market A, now able to compete with generators in B, are likely to be forced by competitive pressures to reduce their costs, which might lead to a reduction in their profits (a). Producers in market B are likely to gain (d + e). Interconnector revenue (c) is derived from the remaining price difference.

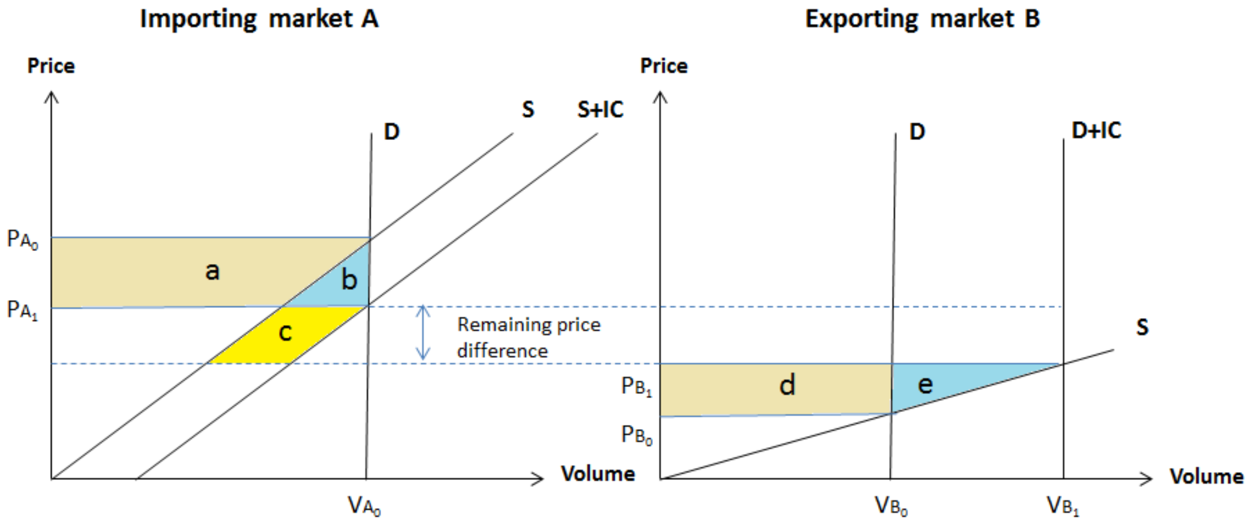


Figure 2 Consumer and Producer Surplus of connected markets

A7 With greater interconnection the price difference between markets will decrease thus the revenue of the interconnector will be reduced as well. This phenomenon is known as ‘cannibalisation’. There is an optimal level of interconnection between any two markets because price differential reduces as capacity increases, i.e. area c in Figure 2 shrinks.

A8 In the enduring stage of ITPR, forecasts of all components of SEW benefits will be key drivers to ascertain the optimum level of interconnection between GB and other European member states. The outputs of this process will include monetised impacts on GB consumers, producers and considered interconnectors.

A9 Due to modelling limitations, only monetary surplus relevant to GB consumers associated with interconnectors recommended in the Future Energy Scenarios 2015 will be analysed. Hence, the focus of the year one assessment will be consumer surplus only. Assessment of producer surplus and interconnector revenues will be excluded. The reasons for these exclusions, which are based on modelling limitations, are presented later in this document.

Appendix B: NOA for Interconnectors Methodology for 2015/16

Introduction

B1 This section outlines the methodology proposed for Network Options Assessment for interconnectors for 2015/16. The purpose of this assessment will be to forecast the range of consumer surplus which could be captured by GB consumers as a result of different levels of interconnectors proposed across the four Future Energy Scenarios 2015.

B2 The section also provides an overview of the market model which will be used by the SO for this assessment.

Pre-Requisite Study Work

B3 The starting point of the process is National Grid Future Energy Scenarios (FES) which include generation plant ranking orders and demand forecasts for each scenario. The ranking order for each scenario contains both existing and planned / proposed interconnectors.

B4 All simulations are carried out using an unconstrained network, i.e. no physical limitations of the GB network will constraint power flows. Constraint costs for each interconnector depend on the connection point to the National Electricity Transmission System. As connection points are not typically approved at this point in time, constraint costs (as well as capital costs) will not be assessed as part of this work. However, from 2016 onwards with the new Pan-European Market Model in place, this work will include network considerations to determine the optimal level and location of interconnector capacity.

Electricity Scenario Illustrator (ELSI)

B5 The market modelling tool currently used by National Grid is called ELSI; it is used to forecast the constraint costs for different network states and scenarios. It is an open source Excel based tool, developed in-house and made available to stakeholders to conduct their own constraint forecasting. The high-level assumptions and inputs used in ELSI are outlined in Table 1.

Table 1 Assumptions and input data for ELSI

Input Data	Current Source	Description
Fuel price forecasts	FES	20 year forecast, varies by scenario
CO_2 forecasts	FES	20 year forecast
Plant efficiencies and seasonal availabilities	Historical data	
Plant bid and offer prices	Historical data	Related to SRMC costs
Forecast system marginal prices for overseas markets	Baringa	20 year forecast, varies by scenario and market
Wind data	Pöyry (historical)	Wind load factors for various zones around the UK
Demand data	FES	MW annual peak and zonal distribution

Load duration curve	Historical data	2012/13 outturn data converted into ELSI periods
Maintenance outage patterns	Historical data	Maintenance outage durations by boundary

B6 The model simulates 4 periods per day for 365 days per year (=1460 periods per year) and is set to simulate 20 years into the future. The primary output for the interconnectors' welfare benefit assessment process, particularly measured as consumer surplus, is the annual System Marginal Price (SMP) forecast.

B7 ELSI is a zonal fuel type model. A distinction between generators of the same fuel type in the same zone is not possible. Therefore, output data, e.g. volumes of output (and thus costs), cannot be attributed to specific generators. Consequentially, producer surplus impacts associated with different levels of interconnection cannot be calculated and is therefore excluded from this process. For similar reasons, forecasts or interconnector revenues are excluded from the assessment.

B8 Hence, only consumer surplus of the SEW benefits will be assessed in 2015/16. The total pan European consumer surplus across all impacted markets *m* can be defined as the summation of the product of volumes of market *j* and its net change of price attributable to this interconnector.

$$SEW = \sum_{j=1}^{m} \Delta price_j * volume_j \quad (1)$$

B9 That said, the focus of this assessment will be to forecast consumer surplus for GB consumers only.

Interconnector Welfare Benefit Process

B10 All scenarios within the most recent FES 2015 publication are considered.

B11 Each scenario is studied in isolation; the following description refers to the study of one scenario, the process is repeated (in parallel, since there is no dependency) for the other scenarios. Since the FES scenarios show generation and demand forecast for a 20 year period, all ELSI studies span 20 years.

B12 For a specific FES scenario, the counterfactual case is defined as the current network state plus all interconnectors confirmed in the latest Cap and Floor assessment and earlier assessments (e.g. Nemo and Eleclink), see Table 2. The study case to which the counterfactual is compared consists of all existing interconnectors as well as those planned / proposed.

Table 2 Cap and Floor 2014 projects and earlier assessments

Project	Connection date	Capacity [MW]
Nemo	2018	1000
Eleclink	2018	1000
FAB	2020	1400
Viking	2020	1000
IFA2	2020	1000
NSN	2020	1400
GreenLink	2020	500

B13 Simulation results deliver SMPs for the study and counterfactual cases. The difference in SMP multiplied by annual demand gives the annual Welfare Benefit for GB consumers.

$$Annual\ SMP = \sum_{i=1}^{n} \frac{USMP_i * t_i}{8760h} \qquad (2)$$

with $USMP_i$ = SMP for time period i [$USMP_i$] = £/MW

t_i = time period i [t_i] = h

n = amount of time periods (for ELSI n = 1460/a)

Annual SMP = total demand weighted averaged System Marginal Price [Annual SMP] = £/MWh

$$Annual\ Demand = \sum_{i=1}^{n} Demand_i * t_i \qquad (3)$$

with $Demand_i$ = Demand for time period i [$Demand_i$] = MW

Annual Demand = total annual demand [Annual Demand] = MWh

$$\Delta SMP = SMP_1 - SMP_0 \qquad (4)$$

with SMP_0 = Annual System Marginal Price of the counterfactual case

SMP_1 = Annual System Marginal Price of studied case with higher interconnection

$$Annual\ Welfare\ Benefit\ Consumer\ Surplus = \Delta SMP * Annual\ Demand \qquad (5)$$

B14 Equations (2) to (5) lead to the formula to calculate the Annual Welfare Benefit Consumer Surplus, which is shown in equation (6)

$$Annual\ Welfare\ Benefit\ Consumer\ Surplus = \sum_{i=1}^{n} t_i * Demand_i * [USMP_{1i} * t_i - USMP_{0i} * t_i] \qquad (6)$$

B15 A simplified example is presented below:

- Annual demand weighted averaged SMP for counterfactual in year 1 = £46/MWh
- Annual demand weighted averaged SMP for study case in year 1 = £44/MWh
- Annual demand in year 1 = 270TWh
- Welfare Benefit in year 1 = (£46/MWh – £44/MWh) * 270TWh = £540m

B16 The procedure is applied for all years and scenarios. An example how Welfare Benefit assessment against FES2015 scenarios will be presented is shown in Figure 3 below. Please note that the forecasts presented in the graphs below are only for illustrative purposes and do not represent outputs of any model simulations.

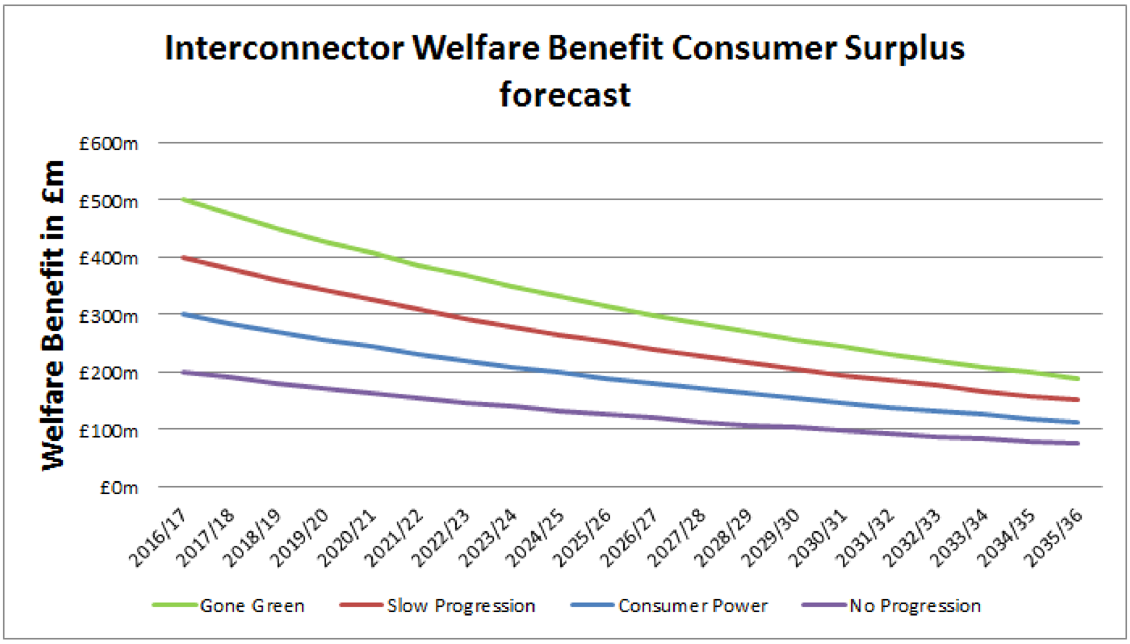


Figure 3 Interconnector Welfare Benefit Consumer Surplus across all Future Energy Scenarios

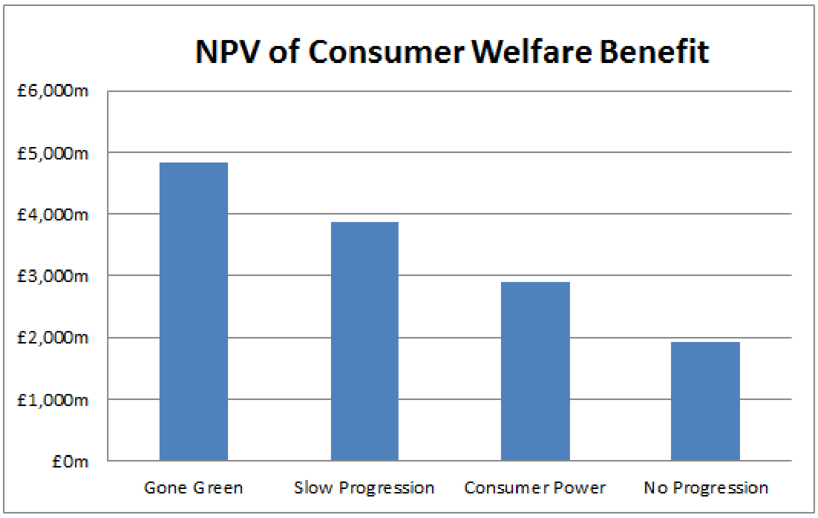


Figure 4 Net Present Value of Interconnector Welfare Benefit Consumer Surplus across all Future Energy Scenarios

Process Output

B17 The Welfare Benefit in terms of consumer surplus for the 20 year forecast horizon is assessed against the most recent Future Energy Scenarios. The outcome of this assessment is a monetary figure that GB consumers are likely to gain dependent on the level of interconnection considered in the respective scenarios.

B18 This output is required to be published by 31 March 2016.

SO Process for Input into TO Led SWW Needs Case Submissions

System Operator

September 2015

nationalgrid

Version	**FINAL 1.0**
Date	**29 September 2015**

About this document

This document contains National Grid System Operator's proposed methodology for inputs into TO led Strategic Wider Works submissions. The methodology responds to the new requirements for the SO as part of the NOA process, as outlined in Licence Condition C27 in respect of the financial year 2015/16.

SO Process for Input into TO Led SWW Needs Case Submissions

Contents

Strategic Wider Works Overview 3
Strategic Wider Works Process and the SO's Role 5
Appendix A: Strategic Wider Works (SWW) Process Flow Diagram 9
Appendix B: Cost Benefit Analysis Flow Diagram 10
Appendix C: Cost Benefit Analysis for TO led Needs Cases 11
Appendix D: An Illustrative new connection / reinforcement CBA example 19

Strategic Wider Works Overview

1 RIIO-T1 identified large transmission projects, which strengthen or extend the electricity transmission system, as wider works outputs. These are triggered by a need to increase the capacity of the network or to extend the network to accommodate new generation and lead to economically efficient transmission of electricity in the GB, as well as comply with network security standards.

2 Ofgem's Guidance on the Strategic Wider Works (SWW Guidance)[1], which was published in October 2013, states that there was uncertainty around the timing and cost of some large transmission projects at the time of finalising RIIO-T1. The document suggests this was predominantly due to extent of these projects' dependency on the level of future generation. Considering the scale of the investments involved the SWW Guidance states that the potential impacts of this uncertainty on GB consumers could be significant.

3 The SWW Guidance states that to help manage this uncertainty, flexible Strategic Wider Works arrangements were included in RIIO-T1 to consider large transmission projects when more information was available to inform decisions on whether the investment is in the interests of existing and future consumers.

4 The detailed process regarding the Strategic Wider Works (SWW) arrangements for the Transmission Owner (TO) is presented in the SWW Guidance. However, it is worth noting that the process involves approvals from Ofgem at three distinct stages:

a. Eligibility: To be eligible, the proposal must meet pre-defined criteria including the level of the expected cost and outputs it is expected to deliver. Further details on the criteria and the information required for eligibility assessment is presented in the SWW Guidance. If the project is eligible for assessment, Ofgem will initiate the review of the Needs Case submission, as set out below.

b. Needs Case[2]: The purpose of the Needs Case document is to present technical and economic rationale and necessary evidence to underpin the choice of the preferred option compared to a credible range of alternative solutions. Hence, as part of the review of the Needs Case, Ofgem seek to review the TO's appraisal of technical need and cost benefit assessment across a range of solutions and credible scenarios, which may be based on different factors in relation to generation, demand, fuel price forecasts, renewable subsides, etc. Furthermore, Ofgem seek for evidence on the optimal delivery date of the preferred option. Through this review, Ofgem seek to ensure that, given the range of uncertainties, the preferred solution

[1] Source: www.ofgem.gov.uk

[2] Projects which are already in the Transmission Owner's RIIO-T1 Business Plan are envisaged to have their eligibility outlined. Hence, such projects are likely to progress straight to the Needs Case stage.

offers the best long-term value for money for existing and future GB consumers. In most cases, ahead of making any decisions, Ofgem seek to consult stakeholders on their initial views on the Needs Case.

c. Project Assessment: The purpose of the Project Assessment is to present more in-depth evidence on the preferred option and demonstrate the TO's readiness to proceed with the project. There may be some overlap between Ofgem's reviews of the Needs Case and the Project Assessment. In particular, as part of the review of the Project Assessment Ofgem assess whether the TO has developed a robust development plan and risk management arrangements to deliver the project efficiently. Ofgem also review whether the technical plans of the preferred solution are sufficiently advanced to assess the efficient costs and specify a new SWW output. To inform their final decision on the proposal Ofgem will consult stakeholders on the detailed Project Assessment and their views on the SWW output and costs.

5 In addition to the three formal stages, there are ongoing discussions between the TO and Ofgem. Historically, the System Operator (SO) has not been involved in such discussions. Furthermore, in the past the SO has predominantly submitted responses to Ofgem's consultation on specific projects seeking SWW approvals. Although the SWW arrangements continue to be a TO led process, the Network Options Assessment (NOA) process introduced through ITPR seeks to increase the SO's role. Within this context, the purpose of this document is to outline the process and arrangements that will exist between the SO, TOs and Ofgem where the SO will provide input into TO led Strategic Wider Works Needs Case submissions.

6 This document has two distinct components:

a. To provide a high level overview of the general process from initiation to conclusion of Strategic Wider Works arrangements and the SO's role in this wider process; and

b. To provide a detailed Cost Benefit Analysis (CBA) Methodology, which is the SO's principle contribution to TO led Needs Case submissions[3].

7 It is important to note that whilst the CBA undertaken by the SO will lead to recommendation of a preferred, most economically efficient, option to meet the system needs, any investment decision will remain with the TOs. Also note that the process summarised in this document, particularly regarding the SO's role in the CBA and the wider SWW process, reflects the default position for a typical network reinforcement project seeking approval through the SWW route.

8 Projects with more bespoke requirements may require a different approach, which would be developed and agreed though joint working between the respective TO and the SO, and subsequently presented to Ofgem for approval prior to commencing the

[3] Please note that this is the default SO role for typical new projects. Details regarding SO's activities for existing projects at different levels of development are also outlined later in this document.

preparation of the SWW Needs Case. This may include analysis other than CBA, for example, system operability.

9 Furthermore, the content of this document is based on the current process outlined in the SWW Guidance. We understand that the existing SWW process is currently being reviewed. As this process changes, the contents of this document may need to be refreshed.

Strategic Wider Works Process and the SO's Role

10 The process for SWW Needs Case and Project Assessment development from start to submission consists of various sequential activities. The text below outlines these activities and the SO's role across them for typical new projects seeking necessary SWW approvals for investment on the transmission network. By the nature of the activities outlined, the SO's role in the SWW process will be to provide the necessary support to the TOs and Ofgem in their respective decision making processes.

11 There are considerable linkages between the annual NOA Report process and the SO's role in the wider SWW process. These are also captured in the relevant steps outlined below.

12 **Step 1: Identification of the system need**. This could be achieved through the following channels.

a. SO assesses the system need through an annual Electricity Ten Year Statement (ETYS) process, which subsequently informs the NOA Report. The analysis may result in the SO requesting the TO to consider initiating the preparation of a SWW Needs Case.

b. SO and TOs regularly discuss and review network capacity issues and the need for SWWs in a particular TO's area at Joint Planning Committee (JPC) meetings. The SO may request the TO to consider initiating the preparation of a SWW Needs Case.

c. SO may request the TO to consider initiating the preparation of a SWW Needs Case, based on any new information which SO and / or TO may have obtained (e.g. updated information regarding certain customer connections).

13 Following the trigger, the SO will engage with the TO to understand the context of the project, particularly if such discussions haven't already been undertaken as part of the NOA Report process or the JPC. In addition to understanding the project's background, the discussions will seek to establish whether the project demands a different approach on SO's wider role and the CBA, to those identified in this document, due to any non-typical requirements. If yes, the SO and TO will work together to develop the bespoke approaches, as necessary.

14 Another key outcome of this meeting will be development of an issues log, which will be jointly maintained by the TO and SO throughout the project. This may be required to be shared with Ofgem at any stage of the SWW process.

15 **Step 2: Evidence for Eligibility Assessment**[4]. The TO prepares the evidence for eligibility assessment to provide confirmation to the SO that the works required are Strategic Wider Works. The TO engages with Ofgem to share the evidence prepared for the eligibility assessment for initial feedback. The TO may seek the SO's support to prepare the required evidence, as necessary.

16 **Step 3: Ofgem's Eligibility Assessment**. Upon receipt of the Eligibility Assessment, Ofgem will review whether the project is eligible and meets the qualification criteria. Ofgem may wish to consult the SO at this stage. If the project is eligible for SWW, Ofgem will confirm this to the TO.

17 **Step 4: SO's initial recommendations for a range of scenarios**. The SO makes initial recommendations to the TO regarding the range of scenarios which should be studied for the Needs Case submission.

18 **Step 5: Agree the range of scenarios (SO and TO)**. Through discussion, the SO and TO agree a range of scenarios required to be assessed as part of the Needs Case submission[5]. The TO may wish to study additional scenarios, beyond those agreed with the SO[6]. The TO engages with Ofgem to share the evidence prepared for the choice of scenarios for the Needs Case submission and seek initial feedback.

19 **Step 6: Agree the counterfactual (SO and TO)**. The TO and the SO discuss and agree the definition of the counterfactual state for the network boundaries under consideration as part of the Needs Case. The counterfactual for typical projects is 'do nothing'. If, due to the bespoke nature of the project considered, the definition of the counterfactual requires further considerations, the SO and the TO will engage with Ofgem with appropriate evidence for feedback on this issue, early in the assessment process.

20 **Step 7: Options Development (refresh / update)**. Based on the identified system need, the TO develops options to meet this requirement. This includes an assessment of the:

i. boundary capability increase associated with each solution;

[4] Projects which are already in the TO's RIIO-T1 Business Plan, will progress directly to Step 4.

[5] For projects, where the TO has already initiated the development of the SWW Needs Case, the project historic background may influence the discussions between the SO and the TO, and subsequently the choice of scenarios and requirements for any further analysis (as necessary).

[6] If there is disagreement between the SO and the TO on choice of scenarios, the issue will be recorded with appropriate evidence within the issues log. The TO may wish to look at additional scenarios outside of this process. In the near future, as the SO continues to use an open source model, the SO will share the model with the TO to undertake any simulations for additional scenarios. Once the SO has procured a new model, the SO may need to simulate the additional scenarios on TO's request. However, depending on the SO's rationale on non-inclusion of these additional scenarios, the relevant scenarios may not feature in the CBA report prepared by the SO.

ii. earliest in deliver dates of the solutions developed;

iii. forecast capital expenditure of the solutions with relevant spend profiles, estimates of any significant asset refurbishment works (cost and timing);

iv. asset life span in the developed solutions; and

v. deliverability considerations as identified in the NOA Report methodology.

21 Please note that the TO would have already developed a range of options ahead of initiating the preparation of the Needs Case. They may also feature the respective year's NOA Report. At this stage the TO may need to refresh the network analysis based on the scenarios agreed as part of Step 5.

22 **Step 8: The SO reviews the options**. Consistent with the NOA Report process, the SO's review process will ensure that the TO has considered a credible range of options to meet the system need. This will also include testing system operability of the options, particularly for options (or scenarios) which have not featured in the respective NOA Report.

23 This review process will also involve discussions with the TO to review the technical need and options development process adopted. In addition, to ensure that a credible range of options are included in the Needs Case, the SO may develop any non TO led options at this stage (e.g. non-build options, offshore integration options). Depending on the nature of the project, the TO may request the SO to undertake some additional technical analysis. The type and extent of this analysis will be agreed on a project by project basis.

24 **Step 9: Cost Benefit Analysis (CBA)**. SO requests the TO to provide a range of information to perform the CBA. The SO performs a CBA on the agreed options. (Full details on CBA methodology are presented in Appendix C, while an overview of the CBA process is presented in the Appendix B). Upon completion of the analysis, the SO will provide the TO with an independent CBA report, which will include a recommendation for the least-worst regret preferred option for the project.

25 Along with the report, the SO will also provide a copy of the CBA model to both the TO and Ofgem, including all results of constraint cost simulations for scenarios and options appraised. Depending on the type of model used[7] to forecast the constraint costs, the SO may also be able to provide the model used for constraint simulations (on a confidential basis).

26 **Step 10: TO prepares and submits the SWW Needs Case to Ofgem**. The results obtained from the CBA, are incorporated into the Needs Case submission. The TO

[7] The SO currently uses an in-house developed open source model for constraint cost forecasts. The SO is able to share this model, along with all input assumptions, with the TOs. This model will be replaced in the future by a third-party package. The SO will not be able to share this model with the TOs or Ofgem. However, the SO will be able to share all input assumptions adopted for the simulations performed in this model.

may wish to present additional evidence in relation to the CBA, as necessary. The SO provides additional support as required by the TO.

27 **Step 11: Ofgem's assessment of the Needs Case**. During the Ofgem assessment the SO and TO will jointly respond to any queries from Ofgem. Based on the Ofgem feedback, reconsideration of particular elements of the Needs Case may be required. The SO will provide support to the TO as necessary at this stage (particularly in terms of the choice of scenarios, review of the options and the CBA). Upon receiving all clarifications from the TO and the SO, Ofgem may seek to consult stakeholders regarding the Needs Case. The SO will continue to provide comments through such consultation process.

28 **Step 12: Ofgem's decision on the Needs Case**. Ofgem make a decision on the Needs Case and progress the project to the next stage, as appropriate.

29 **Step 13: The TO prepares SWW Project Assessment**. The SO is unlikely to be able to provide much support at this stage. However, if the costs for the preferred option have changed considerably or there are notable changes in the scenarios, the SO may need to refresh the CBA analysis.

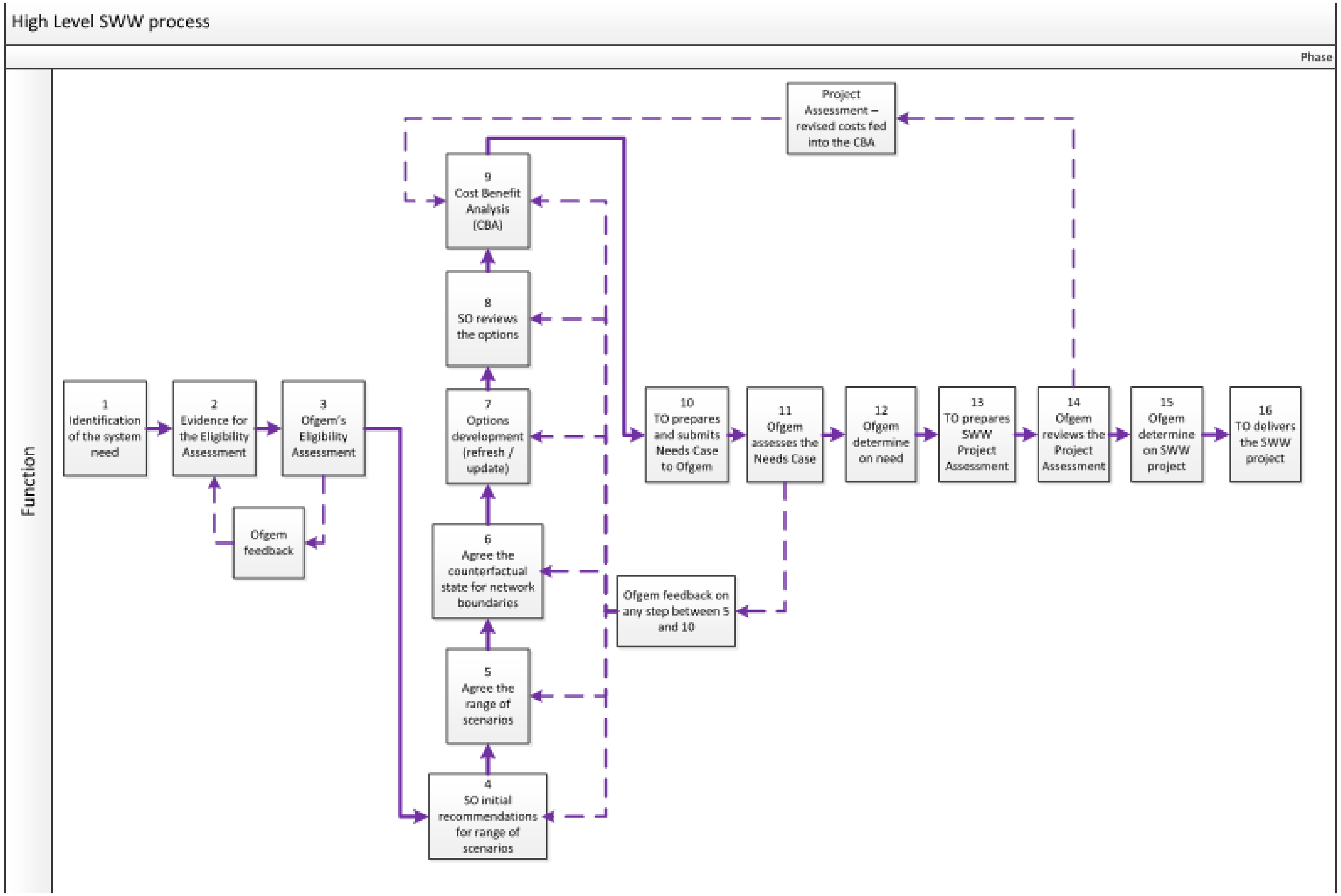
30 **Step 14: Ofgem's review of Project Assessment**. Ofgem will assess the Project Assessment, and the SO and the TO will respond to any queries, as necessary. Ofgem will consult the stakeholders as part of this review. The SO will continue to provide responses through the consultation process. Equally, the SO will provide any further evidence as necessary to support the TO. This may include further analysis on operability and optimal timing.

31 **Step 15: Ofgem determines on the SWW project**, including efficient costs and SWW outputs, and instigates a licence change, as necessary.

32 **Step 16: The TO delivers SWW project**.

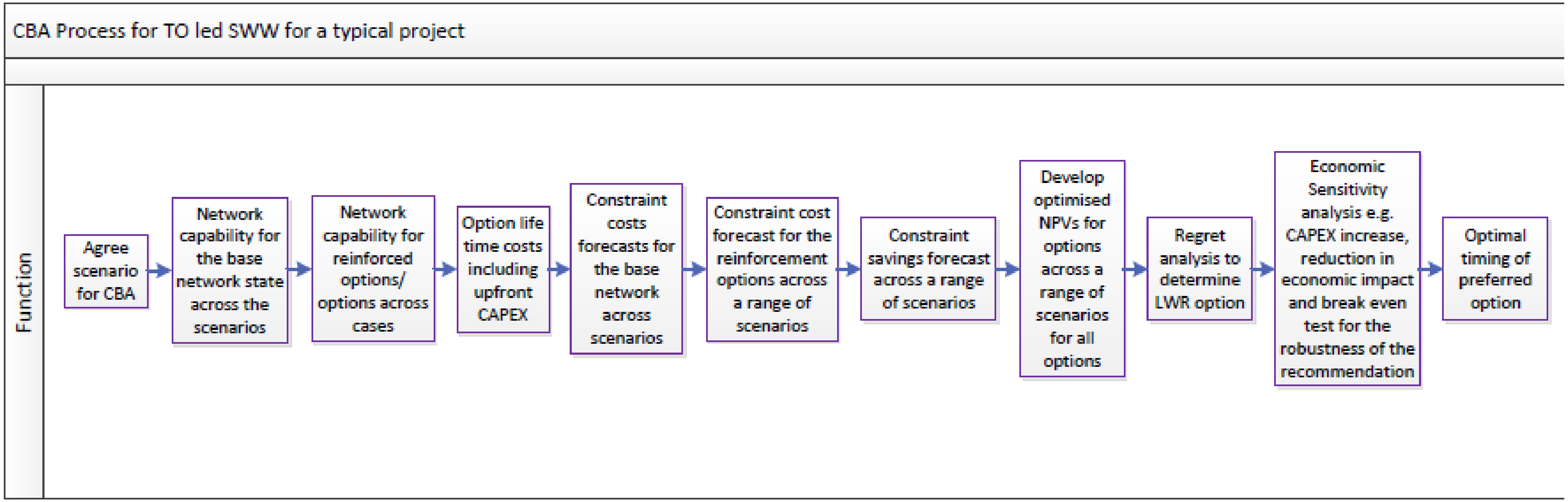
33 The SWW process flow diagram is presented in the Appendix A. The CBA process is presented in Appendix B, while full details of the CBA process are presented in Appendix C.

Appendix A: Strategic Wider Works (SWW) Process Flow Diagram



This diagram shows the overall SWW process. The text in each box corresponds to the descriptions of the stages explained in general methodology above. The numbers correspond to the step numbering in the text.

Appendix B: Cost Benefit Analysis Flow Diagram



This diagram shows the overall Cost Benefit Analysis process performed for a typical new project seeking approval from Ofgem through SWW submission. Detail of the Cost Benefit Analysis methodology is explained in the Appendix C.

Appendix C: Cost Benefit Analysis for TO led Needs Cases

Introduction and Context

C1 On-going changes to industry frameworks such as Integrated Transmission Planning and Regulation (ITPR) and NOA coupled with the forthcoming enhanced SO role of National Grid, place greater emphasis on integrated GB network investment planning and optimisation. These industry changes will raise stakeholder expectations on National Grid activities, and demand high quality Cost Benefit Assessments to support Needs Case documents for network developments.

C2 The Economics Team within Electricity Network Development has been established to appraise the value associated with specific network developments. These developments tend to either follow the prescribed Strategic Wider Works (SWW) process, or stem from a connection application for a new generator / interconnector connecting to the GB electricity system.

C3 National Grid's ETYS process performs a related annual network assessment to help plan future developments on major network boundaries, but does not consider discrete project developments separately or map them across all Future Energy Scenarios (FES) generation backgrounds. The Economics Team provides a detailed appraisal of specific projects to determine the economic merit of different solutions based on prevailing FES backgrounds and pertinent local factors, whilst respecting requirements of the Security and Quality of Supply Standards (SQSS) and the expectations of our NETS stakeholders.

C4 Each network development proposal is managed as a new project entity in which a range of solutions are studied and contrasted. The comparison accounts for forecast lifetime investment costs, lifetime operational savings and the corresponding network value that each solution offers. Assessments are conducted on a GB-wide basis since all projects within the GB market place have implications for the wider GB customer base in terms of capital and operational expenditure (Capex and Opex).

CBA Objectives

C5 The CBA objective is to produce and contrast key economic measures for various network solutions from a GB-wide customer perspective, leading to solution preference based on strict economic criteria. Solution preference is considered across a range of scenarios and accounts for all pertinent cost streams and factors. The CBA relies upon of a series of detailed and structured projections including: -

- FES backgrounds (generation and demand)
- Any local generation (or other) sensitivity with significant influence
- The future network state based on ETYS
- The boundary capability changes associated with each solution (and background)
- Forecast Capital Expenditure by solution (P50, P80[8] values)

[8] Probability (P) is the chance of an investment cost being exceeded. P50 refers to 50% chance and is therefore the mean expectation, whilst P80 implies a 20% chance of being exceeded.

- Any significant asset refurbishment cost and its timing
- The life span of the assets
- Future cost of capital (Weighted Average Cost of Capital or WACC) by investor share
- Social Time Preference Rate (STPR) of 3.5% pa[9].
- Future fuel prices and carbon prices
- Future renewable subsidy projections
- The operating regime of interconnectors

C6 At a high level, these forecasts serve to simulate future market conditions and identify how balancing actions will be utilised by the System Operator (SO). More discussion on how these assumptions contribute to the analysis can be found in Appendix 1 in the form of an illustrative CBA example.

CBA Preference Selection Philosophy

C7 The CBA analysis delivers a series of economic performance matrices reporting the Net Present Value (NPV) and corresponding Regret metrics for each potential solution, under each background. Whilst both the NPVs and Regret measures are reviewed, any emerging solution preference or recommendation is based on a Least Worst Regret (LWR) approach, provided solution stability and robustness can be demonstrated.

C8 Least Worst Regret analysis is designed to identify solutions from the range of possibilities which are least likely to be wrong across the range of uncertainties. It is not designed to pick options that offer the largest benefit (highest NPV), although this often occurs coincidentally. This approach provides a more stable and robust decision against the range of uncertainties, and minimises the chance of a particularly adverse outcome impacting consumers.

C9 The underlying economic philosophy is that it is advantageous to pick the solution that has the lowest adverse consequence across the range of studies, given the uncertainties in forecasts and other assumptions. It requires that all studies are seen as credible at the investment decision stage. Importantly, they need not be equally likely, and are unlikely to be so given the nature of uncertainty within future market place and wider industry.

C10 A regret measure is defined as the difference in the NPV between ‘the option being considered’ and ‘the best possible option under that scenario’, i.e. for each scenario, all options are considered against the option that offers the maximum NPV (taking into account both investment and operational costs). It follows that the best alternative has zero regret against which all other options in the scenario are compared. The mechanics of this can be seen in the Appendix D, which presents a worked example.

[9] Although the HM Treasury’s Green Book recommends reducing the STPR after first 30 years of the appraisals, the SO proposes to adopt the 3.5% p.a. STPR (discount rate) over the entire appraisal period. This is not least because the Treasury’s recommended reduction is unlikely to make any material change to the outcome of the analysis.

Best Practice in CBA

C11 There are usually a plethora of potential solutions to any specific network requirement. In order to focus CBA effort on a summary selection, a multi-criteria 'optioneering' process is required to filter the number of solutions down to a manageable number. Care must be taken to ensure that the set of solutions progressing to CBA retains the wider range and scope. This is because Best Practice in CBA work requires that a sufficiently wide and diverse set of options is progressed to adequately map the full solution space with reasonable resolution. Factors that should be evident in the range of solutions considered include: -

- The most minimal SQSS compliant solution (lowest possible investment cost solution meeting SQSS requirements)
- A range of topographical configurations where credible alternatives exist.
- A range of technologies (where practical)
- A range of capabilities (differing levels of boundary capability)
- A range of investment costs levels

CBA Methodology for TO led Needs Cases

C12 As identified in the core Network Options Assessment Report Methodology document, the NOA will provide investment signals for potential projects seeking to tackle congestion on the GB network. If the investment signal triggers the TO's Needs Case, the SO will assist the TO in undertaking a more detailed CBA. This Appendix provides an overview of the methodology which the SO will adopt for undertaking a detailed CBA as part of the TO's SWW Needs Case submission.

C13 Depending on the nature of the project, the SO may also provide further support on developing and reviewing the technical need of the project. The processes regarding such support are currently being will being developed and will shared with the TOs, Ofgem and the wider industry at a later date.

C14 Driven by the objectives of the CBA and the context outlined above, the overview of the methodology is summarised below:

- Establish the reference case position in terms of constraint costs forecasts associated with the counterfactual network state, across a range of generation scenarios and sensitivities. In order to undertake this assessment, the TO will need to analyse and provide data on counterfactual network capabilities for the boundaries affected for all agreed scenarios and sensitivities.
- Model constraint forecasts for the deliverable options short-listed by the TO across a range of generation scenarios and sensitivities. Again, in order to undertake this assessment, the TO will need to analyse and provide data on network capabilities by boundaries affected for all agreed scenarios and sensitivities for each short-listed investment option.
- Establish the forecasts of economic impact, measured as constraint cost savings, of the short-listed options, across the studied generation scenarios and sensitivities, over the options' assumed asset life.

- Undertake Cost Benefit Assessment, by:
  - Appraising the economic case of the options by adopting the Spackman[10] approach and determining respective NPVs across the studied generation scenarios and generation sensitivities. In order to undertake this analysis, the TO will need to provide life time costs information for all short-listed options, including capital, maintenance and / or refurbishment costs (with annual expenditure profiles) as well as evidence on losses.
  - Establish life-time worst regrets associated with each option appraised
- Make recommendations for the preferred option i.e. the least-worst regret solution, taking into consideration the impact of sensitivities and breakeven analysis.
- Determine optimal timing of the preferred solution by assessing regrets across each scenario and sensitivity and different years of delivery.
- Assess the robustness of the recommendation by assessing the impact of key economic sensitivities e.g. increase in capital expenditure, reduction in forecast of economic impacts, performing breakeven analysis to establish the level of change required in forecast of economic impacts or capital expenditure to result in zero net present value of options across all scenarios and sensitivities.

C15 This process is summarised in the figure presented in Appendix B.

C16 The remainder of this document presents details of various critical elements pertinent to the CBA.

Study Backgrounds

C17 All prospective CBA solutions must be considered against all credible backgrounds such that their performance against each is mapped and understood. This means that all FES backgrounds are studied against all solutions, and any other specific dependencies based on local conditions are also explored across the same range. This provides a matrix of NPV outcomes allowing comparison by solution and by background.

C18 The SO will work together with the relevant TOs to develop and agree a suitable range of credible scenarios for the CBA.

[10] The Joint Regulators Group on behalf of UK's economic and competition regulators recommend a discounting approach that discounts all costs (including financing costs as calculated based on a Weighted Average Cost of Capital or WACC) and benefits at the Social Time Preference Rate (STPR). This is known as the Spackman approach. Further details of our assumptions regarding WACC and STPR are presented later in this document.

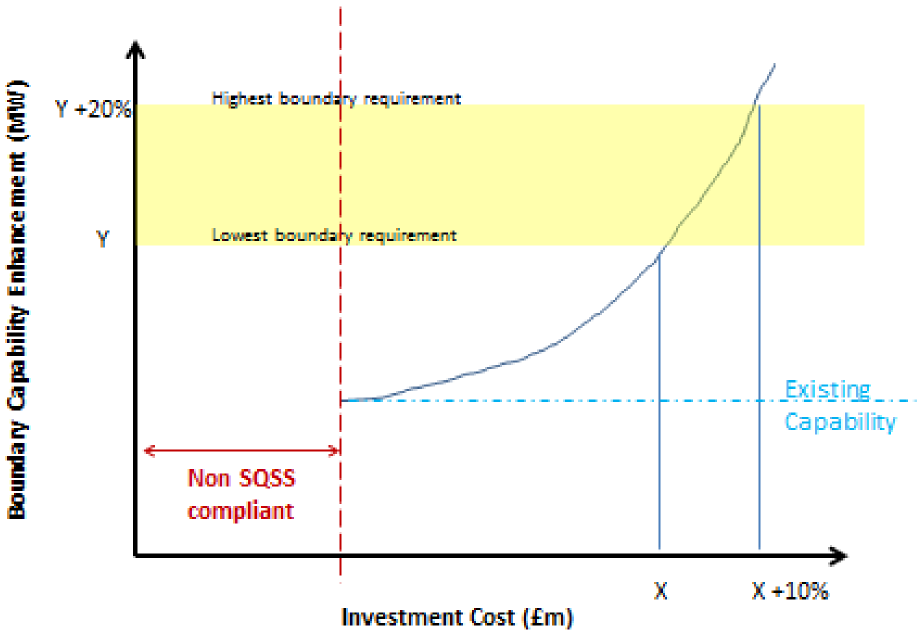
Forecasts and Projections

C19 Future forecasts within the CBA process follow one of two opposing value streams, namely, constraint savings (a consumer benefit) and investment costs (a consumer dis-benefit). These two streams must cover the same time period, but come from different sources. The constraint cost savings are determined by a modelling process called ELSI. The investment forecasts are produced by Transmission Owner (TO) costing teams or National Grid's E-Hub team. Their yearly projections are developed into present value (PV) equivalents using agreed cost of capital and discounting methods within the CBA.

C20 Constraint cost savings are derived by comparing ELSI's annual constraint costs for a particular solution with the corresponding base/counterfactual condition. Where reinforcement improves network efficiency, a constraint saving will occur. Future constraint savings have the same discount rate (STPR, see below) applied to future year values to account for the time-value of money. This provides a PV of constraint cost savings for each solution, for each background.

C21 All future investment costs must account for the investors Weighted Average Cost of Capital (WACC) and future payments discounted (by STPR) to produce a PV of the anticipated investment expenditure. These calculations follow the recognised 'Spackman' accountancy methodology designed to account for the time-value of money.

C22 In some circumstances, such as where the base reference point is the least cost SQSS compliant solution, the corresponding investment cost should be derived from the incremental cost of the solution (the additional expenditure relative to the reference solution). In this way, a presumption that as an absolute minimum the least cost SQSS compliant solution already exists, but that enhanced consumer value in additional incremental reinforcement may be achieved. In simple terms this could be likened to exploring economies of scale as illustrated below:



Constraint Cost Savings forecasting

C23 National Grid's preferred in-house modelling tool for medium to long range network constraint cost forecasts is called 'ELSI'. This tool is capable of producing medium / long term forecasts of network constraint costs for different network states and for various FES backgrounds. FES forecasts provide suitable data for modelling a 20 year period which may, occasionally, be sufficient to reflect the life expectancy of an asset. More typically, asset life is expected to exceed a 20 year period, hence an extrapolation technique is used to populate latter years. Typically, the final (20th) year values are adopted for each and every additional year to match the asset life horizon; although other alternatives may be considered if final year results appear particularly volatile. Most generation and transmission assets are assumed to have a 40 year life span, hence constraint cost savings must span this duration too.

Investment Cost Projections

C24 Each possible design solution is examined and costs are estimated by a specialist team. National Grid's dedicated National Grid team is E-Hub, other TOs have their own teams. Their investment cost projections should detail the total cost (including P50 and P80 contingency provisions), the spread of costs across development years and any significant refurbishment cost anticipated during the assets' life. The yearly investments are mortgaged over the asset life using the WACC assumption, and corresponding future payments discounted by STPR to derive Present Values (PVs) of each solution.

C25 Generally, P50 investment cost values are used in the CBA, however, the analysis is repeated with P80 values providing insight into the way in which delivery risk can influence preferences. This ensures that if a cheap but more risky solution emerges as a preference based on the P50 (ie. mean) values, then the P80 study will reveal this exposure.

Counterfactual / Base References

C26 The Counterfactual or Base network condition is the reference point to which other solutions are compared to identify the scale of benefit offered by the solution.

C27 There are several approaches to establishing a suitable counterfactual reference. Where practical, the base or counterfactual condition is either the 'do nothing' or 'do minimum' condition.

- The 'do nothing' is based on the existing network state without the introduction of this particular project. The 'do nothing' condition lends itself to conditions where the prevailing network state is SQSS compliant but significant network congestion is likely.

- The 'do minimum' refers to that level of investment required for this project in order to meet SQSS requirements. This is helpful where new connection assets are required to meet SQSS.

C28 Occasionally, it may be impractical to derive a counterfactual state. This could be because several low cost compliant solutions co-exist or where SQSS requirements are open to interpretation. Under these circumstances it is reasonable to regard the 'best solution within each background' as the reference point from which others solutions in the same background are measured.

C29 If, due to the bespoke nature of the project appraised, the definition of the counterfactual cannot be defined as the 'do nothing' and requires further considerations, the SO and the TO will engage with Ofgem with appropriate evidence for feedback on this issue, early in the assessment process.

NPVs and Regret Metrics

C30 The economic measures of NPV and corresponding regret matrices are developed to allow cross comparison of the solutions across scenarios and backgrounds. NPVs are generally the difference between PV investment costs and PV of constraint savings. Where constraint savings exceed investment costs then the solution has economic merit relative to the counterfactual state. Where NPVs are negative, then the converse is true.

C31 If the solution delivery timeframes are flexible i.e. not driven by a fixed contracted date, then solution NPVs may flex across different years. This occurs where the constraint savings in early years are lower than the corresponding finance costs or the converse. To explore optimal timing, the NPVs for each study are calculated across the first 10 years from the EISD (Earliest In Service Date) and the largest NPV (and corresponding year) is then determined. This ensures optimal timing for each solution by background is captured in the CBA for the purposes of cross comparison.

C32 Where several solutions show economic merit (positive NPV) then comparison can be made through Regrets analysis. Regret is defined as the difference between the NPV for a particular solution and the best solution across all backgrounds. Preference is then given to solutions that offer the lowest level of regret across all backgrounds and is called the Least Worst Regret (LWR). This LWR mechanism is demonstrated in the Appendix D.

Optimal Timing across all Backgrounds

C33 If divergence of the project's optimal timing (highest NPVs by year) occurs across different backgrounds (as is often the case), a second regret table is developed for any preferred solution(s). This reports the competing pressures across all backgrounds for a specific solution and helps identify the minimum timing regret across early years. This is illustrated in the Appendix.

Results

C34 The CBA methodology is designed to identify a preferred solution that maximises value, minimises risk and identifies optimal timing. Generally, the LWR solution offers the most economic course of action. However, this should be reviewed to establish that the solution is genuinely independent of the others and that it demonstrates a satisfactory level of robustness against unforeseen exogenous variables. This is tested through generic robustness tests in which either: -

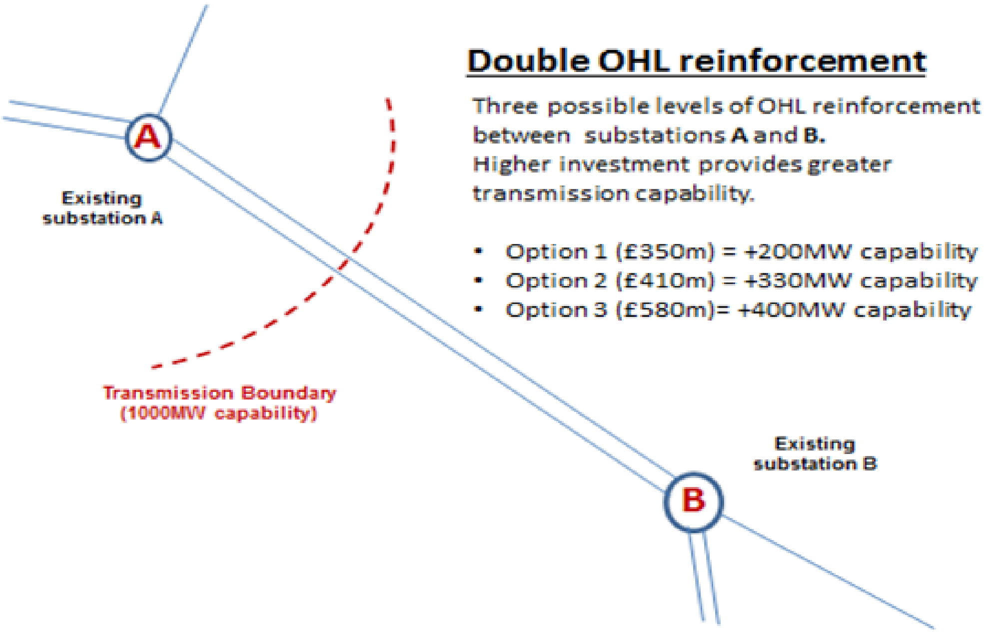
- Constraint cost savings are reduced by fixed percentages without impacting the outcome,
- Investment costs are increased by fixed percentages without impacting the outcome.

C35 Furthermore, the scale of the regrets that drives the LWR selection should be considered in relation to the scale of the investment cost. If a disproportionate increase in capital cost yields only a marginal improvement in regret values (which drives the LWR), then a simple review should also be undertaken. Where investment costs are in the billions and the regrets measures are in the few millions, then preference should be given to cheaper solutions since investment costs are less likely to undershoot than constraint savings overshoot. Investment costs are certainly more tangible and stable than constraint savings across the asset lifetime.

Appendix D: An Illustrative new connection / reinforcement CBA example

D1 Consider an example case where a length of transmission circuit is regularly the critical pinch point resulting in network constraint actions, and that this condition is forecast to increase in future.

D2 The multi criteria optioneering filter has already ruled out any new circuit route as there are much cheaper reconductoring options available which do not present significant planning delays. The counterfactual state is the existing network state with a 1000MW capability without any upgrades. This represents the reference condition from which other solutions are measured. There are four counterfactual models, one for each FES background scenario.



D3 In this example, we have a transmission boundary that requires reinforcement due to changing generation background patterns. The existing network has a 1000MW capability and there are three possible reconductoring options that could be implemented. The options would provide various levels of enhancement and investment cost, as illustrated in the table below.

Option	Capability Enhancement (MW)	Resulting Capability (MW)	*Investment Cost (£m)*
Option 1	200	1200	***350***
Option 2	330	1330	***410***
Option 3	400	1400	***580***

D4 Investment Costs range from £350m to £580, and as investment costs increase, transmission capability increases, but the relationship is not linear, and typically has step increases due to the standard unit sizes of transmission assets.

D5 Each of the three reinforcement solutions represents an increasingly expensive network investment with enhanced boundary capabilities compared to the existing state. The CBA will be able to identify the economic trade-off between investment costs and lifetime constraint savings. All of the options can be delivered within the current year hence no future year discounting is required, and the PV of investment cost is as shown in the table above.

D6 ELSI models are constructed to reflect the corresponding boundary capabilities, and run to determine the yearly constraint costs for each solution against each background. Results are consolidated into Present Values using the STPR assumption discussed previously.

D7 These constraint values are deducted from corresponding counterfactual case values to isolate the savings associated with the solution for each year. These forecasts are repeated across all backgrounds including any relevant local scenario designed to explore the wider solution space.

D8 The PV of constraint savings for each solution, by background is produced and is shown in blue below. The corresponding NPVs are produced by deducting the investment PV from the savings PV. This is shown in the second table below where GG – Gone Green, LCL – Low Carbon Life, SP – Slow Progression and NP – No Progression.

PV of Constraint Savings (£m)	FES Scenario				PV of Investment Cost (£m)
Option	GG	LCL	SP	NP	
Option 1	*£423m*	*£413m*	*£378m*	*£324m*	***£350m***
Option 2	*£800m*	*£720m*	*£600m*	*£430m*	***£410m***
Option 3	*£979m*	*£800m*	*£630m*	*£460m*	***£580m***

NPVs by Solution, by FES Scenario	FES Scenario			
	GG	LCL	SP	NP
Option	**NPV**	**NPV**	**NPV**	**NPV**
Option 1	*£73m*	*£63m*	*£28m*	*-£26m*
Option 2	*£390m*	*£310m*	*£190m*	*£20m*
Option 3	*£399m*	*£220m*	*£50m*	*-£120m*
column NPV max	£399m	£310m	£190m	£20m

D9 The NPV values shown are the maximum (or optimised) values achieved across credible delivery timeframes. The highest value for each background is identified and use as a reference to calculate the regret associated with other solutions. The completed regrets table is shown below.

Regrets £m					
Options	**GG**	**LCL**	**SP**	**NP**	**Worst Regret**
Option 1	*326*	*247*	*162*	*46*	***£326m***
Option 2	*9*	*0*	*0*	*0*	***£9m***
Option 3	*0*	*90*	*140*	*140*	***£140m***
		Least Worst Regret: Option 2			***£9m***

D10 The Worst Regret for each solution (across the rows) is logged, and then the Least Worst Regret identified. In this example the LWR is Option 2 with £9m regret and is the best option across three of the backgrounds. This solution has a £410m investment cost.

D11 If repeating this assessment for credible reductions in constraint savings or increases in investment costs gives the same patterns, then we can conclude that we have found a stable preference that offers protection from adverse outcomes and the best investment value for money.

Optimising Delivery Timescales

D12 Having determined a robust LWR solution, consideration of its delivery date is required. This entails repeating the Regret analysis but with a fixed solution (the LWR) and flexing the delivery year. This means that the NPV values are mapped across each delivery year and compared against the best, by background. This gives a timing regret table as shown below.

LWR Solution	
Commissioning Year	Timing Regret (£m)
Year 1	100
Year 2	69
Year 3	48
Year 4	47
Year 5	97
Year 6	160
Year 7	225

D13 Plotting this relationship reveals the opposing risks of early investment versus late investment. It can be seen that: -

- Commissioning to meet year 4 is the optimal time frame, although year 3 is almost the same.
- The exposure for late delivery exceeds that of early delivery