

Gas Transportation
Transmission Planning Code

nationalgrid

Contents

1	Introduction.....	1
1.1	Document Scope	1
1.2	Document Structure	1
2	Legislative Framework.....	2
2.1	Gas Act 1986 (as amended by the Gas Act 1995).....	2
2.2	National Grid’s Gas Transporter Licence in respect of the NTS	2
2.3	Pipelines Safety Regulations 1996	4
2.4	Pressure Systems Safety Regulations 2000	5
2.5	Gas Safety (Management) Regulations 1996	5
2.6	Environmental Impact Assessment Directive.....	6
2.7	Town and Country Planning Act 1990.....	7
2.8	Integrated Pollution Prevention and Control Directive and the EU Emissions Trading Directive.....	7
3	Policy and Guidelines for NTS Planning.....	9
3.1	Industry Standards and Guidelines.....	9
3.2	National Grid Policies.....	9
4	Investment Planning	11
4.1	Transporting Britain’s Energy Consultation.....	11
4.2	Planning Cycle.....	11
4.3	Ten Year Statement.....	12
4.4	New Projects Requiring Entry or Exit Capacity	13
5	Supply.....	14
5.1	Long Term Supply Scenarios.....	14
5.2	Supply scenario updates.....	16
6	Demand.....	17
6.1	Long Term Demand Scenarios	17
6.2	Demand Forecasts.....	17
6.3	Offtake Capacity Statements and Long Term Planning Information	18

7	Entry Capacity	19
7.1	Long term system entry capacity auctions	19
7.2	Development of supply and demand scenarios	19
7.3	Network Capability analysis for entry capacity	19
7.4	Investment planning analysis for entry capacity	20
7.5	Analysis of long term system entry capacity auction signals.....	20
8	Exit Capacity.....	23
8.1	Long term exit capacity bookings.....	23
8.2	Development of supply and demand scenarios	23
8.3	Network Capability analysis for exit capacity	24
8.4	Investment planning analysis for exit capacity	24
9	Network Analysis	26
9.1	Basis of network analysis models	26
9.2	Analysis Assumptions	26
9.3	Steady State Analysis	27
9.4	Transient Analysis.....	27
9.5	Design Margin.....	27
9.6	Supply Flows	29
9.7	Demand Flows	29
9.8	Storage and Interconnector Flows	29
9.9	Ramp Rates	29
9.10	Standard Volumetric Flows	30
9.11	Entry and Exit Pressures	30
9.12	Compressors	33
9.13	Regulators	35
9.14	Multi-junctions	36
9.15	Gas Quality and Temperatures	36
9.16	Reinforcement Projects.....	37
9.17	Optimal Reinforcement	39
9.18	Alternatives to Investment Projects.....	40

Chapter One

Introduction

1.1 Document Scope

National Grid owns and operates the National Transmission System (NTS) for natural gas transportation in Great Britain. It 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.

This statement is prepared in accordance with the obligations placed on National Grid by Special Condition C11 of its Gas Transporters Licence in respect of the NTS. This licence condition requires National Grid to prepare and consult on a Transmission Planning Code, and comply with the Code in the planning and development of the NTS.

1.2 Document Structure

The document is structured in several chapters as explained below:

Chapters 2 and 3 describe the legislative framework, policies and guidelines in place that have a direct bearing on the planning of the NTS and lead times for investment.

Chapter 4 provides a high level overview of the Planning Cycle.

Chapters 5 and 6 describe the supply and demand assumptions used for planning.

Chapters 7 and 8 describe the commercial entry and exit capacity release processes and their effect on investment planning decisions.

Chapter 9 describes the assumptions used for planning analysis.

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. The key legislation affecting network planning and lead times for investment is described below. For clarity, “National Grid NTS” is used where National Grid is undertaking its duties in respect of the NTS.

2.1 Gas Act 1986 (as amended by the Gas Act 1995)

The Gas Act is the primary UK legislation that governs the transport and supply of natural gas within Great Britain. National Grid holds Gas Transporter Licences in respect of its gas transportation activities for the NTS and the four retained distribution network businesses that are granted and administered by the Gas and Electricity Markets Authority (GEMA), established by the Utilities Act 2000.

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.”

Companies licensed as gas transporters are exempt from the need to obtain authorisation for the construction of pipes under the Pipe-lines Act 1962.

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

National Grid is bound by the terms of its Gas Transporter Licence (“the Licence”) in respect of the NTS. This 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. It requires that National Grid NTS must plan the system to meet the 1-in-20 peak aggregate daily demand, including but not limited to, within day gas flow variations on that day.

It states that the 1-in-20 peak demand level should be calculated to include the load reduction through interruption or for contractual reasons and requires that historic data from at least the 50 previous years should be used when identifying the 1-in-20 peak day.

2.2.2 Special Condition C2: Long Term Development Statement

Under this obligation, National Grid NTS 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 NTS publishes the Ten Year Statement (TYS) each year in accordance with this condition and Uniform Network Code (UNC) Section O (which describes the data that may be published in the statement), after consultation with the gas industry through the Transporting Britain's Energy process.

2.2.3 Special Condition C8D: NTS gas entry incentives, costs and revenues

The NTS entry condition sets out the entry capacity incentive arrangements that National Grid NTS operate under, the obligations on National Grid NTS 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 condition describes two incentive mechanisms that incentivise National Grid NTS to manage its lead times for additional entry capacity release around a default lead time of 42 months.

The details of the Entry Capacity release process are set out in Section B of the UNC and the Incremental Entry Capacity Release (IECR) Methodology Statement.

2.2.4 Special Condition C8E: 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 NTS to manage lead times for additional exit capacity release around a default lead time of 38 months.

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.

2.3 Pipelines Safety Regulations 1996

The Pipelines Safety Regulations (PSR) 1996 were made under the Health and Safety at Work etc. 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” 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 should 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 routing 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-routing of pipelines

PSR further requires 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.

2.4 Pressure Systems Safety Regulations 2000

The Pressure Systems Safety Regulations (PSSR) 2000 aims 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 requires 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.

2.5 Gas Safety (Management) Regulations 1996

The Gas Safety (Management) Regulations (GSMR) 1996 requires all gas transporters 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 emergencies¹, 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.”

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

¹ 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.

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 and (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).

2.6 Environmental Impact Assessment Directive

Council Directive 85/337/EEC: Assessment of the effects of certain public and private projects on the environment (also known as the Environmental Impact Assessment Directive) as amended by Directive 97/11/EC requires Environmental Impact Assessments to be conducted, before development consent is granted, for certain types of major projects which are judged likely to have significant environmental effects.

The Public Gas Transporter Pipe-line Works (Environmental Impact Assessment) Regulations 1999 implement the Directives in England, Wales and Scotland. They require a gas transporter proposing to undertake pipe-line works which fall in Annex I of the Directive to submit an Environmental Statement and apply to the Secretary of State for Business, Enterprise and Regulatory Reform (BERR) for consent to conduct the work.

Pipeline works in Annex II of the Directive 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 do not meet these criteria but nevertheless it is considered that there are likely to be significant environmental effects.

The Environmental Impact Assessment work 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 all the searches, studies and surveys and also sets out National Grid's commitments to environmental management. Once complete the Environmental Statement is submitted to BERR.

It normally takes BERR 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.

The timescales indicated above assume that access can be gained to the land as and when required to complete the studies and surveys needed; at the right time of year for the individual species requiring study. If access cannot be gained to the land, a gas transporter may have to revert to the compulsory purchase powers provided under the provisions of the Gas Act which can take up to 14 months to execute. Upon successful completion of the

compulsory purchase orders, access to the land can be gained and the studies and surveys can then be started.

2.7 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 appropriate Local Council/Local Planning Authority. In the event that planning permission is refused, an appeal can be lodged that would be considered by an independent Planning Inspector appointed by the First Secretary of State or a full Planning Inquiry may be required.

The timescales for gaining planning approval for a development are indeterminate as they are dependent on the type, size and sensitivity of a particular development and are not defined in the legislation. If a Public Inquiry is required it can take up to 12 months to complete and once it is complete the Inspector appointed has to review all the information presented, produce a report and provide a recommendation to the Secretary of State. There is then a further period while the Secretary of State reviews the report and recommendation from the inspector, prior to reaching a determination in regard to the planning permission application.

2.8 Integrated Pollution Prevention and Control Directive and the EU Emissions Trading Directive

Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control (also known as the IPPC Directive) aims to ensure a high level of environmental protection and to prevent or minimise emissions to air, water and soil, as well as waste, from industrial and agricultural installations in the European Community.

The IPPC Directive defines the basic obligations to be met by all the industrial installations concerned that cover a list of measures for tackling discharges into water, air and soil and for tackling waste, wastage of water and energy, and environmental accidents. They serve as the basis for drawing up operating licences or permits for the installations concerned. The IPPC Directive also determines the procedure for applying for, issuing and updating operating permits and minimum requirements to be included in such permits (e.g. compliance with the basic obligations, emission limit values for pollutants, monitoring of discharges, and minimisation of long-distance or cross-border pollution).

The IPPC Directive has been amended by Directive 2003/87/EC of the European Parliament and of the Council establishing a scheme for greenhouse gas emission allowance trading within the Community (also known as the EU Emissions Trading Scheme or the EU ETS).

Further amendments have been made by Directive 2003/35/EC of the European Parliament and of the Council providing for public participation in respect of the drawing up of certain plans and programmes relating to the environment.

The Pollution Prevention and Control (PPC) Act 1999 is the primary UK legislation that enables Regulations to be made implementing the IPPC Directive. Separate Regulations transpose the IPPC Directive in England and Wales, Scotland, Northern Ireland, and the offshore oil and gas industries. These replace the pollution control regimes known as Integrated Pollution Control and Local Air Pollution Control set up under the Environmental Protection Act 1990.

The Pollution Prevention and Control (England and Wales) Regulations 2000 made under the PPC Act 1999 were recently replaced by the Environmental Permitting Regulations 2007 which came into force from 6 April 2008, combining the former with other Regulations dealing with waste management into one regulatory system. The Pollution Prevention and Control (Scotland) Regulations have not yet been replaced, however they have been modified several times to implement further European Directives and make clarifications within the Regulations themselves.

The main impact of the Directives and Regulations in the planning and development of the NTS is the requirement to reduce emissions levels from National Grid NTS compressor sites in England and Wales, and Scotland.

Chapter Three

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 NTS policies used for network planning.

3.1 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/>.

3.1.1 IGE/TD/1: Edition 4 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).

3.1.2 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 100 bar(g).

3.1.3 IGE/GL/2 Planning of Transmission and Storage Systems Operating at Pressures Exceeding 7 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.

3.2 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 NTS procedures and guidelines are described in Chapter 8.

3.2.1 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 100bar(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.

3.2.2 T/PL/NP/4 Policy for above 7 bar Network Analysis

This is National Grid's policy for undertaking network analysis for all high pressure gas transmission pipelines operating above 7 bar(g) consistent with IGE/GL/2. The document covers system modelling, network analysis processes, record keeping and data security.

Chapter Four

Investment Planning

National Grid undertakes investment planning over a ten-year planning horizon on an annual basis. The investment is developed using long term forecasts of supply and demand and other information gathered through commercial processes to book capacity on the system. This Chapter outlines the annual investment planning process.

4.1 Transporting Britain's Energy Consultation

National Grid NTS undertakes an annual Transporting Britain's Energy (TBE) consultation process to gather detailed information in order to supplement the supply and demand assumptions used for investment planning and other forecasting needs. Questionnaires are circulated to a range of industry players (Producers, Importers, Shippers, Storage Operators, Terminal Operators, Transporters and Consumers) requesting supply and demand forecast data and inviting views on National Grid NTS's underlying assumptions for supply and demand. Shippers are required to provide this supply and demand information under UNC Section O.

4.2 Planning Cycle

The annual planning cycle starts after the initial data has been gathered through the TBE process and is used to compile long-term supply and demand forecasts. The process considers those investments that may be required for entry and exit capacity signals using detailed network models of the NTS under different supply and demand scenarios to understand how the system will behave under different conditions over a ten year planning horizon.

During this process, Distribution Network Operators (DNOs) will request exit capacity on the NTS to support their long-term needs, and 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 decide the final set of investments that are necessary to develop the system.

4.2.1 Network Capability Analysis

Network capability analysis is undertaken 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, and the efficient and safe operation of the system. Analysis may be undertaken to identify capability for different needs, for example to identify Constrained LNG requirements, 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 is to find the point at which the network becomes "constrained" i.e. has reached its limits for the given scenario.

The results of this analysis can then be used to inform commercial capacity processes, for example, the level of flow that may be achieved at any entry point under certain supply/demand conditions compared to the obligations to release capacity at the entry point to determine a “constraint volume” of gas at the entry 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.

4.2.2 Confirmation of Existing Projects

During the planning cycle, the first two years of the prevailing investment plan is analysed to verify whether the projects sanctioned during previous plans are still required. In doing this, Licence requirements to release obligation 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.

If it is found that sanctioned projects are not required as previously proposed, then analysis will be carried out to determine which year the project should now be completed for.

4.2.3 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. Investment planning analysis is undertaken to determine the level of investment required to support additional supplies or demands on the system.

4.2.4 Annual Plan Review

The network models developed during the annual planning cycle are checked 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. The audit findings are documented in a plan review report alongside any recommendations for improving the network models and analysis techniques used for future planning cycles. This review document is used in the next planning cycle to update the network model and analysis assumptions.

4.3 Ten Year Statement

The Ten Year Statement details National Grid NTS’s latest supply and demand forecasts, 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 NTS will describe the projects that are determined to be part of its final Investment Plan in the Ten Year Statement, after consideration of the information received from the long term entry capacity auctions (QSEC auctions) and incremental entry capacity release process, the long-term exit capacity bookings made by DNOs and the exit capacity requirements of Shippers.

The Ten Year Statement is published in line with Special Condition C2 of the Licence and Section O of the UNC. Further information on the TBE process and the Ten Year Statement is available on our website at: <http://www.nationalgrid.com/uk/Gas/TYS/>.

4.4 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 NTS are committed to discuss such prospective projects with Customers to help them develop viable projects that deliver benefits for the UK security of supply. Users of the system must, however, book entry and/or exit capacity rights on the system in order to trigger additional investment that may be required to support their potential gas flows onto and out of the system under the prevailing commercial arrangements described in the UNC. It should be noted that there may be a lead-time associated with obtaining access to the system and Customers are encouraged to enter into discussions with National Grid NTS at an early stage so that they fully understand the processes required to connect and use the system.

National Grid NTS is incentivised under its Licence to deliver entry and exit capacity in an efficient and economic manner. The Licence arrangements confirm National Grid NTS's revenue allowances for delivering additional entry or exit capacity. National Grid NTS would expect that such arrangements would be updated to include revenue allowances at new entry or exit points before any auction for entry capacity, or commitment to release exit capacity was made at these points.

Chapter Five

Supply

5.1 Long Term Supply Scenarios

The Ten Year Statement contains detailed information on, supply and demand forecasts, current reinforcement projects and investment plans, and actual flows seen on the NTS in recent years.

Following the annual TBE process, National Grid NTS generally produces a Base Case long term supply forecast and describes a range of possible supply flows around this case. The Base Case is a point of reference from which to develop other supply patterns anticipated on the NTS. Occasionally when there has been considerable uncertainty surrounding potential future supplies, supply cases of comparable weightings have been produced. All of this information is published in the Ten Year Statement.

In order to cope with increasing supply diversity and potential oversupply a range of possible supply patterns must be considered within the investment planning process. Such scenarios enable the modelling of the likely development of supply levels and supply patterns over the course of the ten-year planning horizon. The basic steps involved in developing such supply scenarios are described below.

5.1.1 TBE Base Case and supply ranges

For each demand level and year examined, National Grid NTS has tended to develop a Base Case supply flow level for each supply point. 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.

Where the level of uncertainty remains that more than one case is required to describe the range of future supplies published in the Ten Year Statement, supply scenarios will be developed around each supply case developed through the TBE consultation process. For the purposes of this document it is assumed that a single Base Case forecast is available, although the methods for developing supply scenarios are applicable across more than one TBE supply case.

5.1.2 Supply scenario identification

Generic supply scenarios are 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), and 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 are 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 can 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.

5.1.3 Supply ranking assumptions

For each scenario a ranking order (or merit order) is 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 includes an assumption for the likely 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" - assumed to flow) and the most expensive, fluctuating supplies are likely to sit at the bottom of the ranking order ("volatile supplies" - more price sensitive supplies 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 TBE 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.

5.1.4 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 Base Case forecast; some to decrease below the Base Case forecast in order to balance the increases and the remaining supplies will be fixed at the Base Case forecast.

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

5.1.5 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 is predicted by adding the observed volatility to the Base Case forecasts. This analysis is generally 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 TBE 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.

5.2 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 views 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.

Chapter Six

Demand

6.1 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 Section B and Offtake Arrangements Document (OAD) Section H processes. These are described further below.

6.2 Demand Forecasts

National Grid's gas demand forecasts are developed using detailed analysis of demand drivers including (but not limited to) fuel prices and economic forecasts. Demands are forecast by different market sectors, with forecasts 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 is 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.

Load duration curves of annual gas demand are 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 are 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 would normally use the average load duration curve to generate demand patterns for off-peak analysis.

Sensitivities around the central demand forecast assumptions are also considered in order to produce ranges of potential demand over the longer term.

The Ten Year Statement contains detailed analysis of the assumptions driving the gas demand forecast and the forecast data.

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

6.3 Offtake Capacity 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.

UNC Section B describes the annual Offtake Capacity Statement (OCS) process, which National Grid NTS and DNOs use to agree peak day requirements for DNOs for Offtake (Flat) Capacity, Offtake (Flex) Capacity and Assured Offtake Pressures. The OCS process results in annual capacity bookings and pressure commitments that National Grid NTS is required to meet from the start of the next gas year and for four years into the future. DNOs also provide indicative bookings for a fifth year to signal possible future capacity and pressure requests.

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 pro-rate the OCS bookings using the forecast growth factor developed through the demand forecast process (and published in the Ten Year Statement). This assumption of demand growth is 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.

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 Section H data to develop demand scenarios for off-peak analysis. Typically the information is used to determine demand distribution across Distribution Networks for analysis on different days of the severe and average load duration curves.

Chapter Seven

Entry Capacity

7.1 Long term system entry capacity auctions

National Grid NTS makes NTS entry capacity available in a series of auctions. Signals (bids) received from long term system entry capacity auctions (QSEC auctions) are used within the planning process to confirm the need for investment.

National Grid NTS must, under the terms of its Licence, prepare a proposal for releasing incremental obligated entry capacity and submit this proposal to the Authority 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.

National Grid NTS must therefore submit its proposal for incremental obligated entry capacity to the Authority within one month of the end of the auctions, in order that allocation may occur in line with the UNC requirements and decision period stipulated under the Licence for the incremental obligated entry capacity proposal.

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

7.2 Development of supply and demand scenarios

Supply scenarios will be determined using the latest TBE forecast data as described above. Demand scenarios for entry capacity assessment have tended to be centred on a Base Case with demand sensitivities. Demand is also assessed at peak (1-in-20 conditions), and at average and severe conditions through the load duration curve. Analysis will be undertaken for each relevant year of the ten-year planning horizon.

7.3 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 TBE Base Case.

Entry projects identified from previous planning cycles are reviewed to verify whether the projects sanctioned as part of previous plans are still required. In doing this, Licence requirements to release obligation 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.

If it is found that sanctioned projects are not required as previously proposed, then analysis will be carried out to determine which year the project should now be completed for.

7.4 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. Each supply and demand scenario may generate a number of investment projects for consideration as the supply patterns are varied away from the Base Case supply pattern.

An initial Investment Plan will be determined by considering the investment projects required across the range of supply scenarios and for a range of demand scenarios, to develop a range of projects that best meets the anticipated flow patterns of the system, whilst paying due regard to National Grid NTS's wider obligations. These 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 viewed as indicative and may be modified in the light of further detailed analysis and investigation. The supplementary analysis might also consider routing or siting difficulties arising from environmental, safety and wider societal impacts.

The initial Investment Plan will be updated when the bids placed in the QSEC auction are available. If required, the Base Case is adjusted accordingly.

7.5 Analysis of long term system entry capacity auction signals

The QSEC auctions provide an important source of planning information on the levels of user commitment for baseline and incremental entry capacity. The initial Investment Plan must be developed ahead of the QSEC auction, due to the amount of analysis required. The final Investment Plan will be determined after auction signals have been analysed and potential projects have been reviewed.

Users of the system will place entry capacity auction bids in accordance with the rules set out in the UNC. Once the auction information is received, National Grid NTS will apply the Incremental Entry Capacity Release (IECR) Methodology in line with its duties under the Licence to determine whether additional entry capacity should be made available at any ASEP and the amount of incremental entry capacity that should be made available.

Under its Licence obligations, fixed lead times are available to National Grid NTS both for determination of how much capacity to allocate (including project identification) and for the design and build of the identified projects. The lead times are such that National Grid NTS will, where possible, carry out a certain amount of speculative analysis ahead of an auction to identify what investment could be required 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 NTS 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 Incremental Entry Capacity Release Methodology and how much entry capacity may be substituted to meet the incremental obligated entry capacity requirement as a result of applying its Entry Capacity Substitution Methodology. For the avoidance of doubt, National Grid NTS does 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.

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

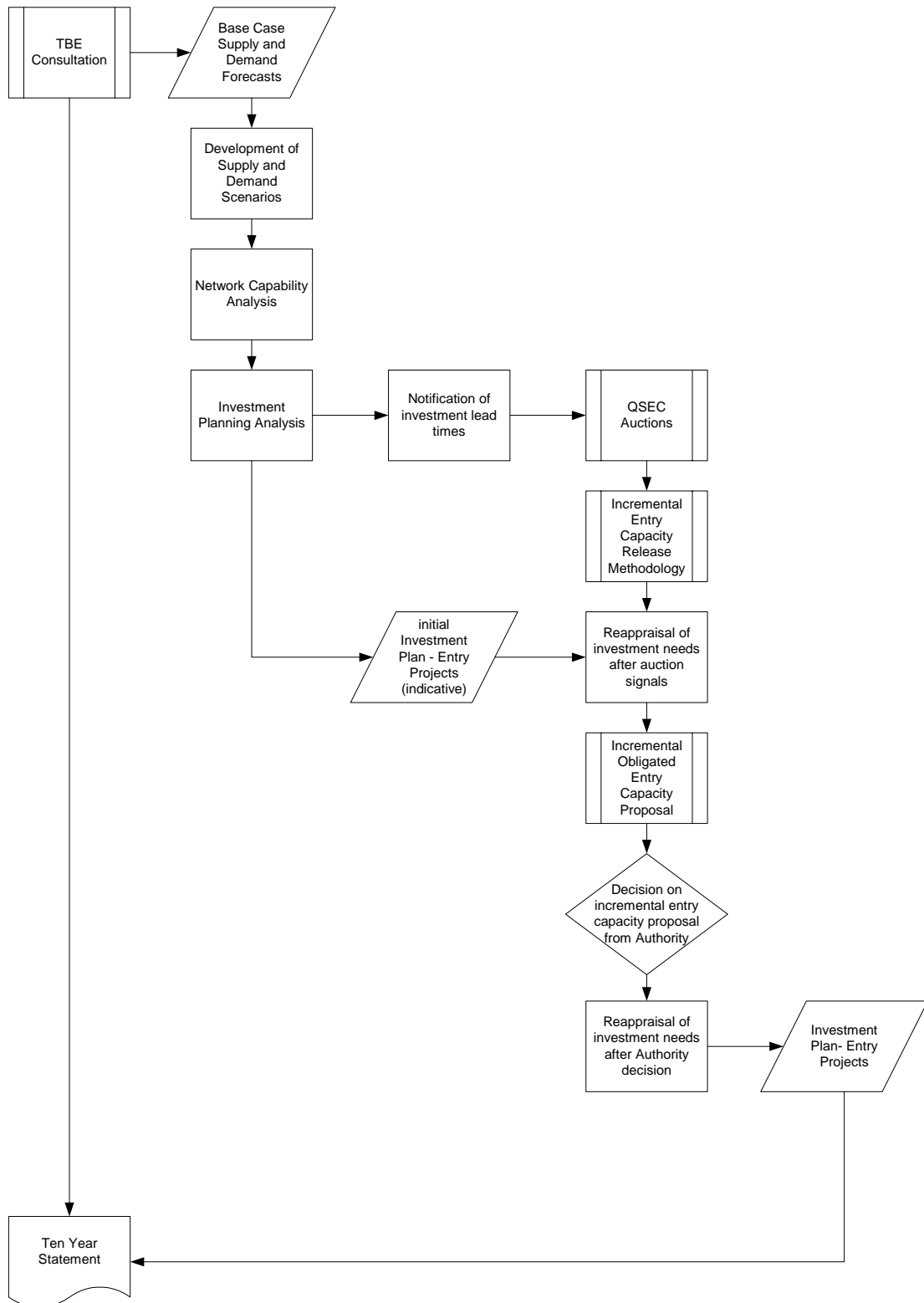
1. Insufficient user commitment is signalled through the QSEC auction to justify the economic case for these projects.

2. The Authority determines that National Grid NTS should not implement the incremental obligated entry capacity proposal made by National Grid NTS under Special Condition C8D of its Licence.

National Grid NTS 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 C8D of its Licence.

National Grid NTS 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 Eight

Exit Capacity

8.1 Long term exit capacity bookings

The processes used to book exit capacity differ from those used to book entry capacity. Two routes to booking long term exit capacity are currently in force². DNOs book their capacity and pressure requirements long term through the OCS process describe in UNC Section B, and are required to provide financial user commitment for additional capacity bookings that would require specific reinforcement on the NTS over a given size by entering into an Advanced Reservation of Capacity Agreement (ARCA) with National Grid NTS.

Shippers may only secure additional exit capacity in the longer term if specific reinforcement is required on the NTS in order to release that capacity and the capacity booking is over a given threshold. Shippers or project Developers (where no Shipper has committed to the project) must provide financial user commitment to trigger such reinforcement by entering into an ARCA with National Grid NTS. Shippers requiring capacity levels that do not meet these criteria must register capacity in the shorter term.

Further detail on the release of exit capacity on the NTS is given in National Grid NTS's Exit Capacity Release Methodology Statement, available on the National Grid website.

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

8.2 Development of supply and demand scenarios

National Grid NTS 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 are 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 TBE Base Case for all Users of the NTS
2. Demand flows that occur in line with DNO OCS bookings and TBE Base Case flows for directly connected NTS loads
3. Demand flows associated with storage sites and interconnector pipelines
4. Demand flows associated with large loads or loads located in sensitive areas of the network
5. Demand flows associated with interruptible loads directly connected to the NTS

² Exit arrangements are currently under review, and therefore new processes may be introduced in the near future to allow users to book exit capacity. The regime described above is National Grid NTS's understanding of the current arrangements for exit capacity booking.

The demand sensitivities will be developed according to the location of the exit capacity being assessed. It is assumed that DNO OCS requests will include the latest assessment of interruptible load in their respective networks.

Demand is assessed at peak (1-in-20 conditions), and at average and severe conditions through the load duration curve. Analysis will be undertaken for each relevant year of the ten-year planning horizon.

8.3 Network Capability analysis for exit capacity

Network analysis is undertaken during the OCS process to identify the existing capability of the NTS to accommodate changes in the Offtake (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 are reviewed to verify whether the projects sanctioned as part of previous plans are still required. If it is found that sanctioned projects are not required as previously proposed, then analysis will be carried out to determine which year the project should now be completed for.

8.4 Investment planning analysis for exit capacity

Investment will be undertaken for increases in the Offtake (Flat) Capacity bookings under the terms of the Exit Capacity Release Methodology Statement. Such increases may require a feasibility study to be initiated to assess possible options in order that the appropriate investment planning analysis may be undertaken. Investment is not undertaken on the NTS for increases in Offtake (Flex) Capacity or Assured Offtake Pressures.

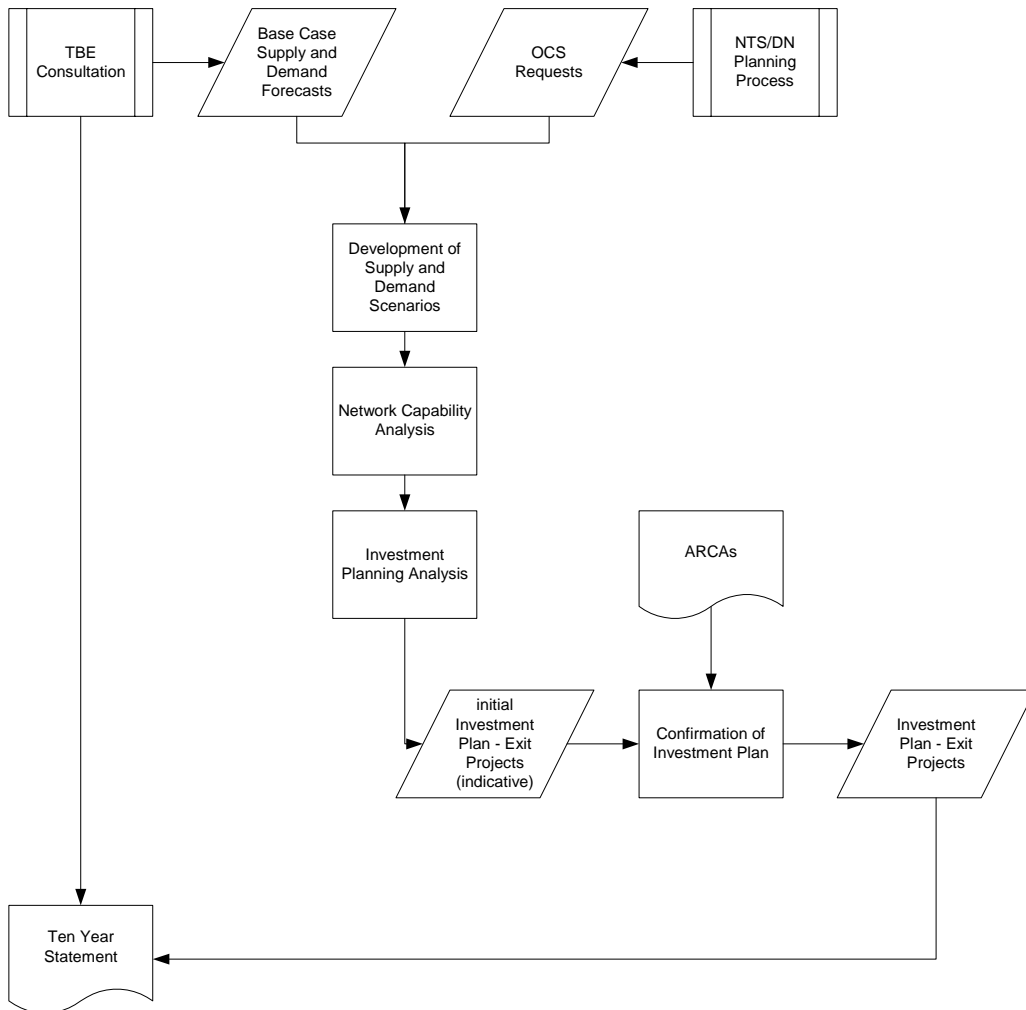
Offtake (Flex) Capacity and requests for increases in Assured Offtake Pressures will be allocated to DNOs through the OCS process within the capability of the system.

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

Parties that are directly connected to the NTS are required to register capacity in the short term under the process defined by UNC Section B. Increases in exit capacity can be requested in line with the Exit Capacity Release Methodology Statement.

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 is also collected through the TBE process, so the annual planning cycle will include the best known information to National Grid NTS 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 NTS will therefore be consolidated into the next or future planning cycles.

Figure 2: Exit capacity investment planning process



Chapter Nine

Network Analysis

9.1 Basis of network analysis models

National Grid NTS use proprietary network analysis software to undertake planning analysis. The software allows 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 may then 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 can be added anywhere to the model connecting to existing points on the model as required to overcome system constraints. The tool can then be used to analyse the enhanced network.

The network analysis undertaken for the NTS relies on a base network model known as the “Master Network”, which contains 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 is generated at the beginning of the annual planning cycle and includes all pipelines and plant planned for completion for the first winter in the ten-year planning horizon. The Master Network is 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 are included in the Master Network.

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

9.2 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 around the start of the gas day at 0600 hours. This linepack can then be used over the day to meet diurnal fluctuations in demand and typically reaches 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 can be modelled individually through steady state analysis or concurrently using transient analysis with suitable demand profiles.

9.3 Steady State Analysis

It is usual practice for longer 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 design 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 is used to represent the start of day condition (0600) and a network with linepack minimised represents 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.

9.4 Transient Analysis

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

Networks are 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.

9.5 Design Margin

A design margin (also referred to as a “flow margin”) is applied to pipe flows within the network model to account for uncertainties that arise when undertaking network analysis far ahead of the gas flow day.

The use of a flow margin for design purposes is described in National Grid’s Safety Case for the NTS (Section 17 - Adequate Network Pressure)³, which states:

“17.7 In the process of Network Analysis an allowance needs to be made for variances in gas flow from the assumptions made in the base case design. This is referred to as the “flow margin”. The flow margin exists to provide a margin of cover for a list of effects or events wherein the actual flows and pressures on the NTS will differ from those in the base case design. This margin takes the form of a percentage increase in flows used for network analysis. There are two elements to the flow margin:

- 1. A Transient Component*
- 2. A Transmission Capacity Component*

³ National Grid Gas, Gas Transporter Safety Case (Gas Transmission) v6 March 2008

Transient Component

17.8 *This element encompasses compressor trips, forecasting errors, suppliers' alerts, producer variation and operational state changes. These are outlined as follows:*

- *Compressor trips - when a compressor trips downstream pressures fall and time is needed to bring on another compressor or LNG to maintain supplies.*
- *Forecasting errors - there is a time delay between distribution systems taking increased rates from the NTS and additional supplies being provided from beach or storage.*
- *Suppliers' alerts - when there is an offshore alert, additional time is also needed to bring on replacement supplies.*
- *Producer variation - the rates at which producers deliver gas, can vary from the assumed steady 24-hour flat rate.*
- *Operational state - as demand changes from day to day the configurations used within the network need to change to meet the new flow pattern.*

17.9 *All of the above refer to a time element, which results in a need for linepack to provide the flexibility to respond to the changes. The margin used to cover these transient elements is 2.5%.*

Transmission Capacity Component

17.10 *Typically on the NTS it takes at least three years from the launch of a project to its commissioning. Therefore, the project will be based on predictions of supply and demand three years ahead. In the interim period the actual pattern of supplies and demands will develop and will differ from the assumptions made at the project launch. An analysis has been carried out on the costs of failure on the NTS against costs of installing additional transmission capacity such that the NTS would fail in just 25% of 1 in 50 winters. The value for the corresponding flow margin is 2.5%.*

17.11 *The overall flow margin is obtained by adding the transient and transmission capacity component together to arrive at a figure of 5%."*

The figure of 5% is applied for steady state analysis at peak 1-in-20 demand conditions for investment planning purposes. For transient analysis there is no requirement for the transient component of the design margin, however the transmission component of the design margin is still required for long-term transient analysis to account for uncertainties in forecast supplies and demands.

No design margin is used for any transient operational analysis (i.e. analysis undertaken for the short term) to ensure the full capability of the pipeline is modelled.

9.6 Supply Flows

Supply flows are required data for the network analysis models, and are derived for the supply scenario that is being considered.

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 is assumed to be taken from the largest entry points on the system, and will be determined by the network analysis software based on the operation of compressors within the model.

9.7 Demand Flows

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

Interruptible demands that are directly connected to the NTS are modelled as not consuming gas under peak day conditions. In order to model the effects of different interruption contracts, different high load conditions may be assumed when assessing contracts for individual loads. For a standard 45-day interruption contract these high load conditions would be derived from Demand Day 46 on the severe load duration curve.

Distribution Networks include their interruption assumptions within their offtake capacity requests as part of the OCS process.

9.8 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 would normally be modelled as supplies under high demand scenarios or when gas prices are high.

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.

9.9 Ramp Rates

Rapid load changes imposed on the pipeline system caused by entry and/or exit flowrates 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 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. The standard ramp rate offered is currently 50 MW/min.

National Grid NTS 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 shut down 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 contracts⁴ 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 NTS that the facilities and operating strategies proposed do not have a detrimental effect on the NTS.

9.10 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°C, pressure of 1.01325 bar and dry gas⁵ and are used to describe “standard volumes” of a gas.

The hydraulic models within the network analysis software used by National Grid NTS 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 are 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 uses 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 are 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 is set at 39 MJ/m³, which approximates to the average CV of the gas in the system. Flows quoted using different CV assumptions are converted to standard volumetric flows at the standard CV before input to the network analysis models to provide a consistent basis for the analysis.

9.11 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 are 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.

⁴ Network Entry Agreements, Network Exit Agreements or Storage Connection Agreements

⁵ Gas that does not contain significant levels of water vapour, condensate or liquid hydrocarbons.

Minimum pressure limits are also observed at exit points and are required for supporting downstream systems or loads. Some points of offtake require a higher pressure at 0600 and/or 2200 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 can 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 Pressures and Offtake Flexibility
7. The effects of maintenance on plant in the vicinity
8. Pipeline maintenance, inspection, remedial work and modification activities in the area

Exit points at extremities of the NTS are likely to experience the lowest pressures on the system.

Network analysis undertaken to determine network capability will model the system to observe the maximum and minimum pressure limits. Where the analysis shows that a pressure cannot be maintained, the supply/demand scenario under analysis is deemed to indicate a “failed” network. Network capability is understood 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.

The following pressure limits must be observed within the analysis:

- Maximum Operating Pressures (MOPs) for with 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

9.11.1 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 are set marginally below the MOP of the pipeline, compressor or entry terminal to be consistent with the operational setpoints used on pressure protection devices.

9.11.2 Assured Offtake Pressures

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

Pressure requests shall 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. Increase volumes of Constrained LNG required to support high load conditions
5. Reduce capability at NTS entry points
6. Reduce available system flexibility capacity
7. Impact on other offtake points in the areas

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

9.11.3 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 can only be changed after giving the Customer 36 months notice.

ANOPs are governed by UNC 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 NTS expects, under normal operating conditions, a given quantity of gas will be available for offtake at a given exit point.

All ANOPs are modelled as minimum pressures for the first three years of the ten year planning horizon. From the fourth year of analysis onwards⁶, if an ANOP cannot be maintained under any scenario considered, National Grid NTS will give notice to the Customer for a reduction in the ANOP, under the terms of the relevant NExA agreement.

⁶ This timeframe is used to allow for the 36 month notice period for changing ANOPs

9.11.4 Contractual Exit Pressures

A Shipper may request that National Grid NTS 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 NTS 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.

9.12 Compressors

Gas compressors are the key plant items used to “pump” gas through the NTS. They are also used to boost system pressures to support exit pressure commitments.

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.

Where the network analysis models show that compressors must operate outside this 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.

Compressor sites are usually designed with at least a one unit redundancy for standby purposes to ensure security of supply.

The network analysis software used by National Grid NTS allows the detailed modelling of these control mechanisms, limiting factors and compressor fuel usage.

9.12.1 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.

9.12.2 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.

9.12.3 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. The maximum 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 used within network analysis models is the base power level that may be achieved under normal operating conditions. Marginal increases in power (peak power) can be attained for very short periods of operation for certain types of gas generator however this can have an adverse effect on compressor performance and design life. Peak power levels are not normally used within investment planning analysis if this becomes a long term requirement as it is more efficient and economic to upgrade the compressor station. In any case peak power would not be used in off-peak analysis.

The network analysis undertaken for the NTS considers 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.

9.12.4 Discharge Temperatures

Compressor station discharge temperatures are generally limited to between 45°C and 50°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.

9.12.5 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 setpoint 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 NTS 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.

9.12.6 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 NTS 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.

9.12.7 Emissions

National Grid NTS is responsible for ensuring its compressor fleet meets legislative requirements relating to emissions under the IPPC 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 must 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.

9.13 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 NTS 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.

9.14 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 NTS 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.

9.15 Gas Quality and Temperatures

Gas quality and temperature effects are 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 a pipeline is also modelled.

Temperature effects modelled 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 are also modelled.

National Grid NTS 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 are 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 are provided to the DNOs ahead of the annual OCS process. The CV assumptions quoted by DNs in their OCS and UNC Section H data are used to convert demand information to standard volumetric flows at a standard CV.

9.15.1 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 have an effect on the capability of the network.

9.15.2 Flow Weighted Average Calorific Value

Where the CV at an offtake is calculated as more than +/- 1 MJ/m³ 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 have an effect on the capability of the network.

9.16 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.

9.16.1 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.

9.16.2 Compressor flow reversal

Where new entry points change the direction of flow in an area, reversal of a compressor flow 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.

9.16.3 Regulators

A regulator project will normally 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.

9.16.4 Aftercoolers

Compressor station discharge temperatures are limited to between 45°C and 50°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.

9.16.5 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.

9.16.6 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.

9.16.7 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.

9.17 Optimal Reinforcement

It is possible that there are a number of reinforcement options identified to increase network capability. A check list 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. Further analysis will be required to identify any environmental, safety or societal impacts that arise as a result of identifying the most economic and efficient overall reinforcement strategy.

<i>Project</i>	<i>Alternative Project</i>	<i>Considerations</i>
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.
	Upgrade upstream compressor and/or pipeline	Consider effect on compressor power requirement to ensure upgrading is feasible within design limits.
Pipeline Reinforcement	Upgrade downstream compressor	Consider compression ratio and discharge temperature requirements to ensure compressors are able to operate within design limits
	Upgrade upstream compressor and/or pipeline	Consider effect on compressor power requirement to ensure upgrading is feasible within design limits
	Compressor flow reversal	Consider whether an existing compressor may be used to flow in a different direction or configuration

9.18 Alternatives to Investment Projects

The following options not requiring capital expenditure will be considered alongside the indicative investment projects identified:

1. Network reconfiguration
2. Compressor utilisation
3. Constrained LNG
4. Pressure sensitivities
5. Commercial capacity management agreements

Each of these options will be evaluated with due consideration being given to National Grid NTS'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.

9.18.1 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 need to be assessed before rejecting the reinforcement project.

9.18.2 Compressor utilisation

It may be possible to utilise compressor units normally reserved for standby or operate units at peak power levels for short periods to avoid reinforcement. 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.

9.18.3 Constrained LNG

There is a requirement to identify the Constrained LNG (CLNG) rates and duration required in the early years of the plan for booking purposes.

To determine the duration of CLNG use for a particular site, analysis will be undertaken for various days between peak and the derived day of first likely use. CLNG is used to support the system in the case of demand changes in the shorter term, where investment lead times prevent immediate system reinforcement. In some cases, use of CLNG may be offset against additional investment on the system both for maintaining end pressures and deferring projects on the upstream systems.

9.18.4 Pressure sensitivities

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 NTS is obliged to maintain all prevailing Assured Offtake Pressures agreed through the OCS process and all contractual pressures determined by Ancillary Agreements. National Grid NTS cannot formally request reductions in offtake pressures from DNOs under the current exit arrangements.

9.18.5 Capacity management

Investment projects may be deferred or avoided if National Grid NTS enters into capacity management agreements to manage the financial risks arising from capacity buyback at entry or exit points. Further risk analysis will be required to determine if this is a viable option.