Gas Transportation Transmission Planning Code

nationalgrid

About this document

National Grid Gas plc ("National Grid") owns and operates the National Transmission System ("NTS"), the high pressure natural gas transportation system in Great Britain in accordance with its role as holder of the Gas Transporter Licence in respect of the NTS ("the Licence").

National Grid has a duty to plan and develop the system in an economic and efficient manner. The Transmission Planning Code ("TPC") is part of a suite of documents, which includes National Grid's Gas Ten Year Statement ("GTYS") and Future Energy Scenarios ("FES"), that describe how the NTS is planned and developed over the long term and how capacity is released to users of the system[1].

This document describes how long term supply and demand scenarios are used to develop the investment proposals published in the GTYS.

This statement of the Transmission Planning Code is effective from [1st April 2017].

Further information about the information contained in this document may be obtained from our Network Design team at:

National Grid
Gas Network Development
National Grid House
Warwick Technology Park
Gallows Hill
Warwick
CV34 6DA

Or by e-mail at: ntsinvestment@nationalgrid.com

[1] http://www2.nationalgrid.com/uk/industry-information/future-of-energy/

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Chapter One

Introduction

1.1 Document Scope

The National Transmission System ("NTS") is the high pressure natural gas transportation system in Great Britain designed to operate at pressures of up to 94 bar(g). Gas is transported through steel pipelines from coastal reception terminals and storage facilities to large consumers (such as power stations and industrial sites), storage facilities and Distribution Networks connected to the system.

National Grid owns and operates the NTS and has a duty to plan and develop the system in an economic and efficient manner. This document describes National Grid's approach to planning and developing the NTS in accordance with its duties as a Gas Transporter and other statutory obligations relating to safety and environmental matters, and is published in accordance with Special Condition 7B of National Grid's Gas Transporter Licence in respect of the NTS ("the Licence").

Special Condition 7B requires that National Grid maintains a Transmission Planning Code ("TPC") that describes the methodology used to determine the physical capability of the system, to inform parties, wishing to connect to and use the NTS, of the key factors affecting the planning and development of the system.

National Grid must comply with the TPC in planning and developing the NTS. National Grid must also review the TPC at least every two years, after consultation with the gas industry. Modifications to this code must be approved by the Gas and Electricity Markets Authority ("the Authority") before they may be implemented.

1.2 Document Structure

This document is structured in several chapters as explained below:

Chapter 2 describes the principal pieces of legislation that have a direct bearing on the planning of the NTS as well as providing more detail on the "1-in-20" Security Standard.

Chapter 3 provides a high level overview of the Network Capability Planning process.

Chapters 4 and 5 describe the commercial entry and exit capacity release processes and their part in the network development process.

Chapter 6 describes the network analysis models and assumptions that underpin them.

Chapter 7 describes the network development options that National Grid will consider when developing the NTS.

Appendix E. contains the methodology for the Determination of the Technical Capacity of the National Transmission System in relation to interconnection points to comply with EU Regulation EC715/2009.

Further information on the UK legislative framework, policy & guidelines for NTS Planning, and the supply & demand assumptions used in NTS Planning can be found in the appendices and a glossary of terms is contained in Appendix F.

1.3 Gas Planning and Operating Standards (GPOS): Changes and impact

National Grid has reviewed the suitability of "1-in-20" Security Standard to ensure that it continues to meet the needs of customers within a framework of shifting external and demands.

Standard Special Condition A9: Pipe-Line System Security Standard refers to the ability to meet a "1 in 20" demand, taking account of such operational measures as are available to the licensee and including within day gas flow variations on that day. As the demands placed on the system evolve, and its changing use affects the impact of within day gas flow variation, National Grid needs to ensure that the system continues to develop and operate efficiently whilst still meeting these needs.

Later chapters and Appendix E provide further detail on how within day gas flow variation is determined and accounted for, to ensure continued efficient planning and operation.

Chapter Two

Legislative Framework

National Grid is required to comply with certain legal requirements in the planning and development of the National Transmission System ("NTS") in Great Britain. This chapter covers the principal pieces of legislation that have a direct bearing on the planning of the NTS as well as providing more detail on the "1-in-20" Security Standard. A full summary of relevant legislation, policies and guidelines is contained in Appendices A and B.

2.1 Gas Act 1986 (as amended)

The Gas Act is the primary UK legislation that governs the transport and supply of natural gas within Great Britain.

Section 9 of the Gas Act states a Gas Transporter has general duties in the planning and development of their system, which are:

" (a) To develop and maintain an efficient and economical pipe-line system for the conveyance of gas; and

(b) Subject to paragraph (a) above, to comply, so far as it is economical to do so, with any reasonable request for him –

(i) To connect to that system, and convey gas by means of that system to, any premises, or

(ii) To connect to that system a pipe-line system operated by an authorised transporter."

National Grid Gas plc is required to hold a Gas Transporter Licence in respect of its gas transportation activities for the NTS. This licence is granted and administered by the Gas and Electricity Markets Authority, ("the Authority"), established by the Utilities Act 2000.

2.2 National Grid's Gas Transporter Licence in respect of the NTS

National Grid is bound by the terms of its Licence. The Licence contains a number of Standard, Standard Special and Special Conditions that National Grid must abide by in developing and operating the network and in conducting its transportation business. The Licence obligations that are relevant to the planning and development of the NTS are described below.

2.2.1 Standard Special Condition A9: Pipe-Line System Security Standards

This condition sets out the security standard for the NTS, which is that the pipeline system must, taking into account operational measures, meet the "1-in-20" peak aggregate daily demand including within day gas flow variations.

The “1-in-20” peak aggregate daily demand is the level of daily demand that, in a long series of winters, with connected load held at the levels appropriate to the winter in question, would be exceeded in one out of 20 winters, with each winter counted only once. This is the Uniform Network Code (“UNC”) definition of the “1-in-20” peak day. It can be found in the UNC Transportation Principal Document (“TPD”) Section Y Glossary.

2.2.1.1 Additional Clarifications

The Pipe-Line System Security Standard does not define or refer to any demand levels at which NTS capability should be assessed, other than the peak 1-in-20 demand. There is also no reference to supply patterns or levels, however the distribution of supplies across the NTS, for a given demand level, can significantly affect the capability to meet the minimum safety/contracted pressures that National Grid has agreed with its customers.

The existing Pipe-Line System Security Standard also refers to within-day gas flow variations (i.e. supply and demand being out of balance) but it does not define the sources and magnitude of within-day variation that should be used to assess NTS capability.

The behaviour of these supply patterns and within-day gas flow variations is regularly reviewed, creating clearly defined event criteria against which NTS capability is assessed. National Grid’s principle aim is to assess network capability against any event or combination of events likely to occur on more than 1 day in any 20 year period. National Grid will consider all appropriate Network Development Options, which includes, for example, commercial constraint management actions, should the NTS have insufficient capability.

2.3 Pipelines Safety Regulations 1996

The Pipelines Safety Regulations (PSR) 1996 are the principal health and safety legislation in the UK concerning the safety and integrity of pipelines). They apply to all relevant onshore UK pipelines to ensure that these pipelines are designed, constructed, operated, maintained and decommissioned safely. In particular they class certain pipelines that transport certain “dangerous fluids” as Major Accident Hazard Pipelines (MAHPs). All natural gas pipelines operating above 7 bar(g) fall into this category.

2.4 Gas Safety (Management) Regulations 1996

The Gas Safety (Management) Regulations (GSMR) 1996 require each Gas Transporter to prepare a Safety Case document that sets out in detail the arrangements in place to safely manage the National Transmission System.

In particular, Schedule 1 states that the Safety Case must contain

> “**17.** Particulars to demonstrate that the duty holder has established adequate arrangements to ensure that the gas he conveys will be at an adequate pressure when it leaves the part of the network used by him.”

2.5 Planning Regime

National Grid has legislative obligations relating to consent authorisations required when developing elements of the NTS in the form of the Planning Act 2008 and the Town and

Country Planning Act 1990. Generally speaking the Planning Act 2008 will apply to the construction of NTS pipelines whereas the Town and Country Planning Act 1990 will apply to the provision of fixed assets such as Compressor Stations and Pressure Reduction Installations.

2.6 Emissions

National Grid has regulatory obligations relating to emissions placed upon it by the Environment Agency (EA) in England and Wales, and the Scottish Environment Protection Agency (SEPA) in the form of:

- The Pollution Prevention Control (PPC) regime (Scotland);
- The Environmental Permitting regime (England and Wales);
- The Large Combustion Plant Directive (LCPD);
- The Medium Combustion Plant (MCP) Directive
- The Industrial Emissions Directive (IED);
- The European Union Emissions Trading Regulations (EU ETS) within the UK.

2.7 European Union Regulations

Following the UK's referendum result on EU membership in June 2016, National Grid notes that EU rules and regulations will continue to apply in the UK until such time as the UK's membership of the EU is withdrawn. National Grid will continue to take forward implementation of EU requirements whilst the terms of the future UK relationship with the EU, including the Internal Energy Market, are defined.

2.7.1 Security of Supply Regulation

The gas Security of Supply Regulation No. 994/2010 aims to enhance security of supply by providing common assessment of Member States' energy security arrangements. Infrastructure resilience is measured against an 'N-1' standard i.e. that in the event of a disruption of the single largest infrastructure, the remaining infrastructure has sufficient capacity to satisfy the total demand occurring on a 1 in 20 demand day.

Chapter Three

Network Capability Planning

This chapter provides a high level overview of the Network Capability Planning process, the National Grid's Future Energy Scenarios consultation ("FES") and Gas Ten Year Statement ("GTYS").

National Grid undertakes network capability planning over a ten-year planning horizon on an annual basis. Network capability analysis is developed using long term supply and demand forecast scenarios developed through the FES process and other information gathered through commercial processes to book capacity on the system. This Chapter outlines the annual network capability planning process. Further detail on the network analysis process and planning assumptions is contained in Chapter 6.

3.1 Future Energy Scenario Consultation

National Grid is committed to stakeholder engagement, listening to our stakeholders and acting on what they tell us. The views of our stakeholders are crucial as we enter a period where the energy industry has to meet the challenges of providing secure and affordable energy, replacing ageing assets and moving to low carbon sources of generation to meet environmental targets.

The annual FES consultation process consists of a series of workshops, bilateral meetings, questionnaires and our annual conference. Through this process we listen to the views of our stakeholders, engage in further discussion with them and act on what they tell us when developing our next set of scenarios.

Our FES document describes in detail the assumptions behind the main scenarios used in planning analysis and future energy scenarios. In the past National Grid produced a single forecast of gas and electricity demand. This approach no longer provides a sufficiently rich picture of possible energy futures. National Grid now uses scenarios representing different views of the future. There are many possible futures, with considerable uncertainty regarding future levels of gas and electricity demand, sources of gas supply and levels of renewable generation, as well as many others areas.

FES questionnaires are circulated to a range of industry players (Producers, Importers, Shippers, Storage Operators, Delivery Facility Operators, Transporters and Consumers) requesting supply and demand forecast data and inviting views on National Grid's underlying assumptions for supply and demand. Shippers are required to provide this supply and demand information under the UNC TPD Section O. The FES consultation forms part of the wider FES consultation process, the results of which are published on the National Grid website.

3.2 Planning Cycle

National Grid will commence its annual planning cycle after the initial data has been gathered through the FES process and will use this data to compile long term supply and demand scenarios. The process will consider the capability that may be required to respond to entry and exit capacity signals from the market. National Grid will use detailed network models of the NTS under different supply and demand scenarios in order to understand how the system may behave under different conditions over a ten year planning horizon.

During this process, Distribution Network Operators ("DNOs") and NTS Shippers can apply for exit capacity on the NTS to support their long term needs, and NTS Shippers may signal their requirements in the long term entry capacity auctions under rules set out in the UNC. The information received from these commercial processes will be used to inform the final set of investments that are necessary to develop the system. National Grid will, primarily, consider any NTS capacity reserved through a Planning & Advanced Reservation of Capacity Agreement ("PARCA") as well as long term signals received for additional capacity above the prevailing obligated/contracted capacity levels, which can be met through capacity substitution, as well as long term capacity bookings/reservations within obligated/contracted capacity levels (noting that in either of the latter two cases this may have been triggered via a PARCA) within the same annual planning process, in order to satisfy its wider duties to develop and maintain the system in an economic and efficient manner.

3.2.1 Network Capability Analysis

National Grid will undertake network capability analysis to identify the ability of the NTS to accommodate a given supply and demand pattern, respecting the maximum and minimum pressure requirements of the network (including locational pressure cover described in Section 6.7.2), and the efficient and safe operation of the system.

Analysis may be undertaken to identify capability for different needs, for example to identify the maximum flow that may be supported at an Entry or Exit Point, or the level of exit flexibility that exists on the system. The type of analysis (steady state or transient) and supply/demand scenarios will vary according to the study required; however the aim will be to find the point at which the network becomes "constrained" i.e. has reached its limits for the given scenario.

National Grid will use this analysis to inform commercial capacity processes, for example, the level of flow that may be achieved at any network Entry or Exit Point under certain supply/demand conditions compared to the obligations to release capacity to determine a "constraint volume" of gas at that Entry or Exit Point. It should be noted that it is not possible to directly model the concept of capacity in the commercial sense within these physical network models as the entry / exit flow capability will vary from scenario to scenario.

3.2.2 Confirmation of Existing Projects

During the planning cycle, National Grid will analyse the first two years of the prevailing Investment Plan (See Section 3.3 "Gas Ten Year Statement") to verify whether the projects sanctioned during previous planning cycles are still required. In doing this, Licence requirements to release obligated capacity levels, commitments from entry capacity and commitments on exit for flat capacity, flexibility and pressures will be taken into account. National Grid will also maintain a regular dialogue with Shippers, DNOs and Developers to ensure that information on the progression of their projects may also be used to inform

National Grid's investment decisions in a timely manner. In accordance with the UNC[2], Shippers, DNOs and Developers will be required to provide demonstration information[3] to National Grid NTS to show that the customer project is proceeding before capacity is allocated and investment works commenced.

If it is found that sanctioned projects are not required as proposed through previous planning cycles (for example, due to changes in the underlying supply and demand forecasts, or as a result of new information provided to National Grid by Shippers and Developers or new information made available in the public domain) then analysis will be carried out to determine which year the projects should now be completed for.

3.2.3 Investment Planning Analysis

Investment Planning Analysis is concerned with identifying the possible reinforcements that can be made to the pipelines and plant on the NTS to increase the capability of the system. National Grid will undertake investment planning analysis to determine the level of investment required to support changes to supplies or demands on the system.

3.2.4 Annual Plan Review

National Grid will check the network models developed during the annual planning cycle to ensure that the correct planning assumptions have been used, that project alternatives have been considered and that there is consistency across the ten-year planning horizon. National Grid will document the audit findings in a plan review report alongside any recommendations for improving the network models and analysis techniques used for future planning cycles. This review document will be used in the next planning cycle to update the network model and analysis assumptions.

3.3 Gas Ten Year Statement

The Gas Ten Year Statement ("GTYS") details National Grid's latest supply and demand scenarios, proposed system reinforcement projects and investment plans. It is published at the end of the annual planning process and provides the platform on which the next annual planning process is built. National Grid will describe the projects that are determined to be part of its final Investment Plan in the GTYS, after consideration of any capacity reserved or allocated via a PARCA, as well as information received from the long term entry and exit capacity bookings made by DNOs and Shippers.

From 2016 we have begun to publish the Gas Future Operability Planning ("GFOP") document alongside the GTYS, to provide a clearer vehicle to engage with stakeholders on the operability challenges facing the NTS into the future.

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[2] UNC TPD Section B, para 3.3.4(b) & 3.3.5

[3] Typical demonstration information requirements can be found in our 'Planning & Advanced Reservation of Capacity Agreement (PARCA), A Guide for Customers" document located on our website at: http://www2.nationalgrid.com/UK/Services/Gas-transmission-connections/Capacity-and-connections/Processes/PARCA-Framework/

3.4 New Projects Requiring Entry or Exit Capacity

From time to time, there are enquiries made by customers on new projects designed to deliver additional gas supplies into the UK market or connect new storage facilities, interconnector pipelines or loads to the system.

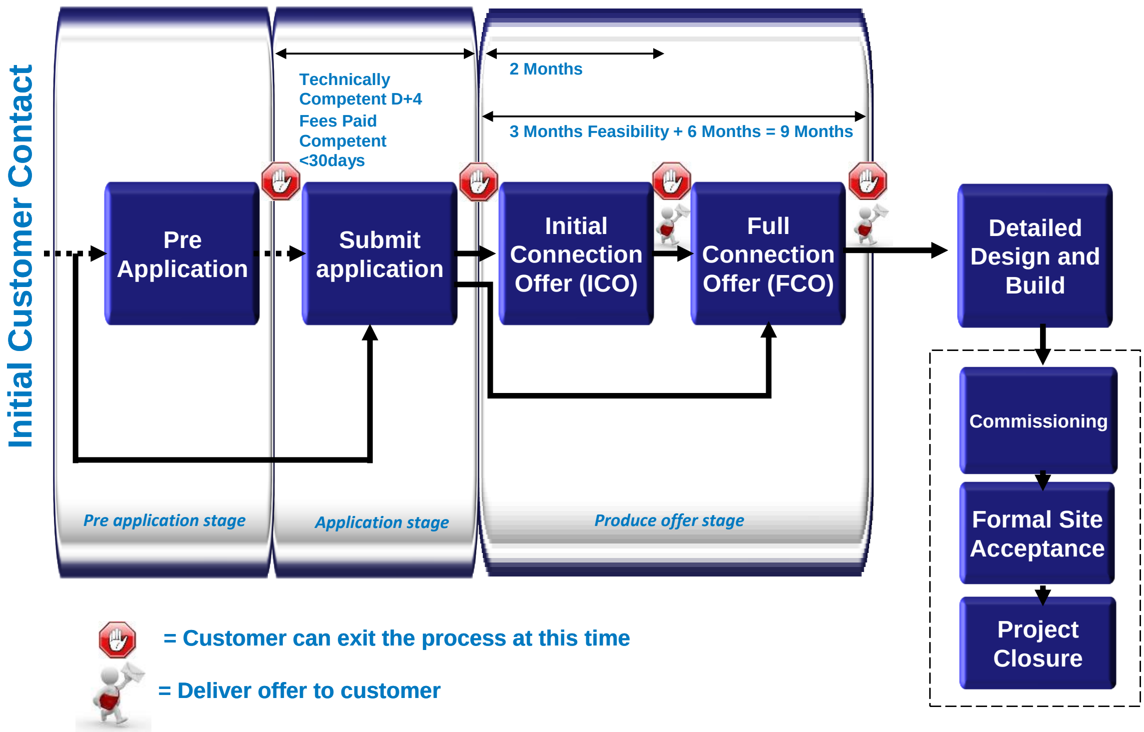
National Grid will discuss such prospective projects with customers to help them develop viable projects that deliver benefits for the UK security of supply. Both a physical connection and commercial capacity rights are required to physically input gas to, or offtake gas from, the NTS. These are currently acquired through separate processes; please refer to Chapter 4 "Entry Capacity" and Chapter 5 "Exit Capacity".

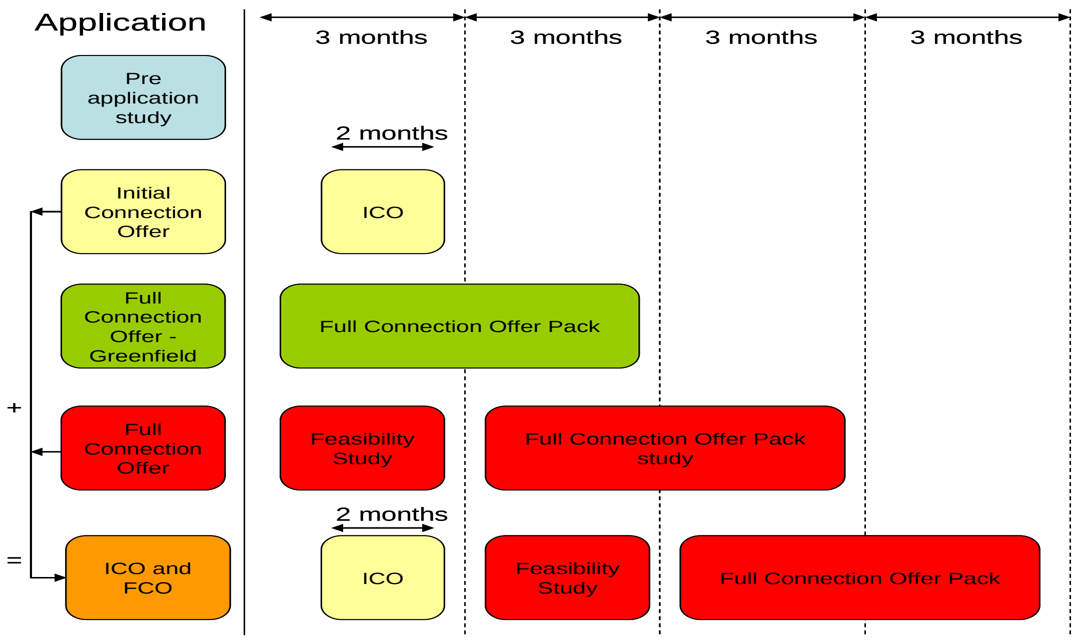
3.4.1 Physical Connection

In order for a customer to connect to the NTS or to modify an existing NTS connection, they must first progress through stages of the formal application process for Connection Offers. This process starts after initial contact with National Grid and varies depending upon what the customer requirements are. For example, initially, the customer can request and pay for National Grid to provide an indicative view of the connection layout, an overview of the engineering/design work which would be required (including any specific studies) and an early estimate of construction costs should they wish to continue along the connections process.

Prior to a detailed design stage and construction of the physical connection, the customer will be required to pay National Grid to provide a formal offer for the connection to specify amongst other things, a connection completion date, a programme of works, delivering any specific design/engineering study reports and a draft construction agreement.

The timescales for National Grid to deliver outputs for each stage of the connections process will depend upon the stage itself and complexity of the project. On completion of each stage of the connections process, the customer has the opportunity to exit the process. The connections process is summarised in the diagrams below:





3.4.2 Securing Entry and Exit Capacity

Users of the system must obtain entry and/or exit capacity rights on the NTS to flow gas and in order to trigger additional investment that may be required to support their potential gas flows onto and out of the NTS under the prevailing commercial arrangements described in the UNC. Currently, to trigger entry investment, Firm NTS Entry Capacity and Firm NTS Exit Capacity, requiring specific exit reinforcement to the system, can only be reserved and allocated through the signing of a Planning & Advanced Reservation of Capacity Agreement ("PARCA") with National Grid.

A PARCA is a multi-phased bilateral contract, between National Grid and a customer, which, would allow Firm Quarterly System Entry Capacity and / or Firm Enduring Annual NTS Exit (Flat) Capacity to be reserved for that customer, whilst they develop the initial phases of their own project. Any NTS Capacity initially reserved via a PARCA would, subject to a need case for that capacity being sufficiently demonstrated and any necessary planning permissions being received, be allocated exclusively to the PARCA applicant, or, where the PARCA applicant is not a UNC party, a NTS User(s) nominated by the PARCA applicant.

A PARCA would facilitate customers approaching National Grid early in the development of their own project in order to reserve NTS Entry and / or Exit Capacity without the need to fully financially commit to the formal capacity booking at that stage, other than the security required for reserving the capacity in Phase 2 of the PARCA, thereby reducing a potential barrier to participation.

National Grid is incentivised under its Licence to deliver entry and exit capacity in an efficient and economic manner. The Licence arrangements confirm National Grid's revenue allowances for delivering additional entry or exit capacity and such allowances will be calculated in accordance with the Generic Revenue Driver Methodology as part of the PARCA process. National Grid would expect that such arrangements would be updated to include revenue allowances upon the allocation of additional entry or exit capacity[4].

It should be noted that there may be a lead-time associated with customers obtaining access to the system. Under the requirements of the Planning Act, the anticipated lead time for the delivery of the majority of reinforcement projects is up to 7 years (84 months). Customers are encouraged to enter into discussions with National Grid at an early stage so that they fully understand the processes required to connect and use the system.

A PARCA is split into a number of phases with each phase designed to deliver a subsequent stage of Planning Act requirements.

The table below is a generic timeline that was developed by National Grid which illustrates the process steps leading up to a submission to the Planning Inspectorate and how the PARCA process overlays these steps.

PARCA Phase	Planning Act Stage	Activity	Duration
0		Pre-contract discussion between National Grid and the Customer	
1	Strategic Optioneering	Establish the need case and identify technical options	Up to 6 months
2		Develop Strategic Options Report (SOR)	Up to 6 months
	Outline Routing and Siting	Identify Preferred Route Corridor / Siting Studies	Up to 15 months

[4] For further information please refer to the following entries in the Appendices

Special Condition 5F: NTS gas entry incentives, costs and revenue (Appendix A)

Special Condition 5G: NTS gas exit incentives, costs and revenues (Appendix A)

Generic Revenue Driver Methodology Statement (Appendix F)

	Detailed Routing & Siting	Undertake EIA (Environmental Impact Assessment) & detailed design	Up to 24 months
	Development Consent Order (DCO) Application preparation	Formal consultation, finalising project, preparation of application documentation	
	DCO Application, Hearings and Decision	Submission and examination	Up to 15 months
		Approval process	
3	Construction	Capacity bought by Customer National Grid Construction Programme	Up to 24 months

3.4.3 Alternatives to Investment

When considering a customer's request for incremental capacity, in addition to physical investment, we will also consider all commercial options and operational arrangements that are available to us in order to determine the most efficient overall solution. These are described in more detail later in this document under Network Development Options (7.1).

3.4.4 Securing Entry and Exit Capacity at Interconnection Points

Separate processes to trigger investment at Interconnection Points come into force from 1st April 2017. These processes have some common aspects to the PARCA process that applies at non-IP points, by providing a clear and structured process to signal interest in incremental capacity and the provision by National Grid, in conjunction with adjacent TSOs, of technical reports to confirm the mechanisms, timescales and costs for the provision of this capacity. The differences in the two approaches derive from the need to develop joint proposals between adjacent TSOs, for which regulatory approval needs to be obtained, and are reflected in changes to the stage of the process analogous to phase 1 of a PARCA.

It should be noted that there may be a lead-time associated with customers obtaining access to the system. Under the requirements of the Planning Act, and combined with the extended timescales associated with the incremental process at Interconnection Points, the anticipated lead time for the delivery of the majority of reinforcement projects is up to 8½ years (102 months). Customers are encouraged to enter into discussions with National Grid at an early stage so that they fully understand the processes required to connect and use the system.

The incremental process at Interconnection Points is split into a number of phases with each phase designed to deliver a subsequent stage of Planning Act requirements, illustrated in the following table. An approximate mapping to the phases of the PARCA process is provided for information.

PARCA Phase	IP Process	Planning Act Stage	Activity	Duration
0			Pre-contract discussion between National Grid and the Customer	
1	Market Demand Assessment	Strategic Optioneering	Establish the need case	Up to 4 months
	Design Phase		Identify technical options	Up to 8 months
	Regulatory Approval		Regulatory approval	Up to 6 months
2			Develop Strategic Options Report (SOR)	Up to 6 months
		Outline Routing and Siting	Identify Preferred Route Corridor / Siting Studies	Up to 15 months
		Detailed Routing & Siting	Undertake EIA (Environmental Impact Assessment) & detailed design	Up to 24 months
		Development Consent Order (DCO) Application preparation	Formal consultation, finalising project, preparation of application documentation	
		DCO Application, Hearings and Decision	Submission and examination	Up to 15 months
			Approval process	
3		Construction	Capacity allocated to Customer National Grid Construction Programme	Up to 24 months

The Market Demand Assessment Window will run for the first time on 1st April 2017. Future windows will open every two years, triggered by the opening of the Annual Yearly Auction

Chapter Four

Entry Capacity

This chapter covers the commercial entry capacity release processes and their part in the network development process.

4.1 Long Term System Entry Capacity

National Grid makes NTS entry capacity available in a series of auctions. Signals (bids) received from long term auctions[5] are used within the planning process to inform the need for investment. The QSEC can also be used to trigger additional capacity release via Entry Capacity Substitution. Where specific reinforcement works to the system are required to meet a request for Incremental NTS Capacity this will only be released where a PARCA has been signed (please see section 3.4.2 for more information on PARCAs)

At non-interconnection points, National Grid must, under the terms of its Licence, prepare a proposal for releasing funded incremental obligated entry capacity, as a result of the signing of a PARCA, and submit this proposal to the Authority[6] for approval. In addition, the UNC requires that notification of entry capacity allocations to Shippers who have bid in the QSEC auction occurs within 2 months of the end of the auction invitation period.

A similar process now exists at interconnection points, beginning with a demand window and involving consultation on the proposal prior to submission to the Authority.

In order to fulfil its obligations under both the Licence and the UNC within the required notice periods, National Grid will undertake network analysis before the annual long term auctions. The basic steps that will be taken before and after the long term auctions are shown in Figure 1 and are described below:

4.2 Development of Supply and Demand Scenarios

Supply and demand scenarios will be determined using the latest FES scenario data as described earlier in this document. For entry capacity assessment other demand scenarios may be used to test demand sensitivities. Demand will be assessed at peak “1-in-20” conditions, and at average and severe conditions (as appropriate) through the load duration curve. Analysis will be undertaken for each relevant year of the ten-year planning horizon.

More information can be found in appendices C and D.

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[5] This includes bids received from the QSEC and Long term Interconnection Point (IP) entry capacity secured through the Annual Yearly IP auctions, detailed in the ENTSOG auction calendar

[6] Within this notice National Grid will, where required, also provide the Authority with the volume of Incremental Obligated Entry Capacity proposed to be treated as Non-incremental Obligated Entry Capacity provided by Entry Capacity Substitution.

4.3 Network Capability Analysis for Entry Capacity

Network capability analysis will be undertaken to identify the capability of the NTS to support required flow patterns under the supply and demand scenarios developed from the FES scenarios.

Entry projects identified from previous planning cycles will be reviewed to verify whether the projects sanctioned as part of previous plans are still required. In doing this, Licence requirements to release obligated capacity levels, commitments from capacity sold to Shippers in entry capacity auctions and commitments on exit for flat capacity, flexibility and pressures will be taken into account. National Grid will also maintain a regular dialogue with Shippers, DNOs and Developers to ensure that information on the progression of their projects may also be used to inform National Grid's investment decisions in a timely manner. In accordance with the UNC[7], Shippers and Developers will be required to provide demonstration information[8] to National Grid NTS to show that the customer project is proceeding before capacity is allocated and investment works commenced.

If it is found that sanctioned projects are not required as proposed through previous planning cycles (for example, due to changes in the underlying supply and demand forecasts, or as a result of new information provided to National Grid by Shippers or new information made available in the public domain) then analysis will be carried out to determine which year the projects should now be completed for.

4.4 Investment Planning Analysis for Entry Capacity

Investment planning analysis will be undertaken where a shortfall, or bottle neck, is observed in the capability of the NTS to support the required flow patterns under the supply and demand patterns tested, where alternative commercial solutions are not economic, under the terms of the Entry Capacity Release Methodology Statement ("ECR")[9]. Each supply and demand scenario may generate a number of investment projects for consideration as the supply patterns are varied away from the FES scenario supply patterns.

An indicative Investment Plan will be determined by considering investment projects and other options across the range of supply and demand scenarios, to develop a range of options that best meet the anticipated flow patterns of the system, whilst paying due regard to National Grid NTS's wider obligations. These will include, but are not limited to, its obligations to develop the NTS in an economic and efficient manner and to maintain a safe and secure system. At this stage these investment projects should be only viewed as indicative and may be modified in the light of further detailed analysis and investigation. The

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[7] UNC TPD Section B, para 3.3.4(b) & 3.3.5

[8] Typical demonstration information requirements can be found in our 'Planning & Advanced Reservation of Capacity Agreement (PARCA), A Guide for Customers" document located on our website at: http://www2.nationalgrid.com/UK/Services/Gas-transmission-connections/Capacity-and-connections/Processes/PARCA-Framework/

[9] http://www2.nationalgrid.com/uk/industry-information/gas-capacity-methodologies/

supplementary analysis may also consider routeing or siting difficulties arising from environmental, safety and wider societal impacts.

The indicative Investment Plan will be updated subject to demonstration information associated with customer driven projects. If required, the FES scenarios are adjusted accordingly.

4.5 Analysis of Long Term System Entry Capacity Signals

Whilst the QSEC and IP Annual Yearly auctions provide an important source of planning information on the levels of user commitment for baseline capacity, it is only through the signing of a PARCA that incremental entry capacity requiring network investment can be released. Notwithstanding this, the indicative Investment Plan must be developed ahead of the QSEC auction, due to the amount of analysis required. The final Investment Plan for the annual planning cycle will be determined after consideration of any capacity reserved or allocated via a PARCA, as well information received from the long term QSEC and IP Annual Yearly auctions and incremental capacity release processes.

Shippers can place entry capacity auction bids in accordance with the rules set out in the UNC. Once the auction information is received, National Grid will apply the ECR methodology in line with its duties under the Licence to determine whether additional entry capacity should be made available at any Entry Point and the amount of incremental entry capacity that should be made available.

Under its Licence obligations, default lead times of 24 months are available to National Grid for the build of the identified projects. National Grid will, where possible, carry out analysis ahead of an auction to identify what investment could be required considering any capacity reserved or allocated via a PARCA and if an anticipated pattern of bids is subsequently received. This analysis may need to be modified if an unanticipated pattern of bids are received in an auction.

National Grid is required to submit an incremental obligated entry capacity proposal to the Authority that describes how much incremental obligated entry capacity has been released as a result of applying its ECR methodology. National Grid can only permanently increase the level of entry capacity at an ASEP having first assessed how much entry capacity may be substituted to meet the increase in accordance with the terms contained within its Entry Capacity Substitution Methodology Statement ("ECS")[10]. Entry Capacity Substitution is the process of substituting Unsold Firm entry capacity from one or more ASEPs to another ASEP where demand for entry capacity exceeds the available obligated capacity quantities for the relevant period.

For the avoidance of doubt, National Grid will not undertake analysis for Entry Capacity Transfer and Trade processes as part of its planning cycle, as these are only applicable in the shorter term and so do not form part of the long term investment process. These processes are described in the Entry Capacity Transfer and Trade Methodology Statement ("ECT&T")[11].

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[10] http://www2.nationalgrid.com/uk/industry-information/gas-capacity-methodologies/

[11] http://www2.nationalgrid.com/uk/industry-information/gas-capacity-methodologies/

National Grid will not proceed with projects identified to deliver incremental obligated entry capacity if any of the following cases apply:

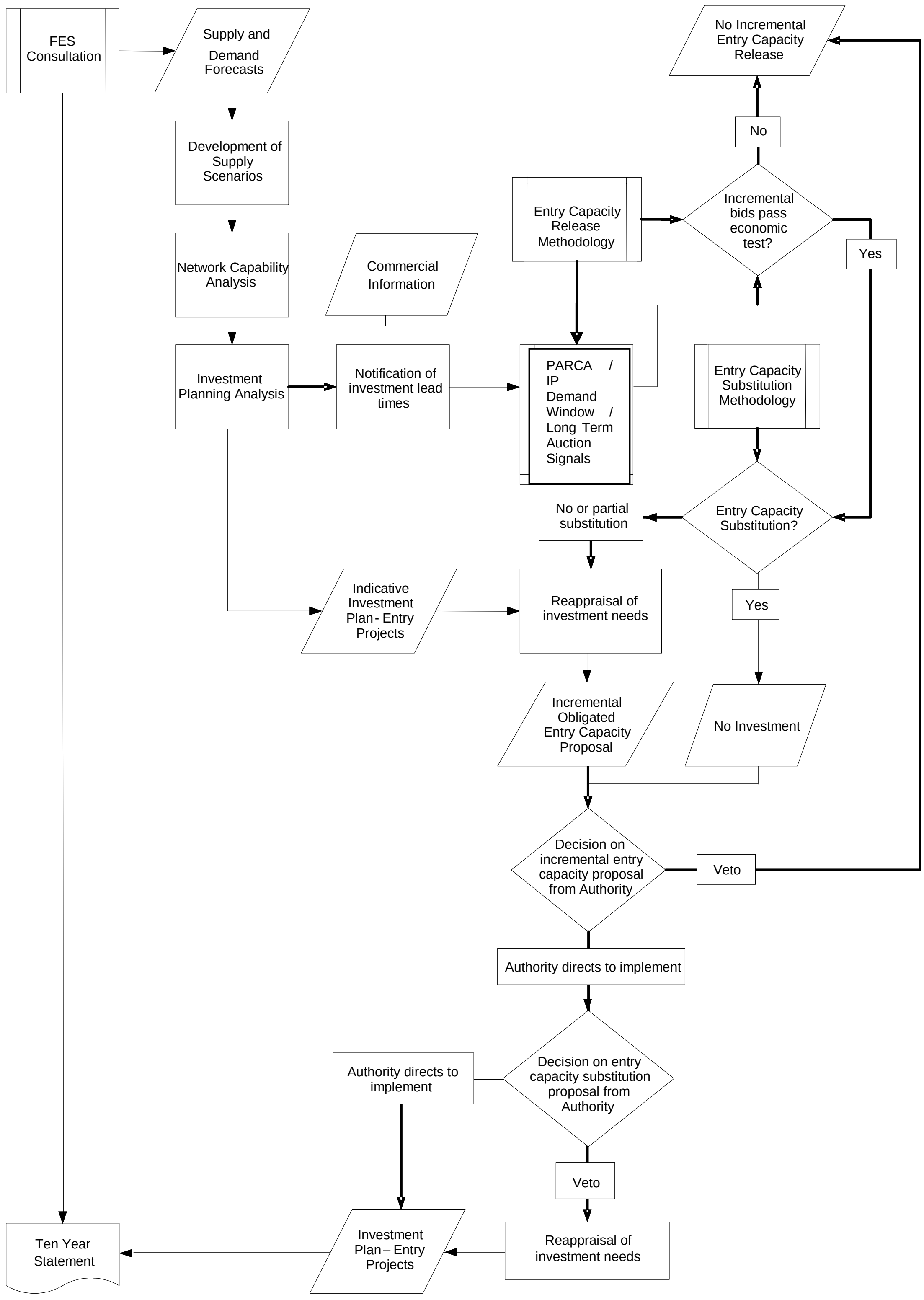
1. Insufficient user commitment has been signalled, through a combination of capacity reserved and allocated through the PARCA arrangements and the QSEC auction, to justify the economic case for these projects.

2. The Authority determines that National Grid should not implement the incremental obligated entry capacity proposal made by National Grid under Special Condition 5F of its Licence.

National Grid will re-evaluate projects identified to deliver incremental obligated entry capacity where the incremental entry obligated capacity proposal is modified in line with Special Condition 5F of its Licence.

National Grid believes that such actions are consistent with its wider obligations to develop the NTS in an economic and efficient manner.

Figure 1: Entry capacity investment planning process



Chapter Five

Exit Capacity

This chapter covers the commercial exit capacity release processes and their part in the network development process.

5.1 Long Term Exit Capacity Bookings

The processes used to book long term exit capacity differ from those used to book long term entry capacity.

Under enduring exit capacity arrangements (from 1st October 2012), NTS Exit (Flat) Capacity for both DNOs and shippers must be secured through an annual application window (held in July of each year), an ad-hoc application (between October and June of the gas year) or through a Planning & Advanced Reservation of Capacity Agreement ("PARCA") with National Grid. Under the EU CAM Network Code (from 1st November 2015) Long term IP exit capacity must be secured through the Annual Yearly IP auctions, detailed in the ENTSOG auction calendar. Where specific reinforcement to the system is required, developers can only secure capacity through a PARCA. NTS Exit (Flexibility) Capacity and pressure requirements for DNOs can be indicated through the PARCA process and, subject to the allocation of capacity via that process, will continue to be booked through the OCS process.

Further detail on the release of exit capacity on the NTS is given in National Grid's Exit Capacity Release Methodology Statement ("ExCR")[12].

The exit process is described in Figure 2 and discussed in more detail below.

5.2 Development of Supply and Demand Scenarios

National Grid will develop supply scenarios for assessing changes to exit capacity bookings that focus on local sensitivities to supply conditions that are known to exist on the NTS. For example, supply scenarios may be developed to explore the conditions on a part of the network when LNG importation or storage withdrawal is assumed, compared to the situation where LNG importation is not present and/or storage injection is required. Demand scenarios assessed may include a number of possible demand sensitivities at each level of demand analysed, for example:

1. Demand flows that occur in line with FES scenarios for all Exit Points on the NTS
2. Demand flows that occur in line with DNO OCS bookings and FES scenario flows for directly connected NTS loads
3. Demand flows associated with storage sites and interconnector pipelines

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[12] http://www2.nationalgrid.com/uk/industry-information/gas-capacity-methodologies/

4. Demand flows associated with large loads or loads located in sensitive areas of the network

The demand sensitivities will be developed according to the location of the exit capacity being assessed.

Demand will be assessed at peak ("1-in-20" conditions), and at average and severe conditions through the load duration curve (as appropriate). Analysis will be undertaken for each relevant year of the ten-year planning horizon. More information can be found in appendix D.

5.3 Network Capability Analysis for Exit Capacity

Network analysis will be undertaken during the OCS/Exit Capacity Allocation processes to identify the existing capability of the NTS to accommodate changes in the NTS Exit (Flat) Capacity requests made by DNOs. Further capability analysis may be undertaken from time to time as a result of enquiries made by customers to connect new loads to the NTS or increase existing loads on the system.

Exit projects identified from previous planning cycles will be reviewed to verify whether the projects sanctioned as part of previous plans are still required. National Grid will also maintain a regular dialogue with Shippers, DNOs and Developers to ensure that information on the progression of their projects may also be used to inform National Grid's investment decisions in a timely manner. In accordance with the UNC[13], Shippers, DNOs and Developers will be required to provide demonstration information[14] to National Grid NTS to show that he customer project is proceeding before capacity is allocated and investment works commenced.

If it is found that sanctioned projects are not required as proposed through previous planning cycles (for example, due to changes in the underlying supply and demand forecasts, or as a result of new information provided to National Grid by Shippers or new information made available in the public domain) then analysis will be carried out to determine which year the projects should now be completed for.

5.4 Investment Planning Analysis for Exit Capacity

Investment will be undertaken for requested increases in NTS Exit (Flat) Capacity, where alternative commercial solutions are not economic, subject to the signing of a PARCA and under the terms of the ExCR. Such increases may require a feasibility study to be initiated to assess possible options in order that the appropriate investment planning analysis may be

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[13] UNC TPD Section B, para 3.3.4(b) & 3.3.5

[14] Typical demonstration information requirements can be found in our 'Planning & Advanced Reservation of Capacity Agreement (PARCA), A Guide for Customers" document located on our website at: http://www2.nationalgrid.com/UK/Services/Gas-transmission-connections/Capacity-and-connections/Processes/PARCA-Framework/

undertaken. Investment will not be undertaken on the NTS for increases in NTS Exit (Flexibility) Capacity or Assured Offtake Pressures.

NTS Exit (Flexibility) Capacity and requests for increases in Assured Offtake Pressures within the capability of the system will be allocated to DNOs through the OCS process.

National Grid will assess requests for changes to NTS Exit (Flat) Capacity first, followed by requests for changes to NTS Exit (Flexibility) Capacity, followed by requests for changes in Assured Offtake Pressures. Off-peak data provided by DNOs under the UNC OAD Section H process will not be treated as a long term booking of NTS Exit (Flat) Capacity or NTS Exit (Flexibility) Capacity.

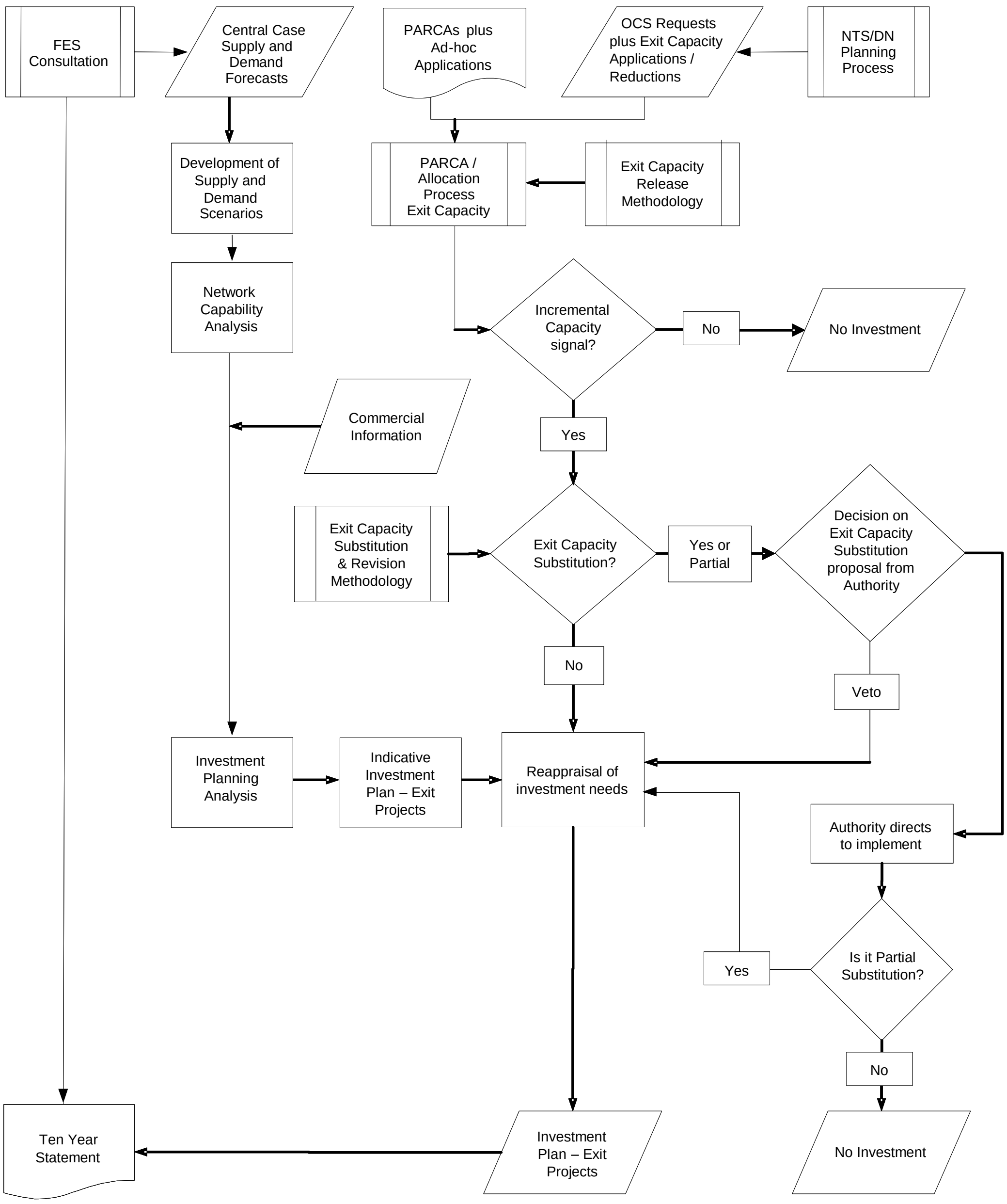
Parties that are directly connected to the NTS are required to register capacity in the short term under the process defined by the UNC TPD Section B.

Increases in exit capacity may be requested in line with the ExCR. National Grid can only permanently increase the level of exit capacity at an Exit Point, subject to the signing of a PARCA, having first assessed how much exit capacity may be substituted to meet the increase as a result of applying its Exit Capacity Substitution and Revision Methodology Statement ("ExCS")[15]. Exit capacity substitution is the process of substituting unsold NTS exit baseline capacity from one or more NTS Exit Points to another NTS Exit Point where demand for exit capacity exceeds the available capacity quantities for the relevant period.

Enquiries may be made at any time about potential increases in load, or new loads connecting to the NTS, although there may be a lead time before additional capacity can be made available. Information on new and existing loads will also be collected through the FES process, so the annual planning cycle will include the best known information to National Grid on directly connected NTS loads, including any previous enquiries made by Shippers or Developers. Any investment required as a result of load enquiries received by National Grid will therefore be consolidated into the next or future planning cycles.

[15] http://www2.nationalgrid.com/uk/industry-information/gas-capacity-methodologies/

Figure 2: Exit capacity investment planning process



Chapter Six

Network Analysis and Assumptions

This chapter cover the network analysis models and the assumptions that underpin them.

6.1 Basis of Network Analysis Models

National Grid will use network analysis software to undertake planning analysis. The software will allow the user to work with a detailed mathematical model of the NTS to understand the likely flows and pressures on the system under a given set of supply and demand assumptions. The user will be able to vary the parameters of the model, including the supply and demand data to understand the physical limitations of the network. New pipelines, compressors and regulators will be added to the model connecting to existing points on the model as required to overcome system constraints. The tool will then be used to analyse the enhanced network.

The network analysis undertaken for the NTS will be derived from a base network model known as the “Master Network”, which will contain the key elements of the NTS including pipes, valves, regulators and compressors. These components are the main elements to control and route the flow of gas through the system from supply points to offtakes.

The Master Network will be generated at the beginning of the annual planning cycle and will include all pipelines and plant planned for completion for the first winter in the ten-year planning horizon. The Master Network will be based on a network that is validated using actual operational data from a high demand day from the previous winter period in accordance with IGE/GL/2. The findings of the validation exercise will be included in the Master Network.

The Master Network will not contain any supply or demand information. The supply and demand data will be entered into the network for the scenarios requiring study. These models will be analysed until the network reaches a mathematical solution. Further analysis will then be undertaken as necessary to reconfigure and reinforce the system to ensure that the flow pattern may be supported within safe plant and pressure limits. All network models will be traceable back to the parent Master Network for that planning cycle.

6.2 Analysis Assumptions

On the NTS there are two critical times during the gas day for analysis, the times associated with maximum and minimum linepack (gas stock) in the system.

Maximum linepack is usually available close to the start of the gas day[16] (typically 0600 hours). This linepack can then be used over the day to meet diurnal fluctuations in supply

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[16] From 1st October 2015, the start of the gas day changed from 06:00 to 05:00; however, the time of maximum Linepack is 06:00 as the change of gas day has not changed exit user behaviour.

and demand, typically reaching a minimum at 2200 hours. The 0600 and 2200 times are used for planning purposes, although maximum and minimum linepack conditions actually observed on a gas day can vary around these times, depending on the prevailing flow patterns within the system.

These conditions may be modelled individually through steady state analysis or concurrently using transient analysis with suitable supply and demand profiles. These profiles reflect the drivers of linepack depletion, through supply profiling, diurnal demand behaviour and demand behaviour such as CCGT. Derived profiles can be based on commercial obligations, historic behaviour or future commercial requirements.

6.3 Steady State Analysis

It is usual practice for long term planning analysis (undertaken more than a year ahead of the gas day) to carry out steady state network analysis as this gives a good approximation of the likely network conditions, is quicker than transient analysis and is as appropriate once forecasting uncertainties are accounted for by the flow margin. Steady state analysis assumes that flows are not profiled across the gas day, and so can be used to identify the transmission capability of the system.

A steady state network with linepack maximised may be used to represent the start of day condition (0600) and a network with linepack minimised may be used to represent the minimum stock condition (2200).

Where reinforcement projects have been identified using steady state, transient modelling may be considered in order to further investigate and refine the potential solutions.

6.4 Transient Analysis

Transient analysis models the changes that may be seen within a gas day. Flow profiles for supplies and demands can be entered, along with changes in operating set points for compressors and regulators to understand variations in pressure, flow and linepack across the system across the day.

Transient networks used for network capability analysis and investment planning analysis will be analysed and solved to ensure that minimum pressures at 0600 and 2200 are not breached, and the total NTS linepack levels are maintained to ensure linepack balance across the day.

6.5 Within-Day Flow Variations

Historically, diurnal storage capability i.e. the ability to meet demands with a daily profile, had been provided predominantly by the Local Distribution Zones (“LDZs”) i.e. the regional transmission systems and connected low pressure distribution networks, with some support from the NTS.

The advent of DN sales created a requirement to formalise the agreement of NTS diurnal storage support and agreed offtake pressures for the DNs. An NTS Exit (Flexibility) Capacity product was defined which allows the DNs to profile their offtake flows and hence gain access to diurnal storage support, which is accessed through the Offtake Capacity Statement ("OCS") process.

As the use of the NTS has evolved, the usage of this diurnal storage capability has increased, not only from DN requirements, but through gas fired power generation responding to the changing electricity market conditions. On the supply side, there is increased profiling behaviour as the supply make-up moves increasingly to larger and more commercially responsive interconnector, LNG and storage sites.

The ability of the NTS to provide diurnal support is largely as a by-product of the DNs varying pressure requirements. The DNs require their highest pressures close to the start of the gas day (typically 06:00) when their linepack and hence pressures are highest but require lower pressures towards the end of the gas day when their linepack levels and hence pressures are at their lowest (typically 22:00).

6.6 Planning for Within-Day Flow Variations

Within-day flow variations are factored into the planning of the NTS through two distinct approaches depending on whether they are foreseeable or unforeseeable variations. Foreseeable within-day flow variations such as DN offtake profiles to meet the DN demand profile, gas fired power generation profiles to meet the electricity demand profile or supply behaviour, whether this is flat or profiled can be modelled explicitly as network models can be built and analysed based on historic or forecast offtake and supply profiles. The underlying assumption is that these can be either forecast (or otherwise accounted for) and will be factored into supply levels and balancing actions.

Unforeseeable within-day flow variations might be categorised as demand errors and might occur at any time and with any geographic distribution. These may be caused by gas fired power generation responding to the sudden loss of wind powered generation. These events cannot be modelled explicitly but a level of linepack cover, representing an operational linepack buffer, is included in the planning process via the application of the Design Margin. These within-day flow variations will not have been forecast and hence balancing actions might only be taken in a reactive manner.

6.7 Design Margin

The Design Margin comprises of two elements: a flow margin and pressure cover. A flow margin is applied to pipe flows and minimum pressures set at the extremities of the system within the network model to account for uncertainties that arise when undertaking network analysis ahead of the gas flow day.

The use of a design margin for design purposes is described in National Grid's Safety Case for the NTS (Section 17 - Adequate Network Pressure)[17], which states:

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[17] National Grid Gas, Gas Transporter Safety Case (Gas Transmission)

"17.7 In the process of NTS Network Analysis an allowance needs to be made for variances in operational gas flows from the assumptions made in the design analysis. This is referred to as a "design margin". This is necessary to provide a margin of cover for a list of effects or events wherein the actual flows and pressures on the NTS will temporarily differ from those in the design analysis. This margin takes the form of a percentage increase in flows used for network analysis.

17.8 The values of the design margin are reviewed periodically in accordance with the changes in operating regimes and the type of network analysis undertaken. The margin is broken down into the following elements:

i. An allowance for compressor station tripping

ii. An allowance for forecasting errors

iii. An element for supply alerts.

17.9 In addition to the above allowances a further margin is added to provide cover at specific extremities to the NTS system, known as pressure cover, and will be applied within the network design analysis. The aim of this element is to ensure that the extremities of the NTS have sufficient locally available line pack to prevent deterioration below the agreed network pressure at the extremities.

17.10 The level of design used and pressure cover will be assessed and the assumptions stated in the Transmission Planning Code. From time to time the value will be externally assessed and any recommendations considered for inclusion."

6.7.1 The Flow Margin

Historically the flow margin was used to account for unforeseeable within-day flow variations and other operational uncertainties on the NTS. The flow margin was composed of two separate components referred to as the transient and transmission components.

The transient component encompassed compressor trips, demand forecasting errors, suppliers' alerts (losses), supply variation away from the assumed steady 24-hour rate and operational state changes.

The transmission component encompasses any demand and supply related changes to the underlying assumptions used during the period between the launch and commissioning of an NTS project.

As described in paragraph 17.10 of National Grid's Safety Case, National Grid shall, from time to time, undertake reviews to validate the flow margin. Future changes to the flow margin will be agreed with the HSE and implemented through revisions to the Transmission Planning Code.

As the usage of the NTS has developed, the significant variation in within day supply and demand flows requires explicit planning. The magnitude to which the flow margin provides allowance for this level of variation and the associated uncertainties is less clear. Following an investigation into the suitability of the flow margin, National Grid will assume a flow margin of 0% and use specific locational pressure cover at system extremities in order to provide an improved means of ensuring that the NTS has sufficient resilience to cope with such operational uncertainties. These include large supply losses, unforeseen increases in demand and compressor trips.

6.7.2 Pressure Cover

Pressure cover is calculated and applied in order to provide resilience for uncertain events.

Pressure cover is calculated for the NTS entry and exit points identified as the most sensitive to various system events. These points are determined by considering the Assured Offtake Pressures and/or Maximum Operating Pressures, the neighbouring supply and demand connections and the proximity of system assets.

Cover is calculated by assessing the impact of a defined event on system pressures at the NTS entry or exit point across the gas day. This is completed using specific network analysis.

Based on the likelihood and impact of defined events, and in line with National Grid's methodology for procuring Operating Margins in the groups shown below, different pressure covers provide resilience for different system events

Operating Margin Group	Associated Pressure Cover used in network capability analysis
Group 1 - Beach supply failure and forecast demand change	Unforeseen supply losses Unforeseen CCGT demand increased
Group 2 - Compressor failure and pipeline failure	Unforeseen Asset Trips
Group 3 - Orderly rundown	n/a

Pressure covers for supply losses and CCGT demand increases (Group 1) are calculated separately but considered together, with the larger of the two covers used (known as the supply and demand cover). Pressure cover for specific asset trips (Group 2) is calculated and used in combination with the supply and demand cover. These covers are then applied at the sensitive Entry and Exit points and used in network capability analysis. Pressure cover is not used for orderly rundown and this is only covered by Operating Margins.

Pressure cover is calculated across a range of supply and demand patterns (see Appendix E for further details). Pressure cover which is specific to the demand level and assets used is then used in our network capability analysis. For example, should CCGT demands in a zone of the NTS be assumed to be at maximum flow levels and therefore cannot suddenly increase further, then this aspect of the supply and demand cover will not be used. Also, should a particular asset not be required to support system pressures, then any asset trip pressure cover associated with this site will not be used.

Pressure Cover provides time for the Control room to manage events on the system. This time is split into 2 categories:

1. Event Management - a period of up to 2 hours allowing the Control room to formulate a response to an uncertainty event and attempt resolution (Entry and Exit)
2. Operating Margins (OM) – Should the control rooms attempted resolution be unsuccessful, a period, defined within Operating Margins contracts, between Control room 'calling' OM and the physical response. (Exit Only)

Pressure Cover - Asset Trip	1
	2
Pressure Cover - Supply / Demand Event	1
	2

The Operating Margins service is used to maintain system pressures in the period post event, before other system management services become effective (e.g. national or locational balancing actions). The OM pressure cover allows for the time lag between National Grid enacting the service and the service provider’s physical response. Due to these network safety implications, National Grid ensure that the OM pressure cover is always met in our network capability analysis. As there is a cost associated with reserving OM gas, the event management cover provides the Control room with additional time to manage events efficiently without having to call on OM regularly and therefore incurring costs for users of our network.

Should the NTS have insufficient capability to meet required levels of pressure cover for a given supply and demand pattern, National Grid will consider all available Network Development Options (Section 7.1) which includes improved network resilience. This may take the form of targeted maintenance to improve reliability of assets, therefore reducing the levels of required pressure cover.

6.8 Operational Analysis

The network analysis assumptions described in this chapter will be applied to all network capability and investment planning analysis undertaken by National Grid for the ten-year planning horizon.

National Grid will use these assumptions as a basis for network analysis undertaken in operational timescales. National Grid will also use other information that is available at the time to supplement these assumptions. For example, this may include information on commissioning programmes for new connections to the system or temporary operating restrictions required on plant for short term constraints.

Operational analysis will be undertaken in the shorter term to:

- Ensure security of supply is maintained
- Determine strategies to facilitate the safe and efficient operation of the NTS
- Assess the impact of operational constraints (such as maintenance activities or plant operating restrictions) on the physical capability of the system
- Determine the physical capability of the network to support commercial processes (such as Entry Capacity Transfer and Trade).

6.9 Operational Balancing Actions

Operational balancing actions form part of the operational measures referred to as part of the "1-in-20" Security Standard.

6.9.1 Operational Balancing Actions

Within-day flow variations on the system may generate gas flows and pressures that the system cannot, or is unlikely to be able to, accommodate. When such flows are unacceptable from a transportation capability perspective, National Grid may choose to use any operational flexibility, including NTS compression and/or linepack to manage the situation, or to use a wider range of tools, which include;

- Buy or sell locational gas.
- Scale back interruptible NTS entry capacity.
- Restriction of Short term access to System Flexibility
- Buy back firm NTS entry and/or exit capacity
- Scale back Off-peak NTS Exit Capacity
- Flow swaps
- Offtake Flow Reductions
- Use other capacity tools, such as Capacity Management Agreements
- Operating Margins

For further information on the range of operational measures, and how and when they are applied please refer to National Grid's System Management Principles Statement ("SMPS").

6.9.2 Operating Margins Gas

Operating Margins ("OM") requirements are requirements for quantities of gas to be delivered to the NTS, or for quantities of gas nominated to be off taken from the NTS to be reduced or delayed for Operation Balancing purposes. National Grid can utilise OM provisions where:

- it determines that, at any time during the gas day, there is an operation balancing requirement which cannot be satisfied by taking other system balancing actions;
- as result of damage or failure on any part of the NTS (other than programmed maintenance) there is an operation balancing requirement irrespective of whether the requirement can be met through balancing actions;
- in a gas supply emergency, OM gas can be used to manage the orderly run-down of the NTS.

6.10 Supply Flows

Supply flows are required data for the network analysis models, and will be derived for the supply scenario that is being considered. Further information can be found in Appendix C.

It is necessary to allow for a quantity of gas to be included with the total supply flow for fuel gas used at compressor stations. This gas will be assumed to be delivered from the largest Entry Points on the system or the final supply balancing point as appropriate. The volume (typically less than 0.5% of national demand) will be determined by the network analysis software based on the operation of compressors within the model.

6.11 Demand Flows

Demand flows are required data for the network analysis models, and will be derived for the demand scenario that is being considered.

DN flows will be modelled with a profile consistent with their NTS Exit (Flexibility) Capacity booking for each relevant offtake at peak conditions and consistent with data provided via the UNC defined Offtake Capacity Statement ("OCS") process for off peak demand levels. Further information can be found in Appendix D.

Power generation offtake demand flows will be modelled with a profile taking into account historical power generation profiles and limited by the requirement to flow to a maximum rate of $1/24^{th}$ of the exit capacity holding.

6.12 Storage and Interconnector Flows

Storage sites and interconnectors will be modelled depending on their assumed behaviour within the supply and demand scenarios being modelled.

Storage sites and interconnectors will normally be modelled as supplies under high demand scenarios or when gas prices are high, unless the supply scenario used dictates otherwise.

Such flows may need to be modelled as demands on the system under certain conditions, for example in the summer months or when gas prices are relatively low, or for contractual reasons (for example where contractual storage re-filling/emptying cycles are observed).

It is also possible that these sites do not flow under certain supply or demand scenarios.

6.13 Ramp Rates

Rapid load changes imposed on the pipeline system caused by entry and/or exit flow rates during a gas day can cause "abnormal" operating conditions which may have a deleterious impact on compressors and existing points of offtake or could affect the safety and security of the NTS. These would normally occur during transient conditions, such as during start-up or during shutdown operating scenarios, when flow fluctuations are at their greatest. These transient events, known as 'Fast Transients', are typically observed over short timescales, typically less than 30 minutes. The standard ramp rate offered is currently 50 MW/min.

National Grid will consider the impact of ramp rates requested above the prevailing standard ramp rate in order to maintain the safety and integrity of the system. This may require additional studies to be undertaken to consider the operating scenarios proposed (e.g. rapid load changes, emergency shutdown events etc.) at the cost of the party making the request.

The agreed limits for ramp rates are incorporated within the relevant entry, exit or storage contracts[18] made with the operator of the connected facility before gas flow can commence.

Due to the interrelationship between some third party facilities and the NTS, the third party may have to demonstrate to National Grid that the facilities and operating strategies proposed do not have a detrimental effect on the NTS.

6.14 Maximum Entry and Exit Flows

The physical capability of installations connected to the system (for example, reception terminals and offtake installations) may impose limits on the maximum flows that can be attained at an NTS Entry or Exit Point. For example, these limitations may arise from site pipework configurations or pipework capacity constraints (where unacceptable pressure drops or excessive gas velocities would otherwise be observed through the pipework). National Grid will observe the maximum flow limits imposed by such physical limitations at entry and Exit Points in the analysis it undertakes.

6.15 Standard Volumetric Flows

The volume of any gas varies with temperature, pressure and molecular composition and is usually quoted in relation to reference conditions. Metric standard conditions for a gas assume a temperature of 15^oC, pressure of 1.01325 bar and dry gas[19] and are used to describe “standard volumes” of a gas.

The hydraulic models within the network analysis software used by National Grid express flows as *standard volumetric flows* (mscmd) whereas commercial flows are usually described in energy terms (GWh/day or kWh/day).

Supply and demand flows will be supplied to the network analysis models as standard volumetric flows assuming a standard Calorific Value (CV), which is equivalent to an energy flow in GWh/day. The network analysis software will use CV data entered at supplies to calculate CVs throughout the network, including demands. This allows the program to convert the demand flow data entered by the user to standard volumetric flows required with the hydraulic models. These assumptions will be used to ensure that energy flows used for commercial purposes (e.g. obligated entry and exit capacity levels) can be consistently and correctly applied within the network analysis models

The standard CV will be set at 39 MJ/m^3, which approximates to the average CV of the gas in the system. Flows quoted using different CV assumptions will be converted to standard

[18] Network Entry Agreements, Network Exit Agreements or Storage Connection Agreements

[19] Gas that does not contain significant levels of water vapour, condensate or liquid hydrocarbons.

volumetric flows at the standard CV before input to the network analysis models to provide a consistent basis for the analysis.

6.16 Entry and Exit Pressures

Pipelines and plant are designed to operate within certain pressure ranges for safety and design reasons. Network capability depends not only on the supply and demand patterns and levels within the network, but also the maximum and minimum pressure limits that must be observed to remain within design limits to ensure safe operation of the network.

Maximum pressure limits will be observed at Entry Points and within the system. They arise at points where gas may flow from a system that is operated to a higher pressure limit.

Minimum pressure limits will also be observed at Exit Points and are required for supporting downstream systems or loads. Some points of offtake require a higher pressure at 06:00 and/or 22:00 depending on the requirements of their downstream systems. These can be Assured Offtake Pressures (AOPs) for a Distribution Network Operator, and Anticipated Normal Operating Pressures (ANOPs) or other contractually agreed pressures for other customers directly connected to the NTS.

The gas pressure that can be supported at a point of offtake may be affected by any of the following:

1. The presence of other significant loads in the vicinity
2. The location of terminals that may turn down significantly (or be shut down) at off peak periods
3. The location of compressors and their likely operation throughout the year
4. The presence of storage facilities in the vicinity
5. System configurations that may change throughout the year
6. The effects on agreed Assured Offtake Pressures and NTS Exit (Flexibility) Capacity
7. The effects of maintenance on plant in the vicinity
8. Pipeline maintenance, inspection, remedial work and modification activities in the area

As discussed in section 6.7, in addition to the minimum and maximum pressure limits, planning and operation will also consider a level of event driven resilience, ensuring that the system is planned and operated such that unforeseen events can be managed both safely and efficiently by the Control room. This resilience will be in the form of a pressure cover, applied to either entry points or system extremities.

Network analysis undertaken to determine network capability will model the system to observe the maximum and minimum pressure limits, including associated pressure covers. Where the analysis shows that a pressure cannot be maintained, the supply/demand scenario under analysis will be deemed to indicate a “failed” network. Network capability will be deemed to have been reached at the point where maximum pressures and/or minimum pressures on the network can only just be sustained within operational tolerances. The resulting network is also known as a “constrained” network.

A “constrained” network indicates a requirement to mitigate a given constraint, either due to inability to meet direct system requirements or to provide sufficient resilience to system events.

The following pressure limits will be observed within the analysis:

- Maximum Operating Pressures (MOPs) for pipelines, compressors and entry terminals
- Assured Offtake Pressures at Exit Points
- Anticipated Normal Operating Pressures at Exit Points
- Minimum contractual pressures within Ancillary Agreements at Exit Points

6.16.1 Maximum Operating Pressures

IGE/TD/1: Edition 4 states, “The sustained operating pressure for a pipeline system should not exceed Maximum Operating Pressure (MOP)”. These guidelines recognise that excursions above this level may occur, due to the variations of pressure regulating devices and instruments used to monitor pressures. Information on such excursions is included within the Major Hazard Safety Performance Indicators reported to the HSE each year. Control pressures used for network analysis models will be set marginally below the MOP of the pipeline, compressor or entry terminal to be consistent with the operational set points used on pressure protection devices.

6.16.2 Assured Offtake Pressures

The Assured Offtake Pressure (AOP) requirements for each offtake to a distribution network will be modelled as minimum design pressures on the system at these points. AOPs will be agreed between the NTS and DNOs as part of the annual Offtake Capacity Statement process, described in the UNC TPD Section B. DNOs may request a change in an AOP under this process; however National Grid are not obliged to accept a request for an increase in pressure at an offtake.

Pressure requests will be subject to inspection and targeted analysis where it is deemed to be appropriate. Incremental pressure requests will be rejected wherever it is assessed that they:

1. Are unsustainable with planned and actual infrastructure
2. Require investments to be brought forward in the investment plan
3. Increase operational costs (particularly compression costs)
4. Reduce capability at NTS Entry Points
5. Reduce available system flexibility capacity
6. Impact on other offtake points in the areas

A range of supply and demand scenarios may be used in this assessment.

6.16.3 Agreed Pressures

Under normal operation National Grid's Control Room is able to request and agree reduced (or increased) pressures with DNOs on a day by day basis, through the Agreed Pressure Process. Where pressures different to the AOPs are regularly agreed under typical operation, these will be taken into account, alongside AOPs, when assessing efficient operation of the NTS.

6.16.4 Anticipated Normal Operating Pressures

There are a number of Anticipated Normal Operating Pressures (ANOPs), which form part of the Network Exit Agreement (NExA) for large consumers. These pressures may only be changed after giving the Customer 36 months notice.

ANOPs are governed by the UNC TPD Section J, which allows a Shipper to request a specified pressure higher than the 25 bar(g) generally applicable to directly connected NTS loads. The ANOP is the lowest pressure at which National Grid expects, under normal operating conditions, a given quantity of gas will be available for offtake at a given Exit Point.

All ANOPs will be modelled as minimum pressures for the first three years of the ten year planning horizon. From the fourth year of analysis onwards[20], if an ANOP cannot be maintained under any scenario considered, National Grid will give notice to the Customer for a reduction in the ANOP, under the terms of the relevant NExA agreement.

6.16.5 Contractual Exit Pressures

A Shipper may request that National Grid enters into an Ancillary Agreement in order to meet a required pressure. Such an Ancillary Agreement may require the Shipper to fund the additional costs incurred by National Grid in order to guarantee the pressure, which will then be made available under all operating conditions in accordance with the agreement. Examples of such costs are reinforcement costs or additional compression required to support the contracted pressure.

6.17 Compressors

Gas compressors are the key plant items used to maintain pressures and overcome pressure decay on the NTS. They are also used to boost system pressures to support exit pressure commitments and, in addition, to reduce the pressure at entry points to increase the system entry capacity and movement of stored gas in the system from one area of the system to another.

Compressor performance characteristics are basically defined by four curves relating to maximum speed, minimum speed, surge and choke. The four curves determine the operational envelope for the compressor. The compressor may operate safely within this envelope, however, different process efficiencies are observed at different points within the

[20] This timeframe is used to allow for the 36 month notice period for changing ANOPs

envelope, which affect the fuel used to compress gas passing through the compressor. The envelope and efficiency characteristics will vary between compressor units.

Where the network analysis models show that compressors must operate outside its envelope to achieve a particular flow and discharge pressure, and where reconfiguring the network does not remove this problem, it is possible that a compressor re-wheel or upgrade is required to ensure that the compressor may be safely operated.

Compressors may be operated under a number of different control mechanisms, for example, to achieve a target suction pressure, discharge pressure, or flow.

Limiting factors in compressor performance are related to the safe operation of the compressor train itself and include the maximum or minimum speed attainable from the gas generator or electric drive used to power the compressor, the minimum gas flows that may be safely permitted through the compressor, the maximum power available from the drive unit to turn the compressor, and the maximum discharge temperatures that may be reached on the outlet of the compressor station. Boundary control systems used to protect downstream pipelines from over-pressurisation may also limit the compressor station.

The network analysis software used by National Grid will allow detailed modelling of compressor envelopes, control mechanisms, limiting factors and compressor fuel usage.

6.17.1 Minimum and Maximum Speeds

The physical capability of compressors is related to the maximum and minimum speed of the associated power turbine/compressor speed. This means that compressor units require a certain flow to be achieved before they can be used to compress gas.

The requirement to limit compressors to operate within the minimum and maximum speed limits imposed by the compressor envelope may constrain network capability.

6.17.2 Minimum and Maximum Flows

In addition to the minimum flow required to turn a compressor on to compress gas, compressors must be operated to ensure that they do not operate under surge conditions (where there is a high compression ratio relative to the flow) as this can damage the compressor.

High flows through the compressor can result in it operating under choke conditions, where high flows are achieved, at a relatively low compression ratio. Choke conditions do not always constrain compressor operation, but could indicate inefficient operation. High flows at or near the maximum speed for the compressor can lead to mechanical problems.

The requirement to limit compressors to operate within the surge and choke limits imposed by the compressor envelope may constrain network capability.

6.17.3 Maximum Power

The maximum power available from a gas driven compressor unit is dependent on various factors including ambient inlet air temperature. Generally, the colder the air temperature, the more power that can be derived to compress gas. Gas quality is another factor that can have an impact on compressor performance. The maximum available power therefore varies throughout the year, and is lower for summer conditions than for winter conditions. The maximum power available from an electrically driven compressor unit is not dependent on ambient air temperatures.

The maximum power that will be used within network analysis models is the base power level that may be achieved under normal operating conditions.

The network analysis undertaken for the NTS will consider the limiting effect of seasonal variations in temperature on power available at gas driven compressor units by relating available power to total NTS demand at different points on the load duration curves. This may constrain network capability, especially at lower demand conditions.

6.17.4 Discharge Temperatures

Compressor station discharge temperatures are generally limited to between 45^{o}C and 50^{o}C (depending on the downstream pipeline specifications) as otherwise damage can be caused to some downstream pipeline coatings. Where consistently high temperatures are seen on the outlet of a compressor, aftercoolers may be used to reduce the gas temperature to acceptable levels and improve downstream transmission capability by virtue of a lower temperature. Where aftercoolers are not present, network capability may be constrained due to the requirement to operate to safe temperature limits.

6.17.5 Suction and Discharge Pressures

Due to gas flow characteristics and the relationship between pressure, velocity and the associated pressure losses caused by friction, it is generally more efficient to utilise the furthest upstream compressors towards their maximum discharge pressures in the first instance to minimise pressure losses and fuel consumption. Compressors near large Entry Points may be controlled on a suction pressure set point to enable high flows from these Entry Points to be accommodated. However, downstream conditions including demand levels and distribution have a key effect on the ability to use compressors effectively.

National Grid will seek to maximise the use of compression by operating compressors towards their maximum discharge design pressures or minimum suction design pressures when undertaking network analysis, subject to other constraining factors such as emissions levels, discharge temperatures, efficient fuel usage and operation within compressor performance envelopes.

6.17.6 Compressor Standby and Station Configuration

Compressor stations across the NTS are designed to meet the anticipated range of flow conditions. Some sites may be used for high demand conditions only, whereas other stations are equipped to allow a variety of different units to be used in parallel and/or in series configuration to achieve different pressure/flow characteristics.

National Grid will ensure that compressors configurations are used effectively within network analysis models, considering the range of configurations that may be used to accommodate flow patterns on the system to maximise the capability of the system, subject to other constraining factors such as emissions levels, discharge temperatures, efficient fuel usage and operation within compressor performance envelopes.

Compressor failure (non-availability) is more likely to occur than a 1-in-20 demand day and hence within or prior to a 1-in-20 demand day a compressor may have failed, therefore we need compressor standby to comply with our obligation to develop the network to meet the “1-in-20” Security Standard. Standby is identified to ensure that the required transmission capability is maintained in the event of a credible loss of any single compressor unit or operationally linked units i.e. common mode of failure at a site.

When assessing Standby requirements National Grid will consider:

- Required Transmission Capability - which will be reviewed on an annual basis considering forecast supply and demand, capacity and other obligations
- Forecast compressor run hours - taking into account a range of forecasted supply and demand levels taking
- Economic and Efficient System Operation – consideration of the trade-off between standby and other commercial solutions e.g., capacity buy-back, supply turn up
- Maintenance – System access (outages) associated with maintenance requirements
- Electricity and/or Gas Fuel Security – the failure of electricity supply for an electric drive may require gas compression standby.

6.17.7 Emissions

National Grid is responsible for ensuring its compressor fleet meets legislative requirements relating to emissions under the Industrial Emissions Directive and EU ETS Directives. Different gas compressor units used on the NTS may have different emissions levels when they are operated. Emissions levels can change across the compressor performance envelope. In general, older machines may have higher emissions than more recently installed units. The network analysis undertaken to model the NTS will consider the appropriate priority for using compressor units to ensure that emissions levels are minimised wherever possible. Electrically driven units do not contribute to site emissions (emissions from these are already accounted for in the power generation sector).

In particular, the total number of running hours agreed with the environmental agencies will be observed for sites with high emissions levels, when undertaking investment planning analysis. Additional investment to reduce emissions levels from sites may be required alongside any reinforcement projects identified to support changes in supplies or demands.

6.18 Regulators

Regulators are used to control and direct the gas flows in the system using either pressure or flow control and may be bypassed when not required. They are also used as pressure protection devices. Regulators induce a pressure drop when they are used to control flows or pressures, and may be limited to a maximum design flow or pressure drop which is modelled in the analysis. A zero pressure drop is assumed where a regulator is bypassed.

National Grid will ensure that regulators are used effectively within network analysis models, in conjunction with compressor and multijunction configurations to maximise the capability of the system. The configurations used will be subject to other constraining factors such as compressor emissions levels, discharge temperatures, efficient fuel usage and operation within compressor performance envelopes.

6.19 Multi-junctions

Multi-junctions are complex arrangements of pipework, valves, regulators and other plant that are used to interconnect pipeline systems and control the flow of gas through the main pipelines in the NTS. Multi-junctions can be located close to compressor stations, and so there is a close interaction between the configurations used at these sites.

The configuration of multi-junctions can have a considerable effect on the network capability and the distribution of gas quality achieved across a distribution network.

National Grid will ensure that different operational configurations at multi-junctions are used effectively within the network analysis models, to maximise the capability of the system, subject to other constraining factors such as emissions levels, discharge temperatures, efficient compressor operation and CV shrinkage levels.

6.20 Gas Quality and Temperatures

Gas quality and temperature effects will be modelled using the network analysis software to ensure accuracy and to monitor their effect on the pressure and flows calculated within the network. The effect of pipeline altitude above sea level on gas pressure within the pipeline will also be modelled.

Temperature effects modelled will include the effect of heat losses through pipe walls to the surround ground, cooling as gas travels through regulators and aftercoolers, and heating as gas travels through a compressor. The effect of changes in ambient air temperature on the operation of compressors and aftercoolers will also be modelled.

National Grid will use estimated gas quality and temperature values for supplies as inputs to the network analysis models, to allow tracking of gas quality and temperature values as gas flows through the network. Estimated values will be derived from data provided by producers and Shippers, as well as historically observed values.

In order that consistent CVs are used for planning across the NTS and Distribution Networks, estimated CVs will be provided to the DNOs ahead of the annual OCS process. The CV assumptions quoted by DNs in their OCS and UNC OAD Section H data will be used to convert demand information to standard volumetric flows at a standard CV.

6.20.1 Wobbe index

The Wobbe index for any gas taken from the NTS must not be less than 47.2 MJ/m3 and not greater than 51.41 MJ/m3 under normal circumstances as described in the Gas Safety (Management) Regulations (GSMR). If a lower Wobbe index is observed at offtakes during the analysis, the network may be reconfigured to bring the impacted offtakes back into specification. It should be noted that this may constrain network capability.

6.20.2 Flow Weighted Average Calorific Value

Where the CV at an offtake is calculated as more than +/- 1 MJ/m^3 compared to the Flow Weighted Average across a Local Distribution Zone within a Distribution Network, there may be an impact upon shrinkage and unbilled energy.

Where this occurs, the network may be reconfigured to bring the impacted offtakes back into specification. It should be noted that this may constrain network capability.

Chapter Seven

Network Development Options

This chapter covers the options that National Grid will consider as part of developing the NTS.

7.1 Network Development Options

When a network constraint is identified there are alternative options we consider to meet customers' signalled incremental needs. The following options not requiring capital expenditure will be considered alongside the indicative investment projects identified. These are not mutually exclusive, with it being possible for a combination of these being used to meet an individual capacity signal:

1. Do nothing - this is a valid option if analysis shows the risk introduced by the incremental capacity is acceptable and can be managed operationally (including through capacity buy backs) or there is existing physical capability;
2. Capacity substitution (described earlier in the Entry/Exit Capacity chapters);
3. Network reconfiguration;
4. Compressor utilisation;
5. Pressure options – e.g. Permanent reductions in AOPs or ANOPs;
6. Commercial Capacity management and Contractual Solutions;
7. Improved Network Resilience;

Each of these options will be evaluated with due consideration being given to National Grid's wider obligations to ensure that the NTS is able to support 1-in-20 peak demand conditions and to develop the NTS in an economic and efficient way.

7.1.1 Network reconfiguration

Reinforcements identified during the development of the Investment Plan in any gas year being modelled may be found to be unnecessary if alternative network configurations are used. However this may also have undesirable effects such as increasing the anticipated levels of CV shrinkage that may be experienced on the system, increasing compression costs or emissions levels, or having an impact on reinforcements required for later years of the plan. Such impacts will be assessed before consideration is given to rejecting the reinforcement project.

7.1.2 Compressor utilisation

It may be possible to utilise compressor units normally reserved for standby or operate units at peak power levels for short periods (see Section 6.17.6). These approaches are not without risks, affect maintenance costs and asset life, and would only be considered in exceptional circumstances where other options are limited or not available.

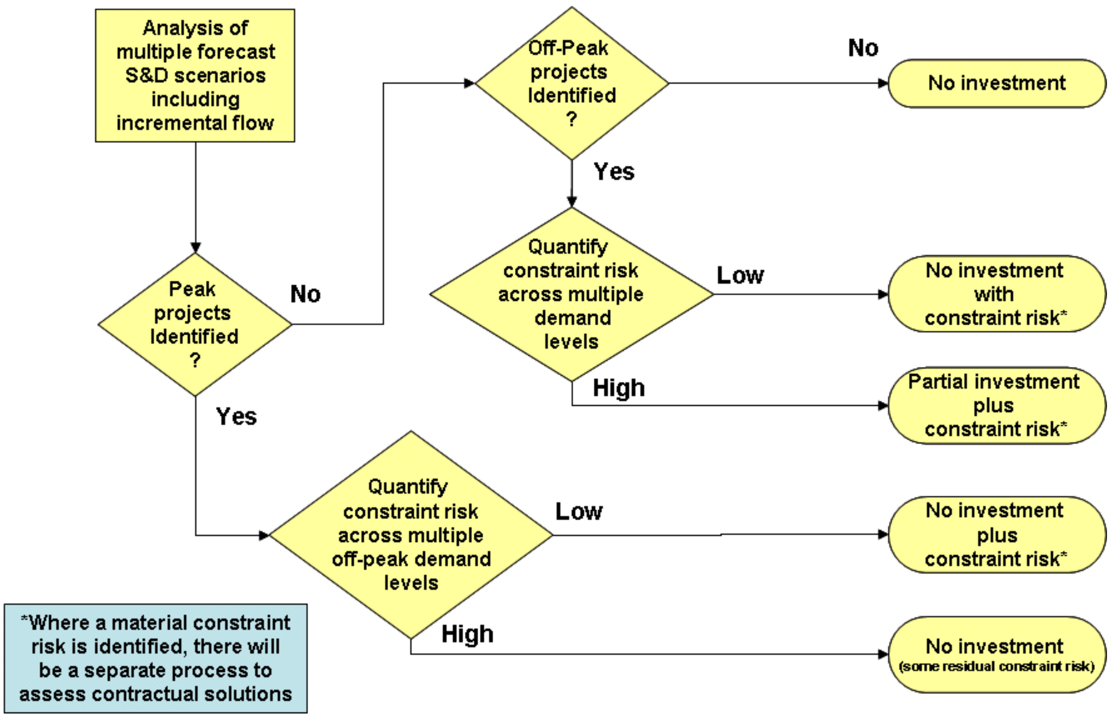
7.1.3 Pressure options

It may be possible to defer or avoid investment if Anticipated Normal Operating Pressures at exit are reduced in line with the 36 month notice period that must be given to customers. National Grid is obliged to maintain all prevailing Assured Offtake Pressures agreed through the OCS process and all contractual pressures determined by Ancillary Agreements. National Grid can formally request permanent reductions in offtake pressures from DNOs by 30th April in each gas year. DNOs have until 30th June to accept or decline these requests.

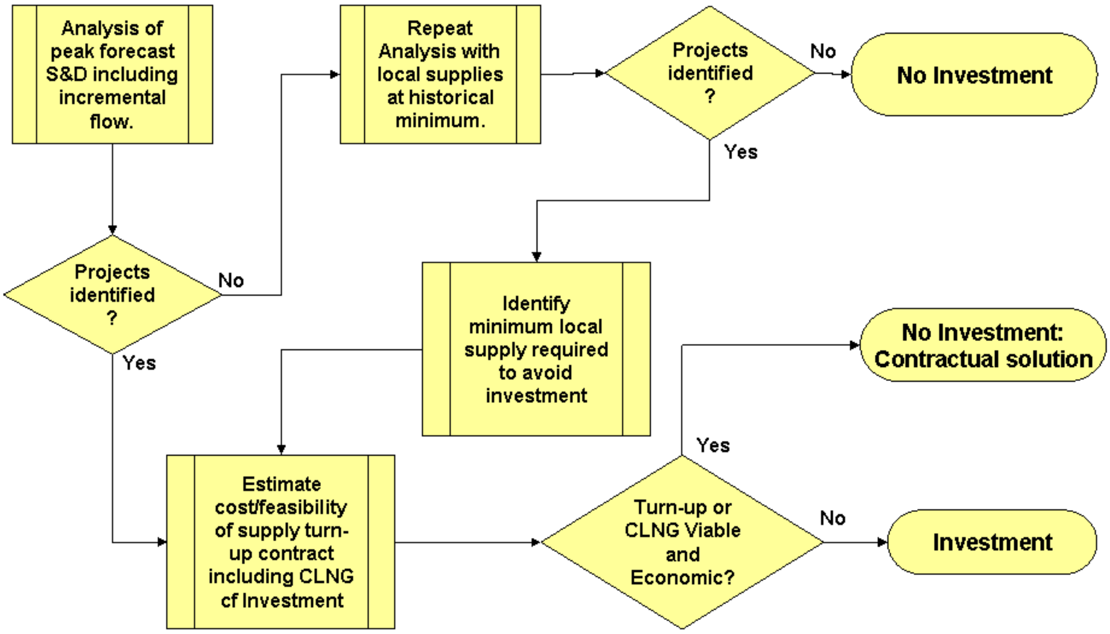
7.1.4 Commercial Capacity management and Contractual Solutions

Investment projects may be deferred or avoided if National Grid enters into capacity management agreements to manage the potential risks arising from constraints and associated capacity buy back at Entry or Exit Points (in accordance with UNC and Licence mechanisms to manage constraints). Further risk analysis will be required to determine if such an agreement is a viable option.

The following diagram outlines the high level process for considering investment verses contractual solutions in relation to entry capacity.



The following diagram outlines the high level process for considering investment versus contractual solutions in relation to exit capacity.



When we have sufficient confidence that an auction or capacity signal will be received from our customers, or that our analysis shows a need to enhance capability for new flow patterns to maintain the existing levels of service, we assess the most efficient means of meeting the requirements.

Where we consider these are unlikely to be met through operational or short-term commercial options, we will assess the likelihood of a successful enduring contractual solution against the potential investment requirement. This could be a number of years ahead of receiving a formal auction or capacity signal.

Potential contract forms fall into three categories:

1. Turn up: a customer agrees to increase supply (or demand) at a specified location;
2. Turn down: a customer agrees to reduce supply (or demand) or to reduce their capacity holding at a specified location;
3. Flow swap: a DNO agrees to increase supply (or demand) at one location and reduce it by an equivalent amount at a different (non-interacting) location.

Evaluation of their economic value will be dependent on the forecast distribution of frequency of use.

7.1.5 Improved Network Resilience

Where a constraint is associated with a network uncertainty event, a solution may be available through either reducing the likelihood of the event occurring, reducing its impact on the system, or through reducing the time required to perform suitable mitigating action. This may take the form of targeted maintenance to improve reliability, improved management tools or reduced contract times.

7.2 Reinforcement Projects

This section lists the common reinforcement projects that may be identified through the investment planning analysis undertaken for the NTS.

The reinforcements identified at this stage should be viewed as indicative projects, which may be modified after further detailed analysis to consider the feasibility and long term viability of the particular project. This may identify issues with routeing or siting arising from environmental, safety and wider societal impacts that mean the project is not progressed through to the construction phase.

7.2.1 Compressor re-wheels

When network analysis results indicate that compressor units continually breach their operating envelope (but are operating within the power limits of the gas or electric drive), it may be determined that the unit(s) on the compressor station are physically incapable of producing the required pressure and flow characteristics if reconfiguring the network cannot resolve the breach. In such a case, a re-wheel (redesign of the compressor performance characteristics) may be required.

7.2.2 Compressor flow reversal

Where new Entry Points change the direction of flow in an area, reversal of a compressor site flow configuration may be required. Although some sites have been designed to allow flexibility of configuration, others may require redesign to allow the compressor to “pump” in the opposite direction.

7.2.3 Regulators

A regulator project may be identified for either pressure protection as a result of an uprating project or to allow a new network configuration (to allow flows to be controlled in a different way). Regulators may also need to be resized to allow for higher flows, or redesigned to allow flow in either direction.

7.2.4 Aftercoolers

Compressor station discharge temperatures are limited to between 45^{o}C and 50^{o}C as above this temperature damage is caused to downstream pipeline coatings. If discharge temperatures constrain compressor operation, it may be necessary to fit an aftercooler, which reduces the temperature of the gas leaving the compressor station. This may also improve the downstream pipeline transmission capability. However, aftercoolers induce a pressure drop and require energy (normally electricity) to operate them, so the overall efficiency of the compression process and contribution to shrinkage must also be taken into account.

7.2.5 Uprating

It may be possible to add additional capability in the system by identifying uprating projects to test and re-certify pipelines and associated plant to increase their Maximum Operating

Pressure (MOP) level. The ability to uprate a pipeline depends on factors such as the construction of the pipeline, testing level and the pipeline materials minimum specified yield strength. For this reason, pipeline uprating is not suitable for all NTS pipelines. Pipeline uprating may need to be undertaken in conjunction with other projects such as compressor up-rating and/or re-wheels. It may be affected by safety issues such as proximity to dwellings.

7.2.6 New Compressor Stations or Units

Where network capability is limited by available compression power and/or maximum or minimum system pressures it is sometimes possible to add further compressor units or develop new stations for areas of the network requiring increased compression.

7.2.7 Pipeline Reinforcement

Where network capability is limited by maximum or minimum system pressures, pipelines may be duplicated (or triplicated) to reduce the pressure drops that are induced by gas flows. The network may also be reinforced by introducing additional pipelines to provide greater interconnection across the system and provide alternative routes for gas to flow from entry to Exit Points. An example of such an interconnection is the Trans-Pennine pipeline that links the East Coast and West Coast NTS pipelines.

7.3 Optimal Reinforcement

It is possible that there are a number of reinforcement options identified to enhance network capability. Reinforcement may be triggered by a requirement to increase network capability either under peak day conditions or away from peak day conditions; reinforcement may also be required to enhance the network capability by modifying existing assets to alter the way that they can be used.

A checklist of potential reinforcement projects is given below, which will be used as guidance in ensuring that alternatives are examined, although this is not an exhaustive list of possible options.

The cheapest capital cost solution may not be the optimal choice over the whole life of the asset therefore the long-term value of each option will be assessed by taking into account the requirements of our stakeholders. This is achieved by assessing environmental factors, the economic and technical viability, the technology used, and the way it is designed, built, maintained, operated and decommissioned.

Project	Alternative Project	Considerations
Compressor Re-wheel	Upstream pipeline	Consider options for pipe diameters and lengths to obtain most economic solution overall.
Regulator	Upgrade upstream or downstream compressor	Consider compression ratio and discharge temperature requirements to ensure compressors are able to operate within design limits
New or Upgraded Compressor (including the provision of aftercoolers)	Upstream pipeline	Consider options for pipe diameters and lengths to obtain most economic solution overall.
	Uprate upstream compressor and/or pipeline	Consider effect on compressor power requirement to ensure uprating is feasible within design limits.
	Combination of smaller compressor units	Consider benefits of additional operational flexibility provided by numerous smaller compressor units against higher cost requirement.
Pipeline Reinforcement	Upgrade downstream compressor	Consider compression ratio and discharge temperature requirements to ensure compressors are able to operate within design limits
	Uprate upstream compressor and/or pipeline	Consider effect on compressor power requirement to ensure uprating is feasible within design limits
	Compressor flow reversal	Consider whether an existing compressor may be used to flow in a different direction or configuration

Appendix A

Legislative Framework

National Grid is required to comply with certain legal requirements in the planning and development of the NTS in Great Britain. The key legislation affecting network planning and lead times for investment is described below.

Gas Act 1986 (as amended)

The Gas Act is the primary UK legislation that governs the transport and supply of natural gas within Great Britain.

Section 9 of the Gas Act states a Gas Transporter has general duties in the planning and development of their system, which are:

" (a) To develop and maintain an efficient and economical pipe-line system for the conveyance of gas; and

(b) Subject to paragraph (a) above, to comply, so far as it is economical to do so, with any reasonable request for him –

(i) To connect to that system, and convey gas by means of that system to, any premises, or

(ii) To connect to that system a pipe-line system operated by an authorised transporter."

National Grid Gas plc is required to hold Gas Transporter Licences in respect of its gas transportation activities for the NTS and the four retained distribution network businesses. These licences are granted and administered by the Gas and Electricity Markets Authority ("the Authority"), established by the Utilities Act 2000.

National Grid's Gas Transporter Licence in respect of the NTS

National Grid is bound by the terms of its Licence. The Licence contains a number of Standard, Standard Special and Special Conditions that National Grid must abide by in developing and operating the network and in conducting its transportation business. The Licence obligations that are relevant to the planning and development of the NTS are described below.

Standard Special Condition A9: Pipe-Line System Security Standards

This condition sets out the security standard for the NTS. It requires that National Grid plans and develops the NTS to meet the Security Standard. The NTS Security Standard is that the pipeline system must, taking into account operational measures, meet the "1-in-20" peak aggregate daily demand including within day gas flow variations.

The "1-in-20" peak aggregate daily demand is the level of daily demand that, in a long series of winters, with connected load held at the levels appropriate to the winter in question, would be exceeded in one out of 20 winters, with each winter counted only once. This is the Uniform Network Code ("UNC") definition of the "1-in-20" peak day. It can be found in UNC Transportation Principal Document ("TPD") Section Y Glossary.

The "1-in-20" peak day is calculated from a statistical distribution of simulated historical peak days. An estimate is made of what demand would be in a particular gas year if historical weather was to be repeated and this process is repeated for each of the years in the weather history. From these simulations there are a number of simulated maximum daily demands (one for each gas year in the historic database) and the "1-in-20" peak day is calculated from each of these demands. It is not the highest demand in the last 20 years, nor is it the demand that would be expected in the coldest weather experienced in the last 20 years. The "1-in-20" peak demand level should be calculated from at least the 50 previous year's historic data[21].

In meeting the "1-in-20" peak day demand the number of premises to which gas will be conveyed and their consumption, and the extent to which the supply of gas to those premises might be interrupted or reduced subject to a contract, should be taken into account.

The Security Standard takes into account available operational measures, for example:

- Constraint management tools including buy back of firm NTS entry and/or exit capacity (see Section 6.9.1)
- Operational balancing actions (see Section 6.9.1);
- Operating Margins gas ("OM") (see Section 6.9.2)

…and any other actions as outlined in National Grid's System Management Principles Statement ("SMPS")[22]

The Security Standard takes into account within day gas flow variations (Section 6.5). Sources of within-day variation could include foreseeable changes such as supply & demand profiling, including DN diurnal, storage and unforeseeable changes such as forecasting errors, suppliers' alerts and producer variation away from the assumed $1/24^{th}$ rate. One of the key requirements of the TPC is to provide clarity on how National Grid plans to meet the "1-in-20" Security Standard taking into account all of these factors, and further information can be found in Section 6.6).

The "1-in-20" Security Standard obligation does not apply directly to entry supplies although it is implicit that sufficient transportation capability must be made available such the Security Standard can be met both in terms of the "1-in-20" peak demand level and a "1-in-50" severe winter and, hence, sufficient entry capability must be available. The "1-in-50" standard is a function of the requirement for transportation arrangements[23] to be consistent with the supplier "domestic customer supply security standards" in regard to available annual supplies.

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[21] More detailed information on the Gas Demand Forecasting can be found here: http://www2.nationalgrid.com/uk/industry-information/gas-transmission-operational-data/supporting-information/

[22] http://www2.nationalgrid.com/UK/Industry-information/Business-compliance/Procurement-and-System-Management-Documents/

[23] Transportation arrangements are defined in the Uniform Network Code and the requirement is defined in Licence Standard Special Condition A11: Network Code and Uniform Network Code

Prior to 'exit reform'[24], a site could either be registered as firm or interruptible, with only firm demand taken into account for planning purposes and the assessment of the "1-in-20" Security Standard. Exit reform, whereby a combination of annual or daily firm or off-peak capacity can be held, has created issues in regard to forecasting the "1-in-20" demand level. A site may not hold firm exit capacity on an enduring basis but may be able to access it on an annual basis year ahead or even on a daily basis within-day, if there is any unsold obligated capacity at the relevant exit point, and hence in timescales shorter than the investment planning process. The risks associated with daily capacity are mitigated by an understanding that the DNs will book enduring exit capacity to comply with the security standard and their own "1-in-20" obligations. Simply relying on enduring bookings may be insufficient and sensitivity analysis surrounding those exit points that can access short term obligated capacity is required.

Special Condition 7A: Long Term Development Statement

Under this obligation, National Grid must publish an annual Long Term Development Statement for the NTS that sets out the likely use of the NTS, and the likely developments of the NTS, any other facilities or pipeline systems that may affect the connection charging and transportation charging arrangements over the next ten years. National Grid publishes the GTYS each year in accordance with this condition and the Uniform Network Code ("UNC") Transportation Principal Document ("TPD") Section O after consultation with the gas industry through the Future Energy Scenarios ("FES") consultation process.

Special Condition 5F: NTS gas entry incentives, costs and revenues

The NTS entry condition sets out the entry capacity incentive arrangements that National Grid operate under, the obligations on National Grid to offer entry capacity for sale, the levels of entry capacity that must be offered for sale, and the process for increasing the levels of entry capacity that must be offered for sale.

The details of the Entry Capacity release process are set out in Section B of the UNC and the Entry Capacity Release (ECR) Methodology Statement. National Grid can only permanently increase the level of entry capacity at an Aggregated System Entry Point (ASEP) having first assessed how much entry capacity may be substituted to meet the increase as a result of applying its Entry Capacity Substitution Methodology.

The condition describes two incentive mechanisms that incentivise National Grid to manage its lead times for releasing additional entry capacity.

Special Condition 5G: NTS gas exit incentives, costs and revenues

The NTS exit condition sets out similar requirements to that for entry capacity. Under the enduring exit arrangements there is an incentive for National Grid to manage its lead times for releasing additional exit capacity.

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[24] Reform of exit capacity arrangements applies to capacity held from 1st October 2012.

The details of the Exit Capacity release process are set out in Section B of the UNC and the NTS Exit Capacity Release Methodology Statement. National Grid can only permanently increase the level of exit capacity at an Exit Point having first assessed how much exit capacity may be substituted to meet the increase as a result of applying its Exit Capacity Substitution Methodology.

Pipelines Safety Regulations 1996

The Pipelines Safety Regulations (PSR) 1996 were made under the Health and Safety at Work Act 1974. These Regulations are the principal health and safety legislation in the UK concerning the safety and integrity of pipelines, and are regulated by the Health and Safety Executive (HSE). They apply to all relevant onshore UK pipelines to ensure that these pipelines are designed, constructed, operated, maintained and decommissioned safely. In particular they class certain pipelines that transport certain "dangerous fluids" as Major Accident Hazard Pipelines (MAHPs). All natural gas pipelines operating above 7 bar(g) fall into this category.

PSR covers four areas:

1. Pipeline design
2. Pipeline safety systems
3. Pipeline construction and installation
4. Examination and maintenance

Operators of MAHPs are required to notify the HSE before construction, use and modification of the pipelines.

The Regulations require that construction of a new MAHP must not start until the operator has notified HSE at least six months prior to the start of construction (of the first stage of construction), although in practice the HSE are involved in discussions on the design and routeing of the pipeline ahead of this notification period. Notification of at least 3 months is also required in other cases, for example in advance of

- Major modifications or remedial work to the pipeline.
- Changes in safe operating limits e.g. pressure uprating
- Changes in fluid composition or type as this may have an effect on pipeline integrity
- End of use of a pipeline (decommissioning and dismantling)
- Changes in pipeline materials and equipment
- Re-routeing of pipelines

PSR further require that a pipeline operator has adequate arrangements in place to deal with an accidental loss of fluid from a pipeline, defects and damage to a pipeline or any other emergency affecting the pipeline. Operators of MAHPs must also have adequate emergency procedures, an appropriate organisation and effective arrangements in place to deal with an emergency involving a MAHP. Since pipelines may typically span large areas of the country, this requires the pipeline operator to liaise with local authorities along the route of the pipeline to ensure that they also have suitable emergency procedures in place to meet their obligations under PSR.

Pressure Systems Safety Regulations 2000

The Pressure Systems Safety Regulations (PSSR) 2000 aim to prevent serious injury from the hazard of stored energy as a result of the failure of a pressure system or one of its component parts.

The Regulations require owners of pressure systems to demonstrate that they:

- Have designed and constructed the pressure system to be safe with the appropriate protective devices where required;
- Have established the safe operating limits of pressure systems;
- Have a written scheme of examination in place prior to the use of the system; and
- Maintain and repair the system to meet the required safety standards.

The written scheme of examination certifies the pressure system (including all protective devices, pressure vessels and pipework) for use and must be approved by a competent (independent) person. Examinations must be carried out by a competent person and must be reviewed at regular intervals as defined by the written scheme. The system must also be maintained properly to ensure that it is safe.

The main protective devices for the NTS are compressor stations, pressure reduction installations and boundary control systems.

Gas Safety (Management) Regulations 1996

The Gas Safety (Management) Regulations (GSMR) 1996 require each Gas Transporter to prepare a Safety Case document that sets out in detail the arrangements in place in four main areas:

1. The safe management of gas flows through the network, particularly those parts of the network supplying domestic consumers
2. The management of gas supply emergencies[25], including those measures in place to minimise the risk of a gas supply emergency occurring
3. The management of reported gas escapes and gas incidents
4. The management of gas quality and composition within safe parameters

Schedule 1 of GSMR describes the scope of the Safety Case. In particular, Schedule 1 states that the Safety Case must contain

> "**17.** Particulars to demonstrate that the duty holder has established adequate arrangements to ensure that the gas he conveys will be at an adequate pressure when it leaves the part of the network used by him."

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[25] The Gas Safety (Management) Regulations 1996 define a gas supply emergency as being an 'emergency endangering persons and arising from the loss of pressure in a network...'. The definition of danger is limited to risks from the gas itself.

The Safety Case must be formally accepted by the HSE. Once accepted, there is a legal obligation on the Gas Transporter to comply with its Safety Case. Any changes to safety management systems, key technical policies and procedures concerning gas supply emergencies, staff resource levels, system operation changes, organisational changes or changes to commercial arrangements may require a material Safety Case revision. Such revisions will need approval by the HSE before they may be implemented.

National Grid Gas's Safety Case contains a section (Section 17: Adequate Network Pressure) that is relevant to the planning and development of the NTS to ensure that adequate pressure is maintained within the network under a range of operating conditions. This section of the Safety Case outlines the guidance documents used in the planning of the NTS (which are also described later in this document) and the use of validated network analysis models for planning (which is expanded upon in this document).

Planning Regime

National Grid has legislative obligations relating to consent authorisations required when developing elements of the NTS in the form of:

- Planning Act 2008
- Town and Country Planning Act 1990

Generally speaking the Planning Act 2008 will apply to the construction of NTS pipelines whereas the Town and Country Planning Act 1990 will apply to the provision of fixed assets such as Compressor Stations and Pressure Reduction Installations.

Planning Act 2008

The Planning Act 2008 (as amended) introduced changes to streamline the planning system by establishing a single consenting regime. Following changes introduced through the Localism Act 2011, the Planning Inspectorate replaced the Infrastructure Planning Commission (IPC), with Nationally Significant Infrastructure Project (NSIP) applications being determined by the relevant Secretary of State. Six energy related National Policy Statements (NPSs) have been produced by the Department of Energy and Climate Change, which were designated in July 2011. They set out the national policy framework for the development of energy infrastructure, and provide the primary basis for decision making.

The Planning Act does not apply in Scotland, and does not apply to gas transporter pipelines in Wales. In these Countries gas transporter pipelines are installed under permitted development rights by virtue of the Gas Act 1995 (as amended). In response to the requirements of the Planning Act and the impending review of planning requirements in Wales, National Grid has developed a consistent approach for developing major infrastructure projects to be applied consistently across England, Wales and Scotland.

Nationally Significant Infrastructure Projects

The construction of a gas transporter pipeline is considered to be a NSIP when each of the following conditions is met:

1. The pipeline must be wholly or partly in England and either:

   a. the pipeline must be more than 800mm in diameter and more than 40km in length, or
   b. the construction of the pipeline must be likely to have a significant effect on the environment; and

2. The pipeline must have a design operating pressure of more than 7 bar gauge; and
3. The pipeline must convey gas for supply (directly or indirectly) to at least 50,000 customers, or potential customers, or one or more gas suppliers.

Gas transporter pipelines (including new pipelines and diversions) that are less than 800mm in diameter and 40km in length are only considered NSIP developments if the construction is likely to have a significant effect on the environment. The Infrastructure Planning (Environmental Impact Assessment) Regulations 2009 (see below) provide a 'screening' mechanism to establish whether the proposed works are likely to have a significant effect on the environment.

In England, works associated with a NSIP may be included within the Development Consent Order (DCO) application to be determined by the Secretary of State for Energy and Climate Change.

Impact of the Planning Act

The Planning Act requires pre-application consultation and engagement with affected and interested parties during the development of the project. As previously mentioned, in response to these requirements, National Grid has developed an approach[26] for developing major infrastructure projects which sets out in a transparent way the stages of project development and when during the process relevant stakeholders are consulted. National Grid has developed a generic timeline to illustrate the various stages in the project development process (see table below).

This approach includes greater documentation of network analysis, project optioneering, engineering design activity and wider consultation with stakeholders than in previous planning regimes. This increases the time required to complete the overall process, but means that stakeholders' views are incorporated earlier, improving the certainty of the outcome. However, this new regime does not affect the actual build time to deliver new infrastructure, which will remain largely unchanged (subject to consent conditions, terrain and weather).

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[26] National Grid's approach for electricity projects is set out in the link below. A similar document is being prepared for gas projects.

http://www.nationalgrid.com/uk/Electricity/UndergroundingConsultation/ApproachToDesignAndRouteingOfNewLines/

Planning Stage	Activity	Duration
Strategic Optioneering	Establish the need case and identify technical options	Up to 6 months
	Develop Strategic Options Report (SOR)	Up to 6 months
Outline Routing and Siting	Identify Preferred Route Corridor / Siting Studies	Up to 15 months
Detailed Routing & Siting	Undertake EIA (Environmental Impact Assessment) & detailed design	Up to 24 months
Development Consent Order (DCO) Application preparation	Formal consultation, finalising project, preparation of application documentation	
DCO Application, Hearings and Decision	Submission and examination Approval process	Up to 15 Months

As illustrated in the diagram above, the overall planning process is anticipated to take up to 7 years (84 months). The current default lead time, from the receipt of a formal capacity signal to the release of incremental entry capacity, is defined in National Grid's Licence and as this is shorter than the Planning Act timeline, a significant quantity of the pre-application phase works and stakeholder consultation would need to be completed ahead of a formal signal for capacity in order that system reinforcement can be delivered in time for the release of the capacity[27].

As National Grid currently has limited experience of progressing gas pipeline projects through the new planning regime, the timeline quoted above is considered to be generic. It is based on experience from other applications under the Planning Act, guidance on the Government's expectations on pre-application consultation and extensive discussions with a wide range of relevant stakeholders. We consider it to be representative of the timeline for a typical major linear infrastructure project; however, this timeline is not fixed and will vary on a case by case basis according to each project's individual requirements. We recognise that there are concerns amongst some industry participants regarding these timescales and we are working with the Department of Business, Energy and Industrial Strategy (BEIS) and the Department for Communities and Local Government (DCLG) to understand the full implications - as are other industry stakeholders. Notwithstanding the outcome of these on-going discussions, National Grid will endeavour to improve upon these timescales wherever it is possible to do so and by learning lessons from other major projects under the Planning Act whilst maintaining the required quality of consultation and engagement necessary to ensure compliance with the Planning Act.

[27] Regulatory changes through RIIO and commercial changes through UNC are being progressed to address this issue

Town and Country Planning Act 1990

The Town and Country Planning Act 1990 is the land use planning system framework used to maintain a balance between economic development and environmental quality. Each country in the United Kingdom has its own distinct planning system with responsibility for town and country planning devolved to the Welsh Assembly and the Scottish Parliament.

Due cognisance has to be given to the Town and Country Planning Act for the provision of fixed assets such as Compressor Stations and Pressure Reduction Installations. So in order to develop a fixed asset, National Grid is required to apply for planning permission from the relevant local planning authority. Timescales for gaining planning approval for a development vary depending on the type, size, location and sensitivity of a particular development.

In the event that planning permission is refused, an appeal can be submitted within 6 months to the Secretary of State for Communities and Local Government in England and Wales, or the First Minister in Scotland. A Planning Inspector or Scottish Reporter would be appointed to hear the appeal, which may be in the form or written representations, hearing or inquiry. The time from submission of appeal to receipt of a decision depends on the size, scale and complexity of the project and the reasons for refusal, and the type of appeal held. For more complex appeals an inquiry may be held, with approximately half of decisions reached within 26 weeks.[28]

Environmental Impact Assessment Directive

The Environment Impact Assessment Directive (2011/92/EU) requires Environmental Impact Assessments to be conducted before development consent is granted, for certain types of major public and private projects which are judged likely to have significant environmental effects.

An Environmental Impact Assessment examines in a comprehensive, detailed and systematic manner, the existing environment (natural, physical and built) and the proposed pipeline development. This typically requires the completion of a wide range of searches, studies and surveys over four seasons which takes a minimum of 12 months to complete. The Environmental Statement is the culmination of this assessment, and sets out the environmental baseline, the likely significant environmental effects, proposed mitigation measures and any residual effects from the proposed development. The Environmental Statement will also include National Grid's commitments[29] to minimising the effects on the environment.

Infrastructure Planning (Environmental Impact Assessment) Regulations 2009

In England, gas transporter pipeline works that fall within Annex I, or Annex II of the Directive by virtue of their likely significant environmental effects, require an Environmental Statement

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[28] Planning Portal: appeal handling times:
http://www.planningportal.gov.uk/planning/appeals/guidance/handlingtimes

[29] National Grid's Stakeholder, Community and Amenity Policy

to accompany an application for development consent to the Secretary of State for Energy and Climate Change under the Planning Act 2008. These works are classed as NSIPs. From submission of the application to the Planning Inspectorate to obtaining a decision from the Secretary of State may take up to 15 months.

The Public Gas Transporter Pipe-line Works (Environmental Impact Assessment) Regulations 1999

These Regulations apply to gas transporter pipeline works in Wales, Scotland and England. In Wales and Scotland, pipeline works in Annex I of the Directive require an Environmental Statement to be submitted to the Secretary of Statement of Business, Energy and Industrial Strategy (BEIS). For pipeline works in Annex II of the Directive 'the works' may be subject to an Environmental Impact Assessment if they have a design operating pressure exceeding 7 bar(g) or either wholly or in part cross a sensitive or scheduled area. In these circumstances, the Gas Transporter must, before commencing construction, either obtain determination from the Secretary of State that an Environmental Statement is not required, or give notice that it intends to produce an Environmental Statement. The Regulations also provide for the Secretary of State to require an Environmental Statement where proposed works in Wales and Scotland do not meet these criteria but nevertheless it is considered that there are likely to be significant environmental effects. The completed Environmental Statement is submitted to the Department of Business, Energy and Industrial Strategy (BEIS). It normally takes BEIS between 9 to 12 months to review the Environmental Statement, complete the consultations required with all appropriate statutory and non-statutory parties and grant the development consent required.

In England, gas transporter pipelines works that fall within Annex I or II would require an Environmental Statement to be produced and would be an NSIP project requiring development consent under the Planning Act. Pipelines that do not fall within Annex I or II would not require an Environmental Statement.

Emissions

National Grid has regulatory obligations relating to emissions placed upon it by the Environment Agency (EA) in England and Wales, and the Scottish Environment Protection Agency (SEPA) in the form of:

- The Pollution Prevention Control (PPC) regime (Scotland);
- The Environmental Permitting regime (England and Wales);
- The Large Combustion Plant Directive (LCPD);
- The Medium Combustion Plant (MCP) Directive
- The Industrial Emissions Directive (IED);
- The European Union Emissions Trading Regulations (EU ETS) within the UK.

Integrated Pollution Prevention and Control Directive

Emissions reduction investment on the NTS is driven by the Environment Permitting Regulations (2010) in England and Wales and by the Pollution Prevention Control (PPC) regime in Scotland; these regulations were put in place to comply with the European Integrated Pollution Prevention and Control Directive (IPPC Directive) 1999. It should be noted that the IPPC Directive was recast into the Industrial Emissions Directive ("IED") (please see the Industrial Emissions Directive section below) and therefore both the Environment Permitting Regulations and Pollution Prevention Control were amended in 2012 as a result.

The IPPC Directive aims to achieve a high level of environmental protection through integrated prevention and control of the pollution arising from a wide range of industrial and agricultural activities. The legislation was designed to prevent/reduce emissions to air, land and water; noise, odour and vibration; production of waste and environmental incidents. Also, energy should be conserved and allowance made for site remediation as necessary. This was to help resolve environmental problems, such as pollution of air and water, climate change, soil contamination and negative impacts of waste and move the EU closer to sustainable patterns of production.

National Grid's compressor stations are currently permitted and regulated, on an individual basis, under the IPPC Directive. Permits must be obtained for required installations and operation of the installations must comply with these permits, including compliant emissions with the Emission Limit Values[30] (ELVs) based on Best Available Techniques (BAT).

The competent authorities which issue the permits (EA and SEPA) have extensive powers to take enforcement action if conditions of the permits are breached. Enforcement action can range from issuing a letter with an improvement notice to, in extreme circumstances, fines and prosecution.

The permits do not prescribe the use of any techniques or specific technology and they can take into account the technical characteristics of the installation concerned, its geographical location and the local environmental conditions.

In the determination of BAT, the competent authorities that issue permits have to take into account the BAT Reference Documents (BREFs). BAT is applied to achieve a high level of environmental protection, taking into account both the benefits that can be achieved against the associated costs:

- Best: the most effective to give a high level of protection to the environment;
- Available: economically and technically viable;
- Techniques: the technology used and the way in which an installation is designed, built, maintained, operated and decommissioned.

Large Combustion Plant Directive (LCPD) 2001

The LCPD was introduced by the European Parliament and Council to introduce measures to control the emissions to air of oxides of nitrogen (NOx), sulphur dioxide (SOx) and particulates from large combustion plants (i.e. plant with a rated thermal input of equal to or greater than 50 megawatt thermal). The specific aim of this Directive is to take steps to

[30] Subsequently, the Industrial Emissions Directive (see later) led to more stringent Emission Limit Values for the emissions of oxides of Nitrogen (NOx) for all National Grid operated Large Combustion plant (gas turbines >50MW thermal input)

reduce the emissions to air of these pollutants as they are known to damage human health and contribute to acid rain.

The emission limits as defined in this Directive for NOx & SOx were not directly applied to the National Grid's combustion plant by virtue of their age; however, the Industrial Emissions Directive has subsequently removed this age related exemption (see later). These limits were however taken to show 'indicative BAT' as plant was available on the market that could meet the limits.

Industrial Emissions Directive

The Industrial Emissions Directive (2010/75/EU) (IED) came into force on 6th January 2011. IED recasts seven existing Directives related to industrial emissions into a single clear, coherent legislative instrument. The recast includes IPPC, LCPD, the Waste Incineration Directive, the Solvents Emissions Directive and three Directives on Titanium Dioxide.

The timeline for implementation of certain provisions of IED follows the dates below:

- Transposition into UK law by 6th January 2013;
- Implementation from 6th January 2013 in respect of any new installation after that date (i.e. applies to all new plant in operation after the 6th January 2013 regardless of thermal input);
- Implementation by 6th January 2014 in respect of installations already in existence before 6th January 2013 (except large combustion plant) (i.e. will apply to all existing combustion plant <50MW thermal input from 6th January 2014);
- Implementation from 1st January 2016 in respect of large combustion plant already in existence before 6th January 2013. (i.e. applies to all plant >50MW thermal input from 6th January 2016).

The IED contains a provision for a Transitional National Plan (TNP) which allows operators who intend to opt-in enough time to comply with the IED's reduced ELVs. Plants which opt-in to the IED will be required to comply with the new ELVs, however, some flexibility in the early years is allowed through a TNP. The UK Government must submit the plan to the European Commission by 1st January 2013, however, the date by which plant must be nominated for entry into the UK plan is not yet known.

The IED will strengthen the principle of applying Best Available Techniques (BAT) to the way in which compressor installations, along with other assets, are designed, built, maintained, operated and decommissioned through the setting of permit conditions:

(a) The directive states that the competent authority (EA or SEPA) shall set ELVs that, under normal operating conditions shall not exceed the permitted levels associated with the BAT conclusions;

(b) In addition to the requirement to apply BAT, the competent authority may set stricter permit conditions than those achievable by the use of BAT.

Derogations can be granted in specific and well justified cases where an assessment shows that the achievement of emission levels associated with the BAT conclusions would lead to disproportionately higher costs compared to the environmental benefits due to the geographical location, the local environmental conditions or the technical characteristics of the installation concerned. The competent authority shall in any case ensure that no significant pollution is caused and that a high level of protection of the environment as a whole is achieved.

The most immediate impact, affecting Large Combustion Plant only, of the IED for National Grid are the setting of a new ELV for Carbon Monoxide (CO) and a more stringent ELV for the emissions of oxides of Nitrogen (NOx) for all operated Large Combustion Plant (gas compressors >50MW thermal input). Previously, Large Combustion Plant on the NTS was exempt from the LCPD ELV for NOx by virtue of its age. The IED is now, however, removing this age related exemption and the ELV for NOx will now apply to all Large Combustion Plant. Furthermore, the previous LCPD did not include an ELV for Carbon Monoxide.

Large Combustion Plant that cannot meet the new ELVs for NOx and Carbon Monoxide must cease to operate on 31st December 2015 unless certain conditions can be met:

(a) Any non-compliant gas compressors that can be declared as being required for operation for periods of less than 500 hours per annum will be assumed to be for "emergency use" only and the new ELVs will not apply. Operating hours will then be recorded and reported to the Environmental Regulators;

(b) Plant may be entered into the UK TNP which will allow plant to operate within the ELV for NOx until 30th June 2020 provided the plant concerned can meet the new ELVs for Carbon Monoxide;

(c) A written undertaking can be made for individual plant to be able to operate for up to a maximum of 17,500 hours between 1st January 2016 and 31st December 2023. The affected plant must cease operation by 31st December 2023 or when it reaches the 17,500 hour limit, whichever is sooner (ELVs set out in the existing permits as at 31st December 2015 shall apply). It is unclear at this time when this required undertaking has to be made.

Even if these conditions can be met, all existing Large Combustion Plant currently in operation must be compliant with new ELVs for Carbon Monoxide by 31st December 2023.

When the requirement of the directive comes into force emissions from all Large Combustion Plant will be required to be tested on a six monthly basis regardless of the number of hours operated which is currently the case.

It is important to note that the other requirements of the existing Environmental Permitting (England and Wales) and Pollution Prevention & Control Regulations (Scotland) are maintained, i.e. the principles of 'BAT' will still apply to all of the gas compressor stations. Notwithstanding the new impacts arising out of the IED for the larger gas compressors, the drive to reduce emissions of NOx and Carbon Monoxide from the combustion plant with a total rated thermal input of below 50MW remains. The IED applies more stringent ELVs for large combustion plant and also removes the exemption from the Large Combustion Plant Directive previously applied to the NTS compressor fleet.

Medium Combustion Plant (MCP) Directive

The Medium Combustion Plant (MCP) Directive will be transposed into UK legislation by 19th December 2017. During 2015 the MCP Directive was finalised at a European level. The time derogation for gas-driven compressors was originally 2025. National Grid has secured a

longer derogation for gas compressors that are required to ensure the safety and security of an NTS, which now have a further five years (to 2030) to comply with the requirements.
The MCP Directive applies to smaller gas compressors and will affect a further 26 of the NTS compressor units. Other combustion plants, such as pre-heat systems, are also captured as part of this Directive. During 2016/17 we will undertake an audit of this plant type and develop mitigation plans.

European Union Third Package

With respect to planning of the NTS this section outlines the applicable European legislation which National Grid complies with, and outlines the progress of legislation and European network codes that may affect Transmission planning into the future.

The European Union (EU) Third Energy Package is a combination of three EU Regulations and two EU Directives (covering gas and electricity) which were ratified in 2009 and became effective from March 2011. The package seeks to achieve three energy policy objectives of increased security supply, development of a single European energy market, and meeting carbon emission targets. The package provides a framework of new institutions to develop the Network Codes to be applied at a European level. These are the European Network of Transmission System Operators for Gas (ENTSO-G) and the Agency for the Cooperation of Energy Regulators (ACER). The three relevant gas regulations and directives are as follows:

- Gas Directive: 2009/72/EC
- Gas Regulation: (EC) No 715/2009
- ACER Regulation: (EC) No 713/2009

Ten Year Network Development Plan

The EU Third Package established the European Network of Transmission System Operators Gas (ENTSO-G) as a new institution to develop and implement European wide Network Codes and to develop the Ten Year Network Development Plan (TYNDP). The TYNDP is a forward-looking proposal for gas transmission infrastructure investment across over 30 European countries. The requirement for the TYNDP was in Regulation (EC) No 715/2009 which states that a task for ENTSO-G is the creation every two years of a "non-binding Community wide Ten Year Network Development Plan…including a European supply adequacy outlook". The TYNDP provides the following:

- Overview of the European supply and demand situation, through the development of different scenarios;
- Future infrastructure projects, by providing the latest information on potential capacity developments from numerous different types of infrastructure (LNG, Storage, Transmission);
- Models the resilience of the European Network through the development of scenarios by focusing on Market Integration, Supply Potential and Security of Supply.

National Grid has played and will continue to play a very active role in the development of the ENTSO-G Ten Year Network Development Plan. National Grid has a legal obligation enshrined in Article 12(1) of Regulation 715/2009 to co-operate with the TSOs of Europe within ENTSO-G. National Grid provide both physical resources and data both annually and on an ad-hoc basis to help ensure that the TYNDP not only meets but exceeds the obligation placed upon it by the third energy package.

Security of Supply Regulation

The gas Security of Supply Regulation No. 994/2010 “concerning measures to safeguard security of supply” aims to enhance security of supply by providing common assessment of Member States’ energy security arrangements. The regulation facilitates the following:

- ensuring member states provide gas to protected customers;
- ensuring a minimum standard of infrastructure resilience;
- ensuring member states make adequate preparations for a gas supply emergency;
- improving coordination between member states;
- ensuring the internal market for gas functions for as long as possible in the event of an emergency.

Infrastructure resilience is measured against an ‘N-1’ standard i.e. that in the event of a disruption of the single largest infrastructure, the remaining infrastructure has sufficient capacity to satisfy the total demand occurring on a 1 in 20 demand day. Compliance with this standard is calculated by the use of a specified formula which looks at the ratio of total remaining supplies (after removal of the largest infrastructure) over total demand, with any result over 100% being acceptable.

The N-1 standard became legally binding on 3rd December 2014. Our projections forecast that National Grid will meet the required standards, however should this not the be case European Infringement actions would expect to be taken, which could result in significant financial impacts.

Appendix B

Policy and Guidelines for NTS Planning

A number of policy and guideline documents are maintained for the purposes of planning and development of the NTS. Some of these are industry guidelines applicable to all high pressure pipelines. Others are maintained and developed by National Grid to ensure compliance with legislation, industry standards and best practice. This section lists the particular industry standards and National Grid policies used for network planning.

Industry Standards and Guidelines

The guidelines adopted by National Grid are maintained and developed by the Institute of Gas Engineers and Managers (IGEM), which is a recognised authority on technical standards relating to the natural gas industry. These are available from the IGEM website at: http://www.igem.org.uk/.

IGE/TD/1: Steel Pipelines For High Pressure Gas Transmission

This document contains a comprehensive set of guidelines covering the design, construction, inspection, testing, operation and maintenance of high pressure steel pipelines and associated installations used for natural gas transmission, operating between 16 bar(g) and 100 bar(g).

IGE/TD/13 Pressure Regulating Installations for Transmission and Distribution Systems

This document contains a comprehensive set of guidelines covering the design, construction, inspection, testing, operation and maintenance of pressure reduction installations used for natural gas transmission and distribution systems up to 100 bar(g).

IGE/GL/2 Planning of Transmission and Storage Systems Operating at Pressures Exceeding 16 bar

This document contains guidance on the planning of high pressure natural gas networks, including the required agreements and processes between Gas Transporters operating different systems to ensure the continuity of supply across the system boundaries.

National Grid Policies

National Grid ensures that it is compliant with the legislative framework and guidance documents that affect the planning and development of the NTS. Two key policy documents that are directly related to network planning are its policies for Network Planning and Above 7 bar Network Analysis. These apply the recommendations made in the IGEM documents listed above to network planning for the NTS. The policy documents are supported by procedures and guideline documents that are used by analysts undertaking investment planning analysis on the NTS. The assumptions used for network analysis models of the NTS held within National Grid procedures and guidelines are described in Chapter 6.

T/PL/NP/18 Policy for Network Planning

This document sets out the policy requirements for network planning activities for use with all natural gas systems operating at pressures up to 100 bar(g). Network Planning is the process of ensuring that the network can meet the duty required of it under operational and design conditions up to the planning horizon. The policy covers all distribution and transmission networks operated by National Grid and requires transmission networks to be planned in accordance with IGE/GL/2.

The policy is supported by specific sections in IGE/TD/1 and IGE/TD/13 for the design of specific components.

T/PL/NP/4 Policy for above 16 bar Network Analysis

This is National Grid's policy for undertaking network analysis for all high pressure gas transmission pipelines operating above 16 bar(g) consistent with IGE/GL/2. The document covers system modelling, network analysis processes, record keeping and data security.

Appendix C

Supply

Long Term Supply Scenarios

The GTYS contains detailed information on, supply and demand scenarios, current reinforcement projects and investment plans, and actual flows seen on the NTS in recent years.

Following the annual FES process, National Grid NTS will normally produce a number of scenarios for long term gas supply and demand that cover a range of possible futures for the GB energy market (FES scenarios). A number of scenarios will be considered from which to develop other supply patterns anticipated on the NTS. All of this information will be published in the GTYS in accordance with the UNC TPD Section O.

For the purposes of this document it is assumed that multiple scenarios are available. The basic steps involved in developing such supply scenarios are described below.

Scenarios and Supply Ranges

For the long term FES scenarios a number of possible alternative supply scenarios will be analysed in order to capture the range of possible supply patterns that could occur under specific market conditions.

Supplies are modelled at the level required to capture their behaviour, for example at an Aggregated System Entry Point, terminal or sub-terminal level depending on the different sources of gas that enter the system at such points.

Supply Scenario Identification

Generic supply scenarios will be developed through plausible situations that could occur for the NTS. These scenarios are qualitative descriptions of how a supply or group of supplies may react to certain market related events, including global market drivers. Reasoning and background will be included with each case to describe how that particular flow pattern may occur.

Long term planning analysis requires that the supply levels must be matched to the total demand level. Due to the requirement to match supply with demand, some supplies may flow whilst others may not.

In order to model specific supply levels and patterns that meet demands within a particular supply scenario, information is needed on which supplies are believed to more likely to flow than others (essentially a supply ranking), which supplies may be displaced by other sources of gas (supply balancing) and the range associated with a maximum and minimum likely anticipated flows for each supply. It should be noted that these rankings may vary from one supply scenario to another, and that many specific supply levels and patterns may be examined under each generic supply scenario.

Broadly, it is the highest demand days that drive investment. On these days the supply scenarios will be focussed on the potential interaction between:

- LNG imports;
- Pipeline imports; and
- Gas sourced from storage.

The variability in potential supplies from the sources outlined above is considered to be large and the uncertainties are increased by a general lack of evidence to support assumptions about levels of gas flow. The interaction or extent to which one source of gas will displace another is also an unknown factor. Within the broad categories described above, different assumptions will be made for each element (for example, it might be assumed that pipeline import facilities each have different characteristics).

Gas from the United Kingdom Continental Shelf (UKCS) is generally considered to have a greater certainty of being delivered at the beach and as a consequence the range of uncertainty is reduced when compared to LNG imports etc.

At lower demand levels, the planning assumptions will generally favour gas supplies that are lower cost, or cannot be delivered to any other location than the United Kingdom. In this case the sensitivity analysis will focus on the potential for gas that can be delivered to interconnected markets to be delivered elsewhere.

Supply Ranking Assumptions

For each scenario a ranking order (or merit order) will be determined for use in the balancing of supply and demand where more supply is available than that required to meet demand.

The ranking order for a particular supply or supply type will include an assumption for the relative cost of supply, as well as incorporating other more qualitative analyses. The lowest cost and least volatile gas is likely to sit at the top of the ranking order ("base load supplies" that are assumed to flow) and the most expensive, fluctuating supplies are likely to sit at the bottom of the ranking order ("volatile supplies" that are considered to be more price sensitive supplies that are most likely to flow at high demand/price). In this respect, qualitative analysis is particularly important in an environment where there appears to be a marked difference between marginal costs of supply and wholesale gas prices.

Supply ranking will also be developed by incorporating information gathered through the FES process and discussions with Developers/Shippers, for example for new supplies for which detailed cost information is unavailable or untested. Supply ranking may also incorporate observed behaviour from historic flow patterns.

Supply Balancing Assumptions

National Grid NTS will determine the supply balancing assumptions in line with the qualitative requirements of each generic supply scenario. These balancing assumptions will allow some supplies to increase above the FES scenarios; some to decrease below the FES scenarios in order to balance the increases and the remaining supplies will be fixed at the relevant FES scenario.

Supply flow increases above the relevant FES scenario level generally start with supplies at the top of the ranking order and work down. Supply flow decreases below the relevant FES scenario level generally start at the bottom of the ranking order and work up.

Supply Range Assumptions

National Grid NTS will identify the plausible volatility for each existing supply. In determining the ranges, National Grid NTS will consider historic information on actual flows observed on the NTS for existing supplies. The maximum and minimum flow range for well-established supply flows will be predicted by adding the observed volatility to the relevant FES scenario. This analysis will be supplemented by consideration of the trends at each Entry Point. For example, UKCS supplies are well established but the trend towards greater levels of depletion needs to be taken into account when forecasting future levels of gas supply.

Supply ranges will also be based on FES information and discussions with Developers/Shippers where flow behaviour is anticipated to change from historical patterns, for example for new supplies or gas sources, or for supplies that are in decline.

Supply Scenario Updates

Supply scenarios will be reviewed and updated annually as an input to the investment planning process, and will reflect National Grid NTS's view on the range of flow patterns that may occur on the NTS over the ten-year planning horizon.

National Grid NTS may review supply scenarios or develop additional supply scenarios during the planning year, as a result of new information being made available that influences its view on the likely level and flow behaviour of a particular supply. For example, new information may result from discussions with Developers and Shippers, or on the planning consent status of third party developments associated with gas supplies to the NTS or as a result of information received through entry capacity auctions or exit capacity applications.

Appendix D

Demand

Long Term Demand Scenarios

There are primarily two sources of demand information available to National Grid NTS when considering investment planning needs: the gas demand forecasts and information collected through the UNC TPD Section B and the UNC Offtake Arrangements Document (OAD) Section H processes. These are described further below.

Demand Scenarios

National Grid NTS's gas demand scenarios are developed as part of the annual FES process using detailed analysis of demand drivers including (but not limited to) fuel prices and economic forecasts. Indicative forecasts are received from DNOs as required under section H of the OAD and these may also be used as an input to the process. Demand scenarios will be produced for different market sectors, with scenarios produced for both annual gas demand and peak day gas demand.

Peak day forecasts are required under Special Condition A9 (Pipe-Line System Security Standards) of National Grid NTS's Licence to ensure that the network meets the security of supply standard. A 1-in-20 peak day forecast will be produced from statistical analysis of historic weather patterns that determines the demand level that is expected to be reached or exceeded on average once in every 20 years. Such a peak day demand level could be experienced on more than one day in a winter. For a further detail on this, please see Appendix A earlier in the document.

Load duration curves of annual gas demand will be produced from statistical analysis of historic data to determine the number of days each year on average that a demand level is reached or exceeded. Two curves will be produced for investment planning needs: a 1-in-50 load duration curve to reflect severe conditions that may be expected on each day of the gas year, and an average load duration curve to reflect average conditions that may be expected on each day of the gas year. National Grid NTS will normally use the average load duration curve to generate demand patterns for off-peak analysis, however specific analysis (for example for determining turn-up or turn-down contract requirements) will require analysis using the severe load duration curve.

Sensitivities around the demand scenarios assumptions may also be considered in order to produce ranges of potential demand over the longer term.

The GTYS will describe the assumptions driving the gas demand scenarios and the scenario data. Further detail on the assumptions behind the scenarios can also be found in the Future Energy Scenarios document.

National Grid NTS's Demand Forecasting Methodology is published on National Grid's website[31] and contains a detailed description of how statistical models are used to produce peak day forecasts and load duration curves.

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[31] http://www2.nationalgrid.com/WorkArea/DownloadAsset.aspx?id=8589937808

Offtake Capacity Statements, Offtake Pressure Statements and Long Term Planning Information

The UNC requires National Grid NTS and the DNOs to share information to ensure their systems are planned in a coordinated manner.

The UNC TPD Section B describes the annual Offtake Capacity Statement (OCS) and Offtake Pressure Statement (OPS) processes, which National Grid NTS and DNOs use to agree peak day requirements for DNOs for NTS Exit (Flexibility) Capacity and Assured Offtake Pressures respectively.

The Assured Offtake Pressures (AOP) agreed between National Grid NTS and DNOs are applicable for each day of the Gas Year and are independent of demand. AOPs were initially set during the sales of National Grid's Distribution Networks to provide DNOs with sufficiently high system input pressures to meet their planning requirements on days of high demand, up to 1 in 20 forecast peak demand levels. There is an interaction between AOPs and NTS Exit (Flexibility) Capacity when providing DNOs with sufficient levels of linepack to meet their diurnal storage planning obligation.

Under the enduring exit capacity regime, DNOs must book any additional Enduring Annual NTS Exit (Flat) Capacity required through the annual application process. These processes result in annual capacity bookings and pressure commitments that National Grid NTS is required to meet from the start of the next gas year and NTS Exit (Flexibility) Capacity for four years into the future. DNOs may also provide indicative NTS Exit (Flexibility) Capacity bookings for a fifth year to signal possible future capacity

The information provided under the UNC OCS process only covers five years of the ten year planning period. For plan years six to ten, National Grid NTS will adjust the OCS bookings using the forecast data developed through the demand forecast process (and published in the GTYS) to understand potential DNO bookings in the later years of the plan. These assumptions of demand growth are needed to ensure that any projects identified in the early years of the plan can be assessed against potential demand through the ten-year period.

The UNC OAD Section H describes the long term forecast data that is shared between National Grid NTS and the DNOs. Both parties are required to provide the other with their forecast of gas demand, although there is no obligation on either party to use the projections provided. National Grid NTS may use the information provided by DNOs as part of their UNC OAD Section H data to develop demand scenarios for off-peak analysis. For example the information may be used to determine demand distribution across Distribution Networks for analysis on different days of the severe and average load duration curves.

Appendix E

Accounting for uncertainties

This section describes the analysis outputs of National Grid's Gas Planning and Operating Standards (GPOS) project, ensuring that appropriate drivers of within-day linepack depletion, which reflect the conditions and challenges experienced by the GNCC, are taken into account in planning processes across all time horizons.

In addition, this covers the analysis of "uncertainties" around the behaviour of supplies, demands and assets and how these are used in the calculation of pressure covers to ensure that there is sufficient operational resilience for defined unforeseen events to occur.

Supplies

The following section describes National Grid's approach to accounting for increasingly variable within-day supply behaviours. The first subsection, Supply Profiling, considers the increasing tendency for supplies to profile away from a flat rate during day-to-day operations. The second subsection, Supply Losses, considers sudden, unforeseen losses of flow from key supply points. Both behaviours contribute to supply driven linepack depletion and can materially affect the ability to meet the NTS safety and commercial limits.

Supply Profiling

This considers the anticipated supply profiles to be used in network analysis and the resultant supply driven linepack depletion expected during routine operations. In all forms of planning analysis, supplies have generally been modelled as flat; the rate for any given supply point simply the total supply at that point for a given gas day divided equally over the twenty-four hour bars (also known as 'one twenty-fourth rate'). This approximation has generally been adequate to date since, historically, supply driven linepack depletion has been insufficient to materially impact network operations and planning. Increasing within day flexible behaviour however, and in this case a growing tendency to backload supplies within the gas day, has led to the need to revise this approximation and explicitly model within day supply profiling, in addition to flat supplies. The aim of this section then is to describe National Grid's methodology for calculating such profiles for use within network analysis.

The methodology consists of:

- Using historic supply data to calculate the volume of supply driven linepack depletion to be used in network analysis to adequately account for supply profiling. Note that this will set the overall profiling behaviour (i.e. how much backloading and from which supply points) but not the supply profiles themselves.
- Using similar historic analysis to create normalised profiles which, when paired with the required amount of supply driven linepack depletion, can be used to specify the set of supply profiles for a given supply and demand scenario.
- Combining the calculated quantity of supply driven linepack depletion with the normalised profiles allowing the production of the complete set of supply profiles for a given supply and demand scenario.

Calculating an appropriate level of linepack depletion resulting from supply profiles

To calculate the quantity of supply driven linepack depletion, hourly average supply volumes through all relevant supply points for each gas day for a 3 year period are considered.

Thereafter, all known supply losses from the data set are removed using a catalogue of recorded supply losses for the same period. This is to ensure only intentional day-to-day supply profiling is considered, leaving a treatment of unforeseen supply losses and the resultant recovery of supplies to the following section.

With supply losses removed the total supply driven linepack depletion for each remaining gas day is then calculated as follows (in line with the UNC definition for NTS Exit (Flexibility) Capacity)

$$V_{\mathrm{LP}} = V_{22:00} - \frac{2}{3} V_{\mathrm{Total}},$$

where V_{LP} is the total supply driven linepack depletion, $V_{22:00}$is the total volume of gas that entered the NTS between 06:00 and 22:00 of the gas day in question and V_{Total} is the total quantity of gas that entered the NTS on the same gas day. The following histogram shows the distribution of the total supply driven linepack depletion for a 3 year period.

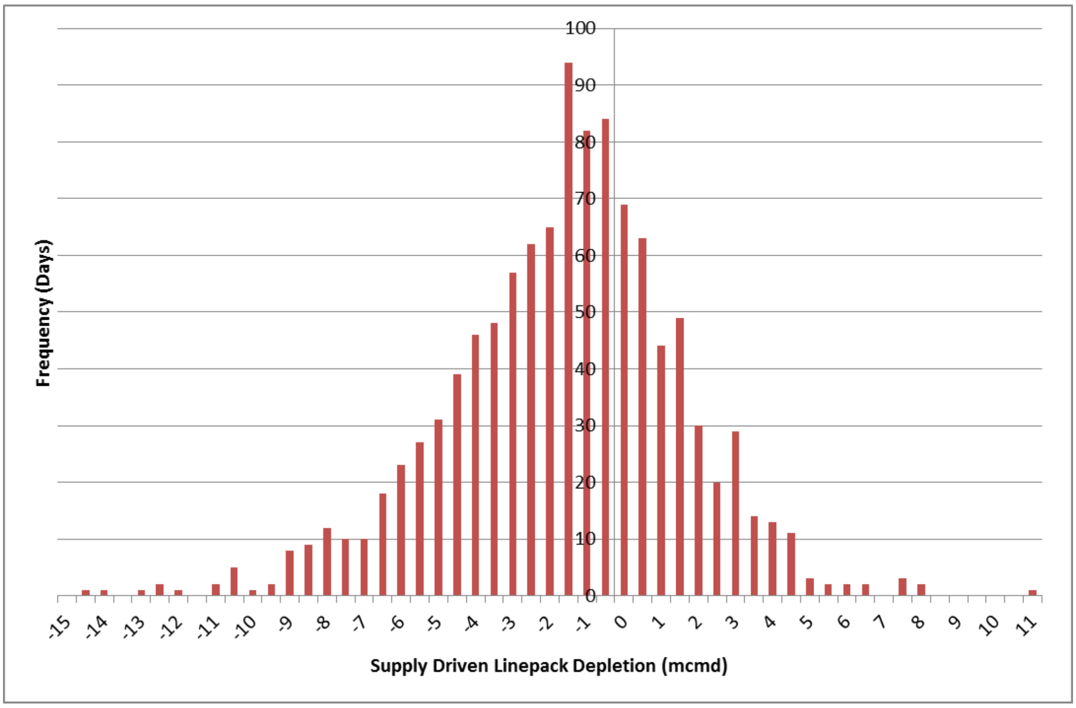

Figure E1: Number of instances of a given total supply driven linepack depletion for a 3 year period.

Figure E1 shows an approximately normal distribution of total supply driven linepack depletion, with an overall preference for backloading. In line with section 2.2.1.1, the equivalent to a '1 day in 20 years' value will be periodically re-assessed. This will provide a maximum quantity of supply driven linepack depletion to be considered, alongside flat supply levels, in National Grid's network capability assessments.

This is a total supply driven linepack depletion at a national level. To break this down amongst supply points, the 25 highest supply driven linepack depletion days are chosen from the data set and the contribution of each supply point is calculated. The cumulative linepack depletion by supply point across those 25 days is analysed and those supply points that make up the top 90% of the cumulative total supply driven linepack depletion across those 25 days are identified. The 95th percentile of the supply driven linepack depletion by supply point across the 25 days is identified and this value is converted into a percentage of the total supply driven linepack depletion

Normalised supply profiles

Whilst the results of the previous section dictate the overall profiling behaviour (i.e. how much backloading and from which supply points), the individual profiles for each supply point are then calculated for use within network analysis. To this end, for each supply point. the normalised supply profiles are identified and then combined with the results of the previous section to produce the complete set of supply profiles for a given supply and demand scenario in the following section.

To do this, National Grid again considers the 25 highest supply driven linepack depletion days and calculates the normalised supply profiles by supply point for each day (a normalised supply profile giving a total of 1 *million cubic metres (mcm)* delivered to the NTS over a gas day). To produce a backloading profile the 5th percentile for each hour before 22:00 across the 25 gas days and the 95th percentile for each hour after 22:00 for each supply point are identified, before re-normalising the resultant profiles. An example of a final, normalised profile is illustrated in Figure E2.

The result then is a set of normalised supply profiles, one for each profiled supply point.

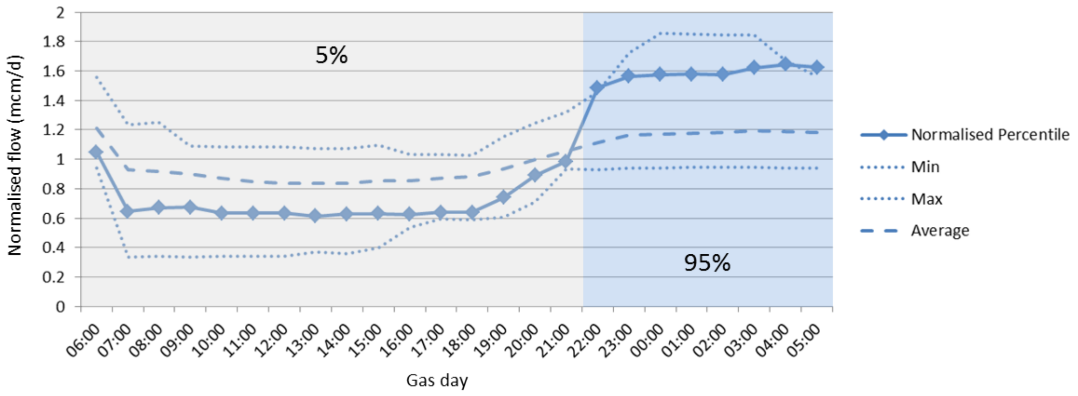

Figure E2: Example normalised supply profile, with maximum, minimum and average profiles illustrated for reference.

Unforeseen Supply losses

This section considers unforeseen supply losses; sudden and significant unplanned reductions from a supply terminal or sub-terminal, capable of materially contributing to within day linepack depletion. To compensate, a combination of additional supplies elsewhere on the network, as well as from the affected sub-terminal itself (after supplies are restored) are then required. Causes of such a loss can include, but are not limited to, offshore production problems (e.g. bad weather), a fault at a particular terminal (e.g. an unforeseen plant failure) or inbound out of specification gas (e.g. a flow reduction caused by a Terminal Flow Advice). For the purposes of this analysis no assumptions are made regarding the cause of the loss, the results being applicable to all supply loss scenarios. The resultant linepack depletion caused by such a loss could result in an inability to meet minimum required pressures. To mitigate this risk, this section describes National Grid's methodology for modelling severe supply losses for use in network analysis.

The methodology consists of:

- Building a supply loss model capable of replicating the pertinent features of real supply losses on the network.
- Choosing appropriate values for the model parameters such that the features of the losses (e.g. magnitude, duration etc.) and subsequent network resilience are sufficient for the agreed requirements.

The model

Figure E3 schematically illustrates a general model for a single supply loss from a given supply point and the associated model parameters. The model is chosen to encompass all the behaviours of a real supply loss pertinent to the GPOS.

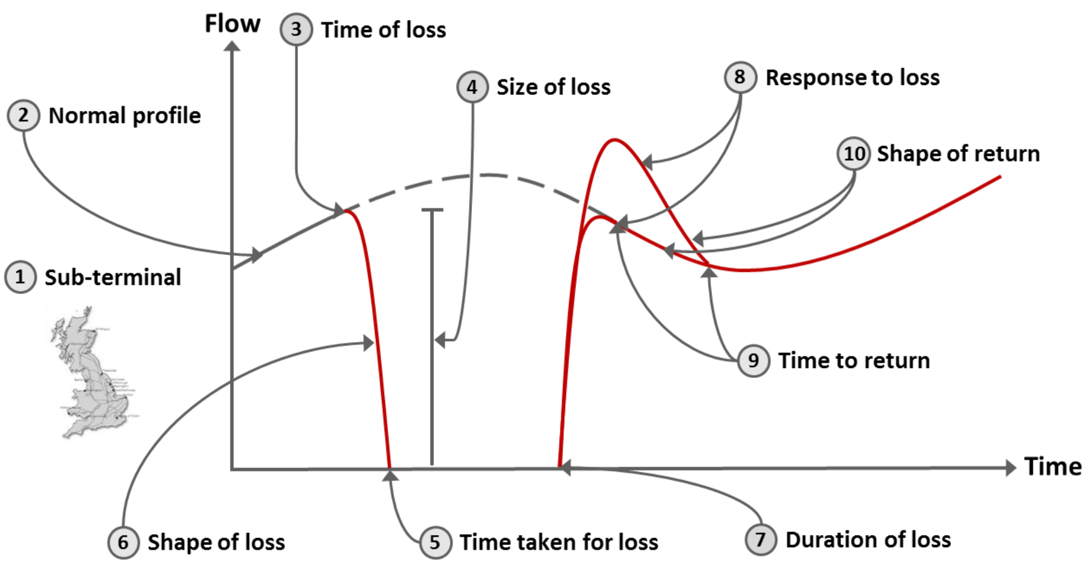

Figure E3: Supply loss model with associated parameters

The model parameters illustrated in Figure E3 are as follows:

1. **Sub-terminal -** The sub-terminal at which a supply loss is being considered.
2. **Normal profile** – The supply profile that would otherwise be assumed in the absence of a supply loss.
3. **Size of loss** – The amount by which the flow drops during the supply loss.
4. **Time taken for loss -** The time period over which the flow drop occurs.
5. **Shape of loss** – The profile of the flow drop itself.
6. **Duration of loss** – The period of time between the end of the flow drop and the start of the flow increase.
7. **Time of loss** – The time at which the loss occurs.
8. **Response to loss -** The mode by which supplies compensate (i.e. a combination of compensation at the affected sub-terminal and alternative sub-terminals on the network).
9. **Time to return** – The time period over which flows recommence to the 'normal profile'.
10. **Shape of return** – The profile of the flow increase itself.

Choosing model parameters

Having defined a suitable supply loss model, values for the model parameters are chosen to ensure that the supply losses modelled and corresponding network resilience are in keeping with the agreed requirements. Historical analysis, business insight, modelling constraints and computational complexity are all used in the determination of the model parameters.

To arrive at the data set used for historical analysis, hourly average supply volumes through all relevant supply points for each gas day for a 3 year period are considered. Thereafter, the hour bar over which the supply rate for each supply point experienced the greatest drop within each gas day is identified. The top ten supply drops for each supply point that reflect true supply losses (i.e. excluding noisy data or data anomalies) can then be identified.

The below details the model parameters. To help clarify the description, refer to Figure E4 below.

1. **Sub-terminal** – The sub-terminals considered to be the highest risk in terms of the potential impact of a supply loss.
2. **Normal profile** –The supply profiles that would otherwise be assumed in the absence of a supply loss are chosen to be those derived in the previous section.
3. **Size of loss** – Losses are to be modelled as 100% (i.e. a drop to 0*mcm/hour*) for the duration of the loss. This is in keeping with a number of 100% losses observed in the historical data.
4. **Time taken for loss** – Modelling is undertaken in hourly time steps. Given the immediate nature of supply losses and that a ramp down in supply lasting for 2 hours or greater could be considered within day profiling, the time period over which the flow drop occurs is to be set at 1 hour.
5. **Shape of loss** – Given that the ramp down is to occur over 1 hour and that hourly time steps are assumed throughout, the ramp down must necessarily be modelled as a constant rate change between the time of the loss at 14:00 and reaching a flow of zero at 15:00.
6. **Duration of loss -** The average loss duration for the sub-terminals considered in the historic data set is approximately 8 hours, with the loss duration defined as the time

taken for the system supply rate to return to its value at the time of the loss. This value is used for modelling purposes, given that a significantly shorter timescale would be unlikely to have a material impact on system pressures, whilst a significantly longer timescale would be considered a potential network emergency.

7. **Time of loss** – Given that the typical duration of a loss is to be set at 8 hours; losses will be set to begin at 14:00 such that their end coincides with the typical time of minimal system linepack (approximately 22:00). This provides the most challenging network conditions, since the supply loss driven linepack depletion will coincide with the daily period of minimal system linepack, resulting in the lowest resultant network pressures.
8. **Response to loss** – Typically the gas deficit caused by a supply loss is compensated by the affected supply point increasing its flow rate after supplies have been restored. As well as this at alternative supply points on the network also increase. For each supply point considered, the responses are pro-rated amongst a selection of supply points according to their historical contributions. To derive these contributions, the difference in flow rate between the loss time and recovery time is calculated, for each supply point, for each of the top ten supply losses.
9. **Time to return** – Whilst a range of flow behaviours are exhibited amongst the losses in the data, from gradual to rapid responses, for the purposes of this analysis we choose the minimum time (i.e. 1 hour) over the last hour of the loss (i.e. from 21:00 to 22:00).
10. **Shape of return** – For the final hour of the supply loss (i.e. from 21:00 to 22:00) all ramp ups are to be modelled as a constant rate increase, again owing to the use of hourly time steps throughout. For each sub-terminal, the extra supply required to compensate for the loss deficit is to then be distributed equally over the remainder of the gas day (i.e. from 22:00 to 05:00), with the exception that during the final hour bar (from 04:00 to 05:00) all flow rates must return to their start of day values in order to conduct network analysis.

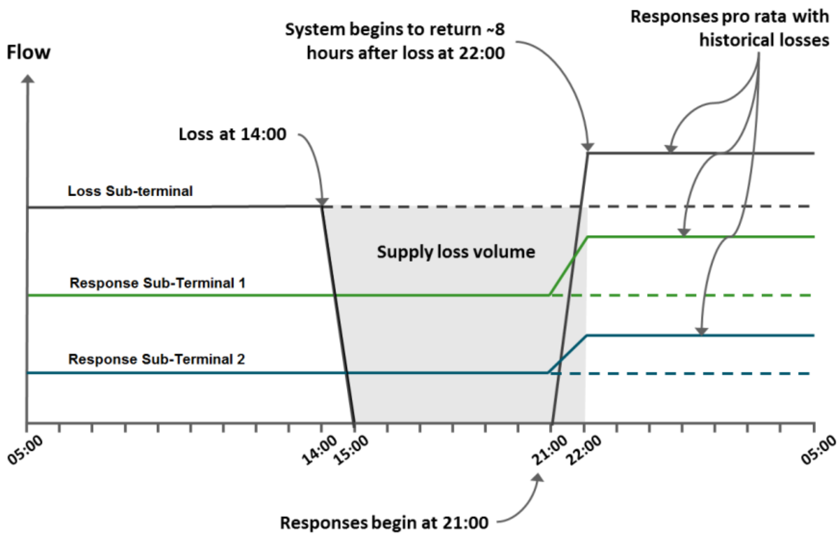

Figure E4: Schematic illustration of parameter choices. Note that this is a representative example and does not directly relate to the final calculated supply losses.

Demands

As the system has changed, alternative supplies connecting to the network along with changing demand profiles has resulted in fundamental changes to the way the NTS is now operated. Over the years a number of CCGTs have connected to the network, resulting in increased demand profiles in some regions. To ensure suitable levels of resilience are in place it is imperative to understand CCGT behaviours and their potential impacts on network extremities.

A CCGT's ability to move away from a forecast demand profile or nominated rates as well as ramping up to higher flows in short periods can have a substantial impact on instantaneous flow rates on the network and hence can contribute significantly to linepack depletion in that region. It is for this reason an appropriate amount of resilience is required.

To this end, two geographical regions have been focused on, these are the South East and South West extremities. Particular focus has been placed on these system extremities as there are a number of connected CCGTs in both regions. Typically these are NTS capacity constrained areas of the network when local supplies are low. Within each region 5 CCGTs and their respective profiles over a 5 year period were observed.

CCGT Demand Profiles

This section describes National Grid's methodology to ensure appropriate demand driven linepack depletion resulting from CCGT demand profiles is taken into consideration.

A number of factors can contribute to the profiling of CCGTs, some of which may have a bigger impact on profiling and hence linepack depletion. Some of the factors can include forecasting errors, weather and the availability of other forms of electricity generation.

Calculating an appropriate level of linepack depletion resulting from CCGT demand profiles

Similar to supply profiling, the 25 days where the NTS saw the biggest regional linepack depletion in the South East, and the South West, due to CCGT profiling are identified. It is these days which are then used as a base to create normalised profiles.

Data sets are created for all 25 days with greatest linepack depletion. These are then used to create hourly flow profiles on each day. Figure E5 shows an example profile of 5 CCGTs on a highly profiled day. The blue line is the total flow seen over the course of the day.

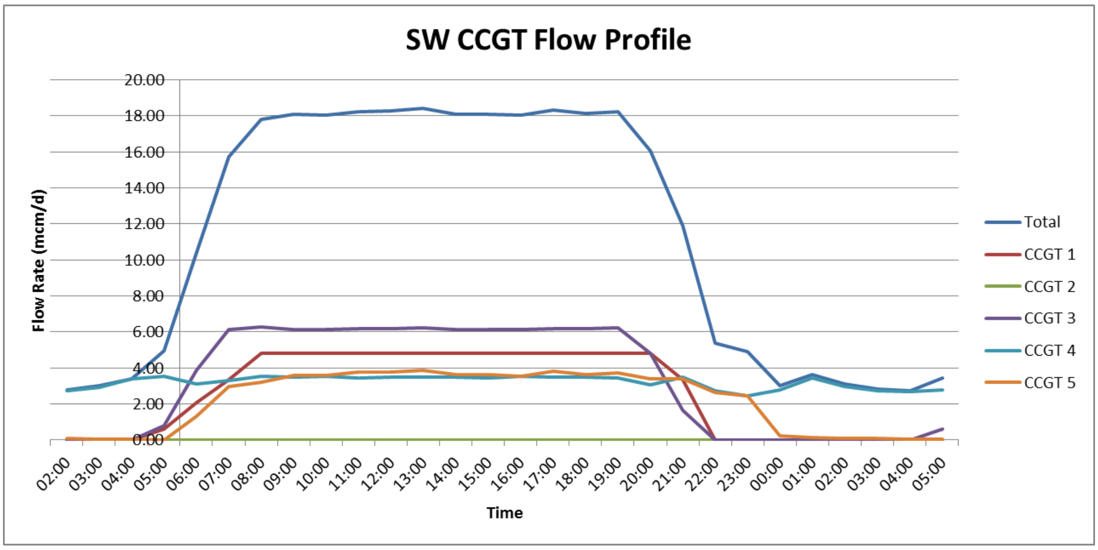

Figure E5: *South West CCGT Flow profile over a real gas day*

Normalised linepack depletion profile

Normalised linepack depletion profiles are created based on the historic data set. To create a linepack depletion profile, the 95th percentile figure (high flow) is used between 06:00 and 22:00 and 5th percentile figure (low flow) used from 22:00 to 06:00 (see Figure E6).

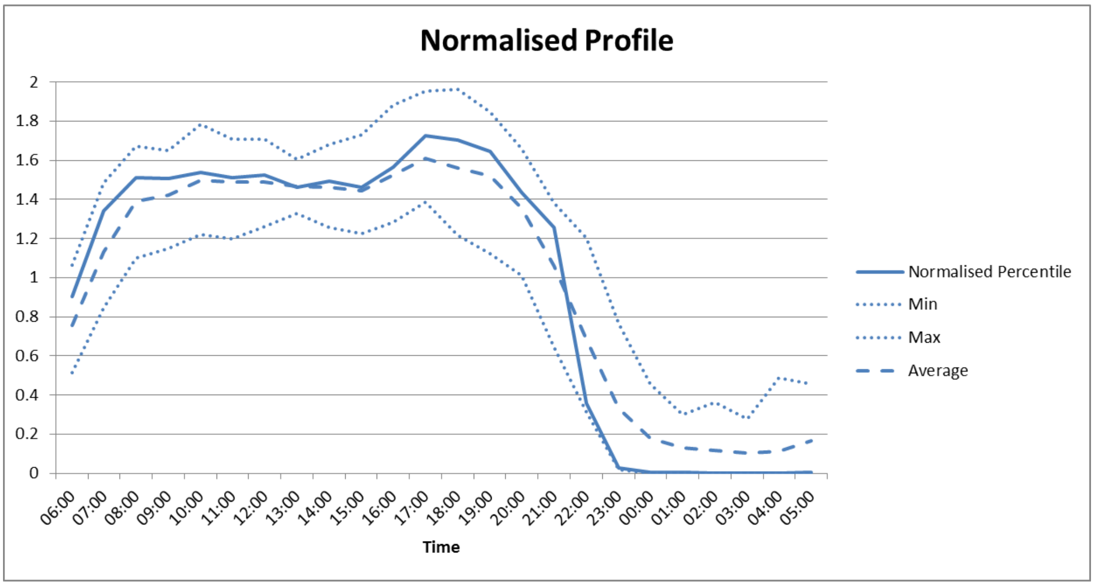

Figure E6: *Normalised linepack depletion profile in the South West, based on 25 highest linepack depletion days*

If the normalised profile, when applied to the forecast end of day volume of a CCGT breaches the MNEPOR of an exit point at any point during the day, the profile is scaled so that the MNEPOR is adhered to.

In order to provide a comparison of this approach to historic levels, the 25 days with the highest CCGT driven linepack depletion in the South West range between 2.5mcm and 3.15mcm of linepack depletion. National Grid's methodology typically generates 2.5mcm of linepack depletion.

Unforeseen Increases in CCGT Demand

A sudden increase in a CCGT's demand can have a substantial impact on instantaneous flow rates on the network and hence can contribute significantly to linepack depletion. Similarly to CCGT profiling, forecast errors, weather and faults on other forms of electricity generation can all contribute to sudden increases in CCGT demand.

CCGT demand increases can occur at any time, however, it is the time at which this demand ramp up begins which is of vital importance to real time operations due to the impact on local pressure and linepack. This sudden ramp up in demand can also have implications on nearby compression, as increased demand will in turn cause nearby compression to work harder to meet downstream pressure requirements and can potentially lead to compressor trips. This behaviour is especially pertinent to both the South East and South West extremities due to their location and the distance they are from NTS supplies. Smaller diameter pipework feeding these extremities also greatly affects pressures when flows increase.

Calculating appropriate increases in CCGT demand

Using historical data collected over 5 years, sudden increases in demand for South East and South West CCGT's are identified. Increases are considered over a 1 hour, 2 hour and 3 hour period.

Based on changes of hourly flow data, CCGT rate changes over the gas day are assessed, illustrated in Figure E7. Maximum rates of change along with a 99th percentile rate of change have been included in the following figure. The 99th percentile is used for network analysis, as all days are included in this data set as this is equivalent to excluding the top 4 days. Figure E7 shows two significant peaks which represent morning and evening demand respectively, analogous to electricity demand.

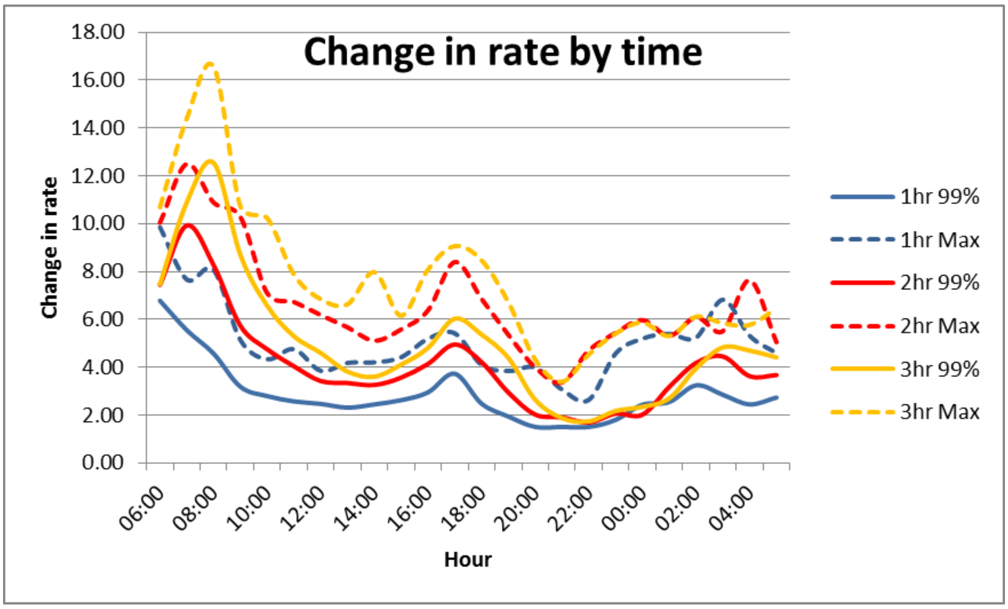

Figure E7: Changes in CCGT demand over time in the Southwest region.

Increased demand profiles

To create a flow profile which incorporates historic ramping behaviour which could then be used in network analysis, the relevant 3-hour increase as described in the previous section is combined with the CCGT demand forecast for each CCGT in the South West and South East for each supply and demand pattern considered. Figure E8 is an example of how the 3-hour ramp rate has been applied to forecast CCGT demand in order to meet the historic maximum flow.

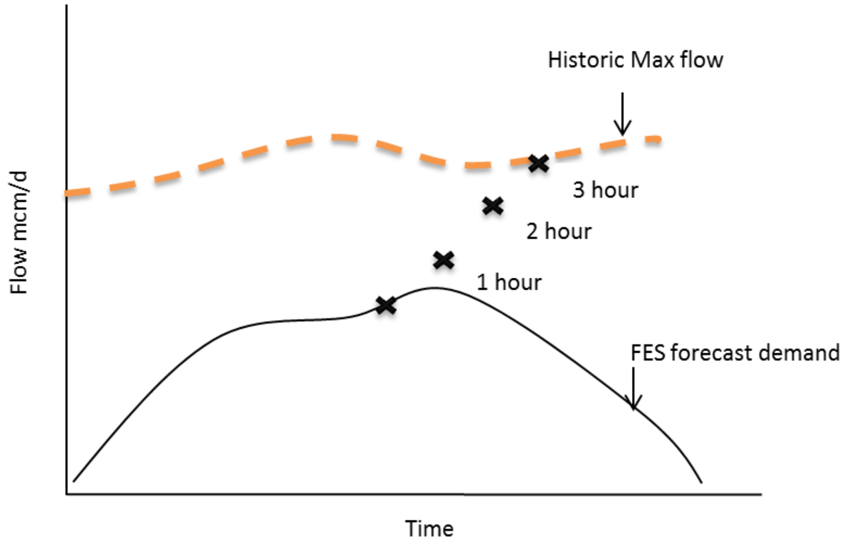

Figure E8: Sudden increase in demand over 3 hours, applied to forecast CCGT demand

Figure E9 shows an example CCGT demand profile for a given supply and demand scenario. The calculated rate of increase has been applied to the flow profile from 14:00. By doing this, additional linepack depletion is experienced due to additional demand increases without an immediate supply response (as experienced by the GNCC in real time operations).

The flow profile is then continued until 22:00 (approximate point of minimum linepack), at which point flow begins to decrease as demand normally turns down or until the end of the gas day to assess the potential impact of flows remaining at their historic maximum.

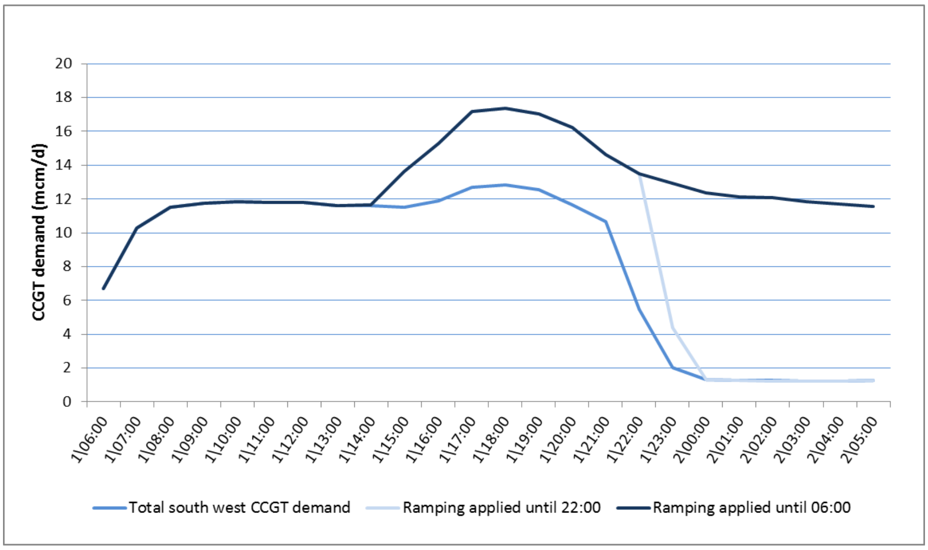

Figure E9: Ramp rate applied to South West Profile from 14:00.

Assets

The NTS is controlled and configured using a variety of assets including compressors, valves and regulators. All ‘controllable’ assets present a risk that they may not respond to control actions from the GNCC. Although processes are in place to mitigate this risk, and occurrences are rare, it remains a possibility. Due to their significant complexity, and associated safety, monitoring and ancillary systems, response failures or trips (either failure to start or unforeseen shutdown whilst running) are more common in compressors. In addition to this, instances of failures to start, or trips, can be exacerbated by operating assets in a mode which is different to which they were designed. For example, the majority of the compressors on the NTS were designed to operate to allow bulk transportation of gas across the country, from North to South, This required, steady, continuous running. Given changes in NTS supply and demand behaviour, compressors are now required to operate much more flexibly, with quick increases, and decreases, in output. Compression failures are likely to have greater impact on the NTS than control failures on other assets.

Effects of a compressor trip

Compressor units are usually started, either to increase falling downstream pressures and move gas towards the demand points, or, closer to supply points, to reduce upstream pressures and enable higher input rates by moving gas away from these locations. When a failure to start, or start-up trip occurs the compressor has no effect on the NTS and fails to increase downstream pressures. This means that the pressure decay or event triggering the use of the compressor continues unaffected.

A running trip (when the compressor suddenly stops whilst in operation) results in a sudden loss of immediate downstream pressure, with the effect continuing downstream as you get further from the compressor. Unless re-started the downstream pressure reduction will continue until the pressure downstream has equalised with that on the upstream side, effectively the local state that would be seen without the compressor running. It is also possible for compressor trips to adversely affect nearby equipment and other compressors, the changing flow and pressure conditions resulting from a trip can cause additional trips of adjacent units. These events can ultimately compromise National Grid’s ability to ensure that system pressures stay within the maximum and minimum operating limits.

Recovery

Compressor trips occur for various reasons, including mechanical failure and sensor faults, and the response time to either re-start a unit or bring an additional unit online can vary. These limits can either be as a result of the time required to get staff to site, if out of normal hours, or as a result of hard coded limits put in place by the manufacturer.

If a response is time critical, and alternate units are available then the GNCC may choose to use an alternate unit on site sooner, or re-configure the NTS and/or use an alternative site to provide partial mitigation.

Trip/start failure frequency

Across the whole NTS there are 68 compressor units, across 25 compressor stations. National Grid assesses the frequency of compressor trips to ensure suitable resilience is maintained. As more compression is typically used during the winter months and at high demand levels, the number of compressor trips observed is higher in these periods. Therefore, resilience is included for the possibility of a compressor trip on any given day where its use is required.

Calculating Locational Pressure Cover

The results of the analysis into magnitude, duration and frequency of supply, demand and asset events are then fed into specific network analysis activities to assess the impact of these events on system pressures, in order to determine appropriate levels of locational pressure cover. These events are considered individually and not in combination.

Analysis is undertaken across a range of supply and demand patterns and national linepack levels in order to determine how the required pressure cover varies accordingly.

Figure E10 shows how pressure cover is calculated for an exit point for a given event at a given supply and demand pattern. The first diagram shows the simulated pressure profile with no event. The second diagram shows the impact of the event on local linepack and hence the simulated pressure at that point. In this example, the Distributions Network's Assured Offtake Pressure cannot be maintained at all times throughout the gas day. Pressure cover is therefore required to ensure that should the event occur, the control room has sufficient time to determine and enact the appropriate response to ensure that the AOP is maintained.

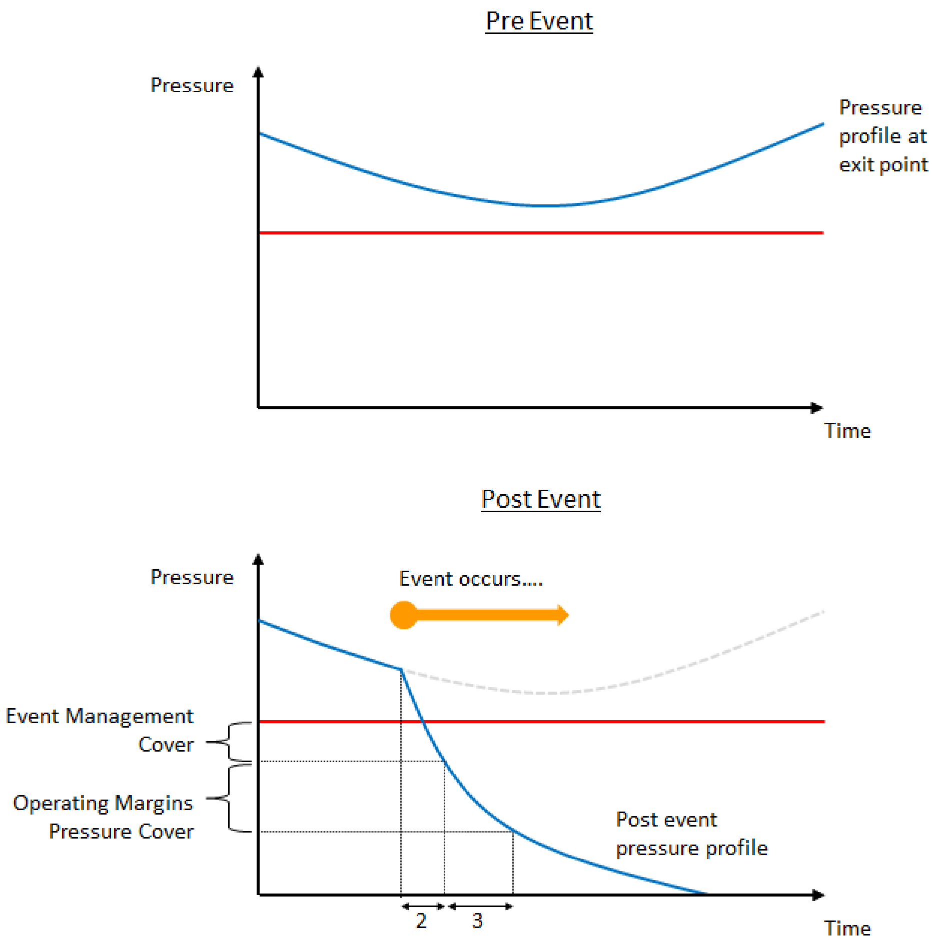

Figure E10: Calculating pressure cover

As described in Section 6.7.2, each pressure cover is calculated based on 2 categories:

1. Event Management – a period of up to 2 hours allowing the Control room to formulate a response to an event and attempt resolution (Entry and Exit)
2. Operating Margins (OM) – Should the control rooms attempted resolution be unsuccessful, a period, defined within Operating Margins contracts, between Control room 'calling' OM and the physical response. (Exit Only)

This is repeated for all defined events across supply and demand patterns and national linepack levels in line with the process described in Figure E11.

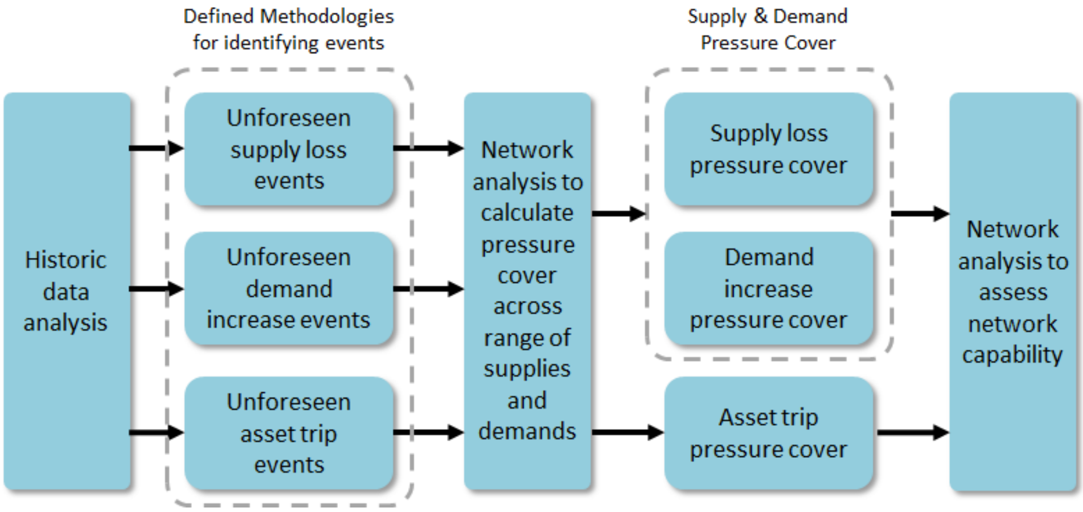

Figure E11: Pressure Cover calculation process

Determination of the Technical Capacity of the National Transmission System - Compliance with Regulation EC715/2009

Background

In order to be compliant with EU Regulation EC 715/2009 of 13 July 2009 on conditions for access to the natural gas transmission networks:

"Transmission System Operators shall publish a detailed and comprehensive description of the methodology and process, including information on the parameters employed and the key assumptions, used to calculate the technical capacity"[32].

"Technical capacity" is defined[33] as "the maximum firm capacity that the Transmission System Operator (TSO) can offer to users, taking account of system integrity and the operational requirements of the network" and must be published "on a numerical basis for all relevant points including entry and exit points"[34].

The National Transmission System (NTS) is a complex gas network with many interactions; hence the technical capacity needs to be defined in respect of statutory obligations and customer requirements as well as physical limitations.

Baselines

In the UK, the establishment of baselines is a Regulator led process which involves the Regulator, the Gas and Electricity Markets Authority ("the Authority"), setting defined quantities of capacity at entry and exit points, to and from, the NTS. Through the Licence[35] the Authority have placed obligations on National Grid Gas (NTS) ("National Grid") to offer this baseline capacity for sale through a number of entry capacity auctions and exit capacity application processes.

Baseline capacity satisfies the above definition of technical capacity in that it:

- can be, and is, offered to users as firm capacity,
- is determined after taking account of system integrity and the operational requirements of the network and
- is determined on a numerical basis for individual, i.e. relevant, points on the network.

Baselines were not set in isolation, but were determined as part of the wider Transmission Price Control Review (TPCR) package negotiated with the Authority, the most recent being TPCR4 covering the period 2007 to 2012. Industry consultations on baselines are incorporated within the broader Licence development covering gas transportation in its entirety, including the capacity regime.

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[32] Commission Decision of 10 November 2010 amending Chapter 3 of Annex I to Regulation (EC) 715/2009, paragraph 3.1.2.(m).

[33] Article 2.

[34] Article 18 paragraph 3.

[35] National Grid Gas plc Gas Transporter Licence in respect of the NTS.

The level of baseline capacity is based on statutory and commercial obligations supported by analysis of the network and its technical limits, i.e. they are based on the operational requirements of the system and its integrity. Once set, the Authority will fix baselines over the relevant price control review period, which has historically been five years. There is scope for varying baselines, but this is subject to defined rules and is subject to Authority scrutiny and approval. In accordance with the Licence, National Grid is obliged to make available to Users the baseline quantity. Hence, as baselines equate to the technical capacity of the NTS, the methodology used to determine baseline quantities is the same as that used to determine technical capacity. This methodology is described in detail below.

Determination of Technical Capacity at Entry Points

It should be noted that the methodology for determining baselines has evolved between different price control periods. The summary below describes the approach taken during the previous price control review (TPCR4)[36]. The key objective in determining Entry Capacity baselines is to set capacity levels that adequately reflect the physical capability of the network at each individual entry point and for the network in aggregate, whilst taking into account changing gas flow patterns on the network.

The following key points were considered in determining baselines and are described in more detail below:

- The Base network;
- Supply and demand assumptions;
- Balancing the network;
- Determining entry point capability;
- Zonal and nodal interactions

The Base Network

As mentioned above, the NTS is a complex gas transmission system with many interactions. In order to support the analysis required for setting baselines, the use of network analysis software (SIMONE) was required[37]. SIMONE is a detailed mathematical model of the NTS which was used to understand the likely flows and pressures on the system under a given set of supply and demand assumptions. The physical network model that was used to support analysis for the prevailing Gas Transportation Ten Year Statement (GTYS) (see below) was used for the network analysis undertaken to help determine baseline quantities. This was referred to as the 'base network' and comprised of existing infrastructure including planned investment.

Supply and Demand Assumptions

Annually, National Grid runs the Future Energy Scenarios consultation which sets out the latest projections for gas supply and demand for all years to 2050. This is based on information collected from many gas industry participants and the outcome of the long term entry capacity auctions. This information is then incorporated into the GTYS which is published at the end of National Grid's annual planning process and explains the latest volume forecasts, system reinforcement projects and investment plans. As published within the GTYS, one of the key drivers for investment in gas transportation infrastructure is the forecast level of "1 in 20" peak day demand, therefore NTS exit points were set to these flow levels. In order to manage the uncertainty in future supply patterns, National Grid developed

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[36] The detailed methodology of how baselines were set for TPCR4 can be found on the Authority website: http://www.ofgem.gov.uk/Networks/Trans/Archive/TPCR4/ConsultationDecisionsResponses/Pages/ConsultationDecisionsResponses.aspx

[37] Since 2010 all network analysis has been completed using the SIMONE (SIMulation and Optimization of NEtworks) analysis software.

a range of supply scenarios in order to determine relevant network reinforcement and investment projects.

Balancing the Base Network

As described above, the base network model is a representation of the existing and planned infrastructure on the gas transmission system. In order to use the model, entry and exit gas flows were required to be loaded into the model. The supply and demand scenarios described above were applied to each entry and exit point on the network model. A key assumption in performing network analysis requires that aggregate supplies entering onto the system must match aggregate demand being taken off the system.

Prior to balancing the network, the aggregate level of forecast supply (for each supply scenario) across entry points was greater than the "1 in 20" peak day demand. The supplies needed to be scaled down to match the peak day demand in order to balance the network. A 'merit order' approach was adopted which involved turning down supplies at storage sites. This was National Grid's standard approach for network modelling. The balanced base network represented the starting point from which to determine network capability.

Determining Entry Point Capability

Network capability at each entry point was defined as the maximum capacity that could be released at that entry point on a "1 in 20" peak day demand given the base network infrastructure and without triggering the need for network reinforcement. The following methodology considered each entry point in isolation. In order to determine the maximum nodal capability, gas flows entering at the chosen entry point were increased beyond the initial supply scenario forecast level (base flows) until a network constraint was identified, thereby indicating the threshold of maximum capability.

To keep the network in balance, a 'least helpful supply substitution' methodology was applied. Under this approach, as the supply at a particular entry point was increased to determine its maximum capability, supplies across other entry points were turned down to keep the network in balance. Selection of the entry points to turn down were those identified as providing the point of least interaction with the entry point in question whilst assuming flows at nearby entry points were relatively high. The difference between the maximum capability and the base flow was referred to as the "free increment" (i.e., the additional capacity that could be released at each entry point when considered in isolation, over and above the base flow). It should be noted that it is not possible to accommodate all of the entry point free increments simultaneously.

Zonal and Nodal Interactions

In addition to local (nodal) constraints there may be additional regional or 'zonal' constraints, i.e. the zonal free increment is less than the aggregate of the nodal free increments in that zone. In order to take these into account, the free increments were then considered on a zonal, rather than nodal basis. For example, if there were three entry points in a given zone with free increments of 50 GWh/d, 100 GWh/d and 20 GWh/d, the 100 GWh/d free increment would serve as a proxy for the maximum zonal free increment.

The maximum zonal free increment was then divided between each node in the zone in such a way that each node received at least the amount of capacity which had already been sold by National Grid in respect of that zone. Any remaining zonal free increment was then allocated in proportion to a measure of the 'size' of the entry point in question. The size of the entry point was approximated by the peak terminal supply associated with that entry point in the prevailing GTYS. The arithmetic mean of the results from all the supply scenarios modelled would then be used to calculate the baseline capacity.

Determination of Technical Capacity at Exit Points

Exit capacity baselines are determined using a 'Practical Maximum Physical Capacity' methodology. The overriding principle behind this approach is that exit capacity baselines are calculated consistent with the maximum quantity of capacity available at each node, given a set of plausible scenarios for flows elsewhere on the network.

This approach therefore takes into account the interaction between nodes. In essence these baselines will be above the 1 in 20 firm forecasts upon which the system is designed.
The methodology for determining baselines is described below:

1. The starting point is to establish a balanced demand and supply position based on 1 in 20 demand;
2. The NTS must be able to simultaneously meet the combined baselines at each offtake without the need for exit investment or significant capacity buy back
3. Increases in demand, to determine the maximum exit capability at an exit point, are matched with increases in supply based on forecast assumptions of additional entry capacity
4. Modelling continues, by increasing exit flow, until investment is required for ‘exit’ purposes

This process identifies the maximum capacity by exit point which has been used to equate to baselines, and hence technical capacity

Appendix G

Glossary

Aftercooler

A device fitted on a compressor station that cools the gas after the compression process, in order that the gas temperature may be maintained within safe limits for the downstream pipeline.

Assured Offtake Pressure (AOP)

A minimum pressure at an offtake from the NTS to a DN that is required to support the downstream network. AOPs are agreed and revised through the annual OCS process.

Anticipated Normal Operating Pressure (ANOP)

A pressure that National Grid may make available at an offtake to a large consumer connected to the NTS under normal operating conditions. ANOPs are specified within the NExA agreement for the site.

Bar

The unit of pressure that is approximately equal to atmospheric pressure (0.987 standard atmospheres). Where the unit of bar is suffixed with the letter g, such as in bar(g), the pressure being referred to is gauge pressure, i.e. pressure relative to atmospheric pressure.

BEIS

Department for Business, Energy & Industrial Strategy.

Calorific Value (CV)

The ratio of energy to volume measured in mega joules per cubic metre (MJ/m^3), which for a gas is measured and expressed under standard conditions of temperature and pressure.

Compression Energy

Gas and electricity used by National Grid to operate the transportation system that includes energy used for compressor fuel, heating and venting.

Compressor Station

An installation that uses gas turbine or electrically driven compressors to boost pressures in the pipeline system. Compressors are used to increase transmission capacity and move gas through the network.

CV Shrinkage

A quantity of energy that may not be billed to end consumers under the Gas (Calculation of Thermal Energy) Regulations 1996. CV Shrinkage arises from variations in CV across an LDZ above a certain threshold. End consumers within the LDZ may only be billed on a maximum CV assumption of 1 MJ/m^3 above the Flow Weighted Average CV entering the LDZ.

Delivery Facility Operator (DFO)

The operator of a reception terminal or storage facility, who processes and meters gas deliveries from offshore pipelines or storage facilities before transferring the gas to the NTS.

Distribution Network (DN)

A gas transportation system that delivers gas to industrial, commercial and domestic consumers within a defined geographical boundary. There are currently eight DNs, each consisting of one or more Local Distribution Zones (LDZs). DNs typically operate at lower pressures than the NTS.

Distribution Network Operator (DNO)

Distribution Network Operators own and operate the Distribution Networks that are supplied by the NTS.

Domestic Customer Supply Security Standard

The availability of a supply of gas which would equal the peak aggregate daily demand for the relevant gas supplier's current domestic customers which, having regard to historical weather data derived from at least the previous 50 years and other relevant factors, is likely to be exceeded (whether on one or more days) on in 1 year out of 20 years. The definition also includes the availability of supplies of gas over a year which could equal the aggregate annual demand, and over the first six months of a year which would equal the aggregate demand during such a six month period which, in each case, is likely to be exceeded only in 1 year out of 50 years.

Entry Capacity

The right to deliver a quantity of gas into the NTS at an Entry Point, as defined in the Licence and UNC TPD Section B.

Entry Capacity Release Methodology Statement

The Entry Capacity Release Methodology Statement ("ECR") is produced in accordance with Special Conditions 9A and 9B of the Licence. The ECR describes the methodology that National Grid employs to determine the quantity of entry capacity that it will release to comply with its obligations in the Licence and Uniform Network Code. It applies to all entry capacity, i.e. existing system entry capacity and additional "incremental" entry capacity, including capacity release at Interconnection Points. In particular, it defines under what circumstances National Grid will accept applications for incremental entry capacity from Shippers received through processes described in the Uniform Network Code, and thereby the level of financial commitment required from those Shippers.

Entry Capacity Substitution Methodology Statement

The Entry Capacity Substitution Methodology Statement is produced in accordance with Special Condition 9A of the Licence. This document describes the methodology that National Grid will utilise when considering the substitution of NTS Entry Capacity from one ASEP to another ASEP where demand for entry capacity exceeds existing obligated quantities. In particular, it defines:

- under what circumstances National Grid will consider such substitutions; and
- the process to be undertaken by National Grid to determine its proposals to substitute capacity and revise baseline quantities.

Entry Capacity Transfer and Trade Methodology Statement

This Entry Capacity Transfer and Trade Methodology Statement ("ECT&T") is produced by National Grid in accordance with Special Condition 9A of National Grid's Gas Transporter Licence (the "Licence").

Entry Point

A point at which gas is delivered into the NTS. The Entry Point may comprise several facilities where gas is delivered. Also referred to as an Aggregate System Entry Point in the UNC.

European Union Emissions Trading Scheme (EU ETS)

European Union market based policy commencing on 1 January 2005 to tackle emissions of carbon dioxide and other greenhouse gases, in order to help combat climate change.

Exit Capacity

The right to offtake a quantity of gas into the NTS at an Exit Point, as defined in the Licence and UNC TPD Section B.

Exit Capacity Release (ExCR) Methodology Statement

The Exit Capacity Release Methodology Statement is produced in accordance with Special Conditions 9A and 9B of the Licence. This document describes the methodology that National Grid employs for the release of all exit capacity, i.e. incremental and existing system exit capacity, including capacity release at Interconnection Points.

Exit Capacity Substitution and Revision (ExCS) Methodology Statement

The Exit Capacity Substitution and Revision Methodology Statement is produced in accordance with Special Condition 9A of the Licence. This document describes the methodology that National Grid will utilise to determine proposals for:

- the substitution of NTS exit baseline capacity from one NTS Exit Point to another where demand for exit capacity exceeds existing obligated quantities; and/or
- the revision to NTS baseline exit capacities at NTS Exit Points where new pipeline infrastructure installed to facilitate the release of incremental entry capacity has a beneficial effect on the availability of exit capacity.

Exit Point

A point at which gas is taken from the NTS. The Exit Point may comprise several facilities where gas may be taken.

Flow Swaps

National Grid NTS and/or a DNO User may request a revision to Offtake Profile Notices (OPNs) for two or more offtakes within a particular Local Distribution Zone (LDZ) where the revised rates of offtake requested are the same as the aggregate rates of offtake under the prevailing OPNs at the time the request is made. The rules around flow swaps are currently contained in UNC Offtake Arrangements Document (OAD) Section I2.4 and I2.5

Future Energy Scenarios (FES)

The Future Energy Scenario Consultation includes questionnaires, as well as one to one discussions with stakeholders, industry workshops and presentations to stakeholders. The

Future Energy Scenarios document describes in detail the assumptions behind our main scenarios used in planning analysis and future energy scenarios.

Gas and Electricity Markets Authority (GEMA)

The Gas and Electricity Markets Authority ("the Authority") governs the natural gas industry in the UK, and is the body that grants and administers licences to Gas Transporters, Shippers and Suppliers.

Gas Future Operability Planning (GFOP)

The GFOP is published annually alongside the GTYS, and contains information on the operability challenges that National Grid foresees for the NTS.

Gas Ten Year Statement (GTYS)

The Gas Ten Year Statement is published annually and contains information on National Grid's long term gas supply and demand scenarios, and investment proposals over the ten-year planning horizon.

Gas Transporter (GT)

Gas Transporters, such as National Grid, are licensed by the Gas and Electricity Markets Authority to transport gas to consumers.

Generic Revenue Driver Methodology Statement

This document is published by National Grid in accordance with Special Condition 9C and contains the statement of the methodology that National Grid employs to determine Revenue Drivers.

GSMR

Gas Safety (Management) Regulations

Health and Safety Executive (HSE)

The HSE is the UK regulatory body responsible for regulating health and safety at work.

Industrial Emissions Directive (IED)

The Industrial Emissions Directive came into force on 6th January 2011. IED recasts seven existing Directives related to industrial emissions into a single clear, coherent legislative instrument. The recast includes IPPC, LCPD, the Waste Incineration Directive, the Solvents Emissions Directive and three Directives on Titanium Dioxide.

IGEM

Institute of Gas Engineers and Managers

Incremental Obligated Entry Capacity

Special Condition 5F of the Licence categorises entry capacity into different classes of capacity for revenue purposes. Incremental obligated entry capacity is capacity that National Grid must offer for sale to Shippers above a pre-determined baseline level (also defined in the Licence) and is triggered through long term auction signals placed by Shippers.

Interconnector

A pipeline transporting gas to another country. The Irish Interconnector transports gas across the Irish Sea to both the Republic of Ireland and Northern Ireland. The Belgian Interconnector (IUK) transports gas between Bacton and Zeebrugge and is capable of flowing gas in either direction. The Dutch Interconnector (BBL) transports gas between Balgzand in the Netherlands and Bacton.

IPPC

Integrated Pollution Prevention and Control

Kilowatt hour (kWh)

A unit of energy used by the gas industry. Approximately equal to 0.0341 therms. One megawatt hour (MWh) equals 10^3 kWh, one gigawatt hour (GWh) equals 10^6 kWh, and one terawatt hour (TWh) equals 10^9 kWh.

Licence

Used in this document to refer to National Grid's Gas Transporter Licence in respect of the NTS.

Linepack

The volume of gas within the National Transmission System at any time.

Liquefied Natural Gas (LNG)

Gas stored and/or transported in liquid form.

Load Duration Curve (1-in-50 Severe)

The 1-in-50 severe load duration curve is that curve which, in a long series of years, with connected load held at the levels appropriate to the year in question, would be such that the volume of demand above any given demand threshold (represented by the area under the curve and above the threshold) would be exceeded in one out of fifty years.

Load Duration Curve (Average)

The average load duration curve is that curve which, in a long series of winters, with connected load held at the levels appropriate to the year in question, the average volume of demand above any given threshold, is represented by the area under the curve and above the threshold.

Local Distribution Zone (LDZ)

A geographic area supplied by one or more NTS offtakes that comprises a part of a Distribution Network.

Locational buys and sells on the OCM

When a Shipper has a clear idea of its supply and demand on a particular day, it may decide to use the OCM to buy gas from or sell gas to the NTS for system balancing purposes. The Shipper might also make Location Specific bids, which can be selected by the NTS when it needs to increase or reduce flows at a particular location.

Millions of Standard Cubic Metres per Day (mscmd)

A standard cubic metre is the unit of volume, expressed under metric standard conditions (15^{o}C, 1.01325 bar, dry gas), approximately equal to 35.37 standard cubic feet. 1 million standard cubic metres is equal to 10^6 standard cubic metres. The units "mscmd" refer to a standard volumetric flow rate.

National Transmission System (NTS)

A high-pressure gas transportation system consisting of compressor stations, pipelines, multi-junction sites and offtakes. NTS pipelines transport gas from terminals to NTS offtakes and are designed to operate up to pressures of 94 bar(g).

Network Analysis

The modelling of the physical behaviour of a network of pipes, compressors and other equipment using mathematical software.

Network Entry Agreement (NEA)

An agreement that sets out the technical and operational conditions for the connection and is required by the Uniform Network Code (UNC). The NEA is agreed between the Delivery Facility Operator (DFO) and National Grid and is normally discussed with the future operator of the entry facility in parallel with the connection process.

Network Exit Agreement (NExA)

An agreement that sets out the technical and operational conditions for the connection point. The NExA is agreed between National Grid and the Facility Operator and/or the Shipper and is normally discussed in parallel with the connection process.

NTS Exit (Flat) Capacity

The right to offtake a quantity of gas from the NTS at a steady rate over a gas day as defined in the UNC TPD Section B.

NTS Exit (Flexibility) Capacity

The right to vary the offtake a quantity of gas from the NTS at from a steady rate over a gas day as defined in the UNC TPD Section B. Only DNOs may hold NTS Exit (Flexibility) Capacity.

Offtake

An installation defining the boundary between the NTS and a DN or a very large consumer. The offtake installation includes equipment for metering, pressure regulation, etc.

Operational Balancing Actions

National Grid utilises a range of tools designed to deliver gas flow rate changes for management of the NTS. Some tools are direct e.g. locational actions. Other tools are less direct e.g. capacity buy-backs, gas trades and are used where commercial actions are anticipated to give rise to flow rate changes.

Offtake Capacity Statement (OCS)

The agreement made between National Grid and DNOs in respect of the DNOs' bookings for NTS Exit (Flat) Capacity, NTS Exit (Flexibility) Capacity and Assured Offtake Pressures as described in the UNC TPD Section B.

Offtake Flow Reductions

In relation to a relevant system exit point, a period of notice may be given to the relevant Gas Transporter of any change to the rate of offtake, an Offtake Rate Change, by means of a modified Offtake Profile Notice. The rates of change can be either an increase or a decrease.

Office of Gas and Electricity Markets (Ofgem)

The regulatory body responsible for regulating Great Britain's gas and electricity markets.

Operating Margins Gas

Operating Margins is a quantity of gas held in store to be used to maintain system pressures if other system management services are considered not to have the desired effect. A quantity of Operating Margins will be kept in reserve to manage the orderly run-down of the System following the exhaustion of all other storage gas and during periods of high demand. Operating Margins may also be used to support system pressures on the Gas Day in the event of a compressor trip, pipe break or other failure or damage to transmission plant.

Offtake Profile Notice

In relation to a relevant system Exit Point or NTS/LDZ Offtake a notification known as an Offtake Profile Notice (OPN) is submitted to the relevant Gas Transporter setting out the rates of offtake throughout the Gas Flow Day. The rules around OPNs are contained in UNC TPD J4.5.

Planning & Advanced Reservation of Capacity Agreement (PARCA)

A PARCA is a multi-phased bilateral contract, between National Grid and a customer, which, would allow Firm Quarterly System Entry Capacity and / or Firm Enduring Annual NTS Exit (Flat) Capacity to be reserved for that customer, whilst they develop the initial phases of their own project.

Peak Day Demand (1-in-20 Peak Demand)

The 1-in-20 peak day demand is the level of demand that, in a long series of winters, with connected load held at the levels appropriate to the winter in question, would be exceeded in one out of 20 winters, with each winter counted only once.

Quarterly System Entry Capacity (QSEC)

NTS entry capacity available on a long term basis (up to 17 years into the future) via an auction process. Also known as Long Term System Entry Capacity (LTSEC).

Regulator

A device that may be used to control gas pressure or flow rate.

Revenue Drivers

Revenue Drivers are the means of increasing National Grid's allowed revenue as a consequence of the release of Funded Incremental Obligated Entry/Exit Capacity to fund the construction of additional assets and/or contractual arrangements to facilitate the release of that capacity.

Scale back of interruptible NTS entry capacity

If the amount or rate at which gas is delivered or will be delivered to the NTS is greater than the system entry capability (as determined by National Grid) or if there is or will be a transportation constrained or localised transportation deficit, interruptible NTS entry capacity holdings can be subject to curtailment at one more NTS entry points on a pro-rated basis per shipper based on shippers' capacity holdings.

Shipper

A company with a Shipper Licence that is able to buy gas from a producer sell it to a supplier and employ Gas Transporter(s) to transport gas to consumers.

Shrinkage

Gas that is input to the system but is not delivered to consumers or injected into storage. It comprises Compression Energy, CV Shrinkage and Unaccounted for Gas.

Storage Connection Agreement (SCA)

A Storage Connection Agreement contains elements of the Network Entry Agreement (NEA) and the Network Exit Agreement (NExA).

Storage Operator

The operator of a storage facility connected to the NTS.

Supplier

A company with a Supplier Licence that contracts with a Shipper to buy gas, which is then sold to consumers. A Supplier may also be licensed as a Shipper.

Transporter

See Gas Transporter.

Unaccounted for Gas

Energy transported through the NTS that cannot be accounted for, for example, as a result of metering uncertainty in the measurement of gas delivered to and taken from the system.

Uniform Network Code (UNC)

The Uniform Network Code is the legal and commercial framework that governs the arrangements between the Gas Transporters and Shippers operating in the UK gas market. The UNC comprises different documents including the Transportation Principal Document (TPD) and Offtake Arrangements Document (OAD).

UKCS

United Kingdom Continental Shelf.

Wobbe Index

The Wobbe Index is a parameter used to measure the interchangeability of fuel gases. Combustion appliances are designed to work safely over a particular range of Wobbe Index.

Appendix H

References

The following documents are available on our website, http://www2.nationalgrid.com/

- Gas Ten Year Statement (http://www2.nationalgrid.com/UK/Industry-information/Future-of-Energy/Gas-Ten-Year-Statement/)
- UK Future Energy Scenarios (http://fes.nationalgrid.com/)
- Demand Forecasting Methodology (http://www2.nationalgrid.com/uk/industry-information/gas-transmission-operational-data/supporting-information/)
- Gas Future Operability Planning (http://www2.nationalgrid.com/UK/Industry-information/Future-of-Energy/Gas-Future-Operability-Planning/)

Capacity Methodologies
(http://www2.nationalgrid.com/uk/industry-information/gas-capacity-methodologies/)

- Entry Capacity Release Methodology Statement
- Entry Capacity Substitution Methodology Statement
- Entry Capacity Transfer and Trade Methodology Statement
- Exit Capacity Release Methodology Statement
- Exit Capacity Substitution and Revision Methodology Statement

UK and European legislative framework documents may be obtained from following websites:

- Office of Public Sector Information (http://www.opsi.gov.uk/)
- European Union (http://europa.eu/index_en.htm)
- BEIS site (https://www.gov.uk/government/organisations/department-for-business-energy-and-industrial-strategy)
- Health and Safety Executive (http://www.hse.gov.uk/)
- DEFRA (http://www.defra.gov.uk/)
- Environment Agency (http://www.environment-agency.gov.uk/)
- Scottish Environment Protection Agency (http://www.sepa.org.uk/)

A copy of National Grid's Gas Transporter Licence in respect of the NTS is available from the Ofgem website on the Electronic Public Register at:

http://epr.ofgem.gov.uk/Pages/EPRSearch.aspx

The Uniform Network Code is available from the Joint Office of Gas Transporters website at:

http://www.gasgovernance.co.uk/.

A copy of the IGEM guidelines mentioned in this document may be purchased at:

http://www.igem.org.uk/.

Appendix J

Document Revision History

Version	Date of issue	Comments
0.1	17 July 2017	Draft document for discussion with industry.