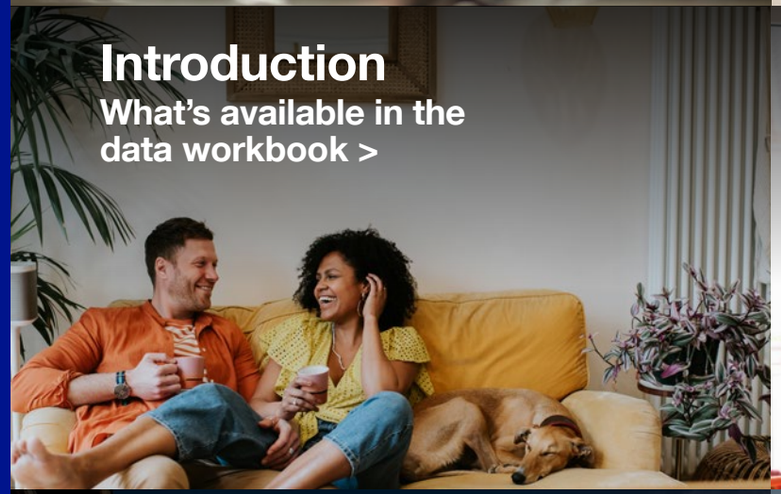
Gas System Operator

# Gas Ten Year Statement 2022


nationalgrid

# Welcome >

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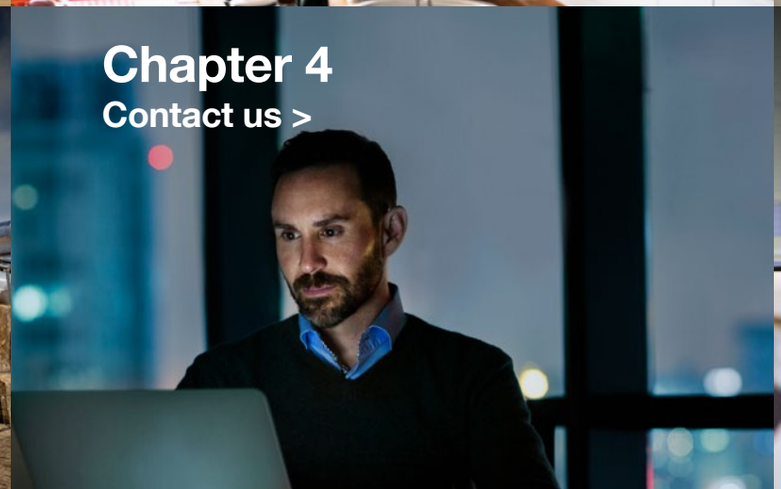

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# Welcome

**The energy sector is constantly evolving. Whether it's changes in the economic landscape, developments in technology, or changing consumer behaviour; there's a constant need to remain mindful of our energy needs today, tomorrow and in the future.**

While there is significant focus on today's energy security, infrastructure and markets due to the impacts of the war in Ukraine, it's important to look to (and prepare for) the future.

The *Gas Ten Year Statement* (*GTYS*) is published annually and aims to encourage and inform debate amongst our stakeholders and the wider industry, leading to changes that ensure a secure, sustainable and affordable energy future. As the name suggests, this publication takes a look at the next ten years for Gas Transmission, explaining the investments and improvements we're making, and plan to make, to the National Transmission System (NTS) to ensure we can continue to provide a safe, secure network that meets the needs of our customers.

We also share the progress and plans we're making for transitioning to net zero by 2050, in line with the commitment made by the UK Government in 2019, and how any changes to legislation have impacted this.

This year's *GTYS* doesn't contain specific information related to the current geo-political climate and the resulting circumstances that are currently requiring the network to operate in a slightly different manner. Some of these differences can put stresses on the network and its assets e.g. high summer LNG flows and very high EU exports. It is likely that additional investments that aren't currently part of our business plan may need to be considered in order to effectively manage these changing requirements.

**Home**
This will take you to the home page.

**Arrows**
Click on these arrows to move backwards or forwards.

**Jump back arrow**
This will take you back to the same page you left via a link on that page.

**Enlarge/reduce**
Hover over the magnifying icon to make charts bigger or smaller.

**Rollover/reveal**
Hover over this icon to display additional information.

**Linked content**
Words in light blue and underlined have links to other pages in this document, or are URLs.

# Introduction

## Our role

We are the owner and operator of the gas NTS in Great Britain – our licence is established under the Gas Act 1986.

We are required to develop, maintain and operate economic and efficient networks and to facilitate competition in the supply of gas in Great Britain. Our primary responsibility is to transport gas safely, efficiently and reliably across the NTS, managing the day-to-day operation of the network. This includes maintaining system pressures within safe operating limits, ensuring gas quality standards are met and acting as the residual balancer for supply and demand if there is a market imbalance.

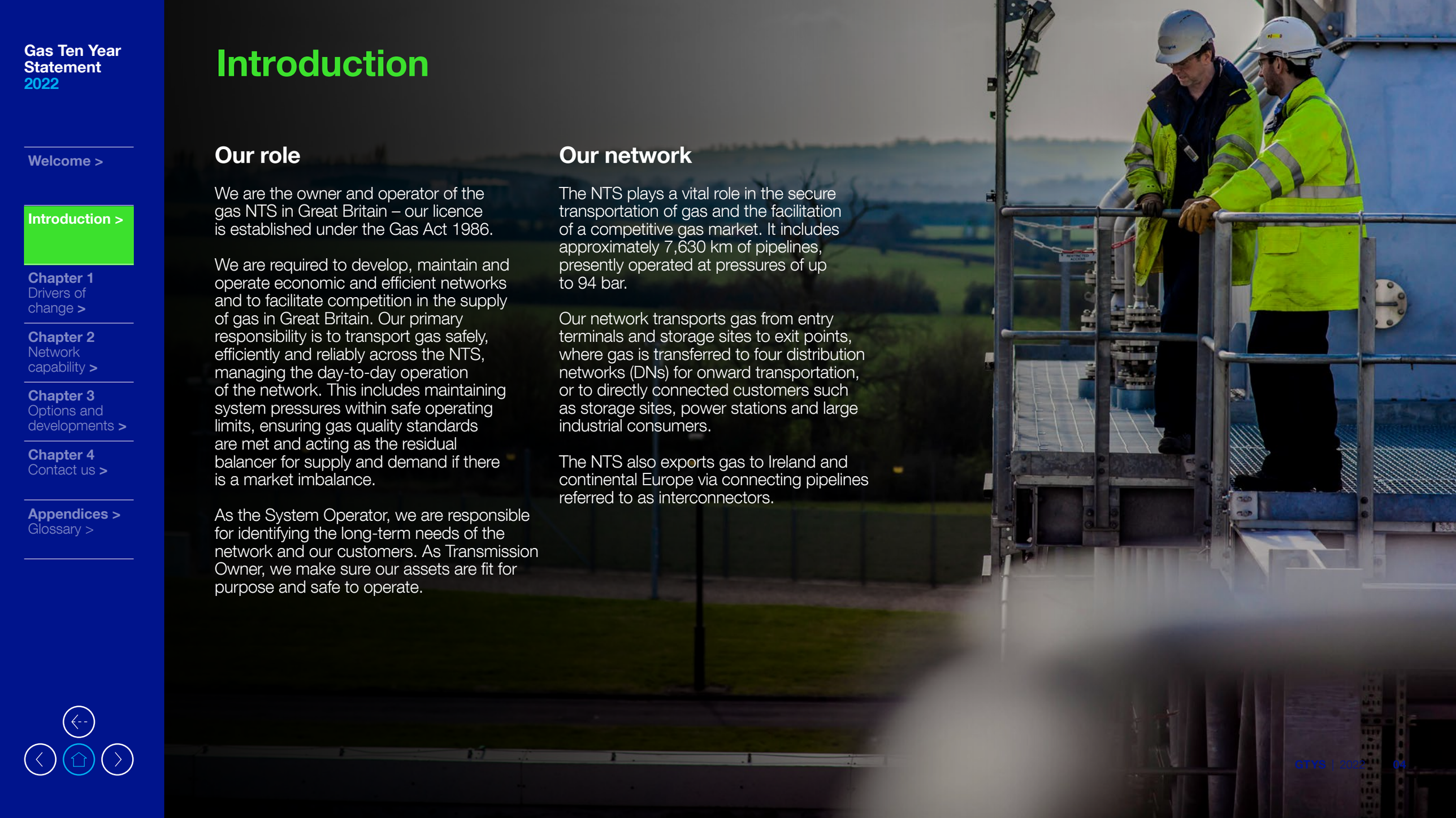
As the System Operator, we are responsible for identifying the long-term needs of the network and our customers. As Transmission Owner, we make sure our assets are fit for purpose and safe to operate.

## Our network

The NTS plays a vital role in the secure transportation of gas and the facilitation of a competitive gas market. It includes approximately 7,630 km of pipelines, presently operated at pressures of up to 94 bar.

Our network transports gas from entry terminals and storage sites to exit points, where gas is transferred to four distribution networks (DNs) for onward transportation, or to directly connected customers such as storage sites, power stations and large industrial consumers.

The NTS also exports gas to Ireland and continental Europe via connecting pipelines referred to as interconnectors.



# What's available in the data workbook

### What's new this year?

We've listened to your feedback and made some updates to the publication this year. Key changes include:

- Removed any content that is already available on our website, to make the publication shorter and easier to digest. Links to this content are available in the Appendix (see appendix 1)
- Expanded our Options & Development section to include further detail on our hydrogen projects and our pathways to net zero.

**As part of the *GTYS* publication we produce detailed analysis and data. For ease of use, we have not included all of this data within this *GTYS* publication. Instead, our workbook is available online and contains the following:**

- All graphs and tables contained in 2022 *GTYS*
- Actual demand for 2021 (TWh)
- Peak day, maximum and minimum physical NTS entry flows for Gas Year 2021/22
- Peak day, maximum and minimum physical NTS exit flows for Gas Year 2021/22
- Gas demand and supply volumes per scenario out to 2050
- 1-in-20 peak day diversified demand per scenario out to 2050
- 1-in-20 peak day undiversified demand per scenario out to 2050
- 1-in-50 peak day diversified demand per scenario out to 2031
- 1-in-50 peak day undiversified demand per scenario out to 2031
- Peak and annual supply by terminal out to 2050
- *ANCAR* updated Entry and Exit Frequency Data.

# Introduction

## Our Network Development Process

One of our key aims for this publication is to make our investment decision process as transparent as possible by outlining the various stages of our Network Development Process (NDP).

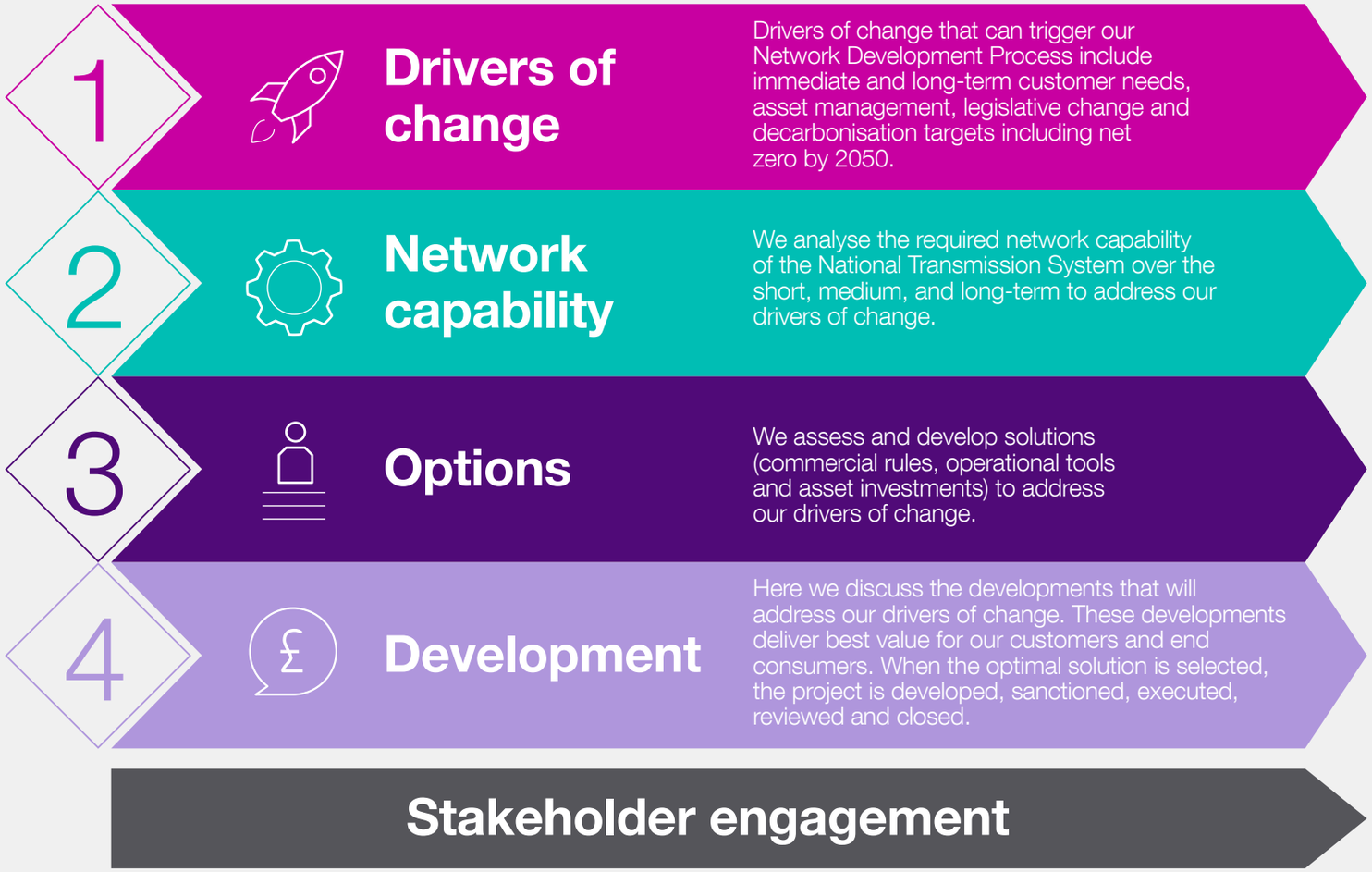
The NDP defines and manages our project lifecycles from inception through to closure. The process defines our methodology for optioneering, developing, sanctioning, delivering and closing projects that address our drivers of change.

The aim of this process is to deliver the best value, fit-for-purpose solutions for identified challenges or opportunities. The process also ensures we consider and meet the needs of regulatory/legislative requirements, our customers and our stakeholders, as well as our own.

The NDP is central to our planning activities and informs the work that we carry out on the NTS. We therefore structure this publication in line with this process, with chapters covering our drivers of change, network capability and options and development.

We also provide information on our transition to net zero and the work we are undertaking with methane emissions and hydrogen.

**Figure 0.1**
Our Network Development Process



# 1 Drivers of change

# Drivers of change

## 1.1 Introduction

**This chapter describes the drivers of change that can trigger stage 1 of our Network Development Process (NDP) (figure 1.1).**

**Figure 1.1**
Drivers of change that can trigger our Network Development Process

**Customers' immediate and future needs**

**Asset management**


**Legislative change**


**Net zero by 2050**

# Drivers of change
## 1.2 Customer needs

### 1.2.1 Future Energy Scenarios

Our long-term customer needs are articulated within National Grid ESO's *Future Energy Scenarios (FES)*, following extensive modelling, research and stakeholder engagement. We use *FES* as the starting point for all our future network planning.

The *FES* are produced each year to identify a range of credible scenarios out to 2050 (figure 1.2). These scenarios consider how much energy might be needed and where it could come from. They look at what the potential changes over this time period might mean for the industry and for its customers. The high-level scenario framework has remained unchanged for 2022 *FES* with axes of "Speed of decarbonisation" and "Level of societal change" retained.

In the *GTYS* we only show *FES* results as far as 2032[1] instead of 2050, as this period is of the greatest relevance to the decisions that need to be taken on the gas network today.

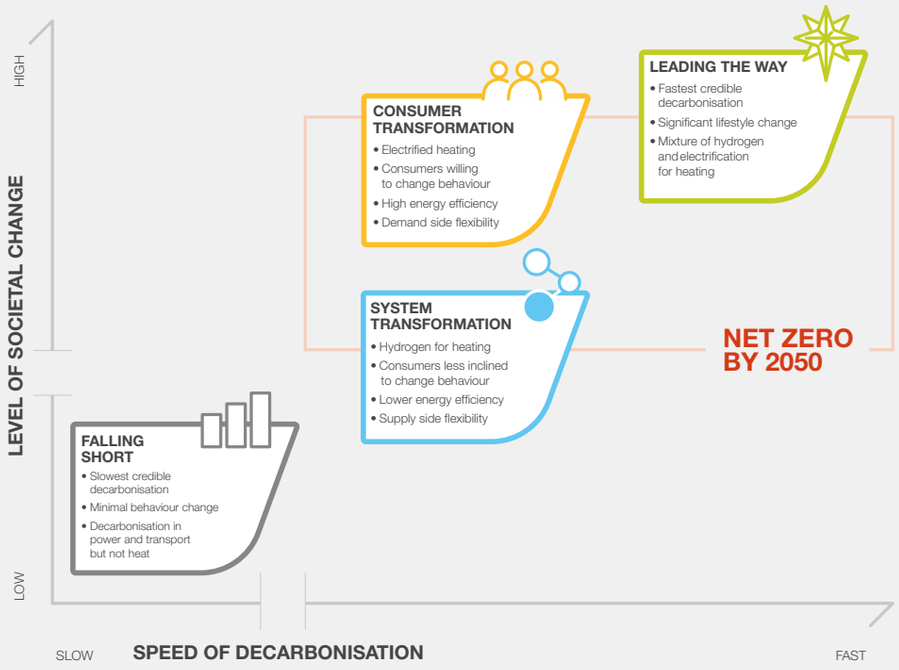
*GTYS* does not repeat *FES*, it instead uses the comparison between now and 2032 to highlight how key potential changes to gas supply and demand over the next decade could impact the gas transmission system.

This year we are utilising a hybrid of 2021 *FES* and 2022 *FES* in our investment decisions. To read more about this, go to section 1.2.4 Future Energy Scenarios review.

**Please note**

The recent announcements made in the UK Energy Security Strategy were made too late for inclusion in the 2022 *FES*. The potential changes will be assessed for inclusion in the 2023 *FES* and as part of any funding submissions if required.

**Figure 1.2**
The 2022 *FES* scenario framework




[1] In response to stakeholder feedback, our *GTYS* charts and tables workbook now also includes the data from the *FES* out to 2050.

# Drivers of change
## 1.2 Customer needs

### 1.2.2 Annual gas demand

Figure 1.3 shows how annual gas demand changes by scenario between 2021 and 2050. The 2021 *FES* data is included to show that, over the next 10 years, there is little change in the predicted reductions. It also shows that there was a reduction in annual demand during 2021, but not by as much as predicted in all three of the net zero scenarios.

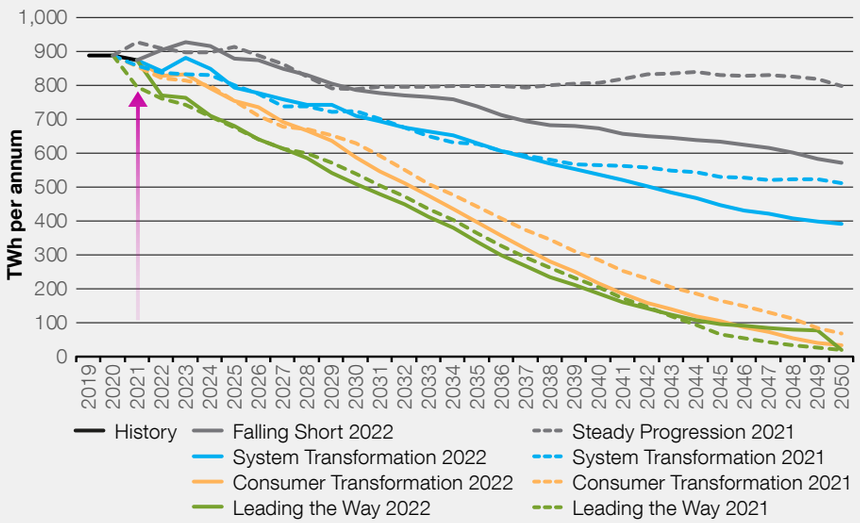
**System Transformation**
requires the least societal change of the net zero scenarios. Hydrogen is favoured for decarbonisation.

**Consumer Transformation**
sees high levels of societal change and a move to the electrification of heat.

**Falling Short**
(previously Steady Progression) continues the current rate of change, has the slowest decarbonisation and is the only scenario that does not meet the 2050 net zero target.

**Leading the Way**
assumes the highest levels of societal change to achieve the quickest and largest reduction in natural gas demand.

**Figure 1.3**
2021 *FES* and 2022 *FES* annual demand comparison



# Drivers of change
## 1.2 Customer needs

### 1.2.3 Peak daily demand

Gas peak day (1-in-20) demand is illustrated in figure 1.4. As with the annual demand assessment, the 2021 *FES* data is included to show that over the next 10 years there is little change in the predicted reductions. Again, it shows that there was a reduction in peak demand during 2021, but not by as much as predicted in all three of the net zero scenarios.

Trends in peak natural gas demand generally mirror annual natural gas demand in each scenario, as many of the factors which influence annual demand also influence peak demand, but the declines are not as rapid.

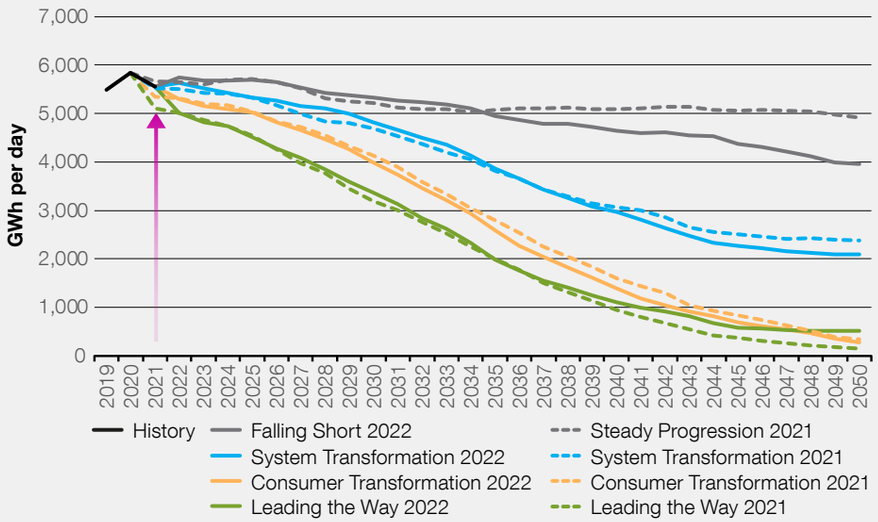
On cold winter days peak demand will continue to be high while large numbers of homes still rely on gas boilers. As the heat sector decarbonises in the net zero scenarios, with greater use of heat pumps and hydrogen boilers, the peak demand for natural gas will reduce.

Gas is still required as an essential electricity generation source when intermittent power generation is producing less. It is also used for heating in gas boilers, hybrid heating systems (electric heat pumps with gas boilers for peak load) or hydrogen production, depending on the scenario.

The 1-in-20 peak demand projections are slightly higher in the net zero scenarios, largely due to last year's assumed reductions not being achieved.

We are currently undertaking a review of the Gas Demand Charging Methodology to ensure that it remains suitable, especially with the level of change we expect to see as we move towards a net zero future.

**Figure 1.4**
2021 *FES* and 2022 *FES* peak day (1-in-20) gas demand comparison



# Drivers of change
## 1.2 Customer needs

### 1.2.4 *Future Energy Scenarios* review

It is becoming increasingly important to review the changes seen in each scenario over the next ten years to understand what needs to happen to make each of them credible.

With the current lack of incentives in place for consumers to change their behaviour, invest in thermal insultation and convert to net zero heating solutions, we do not expect the reductions in demand seen in Consumer Transformation (CT) and Leading the Way (LW) to occur as quickly as predicted. The record gas prices seen recently are driving consumers to turn down their thermostats, but there is no guarantee this will continue when prices reduce.

Although the 2022 *FES* is very similar to the 2021 edition over the next 10 years, there are big differences after this period – as figures 1.3 and 1.4 on the previous pages show.

While the *FES* provides us with detailed insight and analysis, there are a number of uncertainties around the data and how relevant it still is for our forward view in Gas Transmission when considering a wider context. For example, the changes seen in the Falling Short scenario compared to the Steady Progression scenario are driven by consumers converting to heat pumps from gas boilers. There is currently no incentive or policy driving that reduction, and unless that changes, we don't expect to see the level of reduction currently forecast.

Due to these uncertainties, for the next 12 months, we will be continuing to base our investment decisions on the 2021 *FES* Steady Progression (SP) and System Transformation (ST) scenarios. These will be used alongside the 2022 *FES* scenarios of CT and LW.

# Drivers of change
## 1.2 Customer needs

### 1.2.5 Gas supply

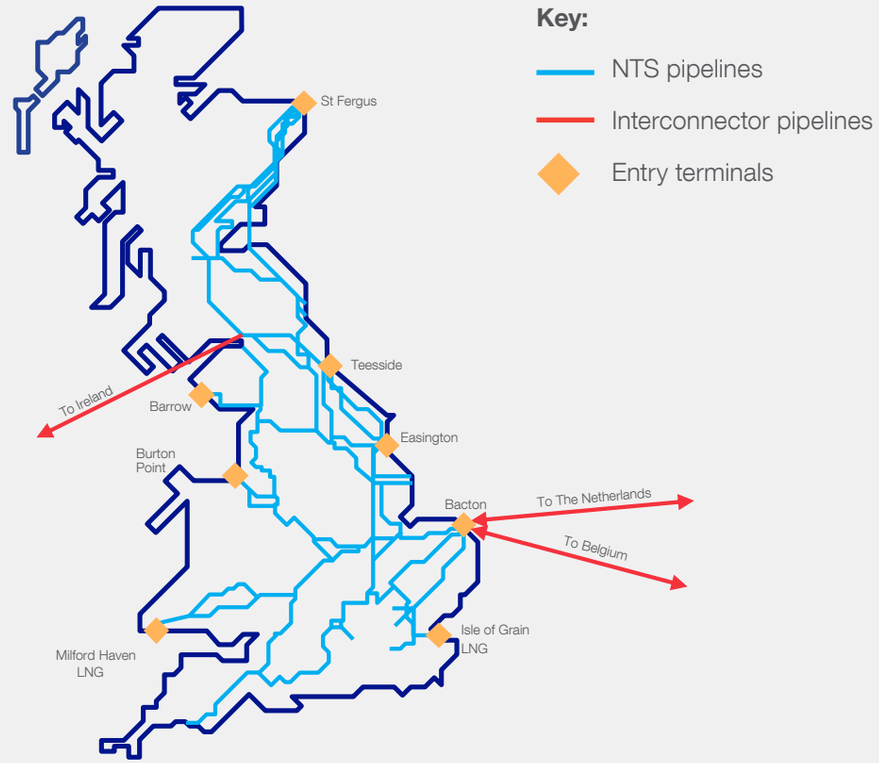
On the NTS, we have diverse sources of supply provided by eight entry terminals (figure 1.5). These deliver natural gas from the UK Continental Shelf (UKCS), the Norwegian Continental Shelf (NCS) and Europe, and liquefied natural gas (LNG) from the world market.

The UK is now dependent on imported gas for 63 per cent of our gas demand on higher demand days. As our import dependency has increased, the use of our network has changed – with a greater proportion of supply entering the network in the south. Due to this, we made the decision to reduce our capability to move gas from the north to south, with compression at Moffat and Warrington compressor stations being decommissioned during RIIO-2. This decision was supported by Ofgem, reducing our obligated capacity baselines at St Fergus and Theddlethorpe as part of the RIIO-2 Final Determinations. We are also reviewing our capability to maintain exit pressures in Scotland as supplies at St Fergus continue to decline.

We are now seeing a greater need for the compression that supports the flexible supply import terminals in the south at Bacton, Isle of Grain and Milford Haven. With some of the compression supporting these terminals impacted by emissions legislation, it is critical we retain the correct level of network capability going forward.

Current demands on the NTS caused by the concerns over energy security, the cost of energy and the war in Ukraine may combine to create necessary drivers of change for the future development of the NTS.

**Figure 1.5**
NTS gas supply terminals



# Drivers of change
## 1.2 Customer needs

**1.2.5 Gas supply** (continued)
Figure 1.6 compares the UK's gas supply composition between 2021 and 2032 for each Future Energy Scenario.

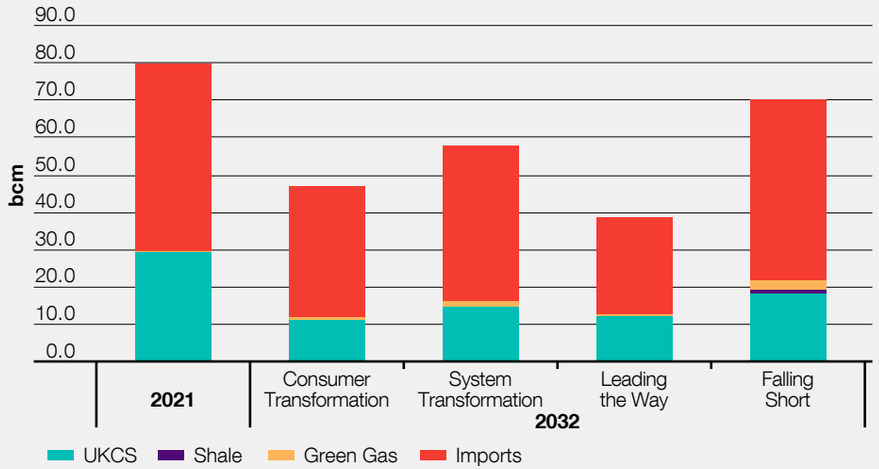
**Consumer Transformation (CT)**
The lower demands for natural gas start to necessitate more flexible supply and so this scenario sees the lowest level of supply from UKCS. This also corresponds to the highest proportion of import dependency across the scenarios.

**Leading the Way (LW)**
This has the lowest natural gas demand of the four scenarios in 2032 due to earlier decarbonisation. However, it sees a relatively slower UKCS decline than Consumer Transformation and so the import dependency is less.

**System Transformation (ST)**
While demand for natural gas reduces slightly in the early years, it levels off in the late 2020s as hydrogen production from natural gas begins to develop. Green gas supplies start to increase in the early 2020s but start to be displaced as hydrogen develops.

**Falling Short (FS)**
This has the highest demand for natural gas across the scenarios and the supply mix is closest to today. UKCS supplies at 2032 are also highest in this scenario. There is a higher proportion of green gas supplied, which is valuable for meeting hard-to-decarbonise demand and can be used in negative emissions technologies. Indigenous shale gas enters the supply mix in the early 2030s, which helps to mitigate the risk of import dependency.

**Figure 1.6**
Comparison of gas supply by scenario between 2021 and 2032



# Drivers of change
## 1.2 Customer needs

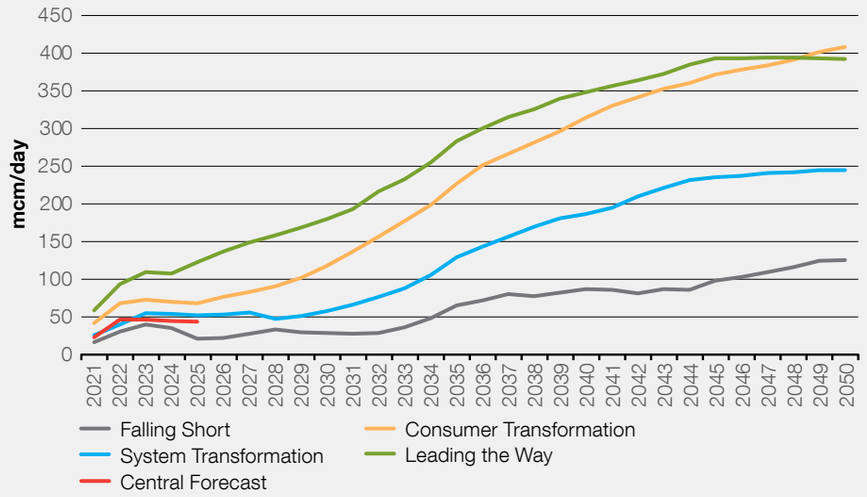
### 1.2.6 Peak supply

In each scenario, we assess whether the NTS has sufficient capability to supply peak demand. To make sure that demand can be met, even if there is a failure in the network, we carry out an assessment assuming that the single largest piece of infrastructure we have is not available. This is known as the N-1 test and is used by the Government in assessing the security of gas supply[2].

In figure 1.7 we show the margin of supply over peak demand under N-1 conditions. The figure shows that supply capacity exceeds peak demand in all scenarios out to 2050.

This national assessment is supplemented by more detailed zonal network capability assessments that assess whether the NTS retains sufficient entry capability as supply profiles evolve over time. This is particularly relevant as UKCS continues to decline and our need to import LNG may therefore increase. These assessments are described in more detail in the network capability chapter of this publication.

**Figure 1.7[2]**
Peak supply margin under N-1 conditions




[2] The quoted numbers differ from those seen in the Winter Outlook publication due to a known network capability constraint being factored into the calculation for that document. The calculation in the *GTYS* has been completed in line with the methodology set out in Gas (Security of Supply) Regulation EU 2017/1938, incorporated into UK law by the Gas (Security of Supply and Networks Codes) (Amendment) (EU Exit) Regulations 2019.

# Drivers of change
## 1.3 Asset management

The NTS is ageing, with many parts of the network more than 50 years old. Carefully managing our asset health is an increasingly important driver of change and trigger for our Network Development Process.

We have developed asset maintenance and asset health programmes to maintain the health of the NTS. Our asset maintenance programme focuses on delivering routine maintenance and monitoring the health of our assets. The asset health programme addresses assets that are either at end of life or have failed, and usually involves refurbishment or replacement, once we have assessed that the asset is still required. These programmes ensure that we can consistently deliver a safe and reliable system to meet the needs of our customers and stakeholders.

Figure 1.8 describes the measures of risk that comprise our monetised risk-based asset management approach. This framework, now called Network Asset Risk Metrics (NARMs), is being used to consistently assess and prioritise all our asset health investment and ensure that we deliver the work that is most beneficial to our customers and stakeholders.

### 1.3.1 Developing our asset management approach

Our approach to asset management is based on the ISO 55001 framework. This sustainable, risk-based approach to managing assets is crucial for ongoing realisation of value.

During 2021/22 we continued to drive incremental improvement of the asset management system to enable us to meet RIIO-2 targets and prepare for RIIO-3. Initiatives implemented include:

- enhancing the use of the Single Value Framework within our decision support tool (Copperleaf). This enables condition and intervention driver comparison, where all investments can be considered in a common currency of monetised risk.
- aligning our asset taxonomy in our Computerised Maintenance Management System (CMMS) to the ISO 14224 standard, and building intervenable units that form realistic building blocks for our Asset Management Plan (AMP).

**Figure 1.8**
Measures of risk

| Category | Service risk measure |
|---|---|
| **Safety** | Health and safety of the general public and employees |
| | Compliance with health and safety legislation |
| **Environment** | Environmental incidents |
| | Compliance with environmental legislation and permits |
| | Volume of emissions |
| | Noise pollution |
| **Availability and reliability** | Impact of network constraints |
| | Compensation for failure to supply |
| **Financial** | Shrinkage |
| | Impact on operating costs |
| **Societal and company** | Property damage |
| | Transport disruption |
| | Reputation |

# Drivers of change
## 1.4 Legislative change

This section summarises the key legislative changes that can trigger our Network Development Process, as these changes will impact how we plan and operate the NTS over the next ten years.

### 1.4.1 Emissions directives, IED and MCPD

The IED is the mandatory minimum emission standard for large combustion plant (> 50 MWth) that all European countries must comply with by 2023, and applies to our larger gas-powered compressors.

The MCPD has a compliance date of 1 January 2030 and applies to the remainder of our gas-powered compressors (> 1 MWth and < 50 MWth).

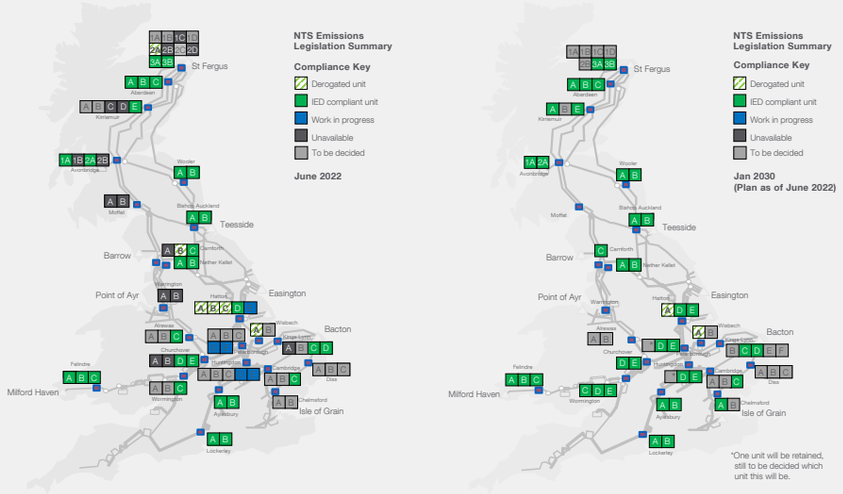
All of our compressors are compliant with current legislation, but many require intervention to ensure compliance by the appropriate date. These interventions include decommissioning, replacement with new compliant units, having emission abatement technology fitted, or being put on Emergency Use Derogation (i.e. having strict run hour limits).

Work is in progress at several sites to deliver compliance to the 2023 IED deadline. Due to the uncertainty in the energy landscape, investment decisions to deliver compliance with the MCPD will be made closer to the 2030 deadline. Details on decisions and progress we have made at individual sites are available in the Options and developments section of this publication.

In figure 1.9, the map on the left shows the sites with funding agreed and development in progress – units coloured blue. Units where funding is yet to be agreed, or further analysis is required, are shown in light grey. Green denotes units that are compliant with future emissions legislation and do not require intervention.

You can find more information about our activities around emissions legislation in our Compressor Emissions Asset Management Plan.

**Figure 1.9**
NGGT compressor fleet status now, and potential 2030 status



# Drivers of change
## 1.4 Legislation change

### 1.4.2 Gas quality
In January 2022, the HSE published a consultation and impact assessment on proposals to change the Gas Safety (Management) Regulations 1996. For full details see appendix 4.

### 1.4.3 Cyber protection
The Network and Information Systems (NIS) Directive came into force in the UK on 10 May 2018 to co-ordinate and raise overall levels of cyber resilience across the European Union (EU). As part of our programme of cyber-security investments, we have continual close engagement with Ofgem, BEIS and the National Cyber Security Centre (NCSC).

As we are an operator of Critical National Infrastructure (CNI), we are increasing our cyber resilience in a proportional manner as part of our RIIO-2 business plan submission and in accordance with the Cyber Assessment Framework (CAF). For more information click here.

# Drivers of change
## 1.5 Net zero

Climate change is the defining challenge of this generation – the decisions we take now will influence the future of our planet. To meet our vision of being at the heart of a clean, fair and affordable energy future, we are constantly monitoring and evolving our organisational capability. We have already made good progress on reducing our emissions – by 68 per cent since 1990. This is well ahead of our original target of 45 per cent by 2020.

Since 2020, the policy landscape with respect to net zero has evolved significantly. A few of the policies published include the Ten Point Plan for a Green Industrial Revolution, the Energy White Paper and the Climate Change Committee's 6th Carbon Budget.

Last year we saw the UK Government pass into law a new target to deliver a 78 per cent reduction in $CO_2$ emissions by 2035, in line with the recommendation from the Climate Change Committee (CCC). We also need to ensure that the Paris Agreement, a legally binding international treaty on climate change, is achieved. Its goal is to limit global warming to well below 2°C, preferably to 1.5°C, compared with pre-industrial levels.

With the need for cleaner energy, new changes to legislation and the target of net zero by 2050, net zero is becoming a more important driver of change for us. We will lead the way in the decarbonisation of gas, investing in a range of solutions such as renewable natural gas, using blended hydrogen in our network and carbon offsetting. Continuing projects such as Project Union and Future Grid are key to achieving this target.

### 1.5.1 Hydrogen

Today, natural gas plays a key role in the energy landscape: delivering three times as much energy as electricity; keeping 85 per cent of the UK's 28 million homes warm; generating electricity; and fuelling many industrial and manufacturing processes.

Hydrogen has been identified as a potential low-carbon replacement for natural gas. Converting our network to carry hydrogen would be a lower-cost, less disruptive option for customers and consumers than replacing our entire network. The UK's Hydrogen Strategy estimates that 250-460TWh of hydrogen could be needed in 2050 to meet net zero, which would make up 20-35 per cent of final energy demand.

The hydrogen policy landscape continues to evolve, some targets include:

- 2GW of hydrogen production capacity by 2025 and 10GW of hydrogen production capacity by 2030 with over 50 per cent of this coming from electrolytic hydrogen.
- Decision on blending up to 20 per cent hydrogen into natural gas grid by 2023.
- The first 100 per cent hydrogen village by 2025 and the first hydrogen town by 2030.
- Hydrogen heating decision by 2026.
- New business models for hydrogen transport and storage infrastructure designed by 2025.

Following extensive consultation with stakeholders we have also published our Hydrogen Roadmap to 2050, showing a potential timeline for the journey to net zero.

**10GW**
**of hydrogen production capacity by 2030**

**100%**
**hydrogen village by 2025**

# Drivers of change
## 1.5 Net zero

### 1.5.2 Building the evidence base for hydrogen

Over the RIIO-2 period (2021–2026), we are continuing to build the technical and safety evidence to enable the transition to hydrogen. This will allow us to be ready to start the conversion to hydrogen by 2026 as committed to in our RIIO-2 business plan.

We are doing this through a number of mechanisms including our innovation programme, FutureGrid, and through industry-wide collaboration. All these activities will enable us to start the transition from natural gas to hydrogen which is being delivered though our flagship programme, Project Union.

In July 2020, National Grid Gas Transmission submitted the FutureGrid project as part of the Network Innovation Competition (NIC) process. The FutureGrid project will build a hydrogen test facility from a representative range of decommissioned assets. Flows of hydrogen and natural gas blends (up to 100 per cent hydrogen) will be tested at transmission pressures to better understand how hydrogen interacts with the assets.

You can find more information on FutureGrid here.

### 1.5.3 Collaboration across the industry

#### Gas Goes Green

The Energy Networks Association's (ENA) Gas Goes Green (GGG) programme launched successfully in April 2020, bringing together all five of Britain's gas networks to deliver the world's first zero-carbon gas grid. The Gas Goes Green Pathway to Net Zero sets out the actions required to achieve this. Since the launch of the programme, several joint reports have been published including:

- Britain's Hydrogen Network Plan
- Britain's Hydrogen Blending Delivery Plan.

#### European Hydrogen Backbone

The European Hydrogen Backbone (EHB) initiative consists of 31 gas infrastructure companies across 28 countries working collaboratively to develop a vision of how dedicated hydrogen infrastructure would develop. In April 2022, an updated vision of the EHB was published, showing a truly pan-European hydrogen network.

# Drivers of change
## 1.5 Net zero

### 1.5.4 Innovation

In 2021/22, we increased our focus on hydrogen-related projects to help us reach our target of net zero by 2050. As part of this, we undertook 17 projects with £2.17m in funding from the Network Innovation Allowance (NIA).

In RIIO-1, we delivered several projects looking into the capability of the NTS to transport hydrogen, and we've continued building on this work, undertaking a wide range of projects that explore the opportunities surrounding hydrogen as an alternative to natural gas.

This includes looking at the possibility of transporting blends of natural gas and hydrogen, identifying the available technology options for 'deblending' hydrogen and exploring whether our existing compressor units can successfully operate with hydrogen. In addition to this, we also looked at ways in which our asset data will need to improve, and the digital technologies available to support us with this improvement.

Some of the projects carried out this year include:

- variable hydrogen blend compression
- new pipeline AI route planning
- inhibition of hydrogen embrittlement effects in steel pipelines
- Gas and Electricity Transmission infrastructure outlook.

This year, the process for the new Strategic Innovation Fund (SIF) began. Alongside our NIA projects, we submitted applications for 11 SIF Discovery phase projects and were delighted to be awarded funding for 10 of them. These projects lasted for two months, concluding in April 2022, and focused on better understanding some of the challenges associated with converting our network to carry hydrogen.

Following their conclusion, we were awarded funding of £1.7m to carry out four projects as part of the next phase of the SIF process – the Alpha phase. You can find out more about these projects in our options and developments section.


# 2 Network capability

# Network capability

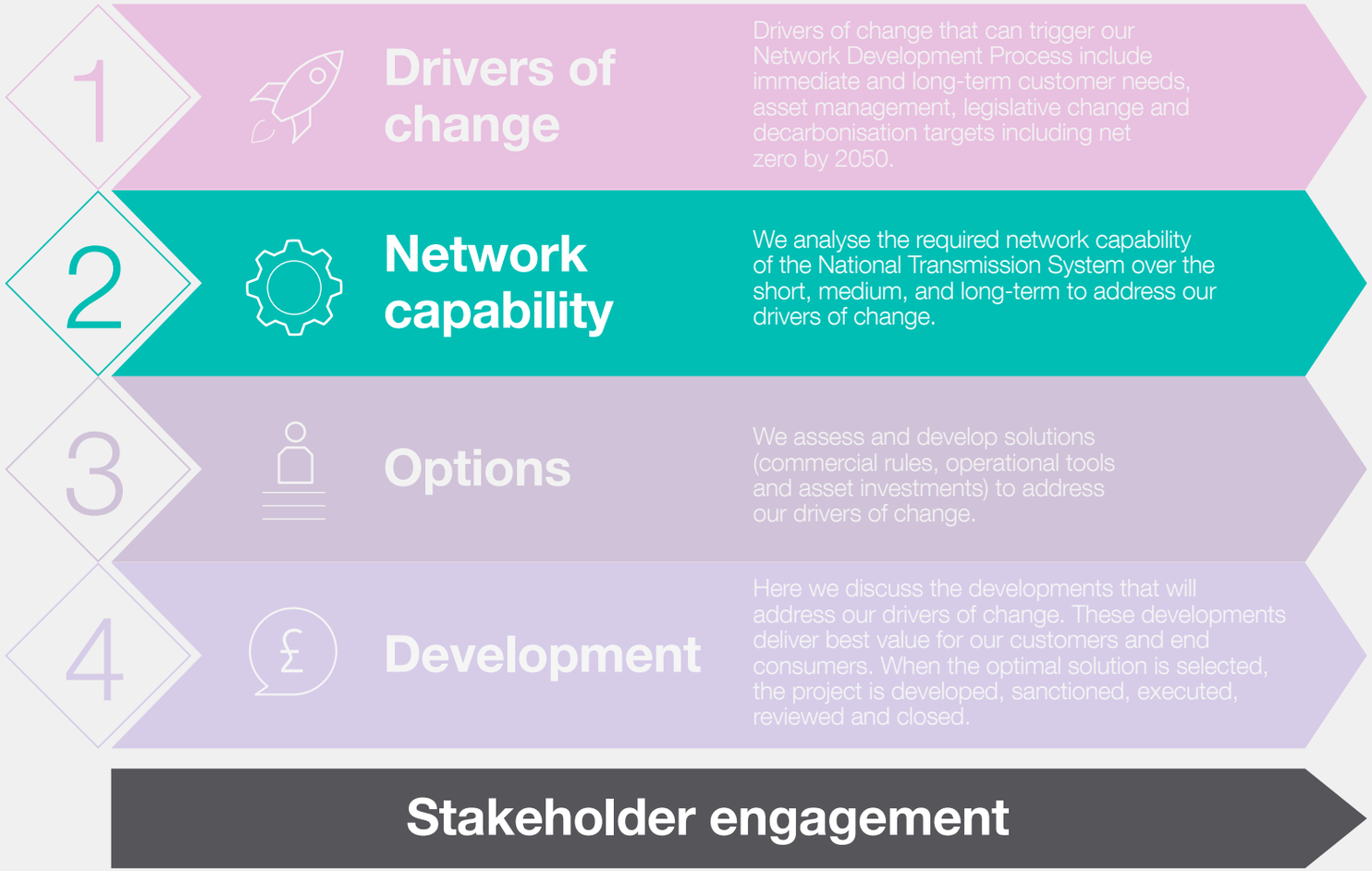
## 2.1 Introduction

**This chapter explores the second stage of our Network Development Process (figure 2.1). Here, we give details of how we analyse and assess the required capability of the NTS to address the drivers of change in each zone.**

The network capability process enables us to demonstrate the physical capability of the NTS and how that capability compares to the needs of our customers, now and into the future.

This assessment is carried out against a range of future supply and demand scenarios using the *Future Energy Scenarios (FES)*.

**Figure 2.1**
Our Network Development Process




**Please note**

The analysis this year is based on a hybrid approach using a combination of 2021 *FES* and 2022 *FES*. This helps us cover a wider range of scenarios given the uncertainties, e.g. which green solutions consumers will invest in.

# Network capability

## 2.2 The Annual Network Capability Assessment Report

Since 2021, we have published an *Annual Network Capability Assessment Report* (*ANCAR*) in June of each year. The document includes information at entry and exit zone level, on both the level of physical network capability and also the level of network capability that can be delivered using commercial tools.

Our most recent *ANCAR* was published in June 2022.

In addition to the core content of the *ANCAR* we also plan to include the following in the 2023 *ANCAR*.

- **Scotland & the North**
  An update on our assessment of options to address risks on Scottish pressures.
- **East Midlands**
  Assessment of the additional export flows to continental Europe via Bacton.
- **North East**
  Assessment of Rough storage returning to service.
- **Enhanced additional content**
  As a result of your feedback we will include resilience curves and linepack management in one or more zones and expand upon the the interzonal flow section.

### Feedback

Your feedback is so important to us – let us know what you'd like to see in future *ANCAR* publications by getting in touch with us at: .Box.OperationalLiaison@nationalgrid.com

As part of our continual engagement, we present an initial view of network capability within this *Gas Ten Year Statement*.

We base this on last year's network capability analysis, applied against a hybrid of 2021 *FES* and 2022 *FES* flow predictions. This allows early sight of any significant changes since last year's *FES* that could impact our investment decisions, and/or highlight any new capability requirements. The flame charts for this analysis can be found in appendix 2.

On the next page we will explain any changes that have been observed since we produced the full *ANCAR* in June 2022.

The specific projects being undertaken in each zone can be found in the Options and developments section.

# Network capability

## 2.3 Summary of changes by zone

### Scotland and the North (zone 1)

The trend of supplies into the St Fergus entry terminal continues to reduce over the coming years, which could result in low pressures or exit constraints. We will continue to assess this as part of both the *ANCAR* process and the projects noted below:

St Fergus

Scotland network exit capability

### North East (zone 3)

Rough storage has now returned to service, this will be assessed in our next *ANCAR*. There are no other significant changes driven by our network capability assessment however there is a legislative change project at a compressor site:

Hatton

### South Wales (zone 4)

Due to forecast LNG supply increases there continues to be a growing number of occurrences where supply may be above capability. This zone has the strongest indication that there may be a need for increased capability. A number of projects are in progress for this zone:

Western Gas Network

Wormington

Tirley

### East Midlands (zone 6) and South East (zone 7)

We have seen a significant increase in export flows via the Bacton interconnector this year and there is some uncertainty about the level of exit flows we may see going forward. This will be a key area of focus for us and a number of projects are ongoing:

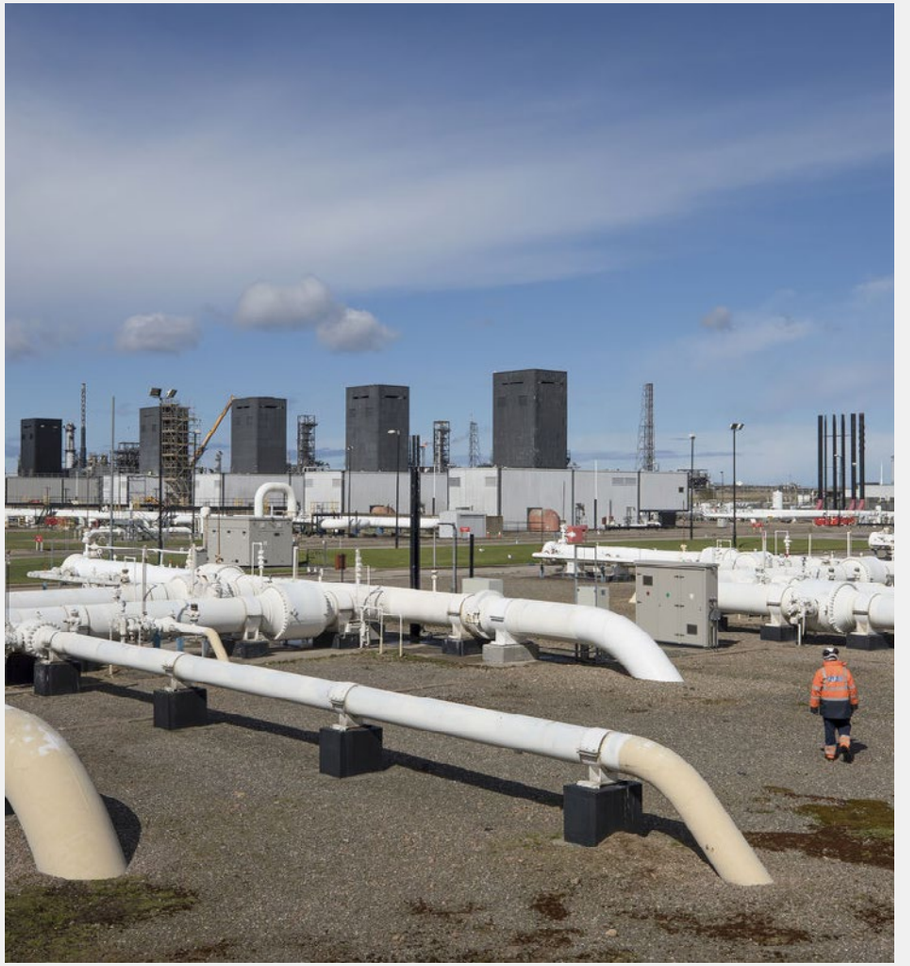
Bacton Campaign

King's Lynn

### North West (zone 2) and South West (zone 5)

There are no significant changes in these zones, however we are delivering legislative change projects at two of our compressor sites in the South West:

Peterborough & Huntingdon



# 3 Options and developments

# Options and developments

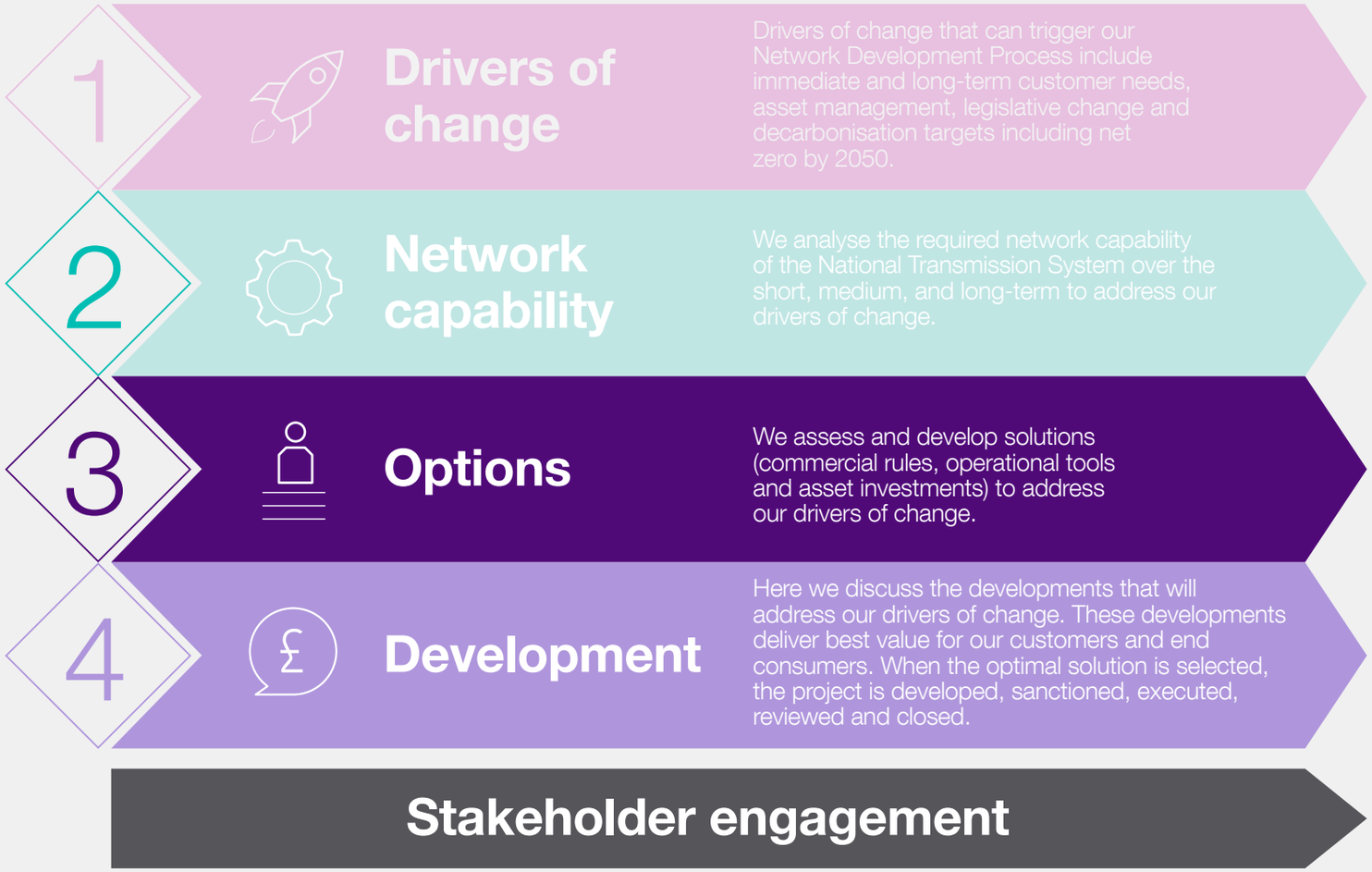
## 3.1 Executive summary

**This chapter summarises the options and developments stages of our Network Development Process (NDP), where options are identified and the preferred option is progressed to address the drivers of change (figure 3.1). The chapter focuses on specific project details and their current development status.**

Stage 3 of our NDP comprises the identification of options using a mix of rules (industry frameworks), tools (commercial arrangements and operational strategies) and assets (physical solutions to ensure we retain the required level of network capability). Each option will usually have a mixture of solutions, with elements of asset solutions alongside both rules and tools.

Stage 4 of our NDP is only reached if the optimal solution to a driver of change cannot be found within our existing network capability. The aim of this stage is to further develop the preferred options based on the direction of travel decided in stage 3. It may be necessary to progress multiple options at the same time to ensure the optimal final solution is progressed to completion.

**Figure 3.1**
The Network Development Process



# Options and developments
## 3.2 Zone 1: Scotland and the North

### Project
St Fergus terminal

**Category:** Asset Management, Legislative Change

### Background

St Fergus terminal is an entry point into the UK in the North of Scotland. The terminal was built in 1975 in a coastal environment which accelerates corrosion degradation. Across the site, investment continues to be made across a number of workstreams to address existing issues that may pose a potential safety risk, while in parallel retaining appropriate levels of compression availability and capability and meeting environmental targets.

### Status

Through 2021/22 we have continued to deliver our asset health investment. Our RIIO-2 plan for St Fergus seeks to optimise investment aligned with managing safety and reliability risks on ageing assets with the efficient delivery of our future compression strategy for the terminal.

### Next steps

We are submitting our proposals to Ofgem as an uncertainty mechanism in 2023. Our preferred options all require at least three new units, with associated Asset Health investments, which is in line with our previous proposal.

**More information about our public consultation for St Fergus can be found on our website.**

# Options and developments
## 3.2 Zone 1: Scotland and the North


## Project
Scotland network exit capability

**Category:** Customer need

### Background

As UKCS supplies have declined, we have experienced periods of low supply alongside periods of high demand. With the network having limited capability to transport gas from south to north, it is becoming increasing challenging for us to manage pressures in Scotland under low flow conditions.

### Status

A range of options have been identified for investment, either in National Grid assets, or by taking the whole system option of investing within the distribution network. The most financially beneficial option from the CBA continues to be investment in the National Grid network. Supplies have declined at a lower rate than original expectations, meaning these investments are not yet needed.

### Next steps

We will continue to monitor expectations for St Fergus supplies and keep the requirement for these investments under review.

# Options and developments
## 3.3 Zone 3: North East

### Project
Hatton compressor station

**Category:** Legislative change

### Background

Hatton compressor station provides network entry capability in the North East and supports network exit capability in the South East and South West. The station consists of one electric unit and three gas-powered units. These latter units are within scope of the IED and will need to be decommissioned or operate with restricted running hours by the end of 2023 in order to remain compliant.

### Status

Funding was awarded through RIIO-2 Final Determination for a single large gas-powered compressor. We are currently progressing delivery of the new IED compliant compressor.

### Next steps

The investment will be completed during the RIIO-2 period.

**More information about our Hatton Gas Compressor Upgrade programme can be found on our website.**

# Options and developments
## 3.4 Zone 4: South Wales

## Project
Western Gas Network project

**Category:** Customer need

### Background

In 2018 a Planning and Advanced Reservation of Capacity Agreement (PARCA) application was received for the Milford Haven Aggregated System Entry Point to increase the current entry capacity baseline from 950 GWh/d to 1,113 GWh/d.

### Status

Capacity has been allocated to the customer and Ofgem have approved the need case. A thorough and detailed analysis of our network revealed the option with the least amount of new infrastructure, the least impact on people and the environment, at the least cost, representing the best value for UK consumers. The work, collectively known as the Western Gas Network project, involves 11km of new pipeline, pressure uprating of the existing pipeline between Milford Haven and Three Cocks (Powys) and supporting works.

### Next steps

Our submission to Ofgem to secure approval for the investment funding will be submitted in 2023. We currently anticipate being able to bring forward the date when the additional capacity will be available from January 2026 to during 2025, with the intention that all project work be complete in 2026.

**More information about our Western Gas Network project can be found on our website.**

# Options and developments
## 3.4 Zone 4: South Wales

### Project
Wormington compressor station

**Category:** Legislative change

### Background

Wormington compressor station supports network entry and exit capability in South Wales. The station consists of one electric unit and two gas-powered units. The latter two units are within scope of the MCPD and therefore will need to be decommissioned or operate with restricted running hours by January 2030 in order to remain compliant.

### Status

In August 2022, through the Wormington uncertainty mechanism, we have proposed that two new MCPD compliant compressor units will be installed at Wormington.

### Next steps

The decision is currently out for consultation, with a final decision by Ofgem expected in 2023.

# Options and developments
## 3.4 Zone 4: South Wales

## Project
Tirley above-ground installation

**Category:** Customer need

### Background

Positioned between two sections of the network that operate at different pressures, our above-ground installation at Tirley performs an important safety function to protect the lower pressure section from the higher pressures in the adjacent section of network. During RIIO-1 we delayed filter maintenance at Tirley to avoid causing constraints on the network due to the inability to isolate individual filters for maintenance. Isolating the whole site restricts flow in South Wales, reducing entry capacity to ~20mcm/d. The restriction would also impact gas flows out of England and into South Wales to meet demand, should Milford Haven not be exporting LNG into the network.

### Status

Funding was awarded through our RIIO-2 submission to install new isolation valves. This will allow for individual filters at the Tirley site to be isolated and maintained without limiting our network entry capability at Milford Haven.

### Next steps

Now that funding has been awarded, the next steps for this project are implementation and delivery.

# Options and developments
## 3.5 Zone 5: South West

### Project
Peterborough and Huntingdon compressor stations

**Category:** Legislative change


### Background

Peterborough and Huntingdon compressor stations support network exit capability in the South East and South West. They have been considered together due to their operational interdependence.

Each station consists of three gas-powered units. These units are within scope of the IED and MCPD, and will need to be decommissioned or operate with restricted running hours by December 2030 in order to remain compliant.

### Status

We are continuing with works at Huntingdon and Peterborough compressor sites to deliver two new IED compliant gas turbines on each site by June 2023. The new units are each 15.3MW in size.

### Next steps

We are continuing to review the requirement for resilience at these sites. We will submit any need for additional new units to Ofgem as an uncertainty mechanism in 2023.

# Options and developments
## 3.6 Zone 6: East Midlands

## Project
King's Lynn compressor station

**Category:** Legislative change

### Background

King's Lynn compressor station supports network entry and exit capability in the South East and East Midlands. The station consists of four gas-powered units. Two of these units are within scope of the MCPD and therefore will need to be decommissioned or operate with restricted running hours by January 2030 in order to remain compliant.

### Status

In our RIIO-2 business plan we proposed that two compliant gas-powered units should be installed at King's Lynn in order to maintain existing capability and resilience at this station.

### Next steps

These proposals are subject to uncertainty mechanisms being submitted in 2023 and could change as options are further refined.

# Options and developments
## 3.7 Zone 7: South East

### Project
Bacton terminal

**Category:** Asset Management

### Background

The Bacton terminal is a key strategic gas terminal into the UK and will continue to operate until at least 2050 under our current *FES* scenarios. The site commenced operation in 1968 in a coastal environment which accelerates degradation, and has operated continuously since, with no site-wide outages. Examination of the risks and consideration of the needs case work at Bacton has identified issues that should be prioritised in the short term and we are considering options to retain safe operation of the site for the long term, and in consideration of net zero.

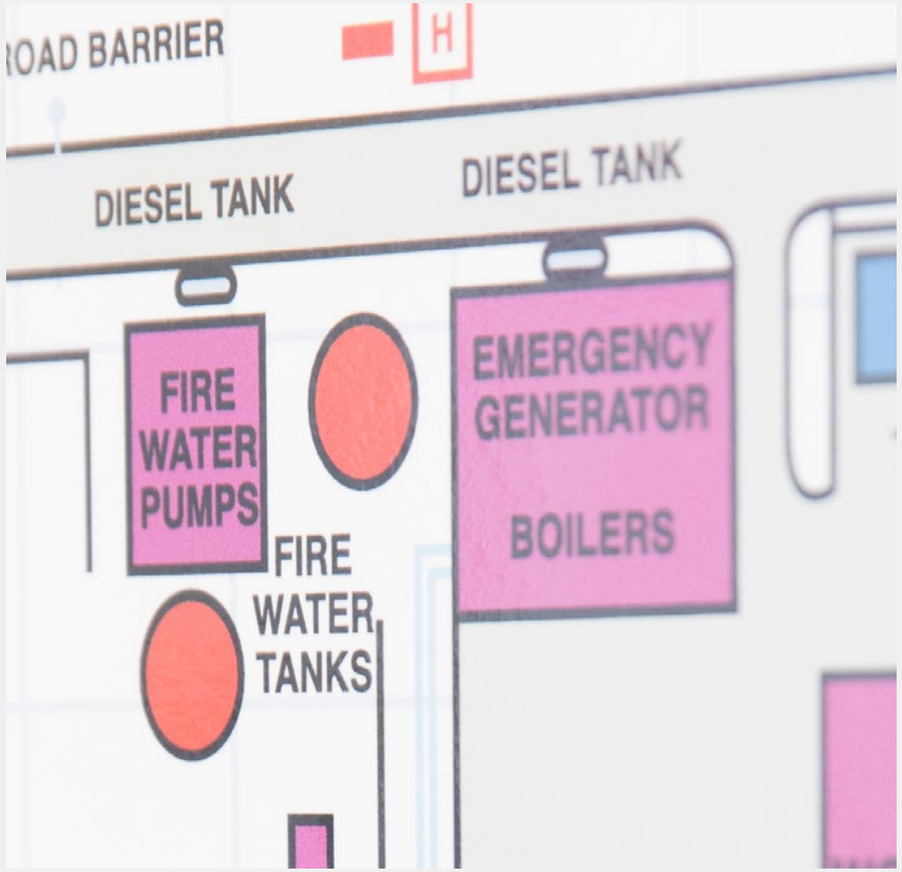
### Status

For our long-term optioneering we are currently commencing further exploratory investigations on our below ground assets on site. The information we gather will provide greater understanding of the risk associated with ongoing use of the ageing assets and their suitability for use as part of a future hydrogen network. It will supplement the studies we have already completed and will form a critical input into our option selection process for the long-term option at the site, subject to an uncertainty mechanism.

### Next steps

While this option selection phase is ongoing, we are undertaking asset health works to maintain the safety and reliability of the current assets. Some of these investments have baseline funding while other works will be subject to an uncertainty mechanism.

# Options and developments
## 3.8 National




**Project**
Redundant assets

**Category:** Asset management

### Background

As the requirements on the NTS change, there are assets on the network that are no longer required by National Grid or our customers to operate the network – these are defined as redundant assets.

Assets that remain on the network for longer than required represent an ongoing maintenance committment and operational cost, as well as having the potential to cause detrimental impacts to the environment.

### Status

A range of scopes to decommission redundant assets and sites was identified and funding awarded through the RIIO-2 Final Determination. In the first year of the RIIO-2 period five redundant asset projects have progressed through design to build stage and have been physically completed.

### Next steps

Eight projects are currently within the detailed design stage, with a further 25 at conceptual design. Projects are forecast to progress across the RIIO-2 period.

# Options and developments
## 3.8 National

### Project
Physical Security Upgrade Programme

**Category:** Legislative change

### Background

Our network is subject to a multitude of security threats, which are ever-changing and increasing in sophistication and persistence. These threats include criminality, espionage, activists and extremists, vulnerabilities within systems and vulnerability from insider action.

Additionally, there is a rapidly growing threat to industrial control systems due to cyber-attacks from a range of hostile forces. The Physical Security Upgrade Programme (PSUP) is a Department for Business, Energy and Industrial Strategy (BEIS) led national programme to enhance physical site security, which commenced in RIIO-1.

### Status

In RIIO-2 our investments cover the latest phase of sites agreed with the government.

### Next steps

Given the relatively short asset lives of the IT hardware and technical assets within these solutions, we have also commenced a rolling asset replacement programme at the sites where solutions were installed in the early phases of the PSUP.

# Options and developments
## 3.9 Cyber protection

## Project
Cyber protection

**Category:** Legislative change

### Background

The Network and Information Systems (NIS) Directive came into force in the UK on 10 May 2018 to co-ordinate and raise overall levels of cyber resilience across the European Union (EU).

As part of our programme of cyber-security investments, we have continual close engagement with Ofgem, BEIS and the National Cyber Security Centre (NCSC).

### Status

As we are an operator of Critical National Infrastructure (CNI), we are increasing our cyber resilience appropriately as part of our RIIO-2 business plan submission and in accordance with the Cyber Assessment Framework (CAF).

### Next steps

We will continue to deliver the plan that has been agreed with Ofgem and BEIS.

# Options and developments
## 3.10 Methane emissions

### Project
Methane emissions

**Category:** Legislative change

### Background

National Grid Gas Transmission (NGGT) plays a critical role in the UK natural gas supply chain. NGGT transports predominantly natural gas from beach landing points at gas terminals and LNG terminals operated by other operators to industrial users, power generators and household consumers via the gas distribution networks.

At COP26 in Glasgow the UK Government, along with 121 other governments, committed to the Global Methane Pledge with the aim of reducing global methane emissions by 30 per cent from a 2020 baseline. Rapidly reducing methane emissions will keep the goal of limiting global warming to 1.5°C within reach and avoid the worst consequences of climate change.

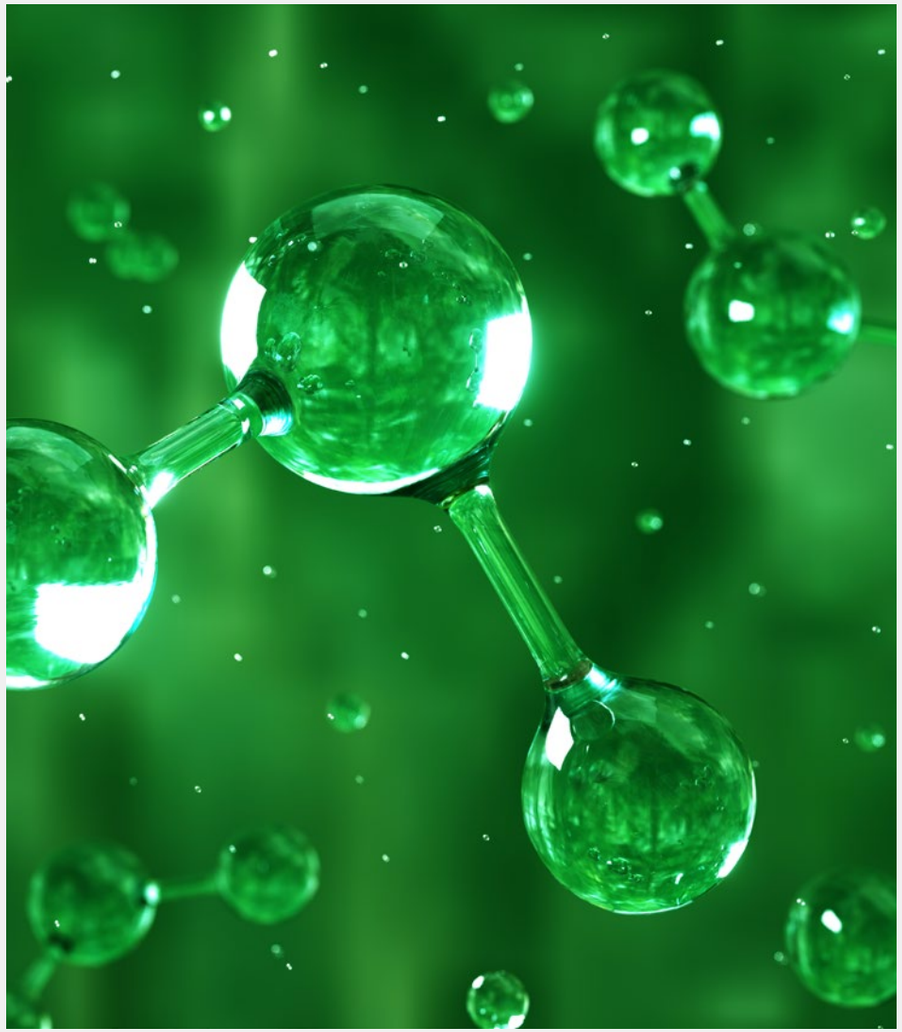
### Status

We are developing uncertainty mechanism submissions collaboratively with Ofgem in 2022, seeking investment in equipment and technology to reduce methane emissions from operating the NTS and improve detection and quantification of fugitive gas escapes.

### Next steps

Submission of uncertainty mechanisms and investment in equipment and technology to reduce methane emissions as agreed with Ofgem.

# Options and developments
## 3.11 Net zero



## Project
HyNTS compression

**Category:** Net zero by 2050

### Background

HyNTS compression investigates and demonstrates the opportunity of repurposing compressor systems for the compression of hydrogen and hydrogen blends in the National Transmission System (NTS).

This project will:

1. build a offline compression testing facility as part of FutureGrid at DNV Spadeadam.
2. identify the percentage hydrogen blend an existing NTS compressor can operate at.
3. demonstrate that an NTS compressor package can be retrofitted to make it suitable for 100 per cent hydrogen.
4. demonstrate that an NTS compressor package can be operated with variable hydrogen blends.

### Status

The operational parameters for a compressor with hydrogen are being mapped out including fuel consumption and heat input. This will drive the conceptual design of phase 2 of FutureGrid.

### Next steps

Complete the conceptual design, commence beta (Delivery) scoping, planning, costing and preparation of business case.

# Options and developments
## 3.11 Net zero

### Project
HyNTS pipeline dataset

**Category:** Net zero by 2050

### Background

HyNTS pipeline dataset looks to develop tools and processes to accelerate the pipeline assessment required for hydrogen readiness of NTS and local transmission system (LTS) pipelines.

### Status

Project is approaching the midpoint of Alpha phase and has made good progress thus far. Various pipeline datasets have been collected from internal teams, systems, and scanned in from archived documents. Potential non-destructive testing technologies have been researched and a technical report has been produced documenting the range of technologies available for pipeline inspection.

### Next steps

Rosen are to complete the collation of data on a specified pipeline section. Once all the available data for the feeder section we have chosen for this project has been identified and pulled into a database, a gap analysis will be undertaken to identify missing datasets. Inline-inspection technologies which can help fill these gaps will be identified and scoped into the beta phase of this project which looks to test these pipeline inspection tools on the FutureGrid hydrogen test facility.

# Options and developments
## 3.11 Net zero

## Project
HyNTS deblending for transport applications

**Category:** Net zero by 2050

### Background

HyNTS deblending for transport applications focuses on the delivery of high purity hydrogen from blended gas networks to enable delivery to transport applications, enabling hydrogen infrastructure to be provided more quickly and with greater resilience.

### Status

At the half way point the HyNTS Deblending project is on track to deliver its objectives of selecting a preferred equipment manufacturer and refuelling station technology. We have selected to work with a new and innovative separation technology called 'Electrochemical separation' that we believe is best suited for the transport application in that the process can separate, purify and compress the hydrogen.

Additionally the team have been looking at likely hydrogen demand and supply profiles on the gas transmission network and also building up a demonstration of the technology out of our offline test facility where we will also showcase the refuelling technology to serve a fleet of vehicles.

### Next steps

For the remaining time of the Alpha phase of this innovation project we will work with the equipment manufacturers to build up a design for the demonstration facility showing a scale up of the technology from where it is today to deliver between 40 and 200kg/day of hydrogen. There will also need to be integration designs between the electrochemical separation equipment and the refuelling pumps which has not been tested to date.

We will also complete the flow profile work and understand what demand there would be at our test facility for hydrogen refuelling ahead of the demonstration. In order to progress this project we will then need to feed all the information gathered into an application for the next stage which would fund the demonstration.

# Options and developments
## 3.11 Net zero

### Project
HyNTS protection

**Category:** Net zero by 2050

### Background

HyNTS protection looks at protecting network assets from hydrogen permeation and maintaining asset lifetime using hydrogen barrier coatings, therefore reducing the cost of maintenance and replacement of network assets through the transition.

### Status

Project halfway through Alpha phase. Two coating systems have been identified by Ultima Forma as potentially suitable for in-pipe coating: laser welded metal foils; and cold sprayed metal. Surface preparation technologies crucial for subsequent coating deposition have been identified and trialled in laboratory settings. The coating solutions are also undergoing hydrogen permeation and wear testing to validate performance.

Electrodeposition technology has been identified as most suitable for removable assets that could be coated offline.

### Next steps

Rosen to outline potential coating delivery systems to enable in-pipe deployment of the two shortlisted coating systems. This will include assessments of the feasibility of incorporating coating systems onto robotic systems.

Ultima Forma to undertake workshop-based demonstrations of coating systems and establish detailed process for coating system deposition on in-pipe and removable assets.

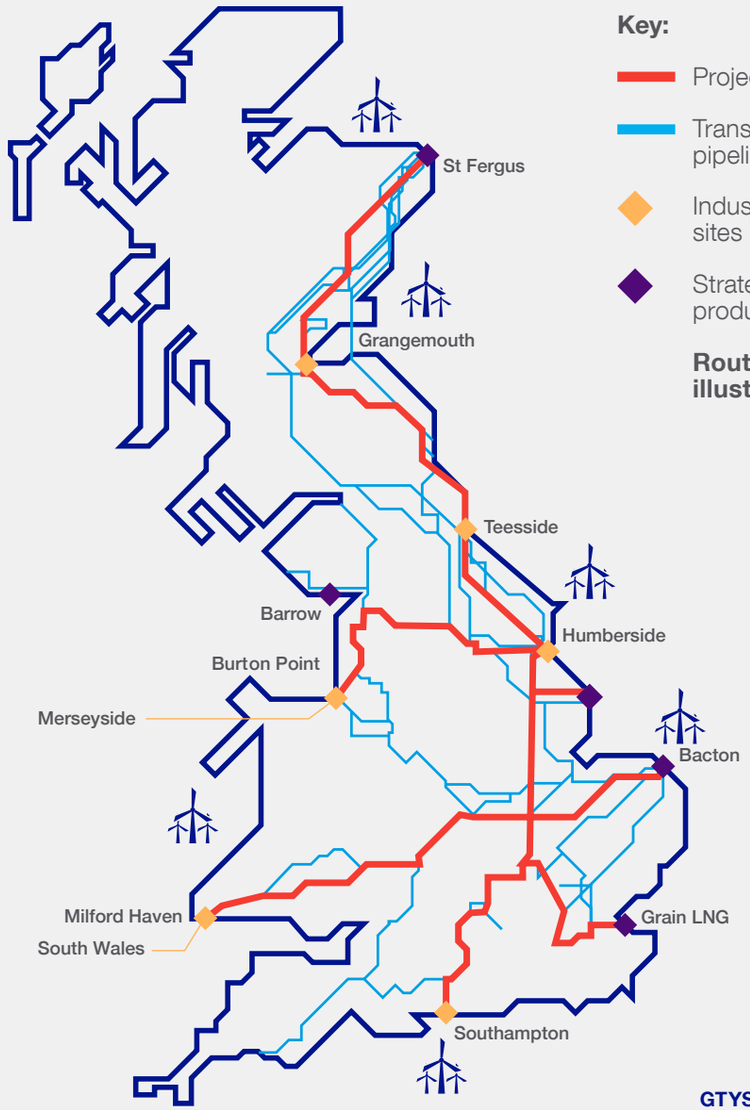
National Grid Gas Transmission to determine business case and implementation plans for the adoption of hydrogen barrier coatings.

# Options and developments
## 3.12 ProjectUnion


**Project Union** will connect and empower a UK hydrogen economy, repurposing existing transmission pipelines to create a **hydrogen 'backbone' for the UK by the early 2030s**. Project Union is a critical step towards net zero.

It spans across the UK connecting all major industrial clusters, hydrogen production centres and linking hydrogen supply and demand. A circa 2,000km hydrogen backbone would be created, representing around 25 per cent of the UK's current natural gas transmission pipelines.

The Feasibility phase will identify **a programme of 'no-regrets' investments** with supporting evidence to inform energy policy that will enable the UK Government to make progress in realising its hydrogen ambitions.



# Options and developments

## 3.12 ProjectUnion

**Decarbonisation of industry and power**

Fair access to low carbon hydrogen enabling businesses to decarbonise. Access to transmission enables hydrogen production at scale.

**Energy storage and resilience**

System resilience to move and store sufficient volumes across the country.

**Connectivity and efficiency**

Connect production and storage with demand, enabling system efficiency through shared infrastructure.

**Market coupling**

Connect isolated production sites, enabling competition, reducing costs and improving security of supply.

**Levelling up and jobs**

Project Union will directly support approx. £300m annual GVA (2021 prices) and 3,100 jobs at peak construction.

**Global leader in green innovation**

Attract global investors by getting best value from national infrastructure and enabling rapid scale up.

**Flexibility and optionality**

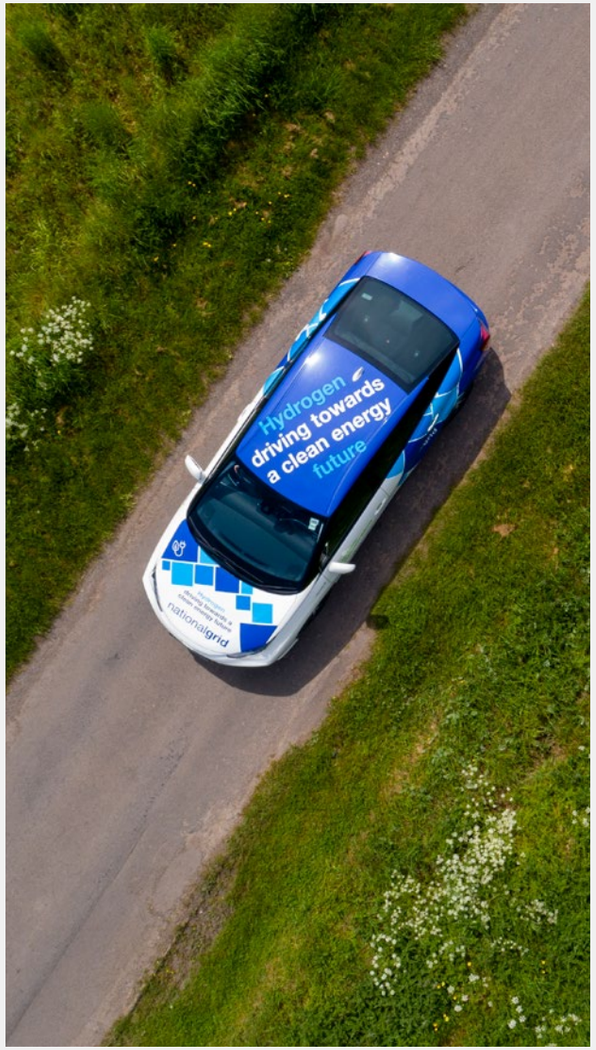
Flexibility in power generation, storage and consumption. Optionality in future hydrogen decisions while maintaining gas networks' delivery.

**Consumer-centric**

Innovative, cost-effective consumer focused energy solutions – for example, the pilot hydrogen town brings scalability and expansion.

**Promote energy independence**

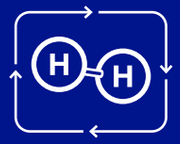
Enable fair access to indigenous supplies around the UK and opens up the potential for export opportunities by connecting to the European Hydrogen Backbone.



# Options and developments
## 3.13 FutureGrid

**An ambitious programme building a hydrogen test facility from decommissioned assets at DNV's facility in Cumbria to demonstrate the National Transmission System (NTS) can transport hydrogen.**

**1**

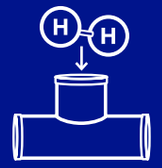



**Offline hydrogen test facility**

A representative range of NTS assets of different types, sizes, and material grades are being supplied from decommissioned assets to build the hydrogen test facility.

- 2% hydrogen
- 5% hydrogen
- 20% hydrogen
- 100% hydrogen

**2**



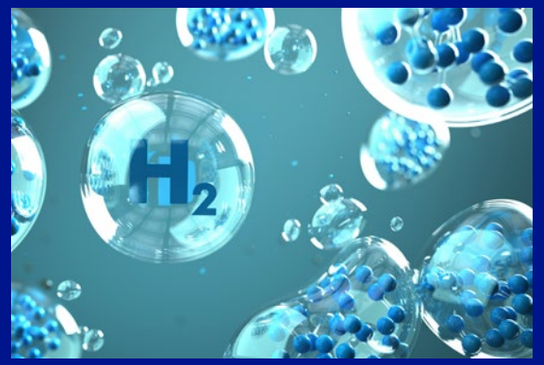

**Standalone hydrogen test modules**

Standalone hydrogen test modules are operating to provide key data required to feed into the main facility, including:

- **Material permeation testing**
- **Pipe coating and CP testing**
- **Fatigue testing**
- **Flange testing**
- **Asset leak testing**
- **Rupture testing**

# Options and developments
## 3.13 FutureGrid

### Building a unique high-pressure hydrogen test facility from decommissioned transmission assets:





DNV · HSE · Northern Gas Networks · fluxys · Durham University

**Key**

1 High pressure storage
2 Ball valve arrangement
3 Ultrasonic meter
4 Customer offtake
5 Block valve
6 Low pressure storage
7 Recompression unit
8 Control room

### National Transmission System (NTS) hydrogen safety case review

FutureGrid will help us gain a full understanding of working and living with hydrogen, to develop processes and procedures – like those we have for natural gas – to allow us to run a safe and reliable hydrogen network. These include:

- Procedure review
- Quantitative risk assessment (QRA)
- Overpressure risk (OR)
- Hazard assessment of the NTS (HATS)
- Hazardous area impact
- NGGT safety case

To find out more about FutureGrid scan the QR code

# 4 Contact us

# Contact us
## Continuing the conversation

### Your feedback is so important to us

Letting us know what you think of the information we share with you, and how we're sharing it, helps us shape our future communications to ensure we're communicating what matters most, in a way that suits you.

Email us with your views and feedback on our publications at:
.Box.OperationalLiaison@nationalgrid.com

### National Grid Gas Transmission

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Registered in England and Wales
No. 4031152
www.nationalgrid.com/gas-transmission

# Appendices/ supporting information

# Appendix 1
## 1.1 Useful links

### 1.1.1 Capacity

- Capacity methodology statements | National Grid Gas Transmission
- Capacity | National Grid Gas Transmission
- Disconnections | National Grid Gas Transmission
- Entry capacity | National Grid Gas Transmission
- Reserving capacity (PARCA and CAM) | National Grid Gas Transmission
- Exit capacity | National Grid Gas Transmission

### 1.1.2 Connections

- Our RIIO-2 re-opener applications (2021-2026) | National Grid Gas Transmission
- Connections | National Grid Gas Transmission
- Connection application process overview | National Grid Gas Transmission
- Connecting to the NTS – overview and guidance | National Grid Gas Transmission
- Statement for Gas Transmission Connection Charging | National Grid Gas Transmission
- National Grid Connections Portal | National Grid Gas Transmission
- Constraint management | National Grid Gas Transmission

### 1.1.3 NTS route maps

- Network Route Maps | National Grid Gas Transmission

### 1.1.4 Other publications

- *ANCAR* | National Grid Gas Transmission
- Gas Future Operability Planning (GFOP) | National Grid Gas Transmission
- Connections document library | National Grid Gas Transmission

# Appendix 2 – Network capability

## 2.1 Network capability zones

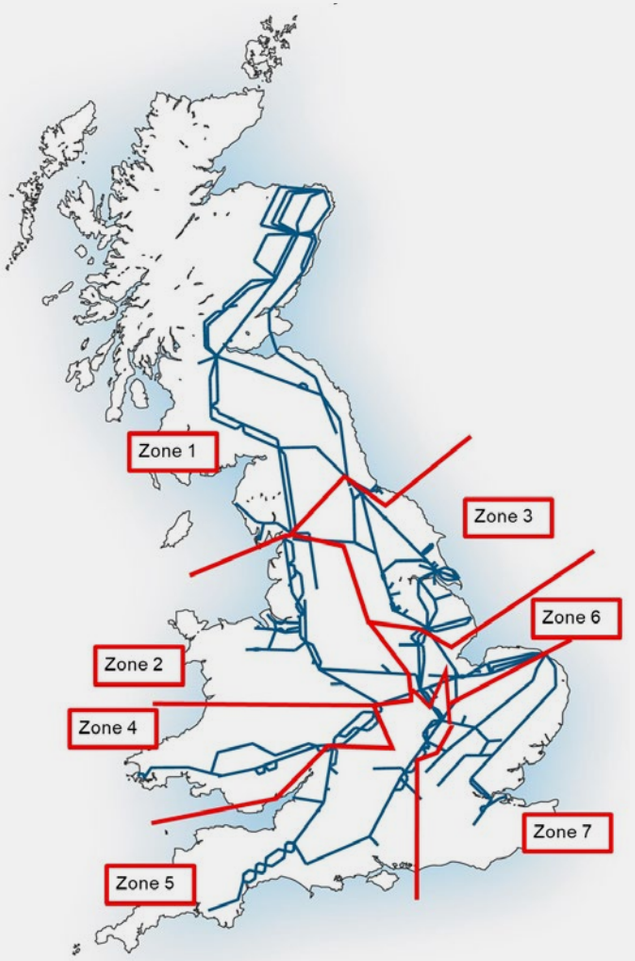
The National Transmission System (NTS) is a complex system of physical assets such as pipes, compressors, valves, supply points and offtakes. In order to simplify this, the analysis of the NTS has been partitioned into zones that correspond to the way in which gas flows through it. Figure A2.1 gives a simplified view of the NTS and the zones.

To assess both entry and exit capability, the NTS has been divided into seven zones:

- Zone 1: Scotland and the North
- Zone 2: North West
- Zone 3: North East
- Zone 4: South Wales
- Zone 5: South West
- Zone 6: East Midlands
- Zone 7: South East.

East Midlands and South West do not have sufficient entry points to include these in the entry capability assessment, so are omitted.

**Figure A2.1**
Network capability entry and exit zones



# Appendix 2 – Network capability

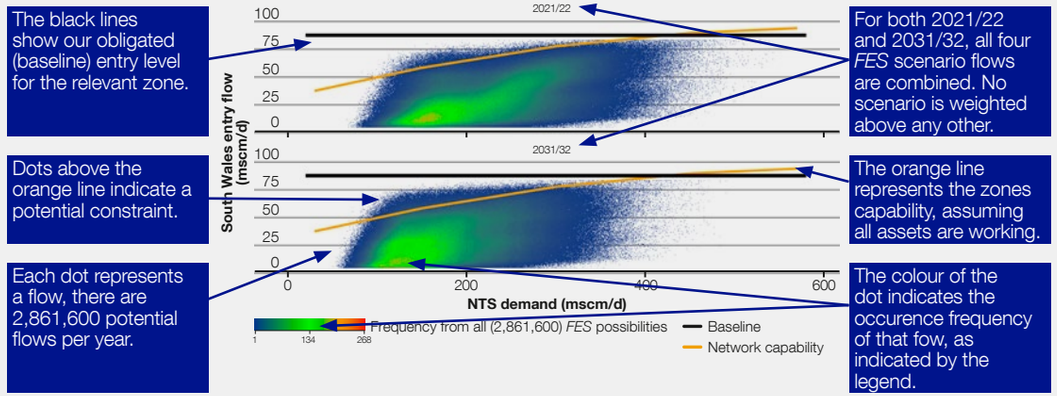
## 2.2 Network capability visualisations

The visualisation of the network capability is an evolving attempt to explain network capability and its future requirements. The vertical axis reflects the absolute level of entry flow for the zone under consideration. The horizontal axis reflects the assumed pattern of national demand.

We analyse capability at a minimum of three different demand levels, Summer (low demand), Winter (high demand) and a midpoint demand. By interpolating these points we create network capability curves. As each of the Future Energy Scenarios are equally plausible, and broadly similar for the next decade, we have combined all the flow data for the year 2022/23 into one heatmap and the flow data for 2031/32 into a second heatmap.

Figure A2.2 gives an explanation of what we show on the network capability charts. For exit we do not use a line but instead a single figure per zone which is the 1-in-20 peak demand day level. This aligns closely with our Pipeline Security Standard obligation, and the exit design criteria for the NTS.

**Figure A2.2**
Entry network capability visualisation



# Appendix 2 – Network capability

## 2.3 Scotland and the North (zone 1)

Figure A2.3 Figure A2.4

**Figure A2.3**
Scotland and the North entry heatmap 2022/23 and 2030/31

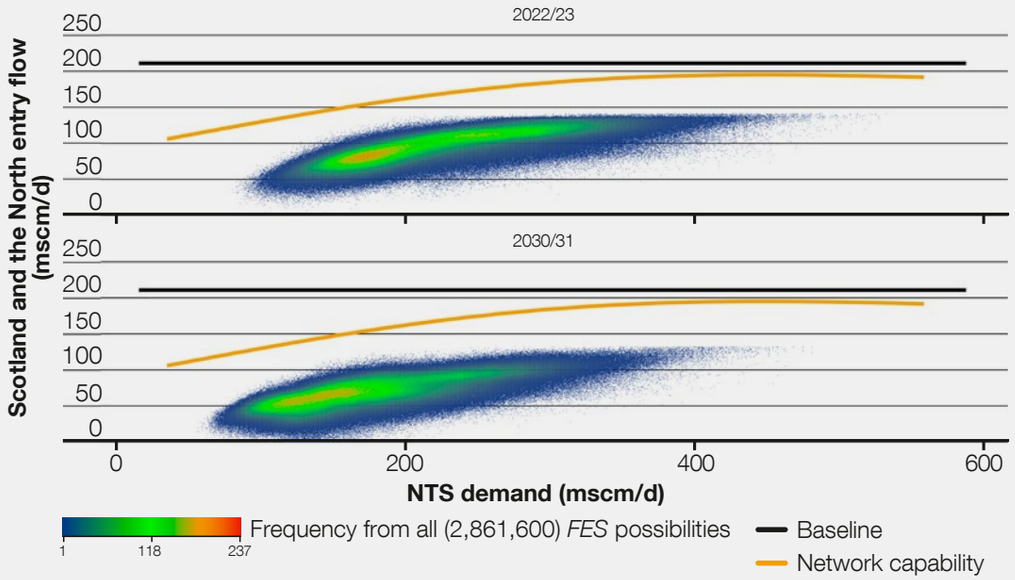
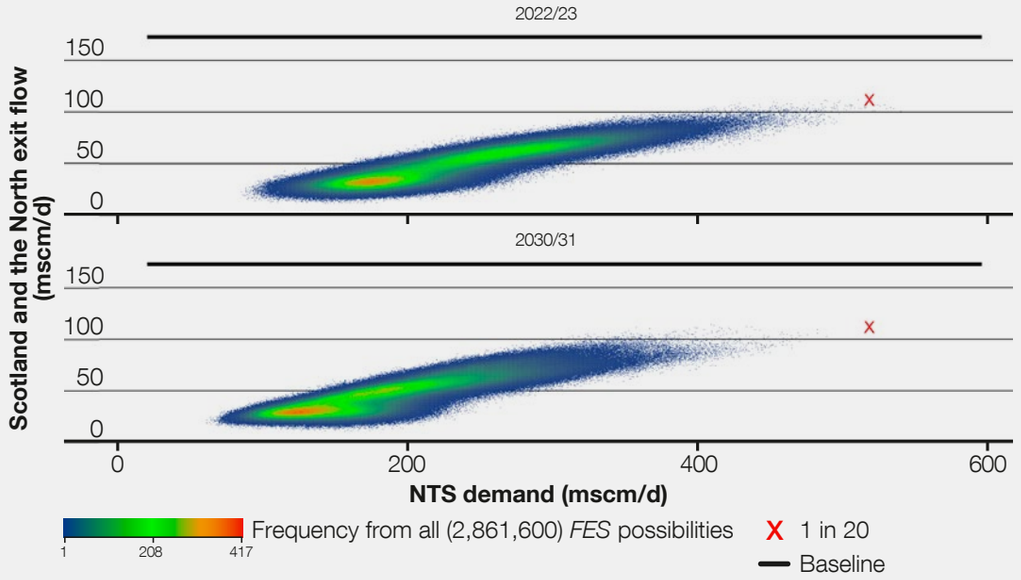



**Figure A2.4**
Scotland and the North exit heatmap 2022/23 and 2030/31



# Appendix 2 – Network capability

## 2.4 North West (zone 2)

Figure A2.5 Figure A2.6

**Figure A2.5**
North West entry heatmap 2022/23 and 2030/31

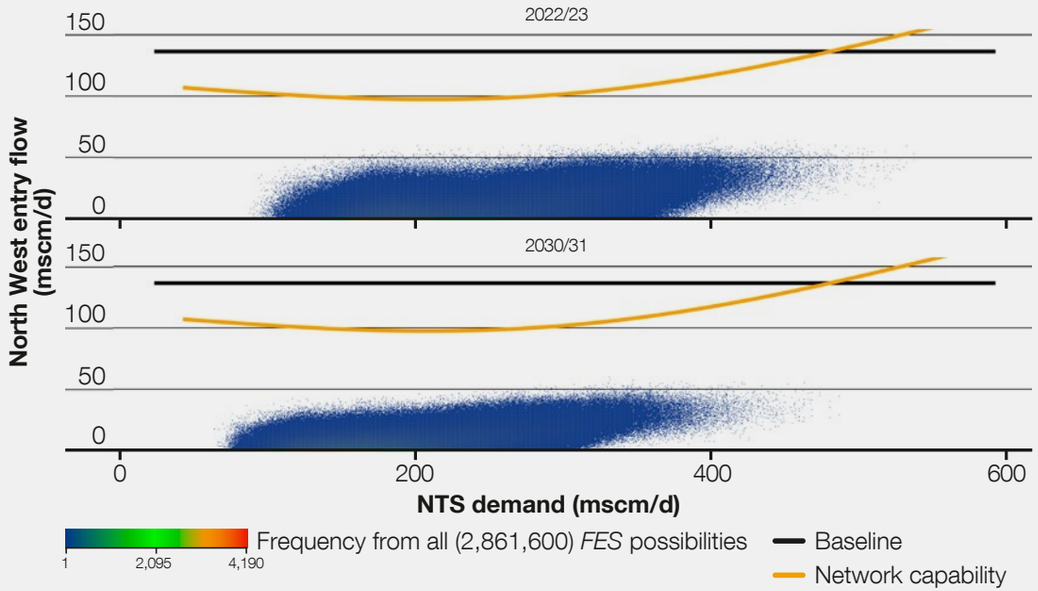
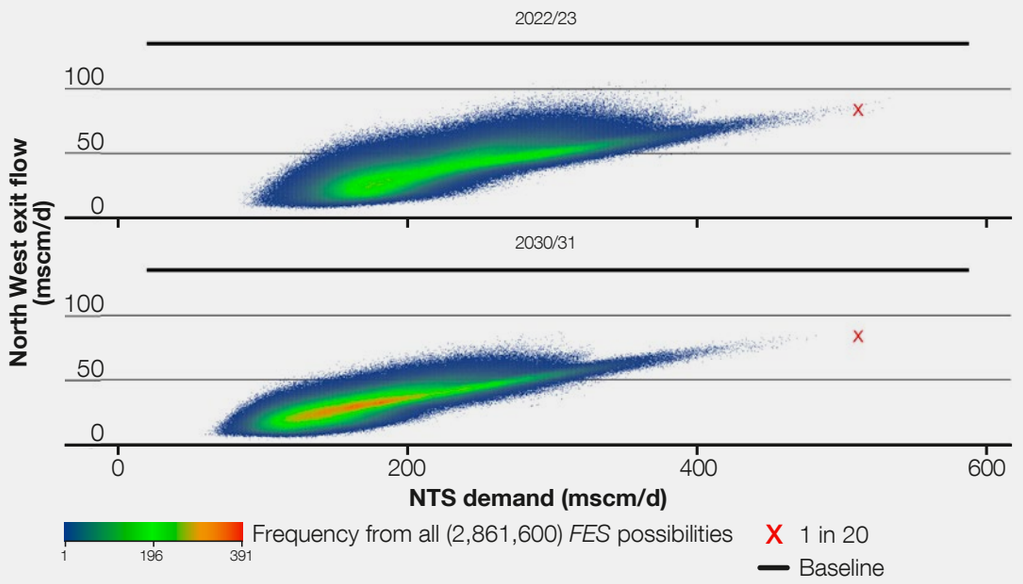



**Figure A2.6**
North West exit heatmap 2022/23 and 2030/31



# Appendix 2 – Network capability

## 2.5 North East (zone 3)

Figure A2.7 Figure A2.8

**Figure A2.7**
North East entry heatmap 2022/23 and 2030/31

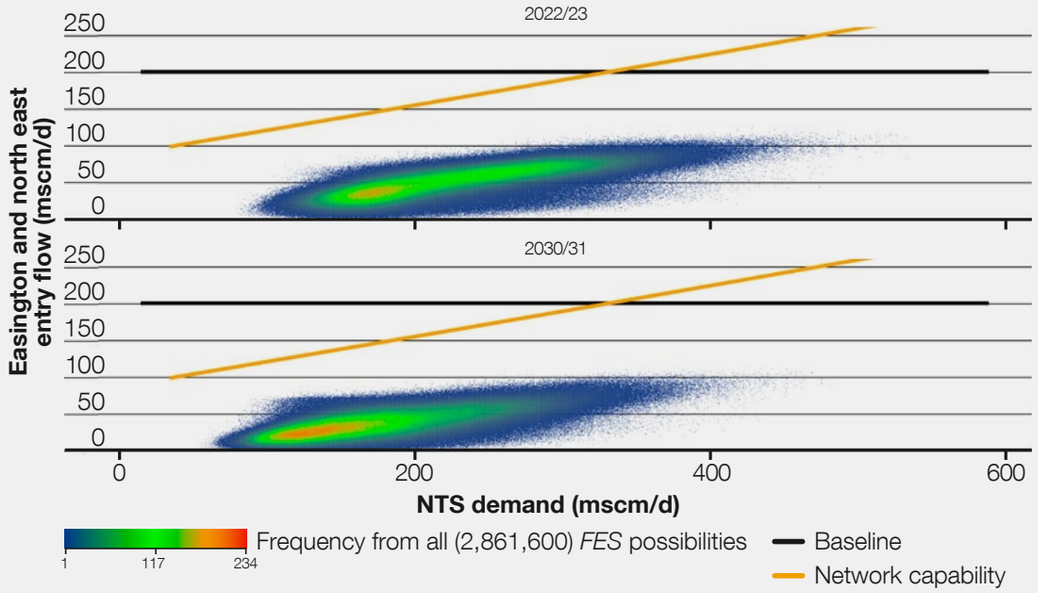
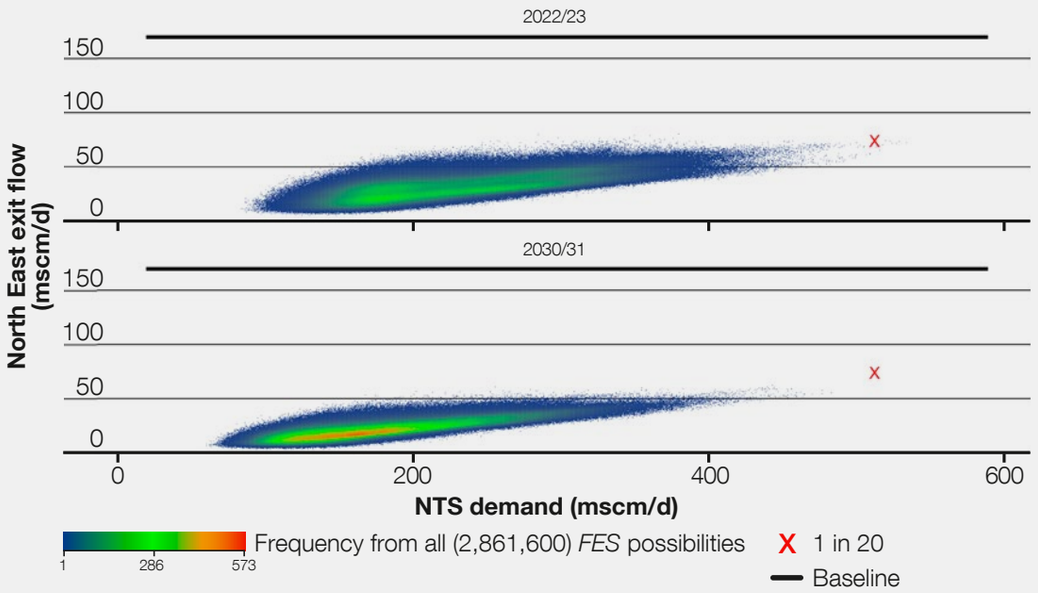



**Figure A2.8**
North East exit heatmap 2022/23 and 2030/31



# Appendix 2 – Network capability

## 2.6 South Wales (zone 4)

Figure A2.9 Figure A2.10

**Figure A2.9**
South Wales entry heatmap 2022/23 and 2030/31

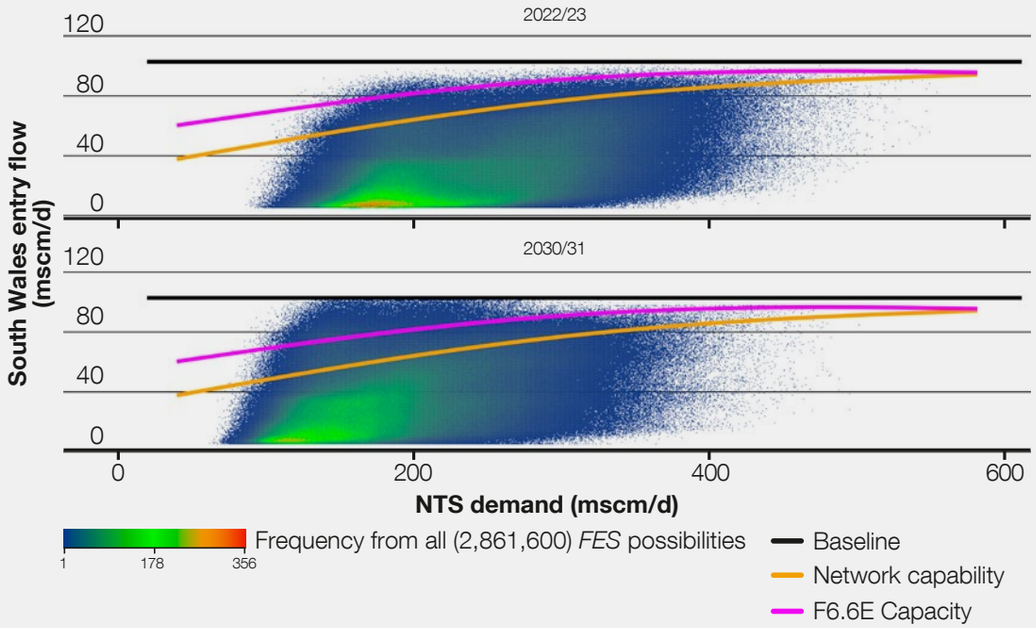
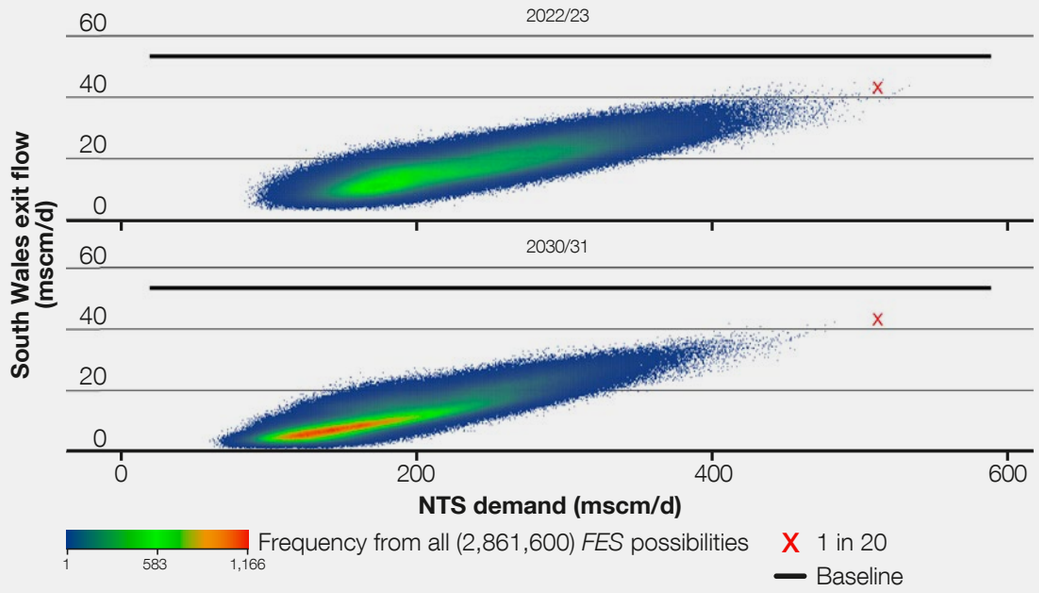



**Figure A2.10**
South Wales exit heatmap 2022/23 and 2030/31

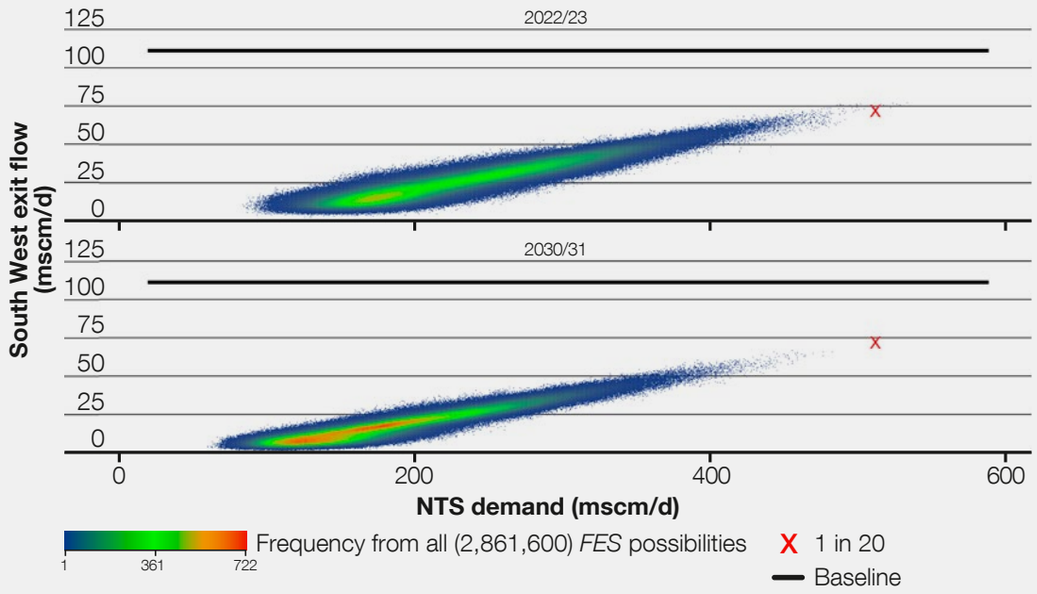


# Appendix 2 – Network capability

## 2.7 South West (zone 5)

Figure A2.11

**Figure A2.11**
South West exit heatmap 2022/23 and 2030/31

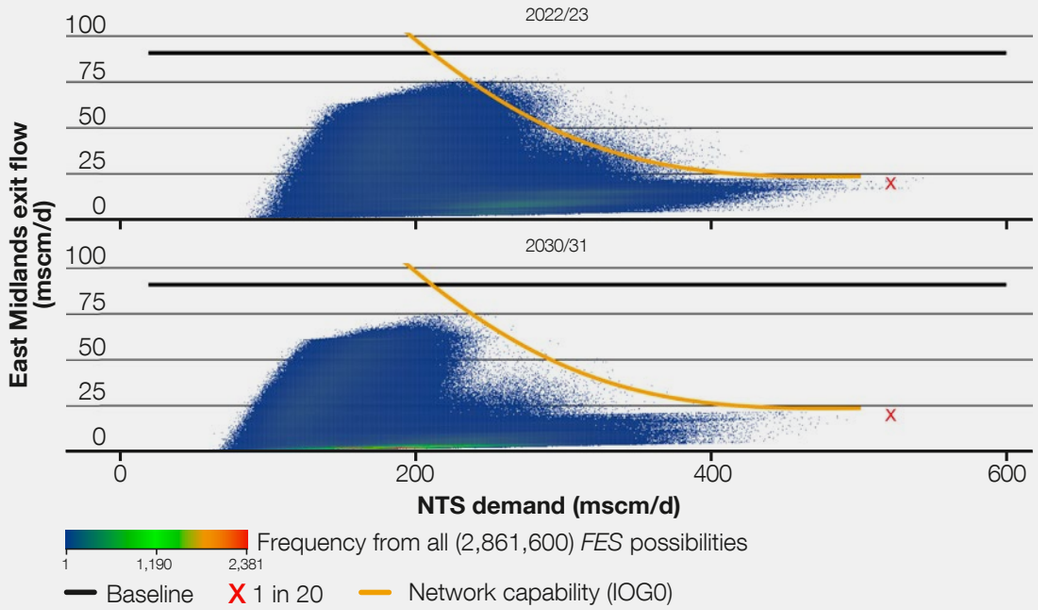


# Appendix 2 – Network capability

## 2.8 East Midlands (zone 6)

Figure A2.12

**Figure A2.12**
East Midlands exit heatmap 2022/23 and 2030/31 (standard *FES*)



# Appendix 2 – Network capability

## 2.9 South East (zone 7)

Figure A2.13 Figure A2.14

**Figure A2.13**
South East entry heatmap 2022/23 and 2030/31

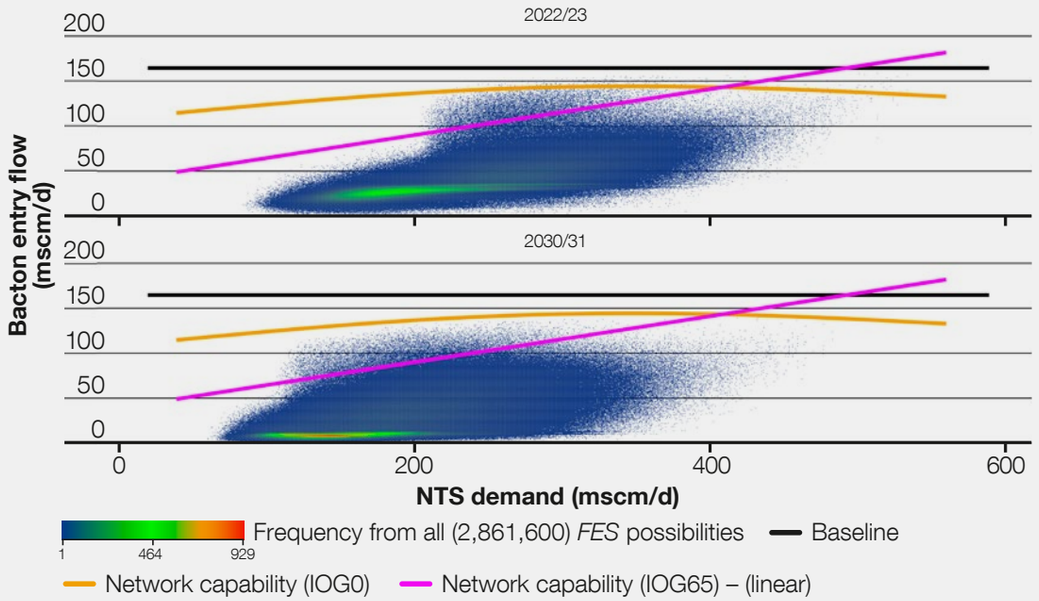
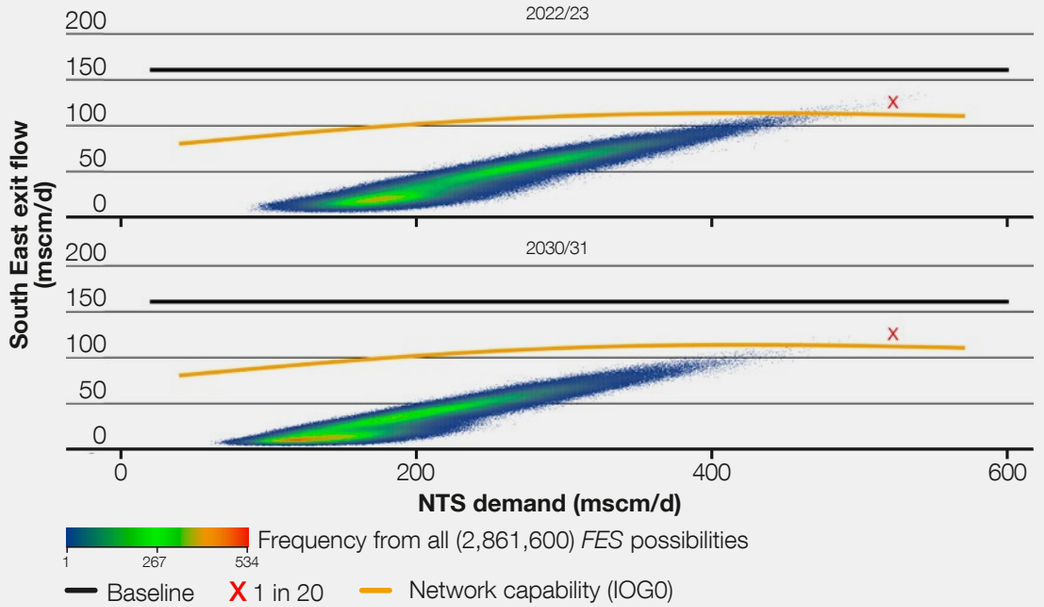



**Figure A2.14**
South East exit heatmap 2022/23 and 2030/31



# Appendix 3
## 3.1 Exit capacity maps

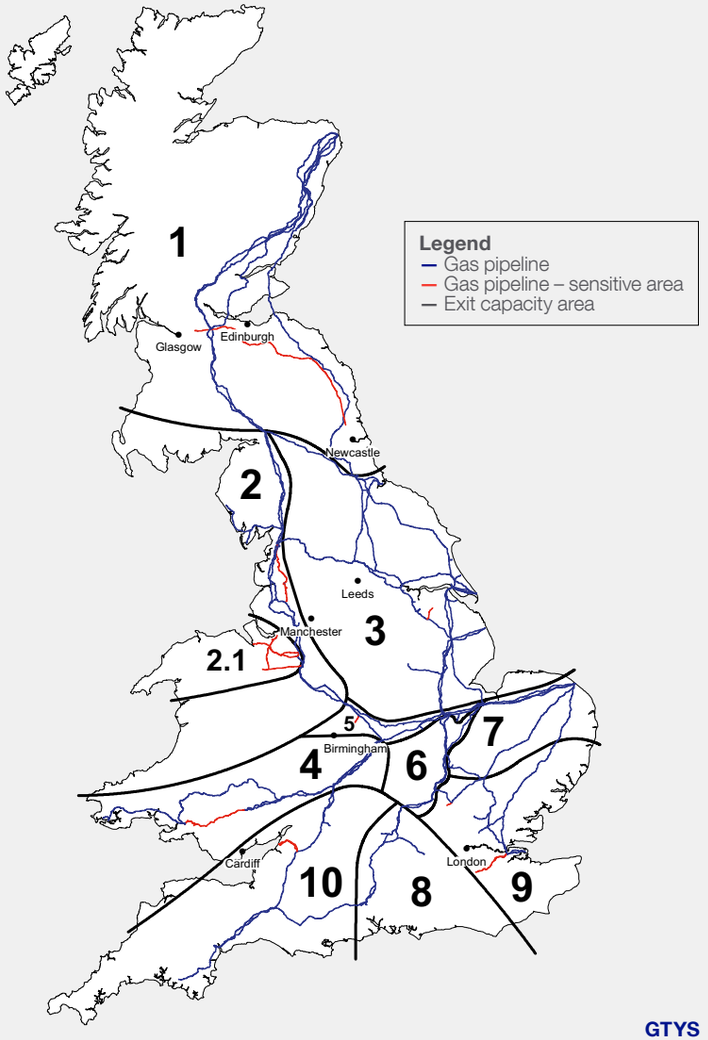
The NTS exit capacity map divides the NTS into zones based on key compressor stations, and multi-junctions (figure A3.1). These zones are purely for information and were created for the *GTYS*.

Within these zones, any new connection and/or capacity request is likely to be met through capacity substitution within the zone. All of our substitution analysis is carried out to the substitution methodology statement rules and while it is very likely that capacity will be substituted from within a zone, it is not guaranteed. In the following section we have provided a commentary explaining the potential capacity lead times and likelihood of substitution in each zone, including areas of sensitivity.

This information is an indication, and actual capacity lead times and availability will depend on the quantity of capacity requested from all customers within a zone and interacting zones.

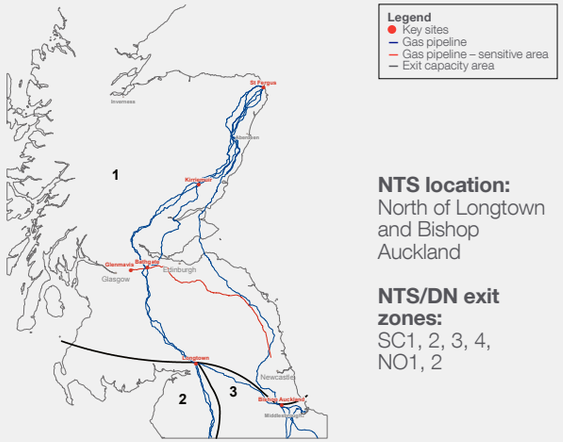
This information recognises the impact Electricity Market Reform may have on interest in NTS connections and capacity.

**Figure A3.1**
NTS exit capacity map



# Appendix 3
## 3.1 Exit capacity maps

**Figure A3.2**
Region 1 – Scotland and the North



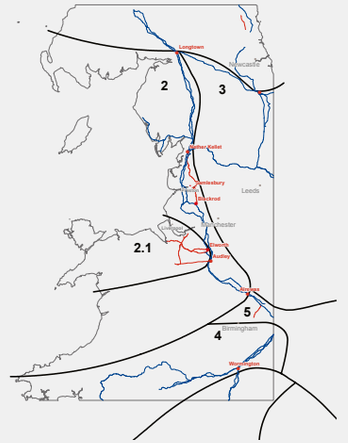

**NTS location:**
North of Longtown and Bishop Auckland

**NTS/DN exit zones:**
SC1, 2, 3, 4, NO1, 2

This region is sensitive to St Fergus flows. High St Fergus flows mean that exit capacity will be available, as flows from the St Fergus terminal are predominately in a north to south direction. As St Fergus flows reduce, exit capacity will be constrained.

There is only a small quantity of substitutable capacity in the area, but compressor flow modifications, including reverse flow capability, can be delivered to provide significant quantities of capacity without requiring Planning Act timescales. Capacity may be more limited in the sensitive area (Feeder 10 Glenmavis to Saltwick) due to smaller diameter pipelines.

**Figure A3.3**
Region 2 – North West and West Midlands (North)



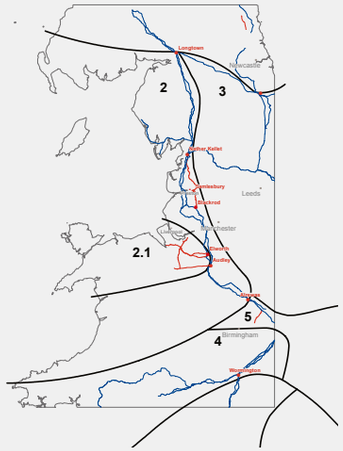

**NTS location:**
South of Longtown, north of Alrewas and east of Elworth

**NTS/DN exit zones:**
NW1, WM1

This region is highly sensitive to national supply patterns and use of storage; this area was historically supplied with gas from the North but increasingly receives gas from the South and from the East across the Pennines. The amount of unsold capacity in the region indicates that capacity could be made available by exit capacity substitution. A capacity request in zone 2 is likely to be met through substitution from zone 2, including zone 2.1, and then from the downstream zones, in this case zone 5. Capacity is likely to be available on the main feeder sections between Carnforth and Alrewas. Potential non-Planning Act reinforcements could release capacity, but then significant pipeline reinforcement would be required, particularly in the sensitive regions between Nether Kellett and Blackrod on Feeder 11.

# Appendix 3
## 3.1 Exit capacity maps

**Figure A3.4**
Region 2.1 – North Wales and Cheshire



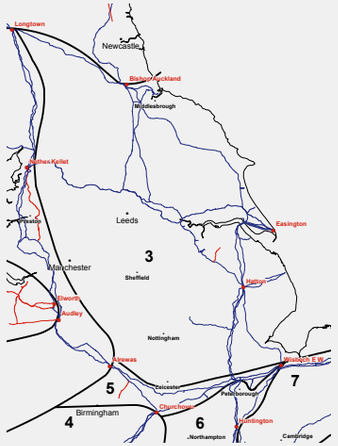

**NTS location:**
West of Elworth and Audley (Feeder 4)

**NTS/DN exit zones:**
NW2, WA1

This is an extremity of the system with limited local supplies (Burton Point) and a significant number of storage facilities.

The quantity of unsold capacity within the region indicates a good probability that capacity could be made available via exit capacity substitution. However, this would be available at direct connect offtakes where capacity can be booked. Potential non-Planning Act reinforcements could release small amounts of additional capacity, but significant pipeline reinforcement would be required, resulting in long (Planning Act) timescales.

**Figure A3.5**
Region 3 – North East, Yorkshire and Lincolnshire



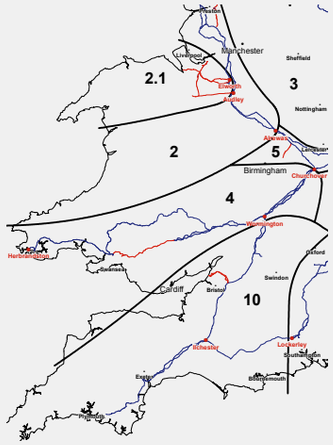

**NTS location:**
South of Bishop Auckland, north of Peterborough and Wisbech and east of Nether Kellet

**NTS/DN exit zones:**
NE1, 2, EM1, 2

There are numerous power stations in this region and this may impact on future ramp rate agreements. The amount of unsold capacity in the region indicates that capacity could be made available through exit capacity substitution. Further capacity should be available without needing reinforcement, assuming stable north-east supplies; however, this may be limited on smaller diameter spurs, including between Brigg and Blyborough on Feeder 7. Non-Planning Act reinforcements, including compressor modifications, could be carried out to make additional capacity available.

# Appendix 3
## 3.1 Exit capacity maps

**Figure A3.6**
Region 4 – South Wales and West Midlands (South)




**Legend**
- Key sites
- Gas pipeline
- Gas pipeline – sensitive area
- Exit capacity area

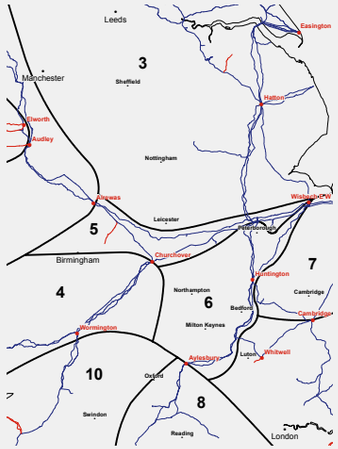
**NTS location:**
West of Churchover

**NTS/DN exit zones:**
WM3, SW1, WA2

Exit capacity availability is highly sensitive to Milford Haven flows. Low Milford Haven flows result in reduced South Wales pressures, which limit capacity. High Milford Haven flows result in reduced pressures in the West Midlands which may limit capacity.

Potential non-Planning Act reinforcements could release small quantities of capacity, but significant pipeline reinforcement would be required, particularly in the sensitive area on Feeder 2, south of Cilfrew between Dyffryn Clydach and Gilwern, due to the different pressure ratings.

**Figure A3.7**
Region 5 – Central and East Midlands




**Legend**
- Key sites
- Gas pipeline
- Gas pipeline – sensitive area
- Exit capacity area

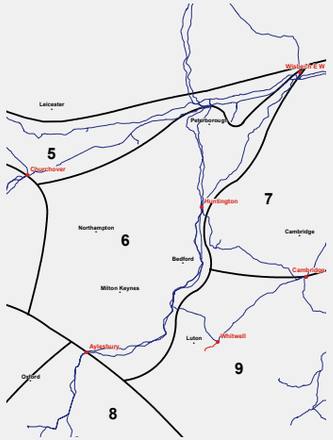
**NTS location:**
South of Alrewas, north of Churchover, west of Wisbech

**NTS/DN exit zones:**
EM3, 4, WM2

The unsold capacity here indicates a limited scope for substitution. Potential non-Planning Act reinforcements could be carried out to release a small amount of capacity, but significant pipeline reinforcement would be required, particularly for the sensitive area on Feeder 14 between Austrey to Shustoke.

# Appendix 3
## 3.1 Exit capacity maps

**Figure A3.8**
Region 6 – Peterborough to Aylesbury



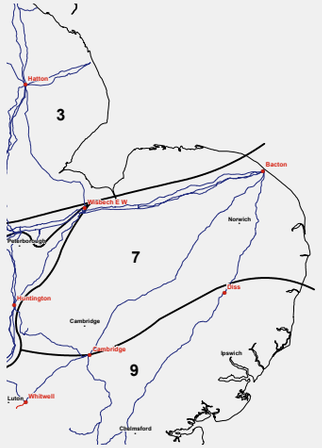

Legend
- Key sites
- Gas pipeline
- Gas pipeline – sensitive area
- Exit capacity area

**NTS location:**
North of Aylesbury, south of Peterborough and Wisbech, west of Huntingdon

**NTS/DN exit zones:**
EA6, 7

Capacity availability is sensitive to demand increases downstream in region 10, the South West. The quantity of unsold capacity indicates limited scope for exit capacity substitution from the single offtake in the region, but there may be scope for substitution from the southern region downstream of Aylesbury. Potential non-Planning Act reinforcements could be carried out to release capacity.

**Figure A3.9**
Region 7 – Norfolk




Legend
- Key sites
- Gas pipeline
- Gas pipeline – sensitive area
- Exit capacity area

**NTS location:**
North of Diss and Cambridge, east of Wisbech

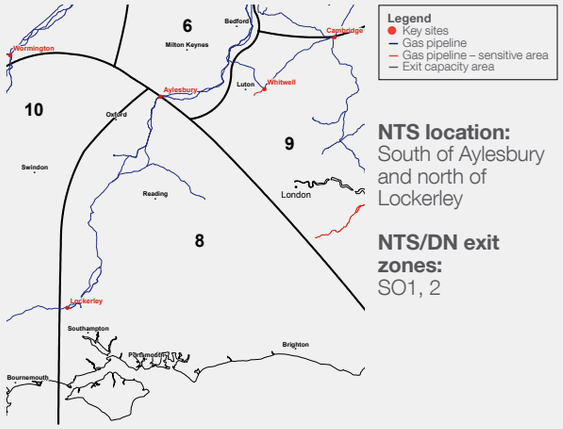
**NTS/DN exit zones:**
EA1, 2, 3

This region is sensitive to South East demand; if demand increases in the South East, capacity may become more constrained.

Unsold capacity here indicates a good probability that capacity could be substituted. Additional capacity could be made available without reinforcement works, assuming stable Bacton supplies.

# Appendix 3
## 3.1 Exit capacity maps

**Figure A3.10**
Region 8 – Southern

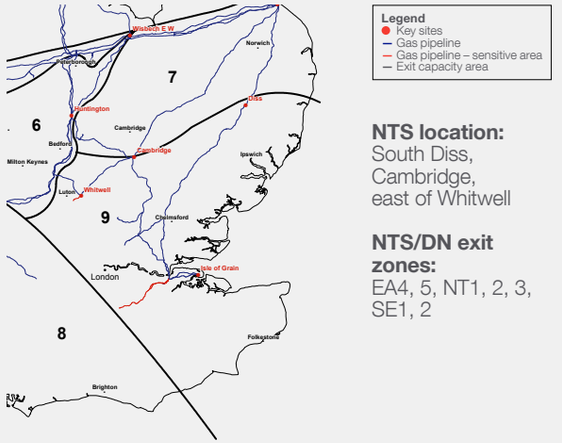



**NTS location:**
South of Aylesbury and north of Lockerley

**NTS/DN exit zones:**
SO1, 2

The region is sensitive to demand in the South West; if demand increases, capacity may become more constrained. The amount of unsold capacity indicates a good chance that capacity could be made available via exit capacity substitution. Potential non-Planning Act reinforcements (compressor station modifications) could release a small amount of capacity.

**Figure A3.11**
Region 9 – London, Suffolk and the South East



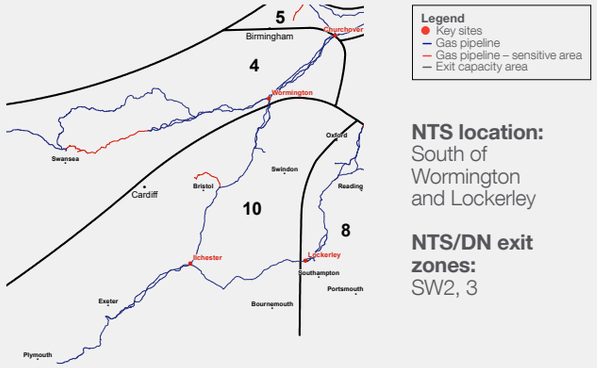

**NTS location:**
South Diss, Cambridge, east of Whitwell

**NTS/DN exit zones:**
EA4, 5, NT1, 2, 3, SE1, 2

The region is sensitive to Isle of Grain flows, with low flows limiting capacity. Capacity may be more limited in the sensitive areas at the extremities of the system, for example at Feeders 5 and 18 from Shorne to Tatsfield, and Feeder 3 from Whitwell to Peters Green. The significant number of power stations in the region may impact on future ramp rate agreements. Unsold capacity indicates some capacity could be made available via exit capacity substitution; however, exchange rates may vary between locations. Potential non-Planning Act reinforcements could be carried out to release small quantities of additional capacity but significant pipeline reinforcement would be needed.

# Appendix 3
## 3.1 Exit capacity maps

**Figure A3.12**
Region 10 – South West




**NTS location:**
South of Wormington and Lockerley

**NTS/DN exit zones:**
SW2, 3

Although the quantity of unsold capacity in this region indicates scope for capacity being made available through exit capacity substitution, exchange rates may be high due to small diameter pipelines. Potential non-Planning Act reinforcements could release small quantities of additional capacity, but significant pipeline reinforcement would be needed, resulting in long (Planning Act) timescales, particularly in the sensitive area from Pucklechurch to Seabank on the Feeder 14 spur due to small diameter pipelines. There is also sensitivity to low Milford Haven flows. During peak demand with low Milford Haven flows it becomes more difficult to maintain assured pressures in the South West.

# Appendix 4
## 4.1 Gas quality developments

### GB developments

The review of GS(M)R emanated from the 'Opening up the Gas Market' report and was built upon by the IGEM Gas Quality Working Group which gathered information and produced an evidence case to support changes to the UK gas quality specification. The HSE's consultation sought views on a number of changes to these Regulations; those pertaining to gas quality were to:

- reduce the lower limit for Wobbe Index from 47.2 MJ/m3 to 46.5 MJ/m3
- remove Incomplete Combustion Factor (ICF) and Soot Index parameters
- introduce a Relative Density limit of 0.7
- extend the current class exemption for oxygen in biomethane to a 1.0mol% limit at network pressures below 38 bar.

The IGEM working group proposed to increase the upper limit for Wobbe Index from 51.41 MJ/$m^3$ to 52.85 MJ/$m^3$. HSE decided not to progress this change at this time due to safety risks associated with the potential for increased carbon monoxide emissions from appliances at the higher Wobbe Index and concerns about the effectiveness and costs of potential mitigation measures to manage the risk.

HSE have spent the intervening period analysing responses, conducting follow-up interviews and research and liaising with other government departments and regulators to ensure that the evidence obtained from the consultation is turned into a comprehensive and robust impact assessment.

At the time of writing, the next step is to submit the impact assessment to the Regulatory Policy Committee for scrutiny and consult with the HSE Board on this analysis. Thereafter, HSE hope to be able to make recommendations to ministers for any regulatory changes and publish the government response to the consultation in autumn 2022, with a new statutory instrument to follow if required.

We are keen to ensure that if these changes to the UK gas quality specification are approved, they can be implemented in a timely manner and have therefore completed work this year in conjunction with the industry to plan for implementation.

The proposed removal of ICF and Soot Index and replacement with Relative Density would require implementation in all of our contractual arrangements with entry terminal operators, however, because the Wobbe Index proposal is an expansion to the existing range, this change would be voluntary, according to individual terminal operators' preferences. We therefore engaged with all such operators in order to establish which terminals would want to implement this change.

# Appendix 4

## 4.1 Gas quality developments

Feedback was received from some of our exit customers that they would need to assess the impact of a widened Wobbe range on their operations and requested that we produce a view of where lower Wobbe gas might manifest on the network if the change was approved.

We therefore obtained information about forecast delivery volumes and Wobbe Index from the relevant terminal operators and produced network penetration analysis that indicated the parts of the network where lower Wobbe gas may be present and the circumstances under which it would occur.

A particular challenge is that the Bacton interconnectors are currently not able to accept gas with a Wobbe Index below the current lower limit of 47.2 MJ/$m^3$ when exporting to the continent due to specification constraints on the networks of continental TSOs and we are therefore working with these TSOs to establish what would need to be done to amend those specifications to maximise the benefit of this change, if approved.

If the HSE approve the amendment to the Wobbe Index lower limit, we would expect to bring forward a UNC Modification Proposal to enable the relevant entry specification limits to change with suitable transparency arrangements, with the network analysis referred to above being available to inform the industry's assessment of that proposal.

We are also exploring the provision of additional gas quality data to the industry. This began with a Gas Markets Plan (GMaP) project in the spring and has now evolved into two workstreams; one looking at the requests from industry participants for National Grid to make additional gas quality data available based upon current technology and another, to commence at a future time, which will consider data requirements and technology required as we move through the energy transition and as hydrogen is introduced to the networks.

In relation to the former, we have worked with stakeholders to develop a project scope and a Request For Information to our exit customers, that has now been issued, which seeks to establish both what is required and why provision of such data would be beneficial.

Separately, we have been reviewing the NTS specification for mercury content via an industry questionnaire and operational sampling and will communicate the outcome of this work in due course.

# Appendix 5

## 5.1 Some of the hydrogen projects carried out this year

### 5.1.1 Variable hydrogen blend compression

This is a desktop study to understand how compression of variable blends of hydrogen and natural gas in the National Transmission System (NTS) could be managed at minimal cost. The project investigates the effects of varying hydrogen blends on compressor operation and researches the potential modifications that could enable a variable blend of hydrogen to be processed using our existing compressors. Alongside this, the study explores alternative compression technologies and sensing systems that can potentially enable the compression of variable gas blends on the NTS.

### 5.1.2 New pipeline AI route planning

Project Union is looking to repurpose parts of the National Transmission System (NTS) to be used for hydrogen transmission between different industrial clusters. Alongside repurposing some equipment, other areas of the network will require new pipeline to be built. There are several factors to consider when selecting routes for new pipelines and, traditionally, desktop exercises are used to investigate the different options. These activities require a significant amount of time and resource and are often not explored in detail. The aim of the new pipeline AI route planning project is to use an artificial intelligence (AI) based tool or platform to allow for rapid exploration of potential routing options for new pipelines.

### 5.1.3 Inhibition of hydrogen embrittlement effects in steel pipelines

Several studies have shown that the presence of oxygen can almost eliminate the negative effects of hydrogen on pipeline steels. While this strong evidence is available for certain steel grades and operational conditions, the findings don't apply for all conditions seen on the NTS. To make sure there's enough data for our NTS pipelines, this project will gather experimental evidence for NTS specific materials (X52 to X80 pipe) and operating conditions (40 to 85 bar of pressure), to evaluate the impact this has on: tensile strength – the resistance of a material to break under tension fracture – and the resistance of a material to cracking fatigue – the resistance of a material when exposed to recurring pressures and stresses.

### 5.1.4 Gas and Electricity Transmission infrastructure outlook

The interaction between gas and electricity energy systems is likely to increase as we move towards net zero. Therefore, the transmission and distribution networks across the UK and Europe will need to better interact, to efficiently balance energy production with demand and use. Alongside this, the potential solutions currently being explored to decarbonise transport, heat, industry, and power have the potential to overlap. This project is a desktop study that reviews data from several sources to better understand these interactions for the UK transmission networks (both gas and electricity) and to determine the optimum method for interaction in future.

# Appendix 6
## 6.1 Import and storage infrastructure

Tables A6.1 + A6.2

Great Britain is served through a diverse set of import routes from Norway, the Netherlands, Belgium and from other international sources through the LNG import terminals. Total import capacity is currently around 146 bcm/year, split into three near equal parts: Continental Europe (43 bcm/year), Norway (55 bcm/year)* and LNG (48 bcm/year). Table A6.1 shows existing import infrastructure and table A6.2 shows proposals that we have been officially made aware of.

**Table A6.1**
Existing import infrastructure (Source: National Grid)

| Facility | Operator/Developer | Type | Location | Capacity (bcm/year) |
|---|---|---|---|---|
| **Interconnector** | Interconnector Limited | Pipeline | Bacton | 25.5 |
| **BBL Pipeline** | BBL Company | Pipeline | Bacton | 16.4 |
| **Isle of Grain 1-3** | National Grid | LNG | Kent | 19.3 |
| **South Hook 1-2** | Qatar Petroleum and ExxonMobil | LNG | Milford Haven | 19.9 |
| **Dragon 1** | Shell / Petronas | LNG | Milford Haven | 8.9 |
| **Langeled** | Gassco | Pipeline | Easington | 24.9 |
| **Vesterled** | Gassco | Pipeline | St Fergus | 13.5 |
| **Tampen** | Gassco | Pipeline | St Fergus | 9.9 |
| **Gjoa** | Gassco | Pipeline | St Fergus | 6.2 |
| | | | **Total** | **144.5** |

**Table A6.2**
Proposed import infrastructure

| Project | Operator/Developer | Type | Location | Capacity (bcm/year) | Status (bcm/year) |
|---|---|---|---|---|---|
| **Isle of Grain 4** | National Grid | LNG | Kent | – | Open Season |
| **South Hook 3** | South Hook Gas | LNG | Milford Haven | 3.4 bcm | PARCA submitted |

*Norwegian import capacity through Tampen and Gjoa is limited by available capacity in the UK FLAGS pipeline.

# Appendix 6
## 6.2 Storage infrastructure

Table A6.3 Table A6.4

In the last 12 months no proposals have attained Final Investment Decision (FID) for subsequent construction. The following tables detail UK storage in terms of existing storage sites, those under construction and proposed sites.

It is important to note that due to operational considerations, the space and deliverability may not be consistent with that used for operational planning as reported in the 2021/22 *Winter Outlook* report. The economics, particularly the winter to summer spread, are very challenging for the development of new storage sites. Nevertheless, many new storage sites have been proposed over the past ten years and there are currently plans for nearly 9bcm of space, both for medium-range fast-cycle facilities and long-range seasonal storage.

**Please note**

Tables A6.1, A6.2, A6.3 and A6.4 represent the latest publicly available information to National Grid at the time the *GTYS* went to press. Developers are welcome to contact us to assess or revise this data.

**Table A6.3**
Storage sites (Source: site operators)

| Site | Operator/Developer | Location | Space (bcm) | Approximate max delivery (mcm/d) |
|---|---|---|---|---|
| **Aldbrough** | SSE/Statoil | East Yorkshire | 0.222 | 31.0 |
| **Hatfield Moor** | Scottish Power | South Yorkshire | 0.070 | 1.8 |
| **Holehouse Farm*** | EDF Trading | Cheshire | – | – |
| **Holford** | Uniper | Cheshire | 0.237 | 22.0 |
| **Hornsea** | SSE | East Yorkshire | 0.308 | 12.0 |
| **Humbly Grove** | Humbly Grove Energy | Hampshire | 0.243 | 7.2 |
| **Hill Top Farm** | EDF Energy | Cheshire | 0.045 | 13.5 |
| **Rough** | Centrica Storage | Southern North Sea | 0.768 | 3.9 |
| **Stublach** | Storengy | Cheshire | 0.430 | 36.0 |
| | | **Total** | **2.323** | **127.4** |

*Holehouse Farm currently mothballed.

**Table A6.4**
Proposed storage sites (Source: site operators)

| Project | Operator/Developer | Location | Space (bcm) | Status |
|---|---|---|---|---|
| **Gateway** | Stag Energy | Offshore Morecambe Bay | 1.5 | Planning granted, no FID |
| **Deborah** | Eni | Offshore Bacton | 4.6 | Planning granted, no FID |
| **Islandmagee** | InfrasStrata | County Antrim, Northern Ireland | 0.5 | Planning granted, no FID |
| **King Street** | King Street Energy | Cheshire | 0.3 | Planning granted, no FID |
| **Preesall** | Halite Energy | Lancashire | 0.6 | Planning granted, no FID |
| **Saltfleetby** | Wingaz | Lincolnshire | 0.8 | Planning granted, no FID |
| **Whitehill** | E.ON | East Yorkshire | 0.4 | Planning granted, no FID |
| | | **Total** | **8.7** | |

This list is in no way exhaustive; other storage projects at times have been detailed in the press.

# Appendix 7
## 7.1 Glossary

### Above-ground installations (AGIs)
Refers to parts of the NTS that are installed above ground. AGIs can perform a number of functions, including filtering, heating and pressurising gas. Some AGIs also add oderant to gas.

### *Annual Network Capability Assessment Report (ANCAR)*
This annual report contains an assessment of our network capability. Assessing our network capability enables us to calculate and demonstrate the physical capability of the NTS and how that capability compares to the needs of our customers now and into the future. This assessment is carried out against a range of future supply and demand scenarios using the *Future Energy Scenario (FES)* outputs produced by the Electricity System Operator (ESO). The output of this assessment helps inform potential changes to market rules, commercial tools or physical assets to ensure continued safe and economic operation of the NTS in meeting our customers' needs.

### Asset Management Plan (AMP)
An AMP provides a view of how we will manage, maintain and invest in our assets in line with legislation and our regulatory requirements.

### Assured Offtake Pressures (AOPs)
These are minimum pressures required to maintain security of supply to our DN customers. A significant number of these assured pressures are set at 38 bar, the anticipated minimum pressure in most sections of the NTS under normal operating conditions.

### Assured Operating Pressures
Minimum pressures at an offtake from the NTS to a DN that is required to support the downstream network. AOPs are agreed and revised through the annual Offtake Capacity Statement process.

### Bacton
Bacton manages a large volume of the nation's gas, and is a critical component of the gas transmission network now and going into the future. Bacton is a key dynamic swing node for a large subset of our customer base at an interdependent part of the network. In addition, Bacton bridges GB with EU via two interconnectors (BBL and IUK), and controls flows into the South East to ensure security of supply for London and the west–east transit route for LNG into Europe.

### BBL (interconnector)
A bi-directional gas pipeline connecting Bacton in the UK and Balgzand in the Netherlands.

### Bcm
Billions of cubic metres.

### BEIS
Government Department for Business, Energy and Industrial Strategy.

### Best Available Techniques (BAT)
BAT assessments provide a balance between the costs to the operator against the benefits to the environment.

### Biomethane
Biomethane is a naturally occurring, renewable gas which is produced by anaerobic digestion of organic matter such as dead animal and plant material, manure, sewage, organic waste, etc. Since biomethane is chemically identical to natural gas, it can be used for the same applications as natural gas. It can be used for electricity generation, water heating, space heating, cooking as well as to fuel vehicles.

### Capacity substitution
Capacity substitution involves moving unused capacity from one or more system points to a point where there is excess demand. This is intended to avoid the unnecessary construction of new assets. Exit capacity substitution is the transfer of unsold non-incremental obligated exit capacity from one NTS exit point (the donor NTS exit point) to another (the recipient NTS exit point) where there is demand for Incremental obligated exit capacity.

### Compressor
Compressors are used to move gas around the transmission network through high pressure pipelines. These compressors move the gas from entry points to exit points on the gas network. They are predominantly gas driven turbines that are in the process of being replaced with electric units.

### Computerised Maintenance Management System (CMMS)
This is a digital support tool that helps inform decisions around the management and maintenance of our assets.

### Constraints
A restriction affecting part of the system which results in the gas flows in that part of the system being limited. Entry – where a pressure Terminal Flow Advice is in place at an Aggregated System Entry Points (ASEP) and firm entitled flow rate is greater than the capability/TFA. Exit – Failure (or forecast) to meet a required offtake pressure obligation. Either the User elects not to offtake gas at a pressure lower than obligated or NTS pressure so low that gas will physically not flow through offtake and down stream users affected or low pressure safety limit reached.

### Critical National Infrastructure (CNI)
The UK's Critical Infrastructure is defined by the UK Government as: "Those critical elements of Infrastructure (facilities, systems, sites, property, information, people, networks and processes), the loss or compromise of which would result in major detrimental impact on the availability, delivery or integrity of essential services, leading to severe economic or social consequences or to loss of life."

# Appendix 7
## 7.1 Glossary

### Cyber Assessment Framework (CAF)
The CAF provides guidance for organisations responsible for vitally important services and activities. It provides a systematic and comprehensive approach to assessing the extent to which cyber risks to essential functions are being managed by the organisation responsible. It is intended to be used either by the responsible organisation itself (self-assessment) or by an independent external entity, possibly a regulator or a suitably qualified organisation acting on behalf of a regulator.

### Electrolysis
Electrolysis is the process of using electricity to split water into hydrogen and oxygen. This reaction takes place in a unit called an electrolyzer.

### Emission legislation
Emissions legislation relates to the Industrial Emissions Directive (IED), which is the mandatory minimum emission standard that all European countries must comply with by 2023. The IED aims to prevent and reduce harmful industrial emissions, while promoting the use of techniques that reduce pollutant emissions and that are energy and resource efficient. The EU Withdrawal Act 2018 maintains established environmental principles and ensures that existing EU environmental law will continue to have effect in UK law, including the IED.

### Entry terminals
These terminals allow gas supply to enter the NTS.

### European interconnectors/interconnector
A term used to describe both of the bi-directional gas pipelines that connect Bacton in the UK to Balgzand in the Netherlands (BBL) and to Zeebrugge in Belgium (Interconnector Limited).

### Exit points
Exit points are where gas exits the NTS e.g. to industrial users or to local infrastructure to provide gas to domestic homes.

### Export
Gas demand on the NTS from interconnectors to continental Europe or the island of Ireland.

### Gas Demand Charging Methodology
Charges that users of the gas NTS have to pay and how they are calculated.

### Gas-fired generation
Electricity generated by the burning of gas.

### Green gas
Green gases are renewable and low carbon gases that can be used in place of fossil fuels, reducing carbon emissions in the heat, power, and transport sectors. They include biomethane, bio-propane, and hydrogen.

### Hybrid heating systems
The term refers to a system that uses a heat pump alongside another heat source. Typically, it describes fitting a heat pump alongside a fossil fuel (gas, oil or LPG) boiler.

### Hydrogen
Hydrogen is a clean alternative to methane, also known as natural gas. It's the most abundant chemical element, estimated to contribute 75 per cent of the mass of the universe. Here on earth, while it's present in nearly all molecules in living things, it's very scarce as a gas – less than one part per million by volume. Hydrogen can be produced from a variety of resources, such as natural gas, nuclear power, biogas and renewable power like solar and wind.

### HyNTS compression
HyNTS compression investigates and demonstrates the opportunity of repurposing compressor systems for the compression of hydrogen and hydrogen blends in the NTS.

### HyNTS deblending for transport applications
HyNTS deblending for transport applications focuses on the delivery of high purity hydrogen from blended gas networks to enable delivery to transport applications, enabling hydrogen infrastructure to be provided more quickly and with greater resilience.

### HyNTS pipeline dataset
HyNTS pipeline dataset looks to develop tools and processes to accelerate the pipeline assessment required for hydrogen readiness of NTS and local transmission system (LTS) pipelines.

### HyNTS protection
HyNTS protection looks at protecting network assets from hydrogen permeation and maintaining asset lifetime using hydrogen barrier coatings, therefore reducing the cost of maintenance and replacement of network assets through the transition.

### Industrial Emissions Directive (IED)
The main EU instrument regulating pollutant emissions from industrial installations. The IED was adopted on 24 November 2010. The IED aims to achieve a high level of protection of human health and the environment taken as a whole by reducing harmful industrial emissions across the EU, in particular through better application of Best Available Techniques (BAT).

### Interconnector Limited
The Interconnector (UK) Limited is a bi-directional gas pipeline connecting Bacton in the UK and Zeebrugge in Belgium.

### ISO 14224 standard
ISO 14224 provides a comprehensive basis for the collection of reliability and maintenance (RM) data in a standard format for equipment in all facilities and operations within the petroleum, natural gas and petrochemical industries during the operational lifecycle of equipment.

### ISO 55001 framework
ISO 55001 is an asset management system standard, the main objective of which is to help organizations manage the lifecycle of assets more effectively. By implementing ISO 55001 organizations will have better control over daily activities, achieve higher return with their assets, and reduce the total cost of risk.

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## 7.1 Glossary

### Liquefied natural gas (LNG)
Natural gas that has been converted to liquid form for ease of storage or transport. It is formed by chilling gas to -161°C so that it occupies 600 times less space than in its gaseous form.

### Market participants/industry participants
Those involved in buying and selling gas on the NTS.

### Maximum Operating Pressure (MOP)
This is the maximum pressure that each section of the NTS can operate at and is relevant to connected NTS Exit and NTS Entry Point/Terminals.

### Mcm
Million cubic metres.

### Medium Combustion Plant Directive (MCPD)
The requirements for the MCPD are detailed in Pollution Prevention and Control (Scotland) (Amendment) Regulations 2017 that came into force 19 December 2017 and for England and Wales in the Environmental Permitting (England and Wales) (Amendment) Regulations 2018 that came into force 29 January 2018.

### Methane
Methane ($CH_4$) is a hydrocarbon that is a primary component of natural gas. Methane is also a greenhouse gas (GHG), so its presence in the atmosphere affects the earth's temperature and climate system. Methane is a short-lived climate pollutant with an atmospheric lifetime of around 12 years. While its lifetime in the atmosphere is much shorter than carbon dioxide ($CO_2$), it is much more efficient at trapping radiation. Per unit of mass, the impact of methane on climate change over 20 years is 86 times greater than $CO_2$; over a 100-year period it is 28 times greater.

### MRS (Medium-range storage)/GB storage
Gas storage facilities designed to switch rapidly between injection and withdrawal to maximise the value from changes in gas price.

### N-1 largest loss/'Under N-1 conditions'
The N-1 assessment means that we, as the Gas System Operator, have to ensure that:

- the NTS is designed and built to meet a 1-in-20 peak day demand as required under the Gas Transporters Licence. This is defined as the amount of infrastructure (pipes and compressors etc.) needed to transport the gas that would be required by our customers in the coldest day of winter, in the coldest winter we could expect in a 20 year period.
- the high pressure gas network has sufficient redundancy to meet a 1-in-20 peak day demand, even with the failure of the single biggest piece of infrastructure.

### National Cyber Security Centre (NCSC)
The National Cyber Security Centre (NCSC) is a government department that provides cyber security guidance and support helping to make the UK the safest place to live and work online.

### National Transmission System (NTS)
A high pressure gas transportation system consisting of compressor stations, pipelines, multi-junction sites and offtakes. Pipelines transport gas from terminals to offtakes. The system is designed to operate at pressures up to 94 bar.

### Network Asset Risk Metrics (NARMs)
Used by Ofgem, the Network Asset Risk Metric (NARM) has been developed to quantify the benefit to consumers of a company's asset management activities. In RIIO-2, this will be used as the output to hold the companies accountable for their investment decisions.

### Network capability
This refers to the physical capability of the NTS i.e. how much gas can be transported throughout the system on a given day.

### Network capability zone
The NTS is a complex system of physical assets such as pipes, compressors, valves, supply points and offtakes. In order to simplify this, the analysis of the NTS has been partitioned into zones that correspond to the way in which gas flows through it.

### Norway/Norwegian Continental Shelf (NCS)
Gas supplied to the NTS via pipelines from Norway.

### Ofgem
Office of Gas and Electricity Markets – Great Britain's energy regulator.

### Peak day capability
This refers to the maximum level of supply capability of the NTS.

### Peak demand
This is a 1-in-20 demand which means that statistically, in a long series of winters, it would be exceeded in one out of 20 winters. The 1-in-20 peak day is calculated from a statistical distribution of simulated historical peaks days. It is not the highest demand in the last 20 years, nor is it the demand that would be expected in the cold weather experienced in the last 20 years.

### Peak supply
This refers to the maximum supply that can be achieved on any given day.

### Peaking plants
Peaking power plants, also known as peaker plants, and occasionally just "peakers", are power plants that generally run only when there is a high demand, known as peak demand, for electricity.

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### Planning and Advanced Reservation of Capacity Agreement (PARCA)
Developer and/or NTS Users (Shippers or Distribution Network Operators 'DNOs') can reserve firm NTS capacity through the PARCA process. A PARCA is a bilateral contract that allows entry and/or exit capacity to be reserved for the customer while they develop their own projects.

### Renewable
Forms of energy generation from renewable resources, which are naturally replenished, such as sunlight and wind.

### RIIO-1
RIIO-1 relates to our business plan covering 2013-2021. Ofgem's performance-based RIIO model seeks to ensure consumers get the necessary investment in Britain's energy networks at a fair price. RIIO stands for Revenue=Incentives+Innovation+Outputs. Companies have to meet performance targets, set in consultation with consumers and network users: failure to do so brings automatic penalties.

### RIIO-2
RIIO-2 relates to our business plan covering 2021-2026. Ofgem's performance-based RIIO model seeks to ensure consumers get the necessary investment in Britain's energy networks at a fair price. RIIO stands for Revenue=Incentives+Innovation+Outputs. Companies have to meet performance targets, set in consultation with consumers and network users: failure to do so brings automatic penalties.

### Shale
Shale is a fine-grained, sedimentary rock formed as a result of the compaction of clay, silt, mud and organic matter over time and is usually considered equivalent to mudstone. Shale gas is natural gas found in shale deposits. This natural gas is a mixture of naturally occurring hydrocarbon gases produced from the decomposition of organic matter (plant and animal remains). Typically, shale gas consists of 70 to 90 per cent methane ($CH_4$). This gas can be used for generating electricity and for domestic heating and cooking.

### Single Value Framework (Copperleaf)
A tool to allow objective comparisons to be made around different types of investments, helping to highlight and quantify all the benefits of each investment in order to understand which offers best value, even if the investments are very different.

### Steam Methane Reform (SMR)
SMR is a process in which methane from natural gas is heated, with steam, usually with a catalyst, to produce a mixture of carbon monoxide and hydrogen used in organic synthesis and as a fuel. In energy, SMR is the most widely used process for the generation of hydrogen.

### The Network & Information Systems (NIS)
The Network & Information Systems (NIS) Regulations, aimed at raising levels of cyber security and resilience of key systems across the EU, came into force in the UK in May 2018. The Department for Digital, Culture, Media & Sport (DCMS) is the UK Government department responsible for NIS.

### Thermal insulation
Thermal insulation is designed to improve temperature regulation through installation in walls, floors, ceilings, roofs and other spaces. Insulation can prevent too much heat loss in winter and too much heat gain in summer, therefore reducing the requirement for heating and/or air conditioning, therefore reducing energy demand.

### UK Continental Shelf (UKCS)
UKCS is made up of the areas of the sea bed and subsoil beyond the territorial sea over which the UK exercises sovereign rights of exploration and exploitation of natural resources.

### Uncertainty mechanism
Uncertainty mechanisms (UMs) exist to allow price control arrangements to respond to change. They protect both end consumers and licencees from unforecastable risk or changes in circumstances.

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