Compressor Emissions Asset Management Plan 2022 v1.3

As a part of the NGGT Uncertainty Mechanism Submission

Version 1.3 [redacted]

nationalgrid

1 Contents

Document Change Control Sheet

Document Version	Date	Change Description	Section
V1.3	August 2022	First version released	

2 Executive Summary

2.1. In accordance with National Grid Gas Transmission (NGGT) business priorities, this document, the Compressor Emissions Asset Management Plan (CE-AMP), is an interim view on how we will manage, maintain and invest in our compression assets in line with the emissions legislation to deliver the desired level of service required by our customers and stakeholders, while ensuring the safety and reliability of our network. The CE-AMP accompanies, and gives an updated view of, our Compressor Emissions Compliance Strategy (CECS) that was released in 2019 as part of our RIIO-T2 submission. CE-AMP focuses on the impact of Medium Combustion Plant Directive (MCPD) on our compressor fleet, while including other ongoing Industrial Emissions Directive (IED) investments. A full Compressor Asset Management Plan shall be released in support of our RIIO-T3 Business Plan.

2.2. Our stakeholders have told us, and we agree, that it is important to do the right thing for society and reduce the impact of our activities on the environment. We believe our nation should have a clean, reliable energy system to help address the effects of climate change, improve the quality of the air we breathe and power growth and prosperity in our economy for future generations. We also know that stakeholders want to be able to take gas on and off the system where and when they want, providing heat and energy to domestic consumers. CE-AMP sets out how we intend to balance these needs, reducing our environmental impact through compliance with air quality legislation, whilst ensuring there is adequate compression capability on the gas network to ensure the needs of our customers and UK consumers are met.

2.3. The proposals presented within this document deliver the most cost-effective network solution to meet the current and future needs of consumers.

2.4. As stated in our RIIO-T2 business plan, 28 of our operational compressors are going to be affected by MCPD. These are some of the oldest compressors we operate, many of which are beyond their design life. There are three high-level options for achieving compliance: decommissioning, derogation (i.e. limited/emergency use) or 'make compliant'. Making a unit compliant could be done by replacement of the unit with a compliant one(s) or applying emissions abatement technology to reduce emissions.

2.5. All options to achieve compliance and deliver air quality improvements result in a cost to the consumer with associated impacts on the level of network capability and resilience. Therefore, we have taken an overall network approach to determine the option that meets stakeholder network capability and resilience requirements and achieves compliance in the most cost-effective way.

2.6. Continual assessment of the options using robust cost benefit analysis complemented by qualitative assessments and stakeholder feedback shall be carried out to determine the optimum investment for compliance that incorporates a range of future energy scenarios. We believe our plans represent an optimal compressor investment and system operation plan for compliance with emissions legislation whilst meeting the long-term needs of the network.

3 Context

Compressor Emissions Asset Management Plan

3.1. To support out RIIO-T2 Business Plan, we released our Compressor Emissions Compliance Strategy (CECS) document, covering emissions compliance related works on compressors and other assets affected by emissions legislation.

3.2. In accordance with National Grid Gas Transmission (NGGT) business priorities, this document, the Compressor Emissions Asset Management Plan (CE-AMP), sets out our interim view of how we will manage, maintain and invest in our compression assets in line with the emissions legislation to deliver the desired level of service required by our customers and stakeholders, while ensuring the safety and reliability of our network. CE-AMP is in addition to our previously released CECS, focusing on our investments, with background information covered in the appendixes.

3.3. NGGT continue to play an important role in supporting the energy transition and a potential Hydrogen future; this document outlines the specific journey we will take in relation to our compressor emissions. It sets out how we intend to balance stakeholder and customer requirements and achieve continued compliance with emissions legislation while ensuring there is adequate compression capability on the gas network to meet current and future demands.

3.4. The CE-AMP shall continue to be updated and refined to support our RIIO-T2 Uncertainty Mechanism Submissions and future business plan submissions, focusing on our compressors impacted by emissions legislation. A full Compressor Asset Management Plan shall be released in support of our RIIO-T3 Business Plan.

Emissions Directives

3.5. Environmental legislation has been developed over time, introducing new standards to minimise the impact of industrial activities on the environment and human health. The legislation aims to reduce the pollutants discharged to air, water and land. Some of our gas compressors, and several smaller assets, are impacted by the legislation due to limits on nitrogen oxide (NO_x), carbon monoxide (CO) and of sulphur dioxides (SO_2) emissions to the environment from the combustion of natural gas.

3.6. It is mandatory for all EU countries to comply with the minimum standards set out in the legislation. This legislation has been transposed into UK law, being mandatory and applies to the assets in operation on the gas National Transmission System (NTS). This document will focus on the Medium Combustion Plant Directive (MCPD); see *Appendix A – Legislation* for full details of this and other impacting legislation.

Impact on Gas Transmission’s Compressor Fleet

3.7. Historically, the NTS has been optimised and operated to move high volumes of gas from the North to the South of Britain, using a series of strategically placed compressors on the network. With the development of new Liquefied Natural Gas (LNG) importation terminals and interconnectors with Europe, large volumes of gas are entering the network in the South. Supplies in the North have steadily been reducing as the UK Continental Shelf (UKCS) gas fields deplete.

3.8. Compressors are used on the network to support our ability to enable customers to move gas on and off the transmission system where and when they want, as well as:

- to transport gas away from the supply points to the demand centres
- to provide and maintain pressures within network design safety parameters
- to meet contractual exit capacity and pressure commitments, ensure compliance with the 1-in-20 design security standard
- to provide system flexibility to meet rapidly changing use and conditions
- to provide network resilience against supply losses or very high demand
- occasionally used to facilitate maintenance.

3.9. Any loss of compression has the potential to cause significant impact to customers putting gas on and taking gas off the network. It is therefore essential that our compressor fleet remains available and resilient to the demands and changes placed on the NTS, whilst working within the constraints of the emissions legislation.

3.10. At the beginning of our RIIO-T2 business plan development, our compressor fleet comprised of 28 gas turbine-driven compressors on the NTS that will be non-compliant with MCPD. These 28 compressors are located across 11 compressor stations, with 8 compressors located in Scotland and 20 in England and Wales. See *Appendix B – Compressor Compliance, Utilisation and Emissions* for a full overview of our affected units.

3.11. All 28 units, that are currently non-compliant with MCPD, require intervention prior to the deadline of 1 January 2030. Any of these compressors could breach this legislation without intervention, which would breach the environmental permit for the site, potentially leading to enforcement action. See *Appendix C – Compliance Options* for an explanation of the intervention options available.

Customer Demand Patterns

3.12. All four of the Future Energy Scenarios (FES) 2021[1] scenarios are assessed when making an investment decision to ensure we select the best option and mitigate the risk of asset stranding, or network constraints. To ensure we fully understand the risks for each of the options, we will complete additional sensitives. These sensitivities will be documented in each of the individual submissions Final Option Selection Reports (FOSRs). Our Annual Network Capability Assessment Report[2] (ANCAR) details the current and future capability requirement of our network.

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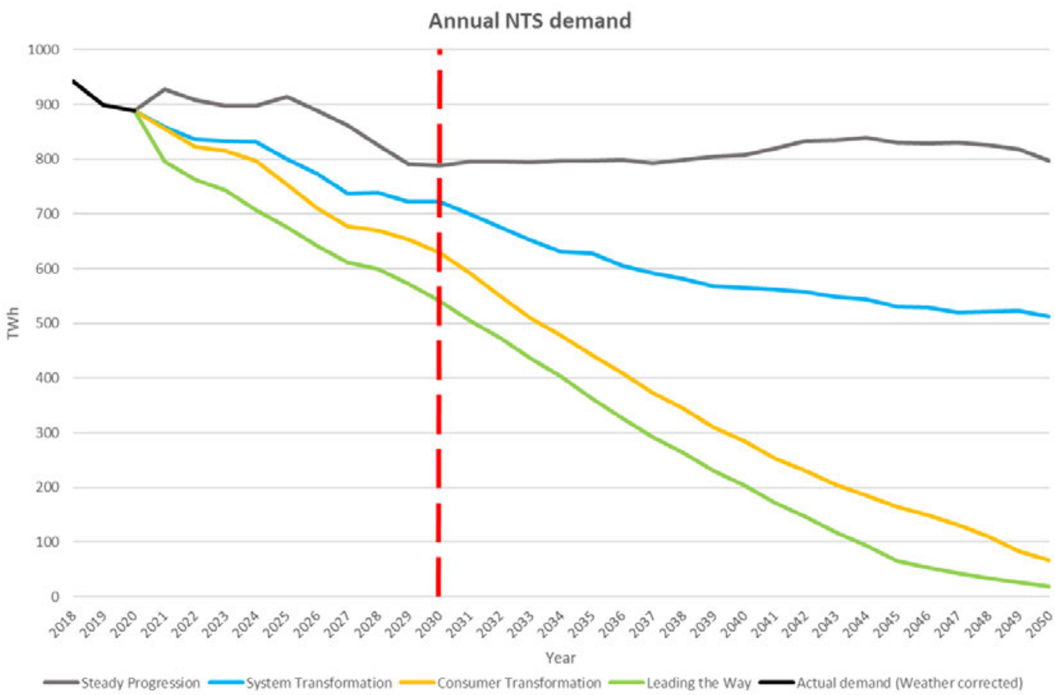
[1] *https://www.nationalgrideso.com/future-energy/future-energy-scenarios/archive*
[2] *https://www.nationalgrid.com/gas-transmission/insight-and-innovation/network-capability*

Our analysis on 2021 Future Energy Scenarios (FES)

3.13. The FES provides three credible pathways to meet the ambitious target of reaching net zero emissions by 2050. We are using these three scenarios, and the fourth scenario that falls just short of meeting the 2050 NetZero target, to assess investment decisions on the NTS for our RIIO-T2 Uncertainty Mechanism Submissions. Figure 1 shows how FES predicts annual natural gas demand to reduce across the four scenarios out to 2050.

Figure 1 - Annual Demand



3.14. With MCPD coming into force in 2030 it is important that we make investment decisions now to enable delivery before the deadline and ensure we can continue to meet our customers' needs. The red line shows that by 2030 all four scenarios have seen annual gas demand reduced by significantly different rates. This difference gives conflicting drivers for the levels of investment required to maintain the network capability, availability and resilience. The main drivers for changes in annual and peak gas demand are:

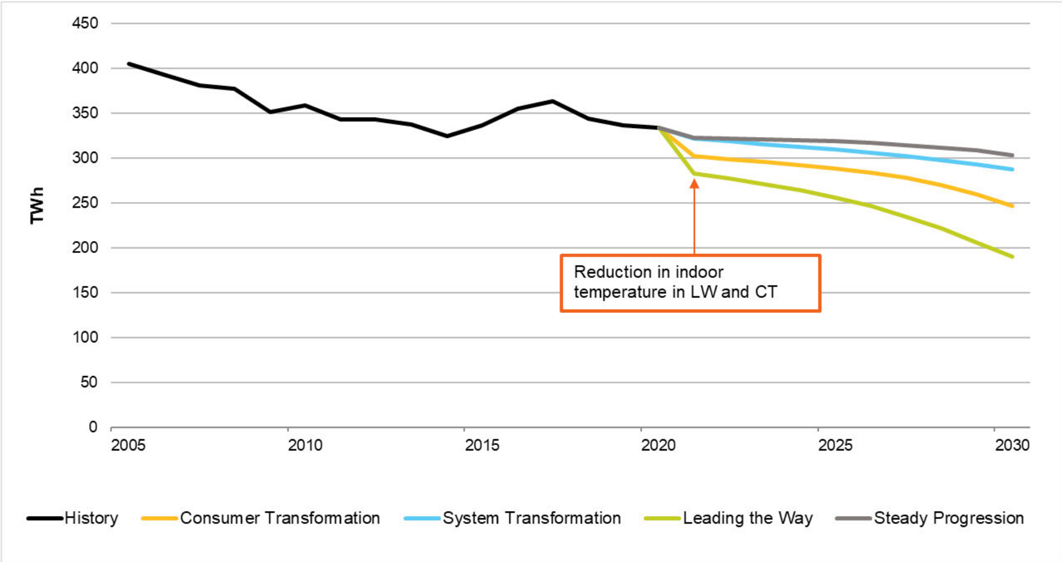
- Heat: Implementation of energy efficiency measures and conversion of residential and commercial properties off natural gas boilers and changes to consumer behaviour
- Power generation: Increased renewable and electrical interconnector capacity reducing the need for gas fired power generation
- Industrial: Switching away from natural gas to low or zero emissions sources like electricity or Hydrogen

3.15. Each of these areas are assessed in greater detail to better understand the likelihood of natural gas demand reducing from today's levels to those predicted in each of the four scenarios.

Heat

3.16. Figure 2 shows how FES predicts the residential demand for natural gas reducing across the four scenarios to 2030. The changes in demand can be split into three separate drivers; energy efficiency measures, changing consumer behaviour and consumers moving away from gas boilers onto low or zero emission alternatives.

Figure 2 - Annual natural gas demand for home heating



3.17. The year one drop in demand in Consumer Transformation and Leading the Way is based on consumers reducing the temperature of their home by either 0.5 or 1 degree Centigrade respectively. Even with the high gas prices seen during the winter 2021/22 the demand level did not drop by this level. Figure 3 shows how the energy efficiency measures impact annual demand. The main driver for the change in the Leading the Way and Consumer Transformation scenarios is the change in consumer behaviour. The further reductions out to 2030 are driven by consumers increasing the thermal efficiency of their home, such as home insulation and triple glazing. The CCC independent assessment of the UK's heat in buildings strategy states[3] "*Rates of improvement in energy efficiency continue to be well below the necessary level, as they have been over the last decade*" and this is unlikely to change without the roll-out of policies on energy efficiency.

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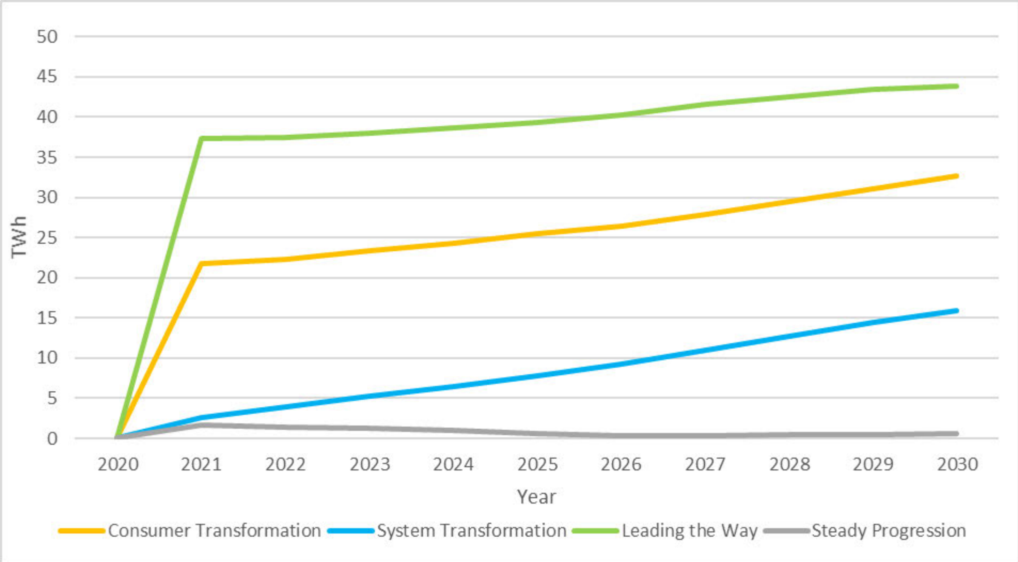
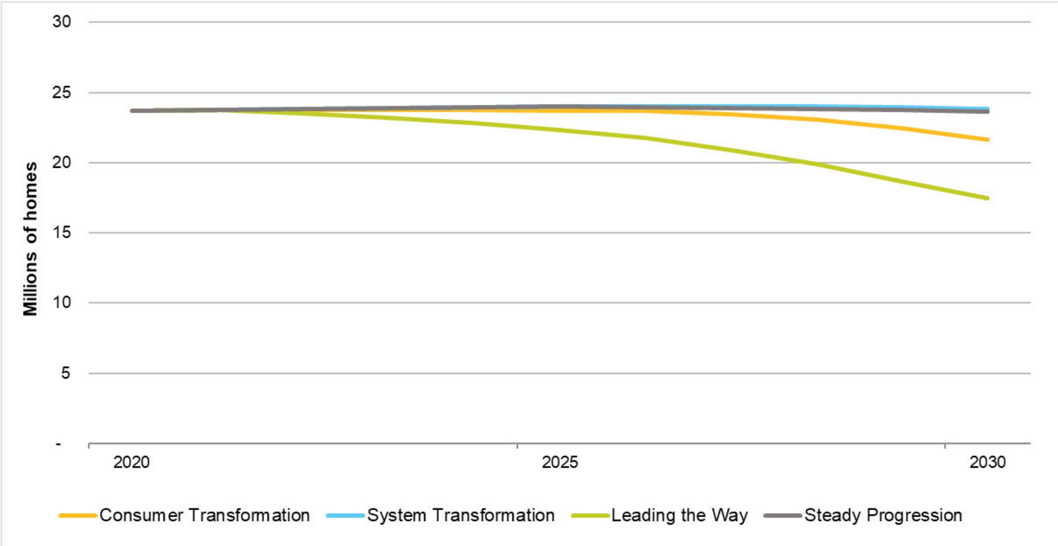
[3] *https://www.theccc.org.uk/publication/independent-assessment-the-uks-heat-and-buildings-strategy/*

Figure 3 - Energy efficient measures impact of annual demand



3.18. The remaining reductions are from consumers replacing their gas boilers with low or zero emission alternatives, such as air or ground source heat pumps. Figure 4 shows how the number of natural gas boilers will reduce between now and 2030. The Consumer Transformation scenario predicts over 2 million consumers will transition off the gas network by 2030, with over 6 million in Leading the Way. With only the Leading the Way scenario having a small number of consumers covert to hydrogen boilers (700,000) by 2030 the others are assumed to have converted to heat pumps or district heating systems.

Figure 4 - Number of homes being heated by natural gas boilers



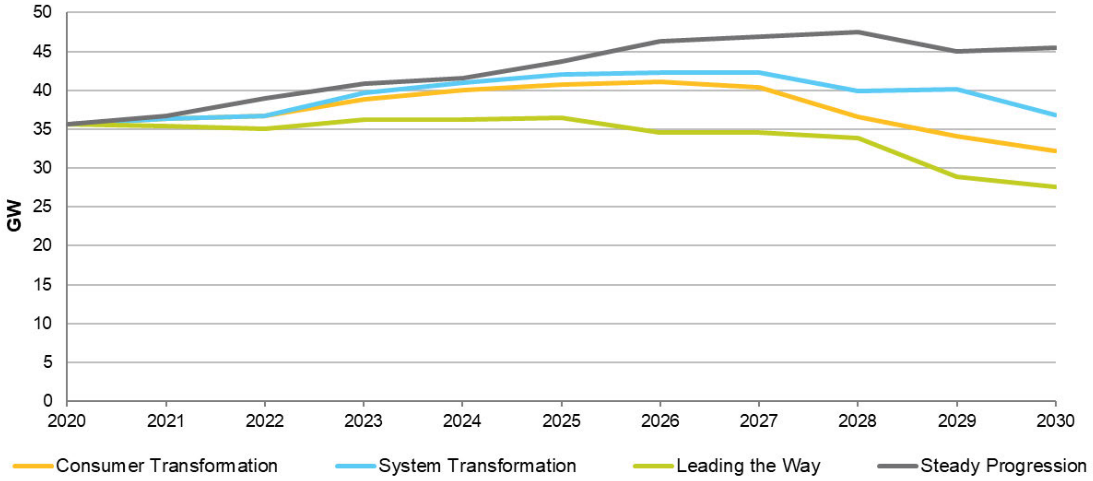
3.19. The government target is to install 600,000 heat pumps a year by 2028. That number includes all new homes, where it is proposed to ban the installation of gas boilers from 2025, and the conversion of the 4 million consumers that are not currently connected to the natural gas network.

3.20. Therefore, the conversion rates seen in the Consumer Transformation (over 400,000 in 2028 and over 800,000 per year by 2030) and System Transformation (over 1 million in 2028 and over 1.2m in 2030) appear very ambitious. Especially with the limited incentives on offer to consumers connected to the gas network to make the significant investment required to improve the thermal efficiency of their homes and to move to the more expensive alternative technologies, like Air or Ground Source heat pumps. As the CCC progress report states *"Even under current record high gas prices, our estimates suggest that the average heating bill for a heat pump is around 10% higher than for a gas boiler."*

Power Generation

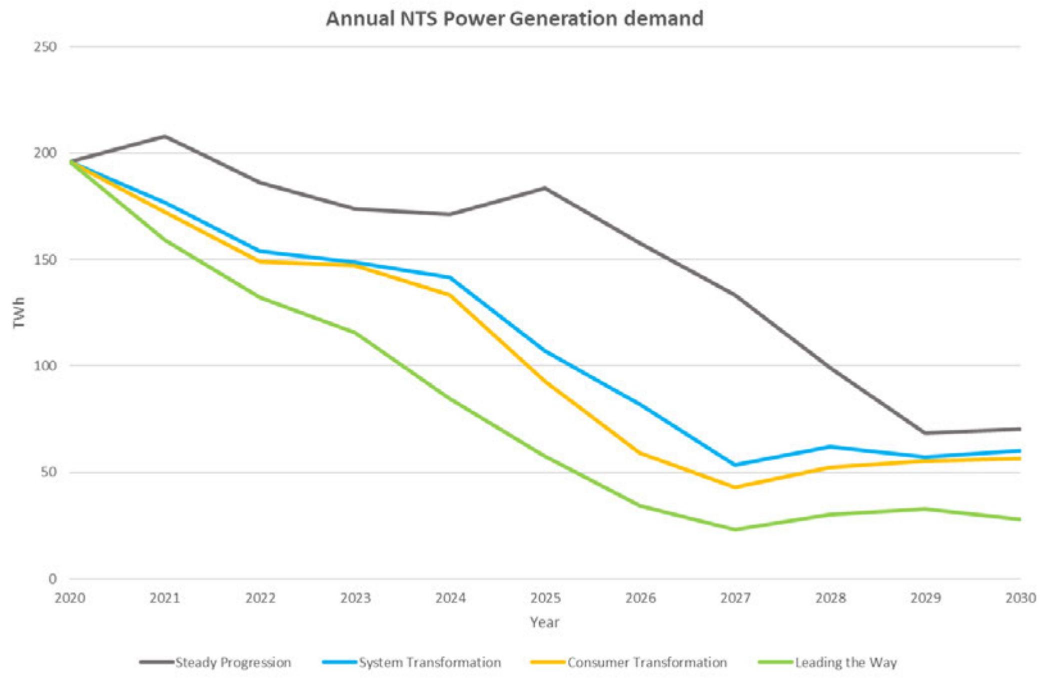
3.21. Figure 5 shows little change in the gas fired power generation capability between now and 2030. This level of capacity is required to manage the intermittent nature of the renewable energy sources being connected. With no significant change in nuclear capacity by 2030, it shows the importance of maintaining 1-in-20 peak capability in the natural gas network so that it can continue to support the electricity network.

Figure 5 - Total natural gas-fired generation capacity including gas CCUS



3.22. Figure 6 shows how FES predicts the annual NTS demand for gas fired power generation to reduce between now and 2030. This is due to increased renewable sources and greater interconnection to Europe. However, as Figure 5 has shown even if annual demand decreased, we would still need to ensure the peak 1-in-20 capability is retained so that we can continue to support the electricity network at times of low wind and solar generation

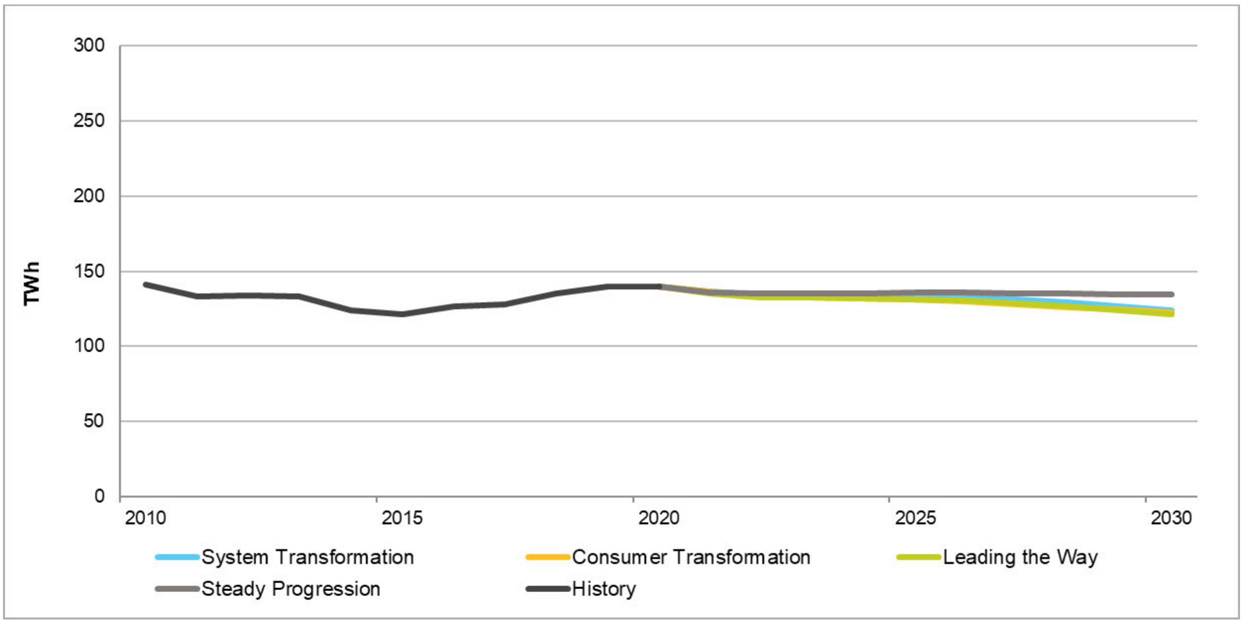
Figure 6 - Gas Fired Power Annual Demand



Industrial

3.23. Figure 7 shows that there is very little change in the difficult to decarbonise industrial processes out to 2030. Some industries do not have a choice of feedstock, gas is their business, and some will rely on Carbon Capture Use & Storage (CCUS) at scale in order to maintain their business. This is due to the sector needing to invest in alternative technologies or look to relocate to the hydrogen hubs as these develop.

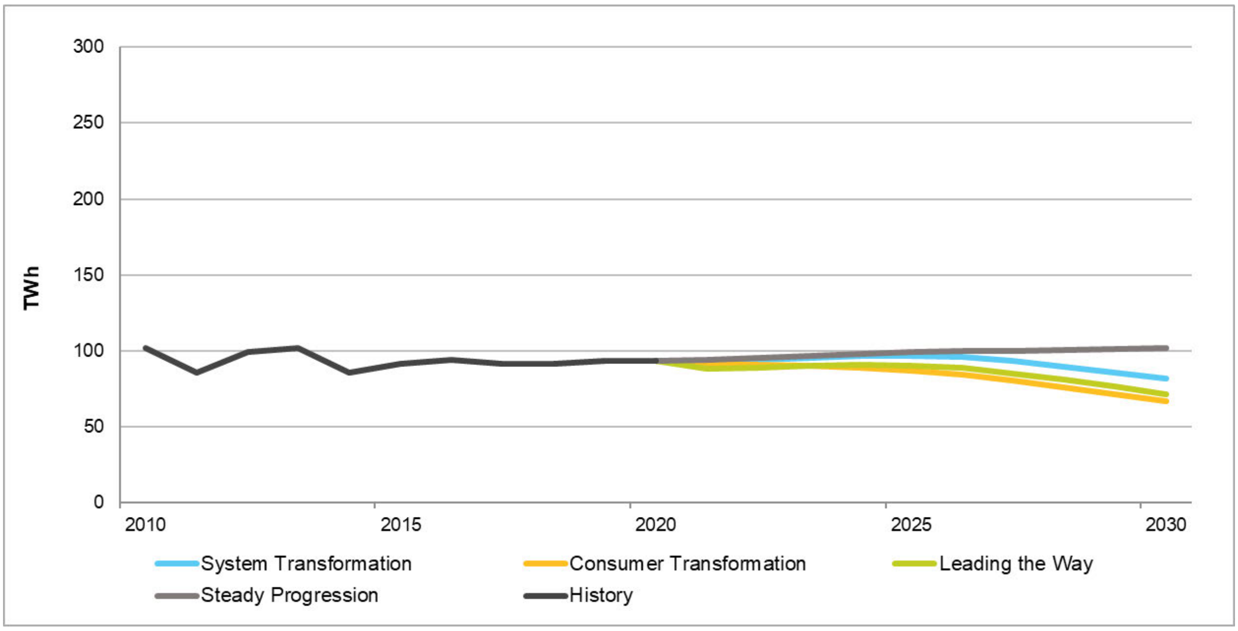
Figure 7 - Annual natural gas demand for the industrial sector



Commercial

3.24. Figure 8 shows how FES predicts the gas demand for the commercial sector to change between now and 2030. The main source of carbon emissions and energy demand in the commercial sector comes from natural gas used for heating. The reductions seen by 2030, and even small levels of reductions, can be considered ambitious without a significant shift in government policy and level of incentives for consumers.

Figure 8 - Annual natural gas demand for the commercial sector



Conclusions

3.25. This review suggests that without significant changes to the current policies and incentives in place it is unlikely that the annual or peak gas demand will decline to the levels suggested in the Consumer Transformation and Leading the Way scenarios by 2030. These scenarios require consumers to act now with limited incentives and at great expense to themselves in both the short and long term. Until government policy changes are implemented, and support given to assist the transition, we consider these scenarios to be very ambitious. What is more likely is a slower start with demands like those seen in the Steady Progression and System Transformation scenarios. Then as policy decisions are made, we will start to see a rapid acceleration in the deployment of a wide range of technologies and innovation. If the policies decisions align with the Consumer Transformation scenario, they would need to be in place by 2023 to see demands reduce below those seen in the System Transformation scenario, and in 2026 for Leading the Way.

Reliability, Availability, Maintainability (RAM)

3.26. To support our Option Selection process within our FOSRs, an idealistic Reliability, Availability, Maintainability (RAM) model which has evaluated unit availability across the entire NGGT fleet has been developed in collaboration with [redacted]. In addition to this, NGGT have also developed a Site Availability Model which is specific to Wormington to aid the FOSR, and shall be produced for the other sites. See *Appendix F – Process* for an overview of the RAM model.

4 Our Strategy to Comply with Emissions Legislation

Strategic Investment Drivers

4.1. The key strategic drivers for investment in our compression assets cannot be considered in isolation but rather in conjunction with one another to maintain a resilient network, they are as follows:

- Compliance with Emissions Legislation
- Asset Duty and Deterioration
- Supply and Demand Scenarios

Compliance with Emissions Legislation

4.2. Stringent environmental legislation has introduced standards to minimise the impact of industrial activities on the environment and human health by reducing pollutants discharged to air, water and land.

4.3. Our gas turbine driven compressors and several smaller assets combust natural gas and are therefore impacted by this legislation, which states we must not exceed defined Emission Limit Values (ELVs) for Sulphur dioxide (SO_2), nitrogen oxide (NO_x) and carbon monoxide (CO).

4.4. Where we can evidence the enduring need for compression, we will identify the appropriate mitigating action by unit/site (in accordance with the legislatively compliant options as detailed in *Appendix C – Compliance Options*) to achieve conformance within mandated timescales.

4.5. The applicable legislation is as follows; the specific details including required dates of conformance are available within *Appendix A – Legislation*.

- The Industrial Emissions Directive (Directive 2010/75/EU), which includes:
  - Large Combustion Plant Directive (LCPD) 2001 (Directive 2001/80/EC);
  - Integrated Pollution Prevention and Control Directive (IPPC) 2008 (Directive 2008/1/EC).
- The Medium Combustion Plant Directive (MCPD) (Directive (EU) 2015/2193).

4.6. Where compressor units have previously been derogated (based on low forecast run hours) in accordance with the legislation, their enduring requirement on the network will continue to be reviewed; where no-longer required, they will be considered for decommissioning.

Asset Duty and Deterioration

4.7. The average technical asset life for a gas compressor is 25 years, with some units on the NTS being over 40 years old. These assets deteriorate with age and use. Factors affecting rates of deterioration include the quality and condition of the fuel and combustion air, the number of starts and stops, and load changes placed on the asset. There can also be significant degradation when left unused for extended periods of time, dependent on the environment that they operate within.

4.8. Original Equipment Manufacturers (OEMs) typically recommend a major overhaul of these assets after a defined level of duty has been met (run hours/starts/stops). We have adopted industry standard practice to refurbish by overhauling and replacing time expired components rather than replacing the entire unit.

4.9. We will continue to assess the required level of resilience of the NTS. A good consistent level of unit availability and reliability shall be upheld, maintaining, and overhauling these assets in accordance with OEM recommendations and our policy is consistent across all European compressor operators

Supply and Demand Scenarios

4.10. In recent years, the pattern of gas flows required by our customers and consumers has become increasingly volatile and less predictable across the network. We are seeing increasing levels of renewable electricity generation, increasing the variability of gas fired power station demand as it flexes to meet the increase and decrease of renewable electricity generation, which in turn is placing more variable demands on our compressor fleet. We have also experienced increased summer running of compressors which have historically only ever operated in the winter months.

4.11. The changing customer driven supply and demand patterns are leading to a change in duty on our compressor fleet; whilst network wide annual consumed hours on our gas-powered units have seen a decline (supported by the operation of Variable Speed Drives), the run hours incurred are greater in areas that have not historically seen high run hours. See *Appendix B – Compressor Compliance, Utilisation and Emissions.*

4.12. It is paramount for the operation of the NTS and for the UK consumer that our compressor fleet remains available and resilient to the demands and changes placed upon it, and that we continue to maintain our compressor assets in accordance with OEM recommendations.

4.13. The annual Future Energy Scenarios (FES) are assessed when making investment decisions to ensure we select the best option and mitigate the risk of asset stranding. Further detail into FES can be found in *Context: Customer Demand Patterns.*

5 Our Plan to Comply with the Emissions Directive

Compressor Emissions Asset Management Plan

5.1. This section summarises our plans for:

- Compressor plant proposed for replacement with new units
- Compressor plant proposed for emissions abatement upgrades
- Compressor plant expected to utilise available emissions derogations
- Compressor plant expected to cease operation

5.2. An overview of our compressor fleet affected by MCPD can be found in *Appendix B – Compressor Compliance, Utilisation and Emissions*, along with information on compressor utilisation and emissions.

5.3. Analysis and reassessment of our funding request for new units at Peterborough (x1), King's Lynn (x2) and St Fergus (x3) as part of our RIIO-T2 Business Plan is ongoing. These sites have been omitted from the section below and are covered in *Delivery Plan*, below.

Replacement with New Units

5.4. Compressor units that are still required to operate on the network beyond 2030 and have high forecast running hours are expected to be replaced with new, compliant compressor units or have emissions abatement technology installed depending on the Cost Benefit Analysis (CBA) output. These replacement units may be of a different size and number compared to the original units depending on future operating requirements and the Best Available Techniques (BAT) recommendations.

5.5. The prioritisation of new builds is based on the criticality of sites for operation of the network and the ability to take outages.

- **We have been granted funding to build a new unit at Hatton under LCPD. We have also been granted funding to build new units at Huntingdon (x2) and Peterborough (x2) under IPPC. Construction at all three sites is in progress.**
- **We are requesting funding to build new units at Wormington (x2) under MCPD.**

Emissions Abatement

5.6. Emission abated units include units that are still required to operate beyond 2030 with potential run hours above 500 hours per year, where a CBA has determined this is the preferred option over replacement.

5.7. Emissions abatement technologies are still evolving, with trials being progressed to determine their viability. Currently the two main abatement trials we are progressing to reduce / limit NO_x levels are Dry Low Emissions (DLE) retrofit and Control System Reduced Performance (CSRP). We are working to ensure they are viable options by working with [redacted] to trial DLE options and [redacted] to trial CSRP. See *Appendix C – Compliance Options* for further detail.

5.8. Control System Restricted Performance (CSRP) emissions abatement technology controls the unit's power in relation to Exhaust Cone Temperature, to prevent NO_x emissions from exceeding the legal limit.

5.9. Dry Low Emissions (DLE) emissions abatement technology injects air into the combustion chamber to create a lean air fuel ratio, which lowers the combustion temperature and reduces NO_x production.

5.10. Depending on the trial results and acceptance of the technologies by environmental regulators as meeting MCPD requirements, these abatement options will be considered for all MCPD units. Currently we are proposing to abate 1-2 units under CSRP, and another unit under DLE to further trial these technologies.

- **We are proposing to install emission abatement technology at 2-3 sites to further trial these technologies.**

MCPD and LCPD Derogations

5.11. Derogated units include all units that are still required for NTS operation but have low forecast run hours (typically below 500 hours per year).

5.12. MCPD units selected for derogation will commence derogation on 1 January 2030.

5.13. LCPD units selected for derogation (three RB211 units) were derogated from 1 January 2016 and are currently operating under Emergency Use/500 hours Derogation. A further three LCPD units were entered into a Limited Life Derogation (LLD) from 1 January 2016 and will cease operation from 31 December 2023 or when they reach 17,500 hours from the start of the derogation period.

- **We have units under the Emergency Use Derogation for LCPD compliance at Carnforth (x1), Hatton (x1) and Wisbech (x1).**
- **We have units under the Limited Life Derogation in-line with LCPD at Hatton (x2) and St Fergus (x1).**
- **Units to be derogated in-line with MCPD shall be determined closer to the 2030 deadline.**

Decommissioning

5.14. Compressor units to be decommissioned include all compressors non-compliant with LCPD, IPPC and MCPD emissions legislation which are no longer required. These units are either being replaced with new compliant units or are no longer required so will not be replaced.

5.15. Decommissioning of MCPD units will take place during and beyond RIIO-T2, once replacement units have been commissioned, or the units are no longer cost effective to maintain. Having a wide decommissioning range will enable us to deliver our outage plan in the most efficient and effective way, minimising costs and the risk of customer disruption. Some decommissioned units will be used for innovation projects, including those involved with the studies of Hydrogen transmission. There are currently three MCPD units being proposed for decommissioning in RIIO-T3.

5.16. There are eight LCPD/IPPC compressor units which have been granted full or partial funding to be decommissioned. Decommissioning shall take place in RIIO-T2 and RIIO-T3.

5.17. Further stakeholder engagement will be carried out to develop our RIIO-T3 plans and if there are any unforeseen, significant asset health issues then these plans would be re-assessed and decommissioning or disconnection of units may take place sooner, ensuring we continue to maintain the required levels of availability and reliability of the network.

5.18. Decommissioning of Carnforth Unit A has been completed ahead of schedule, due to an opportunity that was identified with [redacted] This opportunity saw [redacted] paying all the costs of removing the unit and CAB (Compressor Acoustic Building) from site. They also provided National Grid with a credit note against future work to the value of [redacted] This not only saved the consumers the costs of decommissioning the unit but also reduced the costs of future engine overhauls with [redacted].

- **We have been granted funding to decommission units at Hatton (x2) under LCPD and at Peterborough (x2) and Huntingdon (x2) under IPPC by the end of RIIO-T2.**
- **We have been granted partial funding to begin the design for decommissioning at Carnforth (x2) under LCPD in RIIO-T2, to be completed in RIIO-T3. As noted above, one unit will be completed ahead of schedule.**
- **We are proposing to decommission units at Wormington (x2) and Kirriemuir (x1) under MCPD in RIIO-T3.**

Additional Compressors to be Decommissioned

5.19. There are an additional seven compressor units that are funded for decommissioning in RIIO-T2. These units are included in our Redundant Assets Price Control Deliverable (PCD). Five of these were already disconnected from the NTS at the time of our RIIO-T2 business plan submission.

5.20. There are four additional units which are being disconnected in RIIO-T2 and will be decommissioned in either RIIO-T2 or RIIO-T3 depending upon funding route.

Table 1 - Summary of compressor units to be disconnected or decommissioned in RIIO-T2, excluding emissions funded investments.

Site (Units)	Unit Types	Action	Notes	Funding
Avonbridge (1B and 2B)	2 x SGT400	Disconnect RIIO-T2 Decommission RIIO-T3	Decision has been made to disconnect these units because the gas generator and power turbine of each failed and a CBA determined it was not cost effective to reinstate them.	Disconnection will be requested in the Cyber Uncertainty Mechanism submission. Decommissioning will be included in the RIIO-T3 Redundant Assets investment.
Churchover (A and B)	2 x RB211	Decommission RIIO-T2	Units identified as redundant during development of RIIO-T2 business plan as the units are no longer required operationally.	Funded through Redundant Assets PCD.

Kirriemuir (D)	1 x RB211	Decommission RIIO-T2	Unit identified as redundant during development of RIIO-T2 business plan as the units are no longer required operationally.	Funded through Redundant Assets PCD.
Moffat (A and B)	2 x RB211	Decommission RIIO-T2	Units identified as redundant during development of RIIO-T2 business plan as the units are no longer required operationally.	Funded through Redundant Assets PCD.
St Fergus (2C and 2D)	1 x Berth 1 x RB211	Decommission RIIO-T2	Units are being removed due to safety concerns.	Decommissioning costs will be included in the Asset Health Cabs Uncertainty Mechanism submission January 2023.
Warrington (A and B)	2 x RB211	Decommission RIIO-T2	Units identified as redundant during development of RIIO-T2 business plan as the units are no longer required operationally.	Funded through Redundant Assets PCD.
Total	**11**			

Summary

5.21. A summary of the proposed compressor changes can be seen in Table 2 and Figure 9 below. RIIO-T2 Uncertainty Mechanisms for St Fergus, King's Lynn and Peterborough shall be submitted to Ofgem in January 2023.

Table 2 - Summary of proposed compressor changes in RIIO-T2 and RIIO-T3

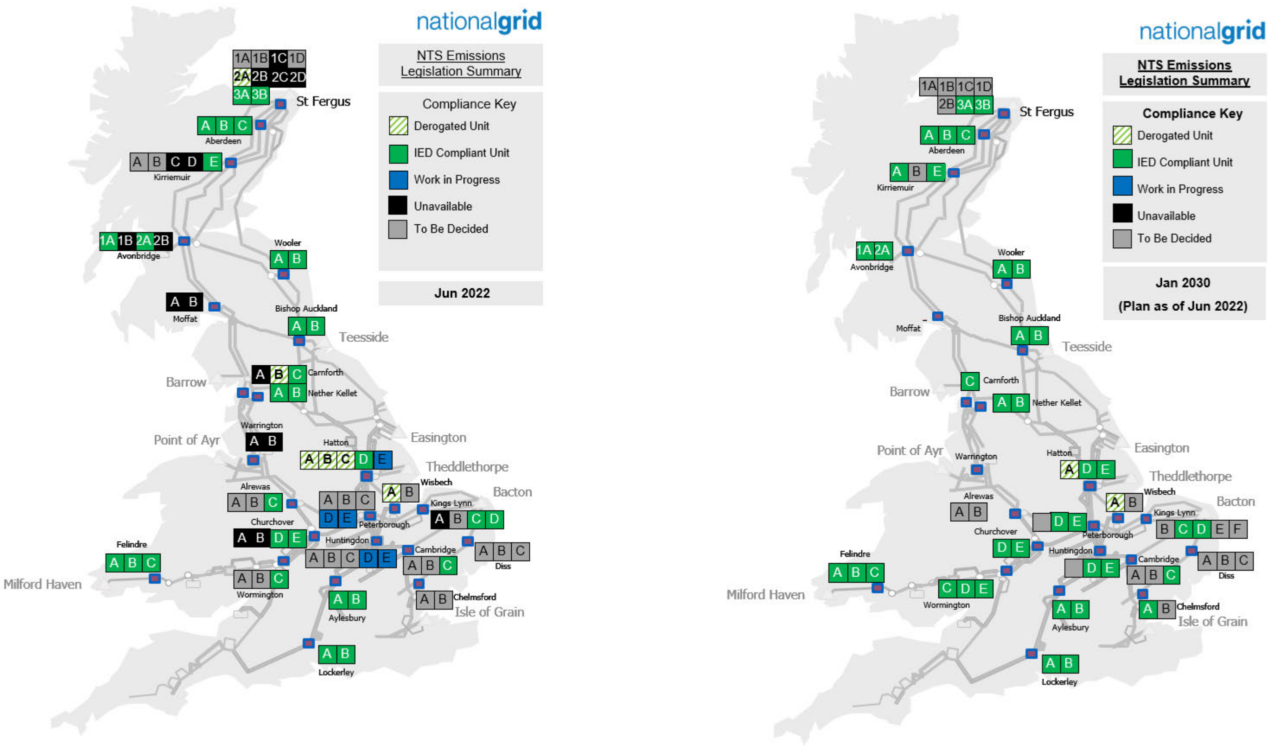
	RIIO-T2 Investments	RIIO-T3 Investments (1 January 2030 compliance date)
New Units	Hatton x 1 Huntingdon x 2 Peterborough x 2	Wormington x 2
Emissions Abatement Upgrade	CSRP Trial x 1-2 DLE Trial x 1	
Derogations – EUD* 500 hours	Carnforth B (LCPD) Hatton A (LCPD) Wisbech A (LCPD)	
Derogations – LLD**	Hatton B and C (LCPD) St Fergus 2A (LCPD)	
Disconnections	Avonbridge 1B and 2B Kirriemuir C (MCPD)	
Decommissioning	Carnforth A (LCPD) Churchover A and B Hatton B and C (LCPD) ***Huntingdon x 2 (MCPD) Kirriemuir D (LCPD) Moffat A and B (LCPD) ***Peterborough x 2 (MCPD) Warrington A and B (LCPD) St Fergus 2C St Fergus 2D (LCPD)	Avonbridge 1B and 2B Carnforth B (LCPD) Kirriemuir C (MCPD) St Fergus 2A (LCPD) Wormington A and B
TBC – Assessments ongoing	**RIIO-T2 Uncertainty Mechanisms:** King's Lynn A and B (MCPD) Peterborough x1 (MCPD) St Fergus 1A, 1B, 1C, 1D and 2B (MCPD)	Alrewas A and B (MCPD) Cambridge x 2 (MCPD) Chelmsford x 2 (MCPD) Diss x 3 (MCPD) Wisbech B (MCPD) Kirriemuir B (MCPD) Huntingdon x 1 (MCPD)

* EUD (Emergency Use Derogation), limiting the plant to an average 500 operating hours per year on a five year average. See *Appendix A – Legislation* for more information

**LLD (Limited Lifetime Derogation), limiting the plant to 17,500 operating hours within the derogation period, 1 January 2016 to 31 December 2023. See *Appendix A – Legislation*

***Decommissioning investments funded in RIIO-T2, could be impacted by UM decisions.

Figure 9 - NGGT compressor fleet status now, and potential 2030 status based on MCPD investments.



Delivery Plan

5.22. Our 2019 RIIO-T2 business plan prioritised new units at Wormington, King's Lynn, Peterborough and St Fergus. All four sites were subject to Uncertainty Mechanisms, with Reopeners required. See *Appendix B – Compressor Compliance, Utilisation and Emissions* for an operational overview of these specific sites.

Wormington

5.23. Currently the site consists of two non-compliant MCPD units (installed in 1989 and 1990), and a single electric VSD unit (installed 2009).

5.24. Our 2019 Business Plan requested funding for two new gas driven units to replace the existing MCPD ones. The revised Cost Benefit Analysis (CBA) and Best Available Technique (BAT) assessments are in line with the original request; building two new gas driven units to replace the MCPD ones.

5.25. This investment would ensure supply constraints are minimised and the site remains MCPD compliant. Additionally, the Planning and Advanced Reservation of Capacity Agreement (PARCA) application for increased flows into Milford Haven further supports the investment proposal and is a key driver for doing the work early in RIIO-T2, to minimise the impact of the outage on the terminal and constraint costs to UK consumers.

5.26. The proposal is to have the two new units installed by 2028, allowing time for operational acceptance prior to the MCPD deadline. Decommissioning of the existing units will be reassessed after the new units have been operationally accepted.

5.27. The Wormington Final Option Selection Report (FOSR), detailing the above, has been submitted to Ofgem August 2022 with this CE-AMP document.

King's Lynn

5.28. Currently the site consists of two non-compliant MCPD units (one disconnected, the other installed in 1973), and two complaint MCPD units (installed 2003).

5.29. Our 2019 Business Plan requested funding for two new gas driven units to replace the existing MCPD ones.

5.30. King's Lynn is a critical site for Bacton entry and exit flows, and Southeast pressures. Bacton exit flows have increased considerably in recent months. We would therefore, seek to complete the MCPD investment as soon as possible to ensure a solution is in place by the MCPD deadline. We are currently reassessing our 2019 Business Plan, with updated data and analysis.

5.31. King's Lynn FOSR, detailing the preferred investment on the site to comply with MCPD is due to be submitted to Ofgem in January 2023.

Peterborough and Huntingdon

5.32. Currently the Peterborough site consists of three units which are non-compliant with MCPD (two installed in 1973, and one in 1978), and two new MCPD compliant units being installed this year (2022) under IPPC.

5.33. At Peterborough, our 2019 Business Plan requested funding for one new gas driven unit to replace the remaining MCPD non-compliant unit. Funding for the decommissioning of two of the three units was also requested and granted specifically through the Redundant Assets theme.

5.34. Our Huntingdon site consists of three units which are non-compliant with MCPD, and two new MCPD compliant units being installed this year under IPPC. Our 2019 Business Plan proposed decommissioning of two of the non-compliant units, and the remaining one to be Derogated to 500 hours. Funding for the decommissioning of two of the three units was granted through the Redundant Assets theme.

5.35. Peterborough and Huntingdon are both critical sites, located in the centre of the network, supporting multiple operational configurations. We would, therefore, seek to complete the MCPD investments as soon as possible to ensure solutions are in place by the MCPD deadline. We are currently reassessing our 2019 Business Plan, with updated data and analysis.

5.36. Peterborough and Huntingdon combined FOSR, detailing the preferred investment on the sites to comply with MCPD is due to be submitted to Ofgem in January 2023.

St Fergus

5.37. Currently the site consists of five non-compliant MCPD units (installed in 1977-1978), two non-compliant LCPD units (installed in 1978, one unavailable and the other derogated), and two electrically driven VSD units (installed 2000).

5.38. Our 2019 Business Plan requested funding for three new gas driven units to replace the MCPD ones.

5.39. St Fergus is a critical site, operating 24/7/365 to supply large volumes of gas into the NTS. We would, therefore, seek to complete the MCPD investment as soon as possible to ensure a solution is in place by the MCPD deadline. We are currently reassessing our 2019 Business Plan, with updated data and analysis.

5.40. St Fergus FOSR, detailing the preferred investment on the site to comply with MCPD is due to be submitted to Ofgem in January 2023.

Other MCPD units

5.41. The remaining MCPD units shall be assessed over the coming years, to ensure that the best solutions are achieved for the network, sites, and units. We have been developing a network resilience model with [redacted] to aid in our analysis and decision making. FES and the Annual Network Capability Assessment Report (ANCAR) shall also feed into the analysis and decision making. For more information on the network resilience model, see ANCAR 2022 and *Appendix F – Process.*

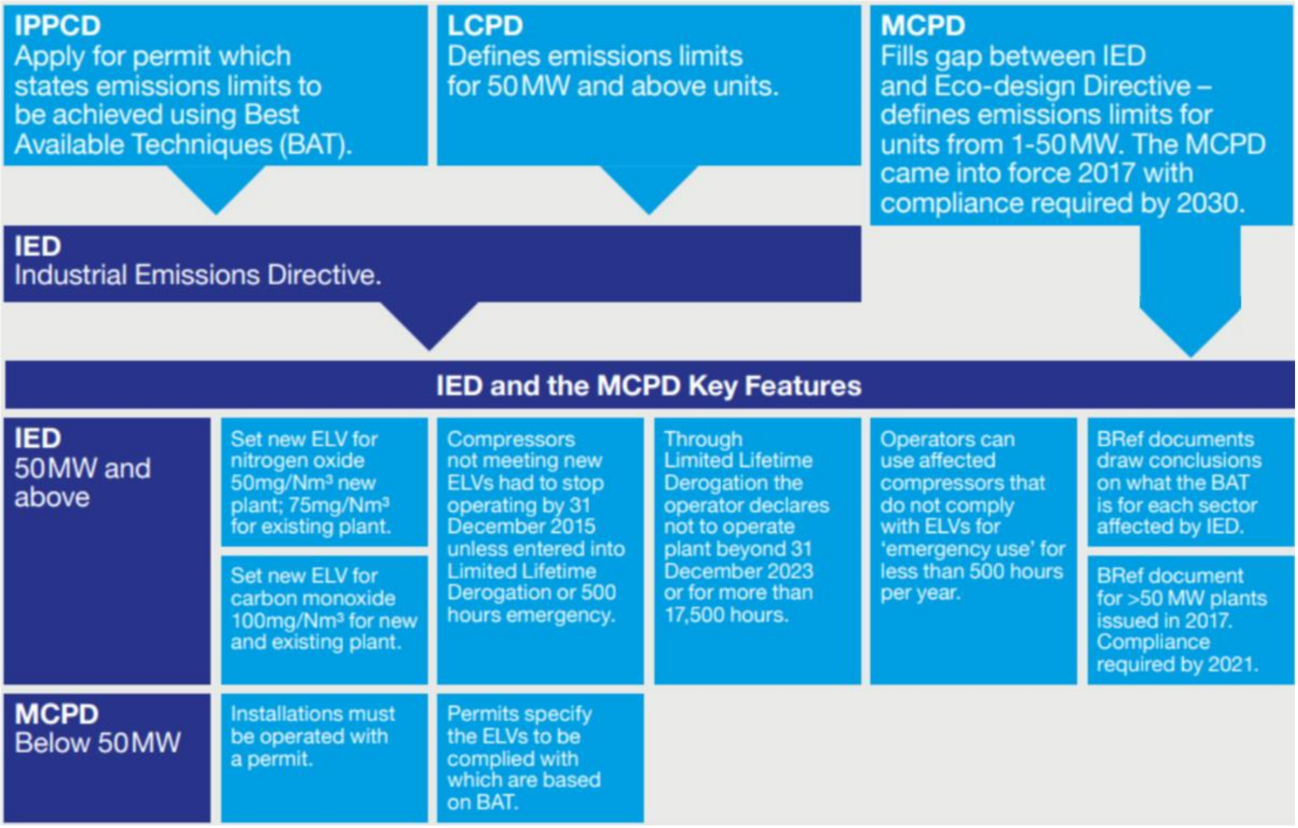
6 Appendix

Appendix A – Legislation

The legislation and how it affects us

6.1. This section introduces all emissions legislation that affects our assets, which is summarised in Figure 10.

Figure 10 - Summary of emissions legislation



The Industrial Emissions Directive (Directive 2010/75/EU)

6.2. The IED brings together existing pieces of European environmental legislation, including LCPD and IPPC. Addressing IED units first has meant that our most polluting compressors have been or are already in the process of being addressed. IPPC directive is replaced by Chapter II, addressing the requirements for permits and the implantation of BAT.

6.3. The major provisions of the IED which impact NGGT and our compressor units are as follows:

The use of permits for installations

6.4. The IED specifies that all installations must be operated with a permit. These permits specify the ELVs for polluting substances likely to be emitted from the installation concerned and also determine the environmental risk of that installation. This mirrors the specifications set out in the IPPC whereby installations must comply with the ELVs set out in their permit, which are based on BAT.

BAT Reference documents

6.5. The IED also introduces an increased emphasis on the status of the BAT Reference (BREF) documents. These BREF documents draw conclusions on what the BAT is for each sector to comply with the requirements of IED. This then forms the reference for setting the permit conditions mentioned above.

ELVs for installations above 50 MW

6.6. The IED states that for installations with a thermal input over 50 MW it is mandatory to comply with the following ELVs;

- Carbon Monoxide (CO) – 100mg/m3
- Nitrogen Oxide (NOx) – 75mg/m3 for existing installations
- Nitrogen Oxide (NO_x) – 50mg/m^3 for new installations

Limited Lifetime Derogation

6.7. The requirements for a Limited Lifetime Derogation state that from 1 January 2016 to 31 December 2023 combustion plant may be exempted from compliance with the ELVs for installations above 50 MWth provided certain conditions are fulfilled:

- The operator makes a declaration before 1 January 2014 not to operate the plant for more than 17,500 operating hours within the derogation period, which started on the 1 January 2016 and ends on the 31 December 2023;
- The operator submits each year a record of the number of operating hours since 1 January 2016

Emergency Use Derogation

6.8. The IED and MCPD allows an enduring derogation from the requirement to meet the specified ELVs, allowing 500 run hours per year, on a rolling five-year average with a maximum of 750 run hours permitted in a single year. As with the Limited Lifetime Derogation, this derogation has been applicable from 1 January 2016 and a number of our operating units have been entered into this derogation.

Large Combustion Plant Directive (LCPD) 2001 (Directive 2001/80/EC)

6.9. The LCPD applies to all combustion plants with a thermal input of 50 MW or more. Such combustion plants must not exceed the Emission Limit Values (ELVs) as defined in the directive. An ELV is the maximum permissible rate at which a pollutant can be released by an installation. The ELVs set out in this directive can be met in one of two ways which are summarised below:

- All equipment is fully compliant with the specified Emission Limit Values and can be operated without restriction.

- Choose to restrict the operation of non-compliant equipment by entering it into one of two available derogations under the IED, either the LLD or the EUD.

6.10. Any non-compliant plant and equipment not operating under derogation cannot be used after **31 December 2023**.

Integrated Pollution Prevention and Control Directive (IPPC) 2008 (Directive 2008/1/EC)

6.11. Under the IPPC, any installation with a high pollution potential is required to have a permit. One of the pre-requisites for this permit is that BAT are used to prevent or reduce the emission of pollutants. BAT assessments are required when developing a solution to avoid or reduce emissions from industrial installations and hence the impact on the environment. BAT assessments take account of the balance between costs and environmental benefits over the full lifecycle of the installation.

6.12. The impact of IPPC means that all our compressor units have a permit which specifies the maximum ELVs to air for that unit. We have an overarching IPPC strategy as agreed with the Environmental Agency (EA), Scottish Environmental Protection Agency (SEPA) and Natural Resources Wales (NRW) which requires us to review our compressors as a fleet on an annual basis, targeting those sites that emit high levels of NO_x to maximise the environmental return. This process is called the Network Review[6].

Medium Combustion Plant Directive (MCPD) (Directive (EU) 2015/2193)

6.13. MCPD regulates pollutant emissions from the combustion of fuels in plants with a rated thermal input equal to or greater than 1 Megawatt thermal (MWth) and less than 50 MWth. The affected assets are referred to as Medium Combustion Plants (MCPs).

6.14. The MCPD regulates emissions of Sulphur Dioxides (SO_2) and Nitrogen Oxides (NO_x) to air through ELVs and requires monitoring of Carbon Monoxide (CO) emissions. ELVs are differentiated according to the plant's age, capacity and type of installation. This legislation was initially set with a deadline for compliance of 2025 for all polluting plant. In 2015 we successfully revised European legislation to extend the compliance date to 1 January 2030 for gas compressors to ensure the safety and security of the national gas transmission system. Our plant impacted includes gas generator powered compressors and a small number of water bath heaters, boilers and standby gas generators. Post 1 January 2030, all non-compliant MCPD units still in use shall be derogated under EUD.

Best Available Techniques

6.14.1. NGGT is legally bound under the IED, implemented through its site Environmental Permit Regulations (EPR) permit (in England and Wales) or a Pollution Prevention and Control (PPC) permit (in Scotland), to comply with the requirements of BAT in respect of its compressor operations. Table 3, below gives the definition of BAT.

[6] *Provided upon email request to: box.GTA.EPR.PPC@nationalgrid.com*

Table 3 - Best Available Techniques defined

• *Best*	The most effective techniques for achieving a high general level of protection for the environment.
• *Available*	Techniques developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions taking into consideration the cost and advantages, whether the techniques are used or produced in the United Kingdom as long as they are reasonably accessible to the operator.
• *Techniques*	Includes both technology and the way the installation is designed, built, maintained, operated and decommissioned.

6.15. NGGT is required to use BAT as the primary selection mechanism for all new and substantially modified compressor machinery trains. This means that when we are looking at solutions for achieving compressor emissions compliance, BAT determines the chosen option for build solutions.

Timeline

6.16. The combustion emissions legislation timescales applicable to NGGT are summarised in Table 4 as provided in Appendix 1 of the Compressor Emissions Compliance Strategy Guidance document from Ofgem[7].

Table 4 - Combustion emissions legislation timescales applicable to NGGT

Date	Legislation	Requirement
17 August 2021	IED Chapter II	Existing LCP that are not subject to IED's Chapter III Limited Life or Emergency Use Derogations must meet the emissions requirements set out in the LCP BAT Conclusions.
31 December 2023	IED Chapter III LCP	Limited Life Derogation comes to end and plant on LLD will cease operation. Remaining plant will either have to operate under 500- hour emergency use derogation, meet Chapter III and LCP BAT Conclusions "New" plant emissions requirements or cease operations.
1 January 2030	MCPD	Derogation for gas compression plants and other assets operating on a national transmission system ceases and all MCPD scale (1-50MW) plant must meet the emission limits as set out in the MCPD,

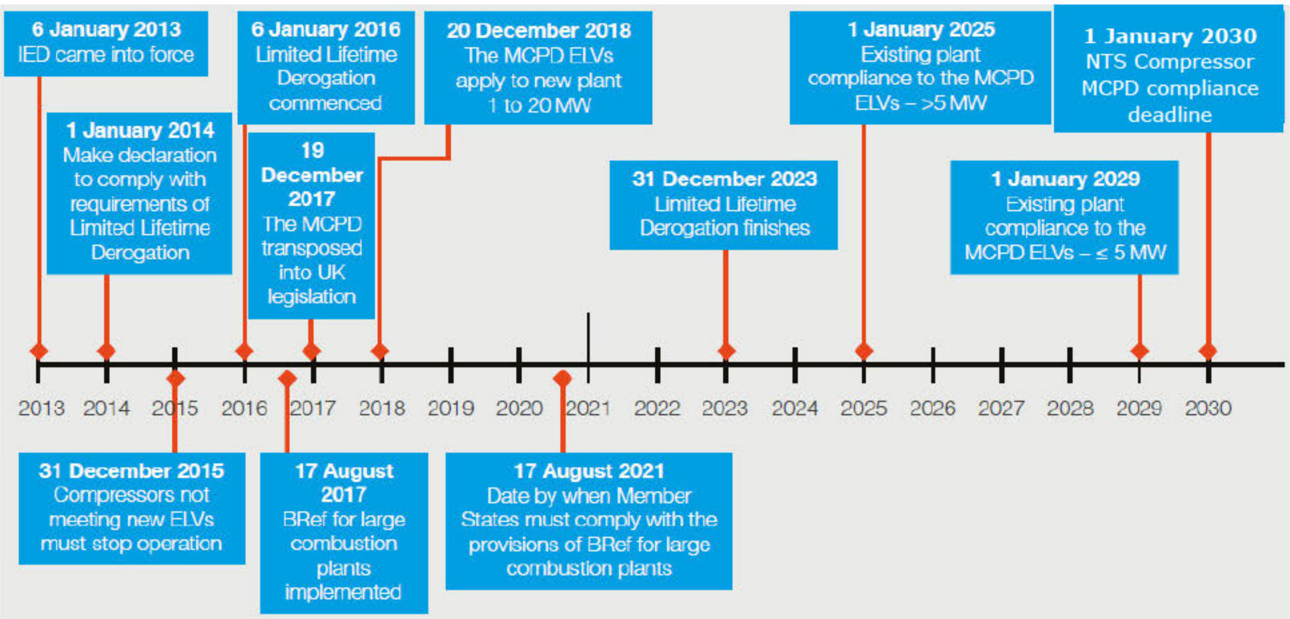
[7] https://www.ofgem.gov.uk/system/files/docs/2019/06/compressor_emissions_compliance_guidance.pdf

		operate under a 500-hour operating hour derogation, or cease operations.

6.17. The key dates summarised in Table 4 are the minimum legal requirements that NGGT must meet.

6.18. An overview of the legislative timeline is shown in Figure 11.

Figure 11 - Emissions legislation timeline



Appendix B – Compressor Compliance, Utilisation and Emissions

Compressor Utilisation and Emissions

6.19. The evolution of the network has resulted in changes to compressor utilisation. Some compressors are now required to support reverse flows, by moving gas in the opposite direction from their original design. Some compressors have become increasingly important across a large demand range. While some are only used during peak demand conditions or certain supply patterns to avoid significant constraints.

6.20. Table 5 shows the predominate use of the different sites that have MCPD units.

Table 5 - Predominate use of MCPD sites

Site	Exit*	Entry**	Transmission***	Profiling****
Alrewas	Y	Y	Y	N
Cambridge	Y	Y	Y	Y
Chelmsford	Y	Y	Y	Y
Diss	Y	Y	Y	Y
Huntingdon	Y	N	Y	Y
King's Lynn	Y	Y	Y	Y
Kirriemuir	N	Y	Y	N
Peterborough	Y	Y	Y	Y
St Fergus	N	Y	N	N
Wisbech	Y	Y	Y	N
Wormington	Y	Y	Y	Y

*Exit: Required to meet pressure and/or exit capacity obligations (including those required for meeting our 1-in-20 licence obligation)
**Entry: Required to meet pressure and/or entry capacity obligations (including those required for meeting our 1-in-20 licence obligation)
***Transmission: Required for bulk transfer between different zones in the network
****Profiling: Facilitates the ability for customers to profile and change their planned gas flows within day

Historic compressor run hours

6.21. Historic run hours for each of the units tell part of the story for MCPD. Historic run hours vary significantly year on year and are dependent on: supply and demand patterns; outages on other units at the site; whole site outages and outages elsewhere on the network

6.22. It is worth noting that the past use alone is not a suitable indication for future requirements. *Context: Customer Demand Patterns* includes information on the Future Energy Scenarios, which provide an indication of the potential energy landscape, and thus the potential requirements of our compressor fleet.

6.23. Historic unit run hours are shown in Table 6. This table highlights, in blue, where units have been running for more than 500 hours. Significant MCPD compressor utilisation can be seen in 2018 in response to the "Beast from the East".

Table 6 - Historic MCPD compressor unit run hours (2014-2021)

Unit	2014	2015	2016	2017	2018	2019	2020	2021	Average (2014-2021)
Alrewas A	20	51	36	22	1362	373	44	261	271
Alrewas B	25	7	9	9	59	265	222	369	121
Cambridge A	18	14	17	46	243	22	52	1158	196
Cambridge B	8	41	38	108	75	2	9	1	35
Chelmsford A	8	22	12	67	961	61	1	8	143
Chelmsford B	105	89	22	813	112	7	6	3	145
Diss A	126	125	20	14	41	8	8	1188	191
Diss B	0	15	15	763	1457	5	2	4	283
Diss C	15	6	11	344	560	59	10	396	175
Huntingdon A	1800	865	238	1635	1892	595	459	613	1012
Huntingdon B	1237	295	451	1381	1082	864	266	1068	831
Huntingdon C	195	1116	376	33	9	249	90	146	277
King's Lynn A	2	4	0	13	N/A	N/A	N/A	N/A	N/A
King's Lynn B	21	7	3	12	747	21	1	178	124
Kirriemuir A	367	155	1234	599	1189	556	390	526	627
Kirriemuir B	11	11	783	823	392	839	334	143	417
Kirriemuir C	9	0	58	107	195	2	2	12	48
Peterborough A	2911	2370	522	30	2143	827	134	569	1188
Peterborough B	2186	1443	1426	2451	3417	1096	2	1813	1729
Peterborough C	2077	1576	482	3221	1558	466	182	1897	1432
St Fergus 1A	3263	2482	942	281	518	92	237	3585	1425
St Fergus 1B	175	25	632	339	447	0	0	300	240
St Fergus 1C	1497	2407	1214	1353	939	4	389	388	1024
St Fergus 1D	833	1371	776	1458	465	0	595	3248	1093
St Fergus 2B	60	253	1337	7	77	840	159	0	342
Wisbech A	94	21	47	11	9	13	7	3	26
Wisbech B	151	30	421	772	65	18	6	22	186
Wormington A	27	32	26	145	12	11	418	567	155
Wormington B	58	27	67	190	23	19	29	198	76

6.24. In addition to unit running hours, it is useful to consider the running hours at a site level to see which sites run most frequently. Historic site run hours for sites with MCPD units are shown in Table 7. This table highlights the highest running hours over the last eight years, coloured red through to white.

6.25. Comparing Table 5 and Table 7, it can be seen that although some sites, like Wisbech, have historically low run hours, they are required for entry and/or exit obligations.

6.26. As can be seen in Table 7, compressor usage at Wormington has increased in recent years as a result of an increase in LNG supplies at Milford Haven.

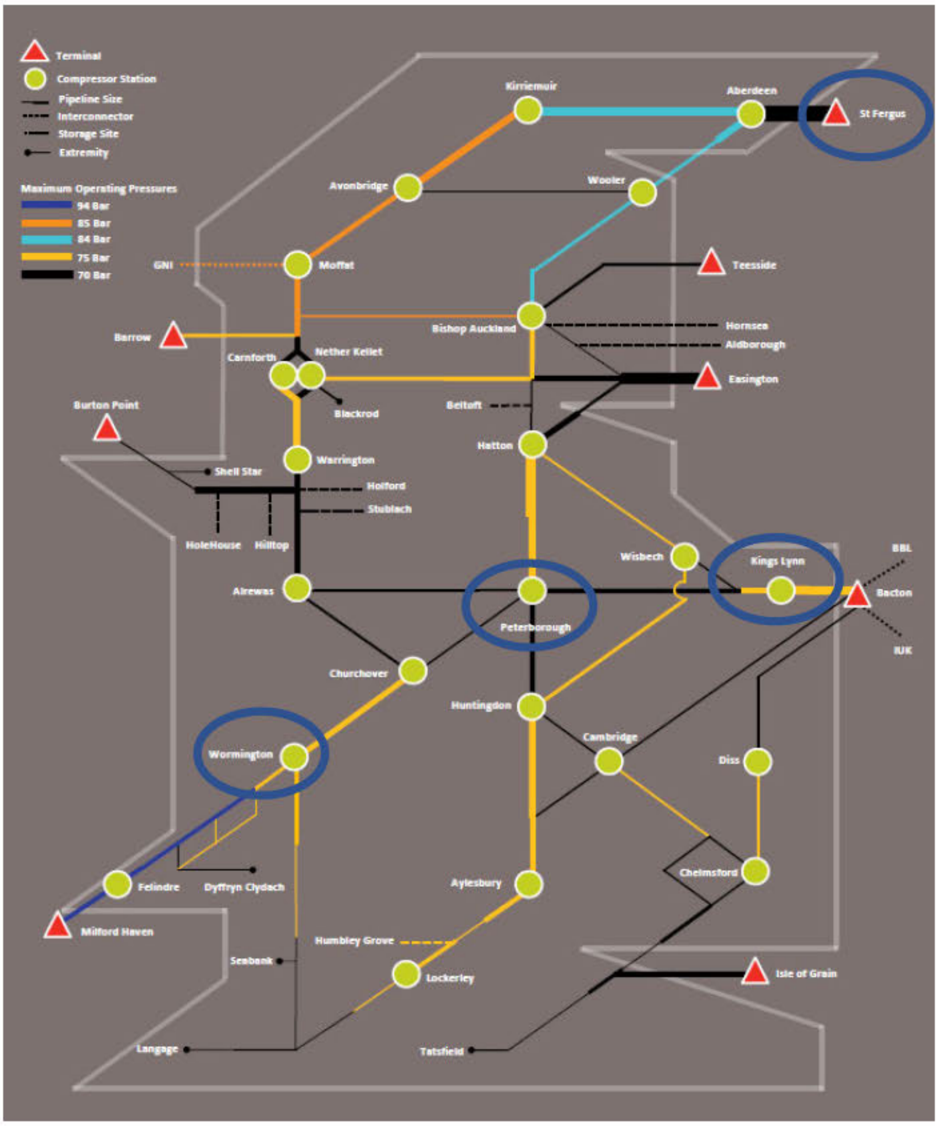
Table 7 - Historic MCPD site run hours (2014-2021)

Site	2014	2015	2016	2017	2018	2019	2020	2021	Average (2014 – 2021)
Alrewas	152	106	129	55	1734	638	267	638	465
Cambridge	54	211	216	340	387	45	84	1220	320
Chelmsford	113	111	34	880	1073	69	7	62	294
Diss	141	145	46	1120	2058	72	19	1589	649
Huntingdon	3233	2276	1065	3049	2982	1708	815	1827	2119
Kings Lynn	304	35	28	186	1887	118	71	1584	527
Kirriemuir	428	1688	5403	1532	1776	3165	794	1033	1977
Peterborough	7174	5388	2430	5701	7118	2389	318	4279	4350
St Fergus	10897	9424	10380	14166	14057	10733	9568	12273	11437
Wisbech	246	51	467	782	74	31	13	25	211
Wormington	1132	1441	1966	1303	2155	818	3078	3007	1863

Specific site overview

6.27. We asked for funding for new units at four of our compressor stations as part of our 2019 RIIO-T2 Business Plan. An overview of these four sites is given below, Figure 12 shows a simplified version of the NTS, with the four sites circled.

Figure 12 - NTS Simplification Map



6.28. Wormington compressor station has recently become critical in supporting NTS gas entering through the Milford Haven terminal and utilisation is likely to remain high over a wide range of network conditions. Due to bi-directional flow capabilities, it is also used to support the extremities in Wales when Milford Haven inputs are low. Compression at Wormington can be required throughout the year, reducing the available maintenance windows.

6.29. King's Lynn is bi-directional and can be considered to have two main "modes" of operation; "import mode" is when the station is required to move gas away from Bacton during high importation scenarios, particularly during the winter. Whereas "export mode" is when the station is required to move gas towards Bacton during high exportation scenarios, particularly during the summer. The site is also critical in supporting high Isle of Grain supplies. Compression at King's Lynn can be required throughout the year, reducing the available maintenance windows. Low availability when required would lead to significant network constraints.

6.30. Peterborough is a central compressor station, linking gas supplies from the East to the demand in the West, supporting Southern demand, and moving gas away from Bacton during periods of high supply.

6.31. St Fergus compressors are required to compress gas from the North Sea Midstream Partners (NSMP) sub terminal at St Fergus, increasing its pressure to the required levels to enter the NTS. As such, the compression is required 365 days a year. This compression service is currently a contractual obligation, with a consultation on the future of charging at St Fergus underway.

Types of Gas Compressors affected by MCPD

6.32. There are currently three types of gas generator in service across the NTS which would fall within the range of the MCPD: the Siemens SGT400 (previously designated as the Cyclone); the Solar Titan; and the Rolls Royce (now Siemens) Avon 1533.

6.33. The SGT400 and Solar Titan engines employ Dry Low Emissions (DLE) technology; these have emissions falling within the ELVs specified by the MCPD and represent BAT. The Avon 1533 gas generators within our fleet are not compliant with the ELVs specified by the MCPD. All 28 units affected by MCPD are Avon 1533s.

6.34. Table 8 lists all compressor sites containing Avons. Where Avons are currently lead units on the site, they are highlighted in blue. At Peterborough and Huntingdon, the Avons will no longer be lead units once the new DLE units have been completed.

Table 8 - NGGT's compressor sites affected by emissions legislation

Site	Total no. of units	No. of Avon units	Primary Unit(s)	Backup Unit(s)	Works in Progress	Primary mode of Avon operation
Alrewas	3	2	1 x DLE	2 x Avons		Single Unit
Cambridge	3	2	1 x DLE	2 x Avons		Single Unit
Chelmsford	2	2	2 x Avons			Single Unit
Diss	3	3	3 x Avons			Single Unit / Series
Huntingdon	3	3	3 x Avons		2 x DLEs (IPPC)	Parallel
King's Lynn[8]	3	1	2 x DLE	1 x Avon		Parallel
Kirriemuir[9]	3	2	1 x VSD[10]	2 x Avons		Parallel
Peterborough	3	3	3 x Avons[11]		2 x DLEs (IPPC)	Parallel
Wisbech	2	1	1 x Avon	1 x RB211 derogated		Single Unit
Wormington	3	2	1 x VSD	2 x Avons		Single Unit / Parallel
St Fergus	9	5	2 x VSD	5 x Avons, 2 x RB211s		Parallel
Total	**38**	**26[12]**	**20**	**17**	**4**	

[8] *This is excluding one Avon unit, A, that is unavailable*

[9] *This is excluding one Avon unit, C, that is unavailable and planned for disconnection in RIIO-T2*

[10] *Variable Speed Drive (VSD)*

[11] *Two units at Peterborough and two units at Huntingdon are being replaced under IPPC through the May 2018 reopener*

[12] *Excluding King's Lynn A and Kirriemuir C that are unavailable*

Compressor Compliance

6.35. Emissions testing is carried out at intervals as specified in the permit. If a compressor runs for less than 2,200 hours in a year, then testing is completed every two years. If a compressor runs for more than 2,200 hours in a year, the emissions test is completed either annually, or after 4,380 operational hours, dependant on which is sooner. An additional test is done if any work is carried out that would cause a change in the emissions profile of the unit e.g. changing the gas generator or replacement of certain ancillary equipment.

6.36. A Predicative Emissions Monitoring System (PEMS) is used during operation, which reads data from the control systems to determine the operating point within the model and equivalent NO_x output. Following each emissions test, the PEMS model is updated to maintain its accuracy. Table 9 summarises the emissions of the Avon compressor units during operational running between 2012 - 2021. Highlighted in red are results above the 150mg/m^3 limit and highlighted in orange are results above 135mg/m^3.

6.37. It can be seen that there are a few units which have not breached the NO_x limit during an emissions test and/or during operational running. However, these units are capable of breaching the limit under specific conditions, and require intervention before the MCPD deadline.

6.38. There are multiple variables that can affect the amount of NO_x produced by the Avon during operation, where it will take a combination of these to push the NO_x levels above the limit. These include, but not limited to;

- ambient conditions
- unit condition
- fuel content
- fuel energy content
- process condition
- unit load

Table 9 - Highest recorded NO_x during operational running for Avon compressor units. Highlighted in red are results above the 150mg/m³ limit and highlighted in orange are results above 135mg/m³.

Site	Unit	Highest operational NO_x recorded (2012-2021)
Alrewas	A	135
Alrewas	B	152
Cambridge	A	138
Cambridge	B	162
Chelmsford	A	117
Chelmsford	B	130
Diss	A	130
Diss	B	140
Diss	C	139
Huntingdon	A	159
Huntingdon	B	156
Huntingdon	C	153
Kings Lynn	A	127
Kings Lynn	B	154

Site	Unit	Highest operational NO_x recorded (2012-2021)
Kirriemuir	A	159
Kirriemuir	B	154
Kirriemuir	C	150
Peterborough	A	164
Peterborough	B	165
Peterborough	C	150
St Fergus	1A	157
St Fergus	1B	145
St Fergus	1C	163
St Fergus	1D	177
St Fergus	2B	160
Wisbech	B	147
Wormington	A	159
Wormington	B	160

Appendix C – Compliance Options

Options description

6.40. The high-level options considered for compliance with MCPD are shown in Table 10. Further detail on these options is provided below.

Table 10 - High-level options for compliance with the MCPD

Decommission	Decommissioning is the option of permanently removing assets from service. This will reduce network capability.
Derogate	Existing non-compliant Medium Combustion Plant will be unable to operate for more than 500 hours per year on a rolling five-year average after 1 January 2030. These assets will not need to comply with MCPD Emission Limit Values. Having limited available hours, these derogated units will impact the ability to meet stakeholder network capability requirements.
Make Compliant	Three high-level options for achieving compliance: 1. Install a new, MCPD-compliant compressor machinery train. 2. Install emissions abatement technology to achieve the specified ELVs.
Commercial options	Options such as turn-up or turn-down contracts with terminals/storage operators for constraint management.

Decommission

6.41. Decommissioning is the option of permanently removing assets from service. Normal asset health investment would be required with the ongoing costs of maintaining the unit until the point of decommissioning would be covered by our asset health plans. Where we are replacing a unit, decommissioning of the old unit is planned to align with the build timescales, and likely to occur after the new units are fully operational. Where we are decommissioning a unit without building a replacement, costs are planned in for RIIO-T3 to ensure network resilience while delivering our RIIO-T2 plan.

6.42. Unit decommissioning includes dismantling and disposal of the compressor train, removal of all associated balance of plant equipment and systems and demolition of the compressor cab. For complete site decommissioning, we are likely to have to undertake work on all the above ground installation to isolate the site from network feeders and fully remove all equipment, above and below ground, and return the site to a greenfield state if the complete site is being removed and deemed appropriate.

6.43. Decommissioning units impacts network capability and resilience, and has implications for the flexibility of service that we can offer to our customers and our ability to respond to a wide range of supply and demand scenarios. Network assessments will be completed to determine the implications of decommissioning the unit, to confirm that obligations can still be met. Decommissioning units will reduce asset health investment and maintenance spend.

Derogate

6.44. MCPD offers a derogation where plant which operates for no more than 500 hours on a rolling five-year average does not need to comply with ELVs, as of 1 January 2030. Having limited available hours, these derogated units will impact the level of network capability and resilience we can deliver. Some sites on the network only have MCPD units, with their availability reducing with age. Derogation as a compliance option must be carefully assessed to prevent a shortfall in network resilience. Although derogated, our Environmental Regulators expect us to use these units for the absolute minimum time to meet the principles of the UK legislation and associated permitting regime, and therefore are our least preferred compliance option. No emission related capital investment would be required in the business plan, however ongoing asset health investment would be required and is likely to increase as the asset ages.

6.45. Where there is an on-going need for a unit on the network, but running hours are expected to be below 500, derogating a unit under Emergency Use Derogation (EUD) is a viable option. The derogation costs in the CBA include full re-life costs, to make sure the unit is maintained to a suitable level for running past 2030.

6.46. EUD limits the unit to 500 run hours a year, on a five-year rolling average, with a maximum of 750 run hours in any year. Units selected and approved for EUD will have limits applied on the deadline of 1 January 2030.

6.47. If the longer-term future of a unit is especially uncertain past 2030, derogation is recommended as an interim solution, effectively deferring the decision on a longer-term solution. This allows us to minimise the risk of spending on a unit unnecessarily. Where this is recommended, asset heath investments will be minimised, therefore reducing the potential cost, however also reducing availability and reliability.

New Units

6.48. Installation of a new, emissions compliant compressor machinery train is another option available to us. When considering the installation of new plant, there are two sub-options: gas or electric drive compression (Variable Speed Drive (VSD)).

6.49. Analysis of the costs of construction (including electrical High Voltage connection) and operation of electric drive compressors has shown that they are only cost effective when operated in excess of 5,200 hours per year.

6.50. A new gas driven compressor chain over an existing one, will have greater fuel efficiency, lower emissions and would be sized accordingly to meet the required demand to minimise network constrains. New units have the potential to reduce fuel usage and CO_2 emissions by 40%, as well as improved reliability and availability.

6.51. Consideration is also given for full site resilience when determining new units. VSD unit(s) providing back-up to existing VSD unit(s) provides no site resilience in the event of an electrical power cut, either locally or the whole electricity network undergoing a black start. Back-up generators enable gas-driven units to remain operational due to their lower electrical consumption than VSDs. Gas-driven units will also remain operation during maintenance on VSD auxiliary equipment, preventing full site outages.

Emissions Abatement – Selective Catalytic Reduction

6.52. Selective Catalytic Reduction (SCR) emissions abatement technology injects ammonia into the exhaust gas, reducing the NO_x levels.

6.53. Additional considerations for SCR over the installation and ongoing maintenance and asset health costs of the unit include: the limit to the longevity of SCR technology; higher fuel consumption; and ongoing ammonia bed replacements, specialist maintenance and disposal activities.

Emissions Abatement - Control System Restricted Performance

6.54. Control System Restricted Performance (CSRP) emissions abatement technology controls the unit's power in relation to Exhaust Cone Temperature (ECT), to prevent NO_x emissions exceeding the legal limit.

6.55. Trials at Huntingdon and Chelmsford to determine the feasibility of applying CSRP onto our existing Avon 1533 units have concluded successful results, confirming the ability to control the unit to ECT limits.

6.56. Additional considerations for CSRP over the installation and ongoing maintenance and asset health costs of the unit includes a reduction to the unit's operating envelop, reducing top end power. Therefore, CSRP is an unlikely option for units that are required to run at high power.

6.57. In order to determine if the environmental regulators will accept CSRP as an MCPD compliance option, one or two sites will be selected for permit trials. Once it has been determined if the environmental regulators, EA and/or SEPA, accept CSRP, all MCPD units selected for CSRP will have their own permit applications submitted.

Emissions Abatement – Dry Low Emissions

6.58. Dry Low Emissions (DLE) emissions abatement technology injects air into the combustion chamber to create a lean air fuel ratio, which lowers the combustion temperature and reduces NO_x production.

6.59. Trials to determine the feasibility of retrofitting DLE onto our existing Avon 1533 and test bed performance trials to confirm NO_x reduction are ongoing.

6.60. Further trials are planned to be completed to determine the feasibility of retrofitting DLE onto our existing Avons through operational trials on one of our units.

6.61. Additional considerations for DLE over the installation and ongoing maintenance and asset health costs of the unit include higher fuel consumption, available space within the cab, and an unknown impact on unit availability.

6.62. There is a long-term risk for the DLE option that it does not have the support of the OEM, is likely to have low production numbers, and could become unsupported in the medium term. There are some mitigations we can implement but they will not remove this risk.

6.63. Mitigations to the DLE development becoming unavailable include:

- NGGT to take on the Intellectual Property for the development under certain circumstance to open up support from other parties.
- Work to develop and resolve further issues.

- Purchase suitable volume to encourage ongoing support.
- Enter into support agreement with developer (not currently being pursued).
- Support developer in trialling and in obtaining more orders from industry.
- Purchase suitable spares.
- The ability to retrofit a standard Avon into the berth, permit allowing (this may only be suitable pre-2030).

Commercial Options

6.64. Commercial options are an important consideration when assessing how to meet the network needs. These solutions potentially avoid the physical use of compressors, and consequently reduce the emissions impact of the fleet overall. Typically, the commercial and regulatory options are suited to short term scenarios, meeting a peak demand and supply pattern linked to a single entry point, rather than a complete alternative option to investment in the compressor fleet. It is also important to note that commercial solutions to meet emissions requirements will have corresponding physical requirements in other areas (for example, if a commercial solution is chosen instead of a new unit option, decommissioning would still have to be undertaken on the existing unit).

6.65. Bi-lateral contract arrangements at either entry or exit points can be used to manage network flows. For example, to help meet the required pressure level at a distribution network offtake, a turn-up contract may be negotiated with the relevant gas shippers at a particular entry point. Flows through that entry point are then increased on request by NGGT, boosting local pressures. A turn-down contract at a power station can be used in a similar way. As an alternative to asset investment, contracts of this type are likely to be the most effective options when linked to single entry points over the short term, and where there is sufficient notice to put these in place.

6.66. Commercial options for MCPD are unlikely to be cost effective due to the sustained long-term requirement to maintain security of supply and to meet our obligations, including 1-in-20 peak demand.

Appendix D – Assumptions

6.67. The following section outlines the assumptions that are made in the development of our CE-AMP, and how our compressor fleet will comply with emissions legislation.

Future Network Flows and Network Impact

6.68. NGGT needs to ensure that it manages the risks associated with medium to long-term uncertainty. The most significant uncertainty is the future network use in a range of possible energy futures.

6.69. Our assessments are based on FES, where we try to balance the risk of asset stranding against the risk of removing network capability too early. See *Context: Customer Demand Patterns* for more information on FES.

Managing Uncertainty - Principles of the compressor emissions plan

6.70. The underlying principles of the emissions plan are to ensure we comply with new and existing legislation while providing the required levels of service to our customers and consumers. To do this, the following basic principles have been applied:

- We have looked at levels of network capability that may be required to meet the needs of stakeholders to take gas on and off the system as and when they want using a range of scenarios.
- All investment decisions will be informed by a robust CBA and consideration of non-monetised risks and benefits.
- All four FES 2021 scenarios are being used to inform our investment decisions.
- Where we propose to reduce the number of existing compressor units, this assumes sufficient reliability of the remaining compression units on our network as overall demand drops into the future. Maximising availability of units will mean investing more heavily in the retained units to make sure they have the levels of capability and reliability required.
- We will consider the age and condition of the existing units and the associated implications in our decision-making, such as reliability and availability (factored into the CBA); obsolescence; the willingness and ability of Original Equipment Manufacturers (OEMs) to provide continued support to older machines; and the ability to replace the skills of an ageing workforce to continue to service the equipment.
- Where there is significant uncertainty around the need for a compressor due to either decreasing flows or other changes in flows, we will consider no/low-regret investment options (for example, derogation of units where possible, or market-based solutions to meet capacity needs, if appropriate) and defer the decision where possible.
- While we are currently unaware of further emissions legislation coming into force, we will ensure that our solutions represent BAT to reduce the likelihood of further investment due to more stringent emissions limits.
- Where we will propose to build new units to achieve compliance and there is significant uncertainty in flows or a broad range of flows expected through a compressor station, we will be guided by the BAT assessment

and are likely to invest in multiple smaller compressor units, rather than a single large unit, to ensure flexibility and futureproofing.

- Where our analysis indicates we no longer need a compressor unit / station, we will assess the options of continuing to operate until the MCPD compliance date of 1 January 2030 versus decommissioning as soon as possible, looking at stakeholder network capability needs. The timing of any decommissioning will be driven by FES forecasts of declining flows, ongoing feedback from our customers and the requirement for the unit to support the overall deliverability of investment and maintenance work on the network.
- Where units are derogated under MCPD legislation due to expected low running hours, there will be an ongoing review of the need for those units. We expect this to allow us to decommission additional units post 2030 as units require significant health spend and running hours decrease.
- As flow patterns change so does the criticality of our compressor, therefore we will respond accordingly by reprioritising the focus of compressor investment.
- Decisions directly related to a hydrogen network shall be deferred until more information is available.

Supply and Demand Scenarios

6.71. To ensure consistency, we have used all four FES 2021 scenarios to assess MCPD unit interventions at Wormington, King's Lynn, Peterborough and St Fergus. The four FES scenarios incorporate a vast array of assumptions and produce a wide range of potential gas demand scenarios. A high-level overview of the changes in FES 22 has also been given.

Availability and Reliability

6.72. Compressors are not always available when needed due to planned and unplanned outages. This can place greater reliance on other units on site or at other compressor stations on the network.

6.73. [redacted] were commissioned to develop an idealistic Reliability, Availability, Maintainability (RAM) model for the average unit of various types of compressor drivers on our network utilising our data to create representative values. For more information on this see *Appendix F – Process.*

Risks

6.74. There are risks specific to certain sites which are included within the specific FOSRs. The overall risks which could apply to multiple sites are:

Technical solutions

- There could be future environmental legislation passed which tightens the limits for acceptable emissions. Where we are building new units, we will investigate technologies that meet current legislative requirements while endeavouring to future-proof against possible further restrictions on emissions.

This will be supported by the BAT process and will be used to differentiate between different compliant options.

- The availability of new, future-proofed technology (for example, the development of compressor units which can be used with a blended mix of gases up to 100% Hydrogen) could change the BAT options available in future. This will be considered as part of the FEED.
- The CBA assumes an asset life for new compressor units. There is a risk that due to the changing energy landscape the use of the NTS will change significantly in this time potentially stranding assets. We are only recommending building new compressors on sites where we are confident the site will be critical in the future.
- The FEED will establish if new units can be built on brown or green field, and within or outside of the existing fence line. The associated costs of these options will influence our recommended option.

Project delivery

- Building on existing sites is likely to require lengthy site outages due to working near to operational plant. Existing compressor units need to be kept operational during winter meaning project delivery can take twice as long compared to building on non-operational land.
- Delays in the completion of in-flight and proposed projects across the NTS could impact availability of outages and resources to complete these investments.
- If building outside of the existing land ownership boundary, then procurement of the land and planning permission could take longer than anticipated or be unsuccessful.
- The wider impact of MCPD across Europe puts pressure on the supply chain, leading to uncertainty over the availability of required asset solutions. For example, the lead time for a new compressor unit can be 12-18 months on average. National Grid is a very small part of the OEM's market and therefore has limited "buying power".
- Uncertainties around the world's future energy supplies may continue to have an impact upon currency as well as cost and availability of materials and contractors which is not currently reflected in our cost estimates.
- The requirement for future site maintenance and outages will be considered, potentially increasing site availability during specific maintenance works as a full site outage wouldn't be required.

Interactions

6.75. This topic also has several interactions with other aspects of our business plan. In particular, our asset health and cyber investment proposals have been developed alongside the emissions compliance work proposed in this document to ensure a consistent overall RIIO-T2 investment proposal. Key interactions are discussed below.

Asset health

6.76. Decisions to replace, abate or derogate will incur different levels of asset health spend. Asset health costs will be higher the more units we derogate or abate as we will need to maintain old units for continued use. In some cases, the unit may need a full refurbishment to bring it back to the required operational condition. For others, we may invest the minimum to keep them available until there is a major asset health investment needed, in which case a decision on the future of that unit will need to be made.

6.77. The phasing of the final proposals has significant impact upon the levels of asset health work required at the relevant sites to maintain safe and reliable operation. For example, if a compressor unit is due to be replaced early RIIO-T2, then less ongoing asset health work will be required than if it is scheduled for later.

External threats (Cyber)

6.78. Cyber costs will be higher the more units we derogate or abate as new units are expected to come with an element of cyber compliance built in (unit control systems). Major cyber investment has been deferred until beyond RIIO-T2 on compressor sites with the least future certainty.

Appendix E – Stakeholder Engagement

6.79. We have heard from and agree with our stakeholders that it is important to do the right thing for society in terms of reducing the impact of our activities on the environment. This CE-AMP sets out how we intend to reduce our environmental impact through compliance with emissions legislation throughout RIIO-T2 and beyond. We will deliver our strategy, whilst ensuring there is adequate compression capability on the gas network, to meet broader stakeholder needs. Summaries of stakeholder feedback and how they have influenced the CE-AMP is shown in the tables below.

	Air quality
Stakeholder segments engaged	Consumer interest groups, Consultants, Supply chain, Customers (entry, exit, shippers), Energy network operators, Env. interest groups, Gas distribution networks, Industry/trade bodies, other energy industry, Regulators. Government and local government, University/think tanks, Domestic consumers, Non-domestic consumers, Major energy users
Objective	Understand stakeholders' views on how we manage NOx emissions resulting from operating the compressor fleet and becoming compliant with legislation Understand consumers' views on local air quality
Channel/method	Workshops, bilaterals, Webinars, Acceptability testing, Consumer listening, Acceptability testing
Key messages	Stakeholders value our work on reducing emissions to improve local air quality and believe we should get on with it as soon as possible. Managing and reducing emissions is very important Customers want us to assess the impacts of any projects against environment, society and operational parameters Consumers listening outcomes: • Local air quality is important to consumers due to the health concerns associated with it • National Grid has a responsibility in improving local air quality because they are part of the transmission process of pollutants to the atmosphere • National Grid should use existing solutions such as the conversion of existing compressors to electric or other solutions that offset emissions such as planting trees. Domestic consumers consider air quality to be important and the majority agree with the proposed investments and its bill impact. A significant proportion (around a quarter) agree with the proposals, but not with the bill impact. There is also some support from domestic consumers for doing more on-air quality than currently proposed, but specific actions are not specified.

Influence on CE-AMP	Our proposals to comply with environmental legislation are in line with stakeholder expectations.

	Future proof compressor build
Stakeholder segments engaged	Independent stakeholder user group, consumer interest groups, Major energy users, Other non-energy industry, Regulators, Government, University/think tanks, Industry/trade bodies, Gas distribution networks, Consultants, Supply chain, Customers (entry, exit, shippers)
Objective	Understand the challenges to our compressor proposals Understand stakeholder's views on future proofing our assets
Channel/method	Workshops, webinars, bilaterals, conferences
Key messages	Stakeholders challenged us to ensure that we were giving due consideration to the UK Government's target to achieve net zero emissions by 2050, including whether we should consider any compressor replacement to be electric drive or hydrogen compatible units. Stakeholders believe we should consider future uses of the gas transmission network when undertaking asset health works. Major energy users stressed the importance of keeping options open, in relation to compressors.
Influence on CE-AMP	We have laid out our consideration of the future of our non-compliant MCPD units within CE-AMP. We have deferred some of our decisions around whether to decommission or derogate units into RIIO-T3.

<table>
<tr><th></th><th>Network Capability</th></tr>
<tr><td>Stakeholder segments engaged</td><td>
<table>
<tr><th>Engagement</th><th>Who</th></tr>
<tr><td>Overview and discussion on approach with Independent User Group (IUG)</td><td>IUG members covering 11 sectors</td></tr>
<tr><td>BAU engagement with customers and stakeholders covering network capability and the proposed ANCAR</td><td>Operational and commercial customers</td></tr>
<tr><td>Online survey to understand preferences for data</td><td>Data community; 51 readers</td></tr>
<tr><td>Shaping the Gas Transmission of the Future Webinar</td><td>GTYS 2,000+ subscribers; 78 attendees</td></tr>
<tr><td>GTYS Annex Network Capability</td><td>GTYS 2,000+ subscribers</td></tr>
<tr><td>GTYS Annex Webinar</td><td>59 registered participants</td></tr>
<tr><td>1-1s with stakeholders</td><td>Energy companies and a construction company</td></tr>
</table>
</td></tr>
<tr><td>Objective</td><td>We have 3 objectives:
1. To further develop and enhance the process and articulation of network capability with stakeholders
2. Using the measures, illustrate stakeholders' needs of the Transmission System against the current capability, identify implications, challenges and opportunities ahead and feed them into the network development processes, and
3. Articulate to stakeholders how the outputs of this work inform our decisions</td></tr>
<tr><td>Channel/method</td><td>Webinars, one-to-ones</td></tr>
<tr><td>Key message</td><td>Overall acceptability of network capability proposals
A very high proportion of domestic consumers accept the business plan proposals in this area. Stakeholders, including entry and exit customers, were also broadly supportive of the plans. Specific concerns were raised around flexibility and zonal capacity and the need to consider net zero. Some asked for more information on the bill implications of network capability.
Use of metrics
Stakeholders had mixed views on whether the level of information provided was sufficient.
Most felt the metrics were either useful or somewhat useful. Additional information requested included: impact on flows/pressures during incidents; charts for all entry and exit zones; more detailed information around flows and pressures in each zone, and potential longer term impact; iterative feedback on the impact of asset closure/reduction on all zones; more on the quantification of risk; the level of capability we are proposing to retain. One</td></tr>
</table>

	stakeholder pointed out the analysis did not take account of the underlying value of the capacity to users. Findings to date suggest there is support for NGGT's proposal for an enduring annual process for engaging on and producing network capability metrics **Trading of priorities and risk** There is evidence that domestic and non-domestic consumers are prioritising reducing reliability risks over affordability. • Domestic consumers would generally like at least as much reliability as they have at present and would be happy to pay more for investments in this area. • Domestic and large and small non-domestic would be happy to pay more in this area for a 1/10,000 reduction in the probability of a supply interruption. • Major energy users stressed the importance of reliability and have pointed out that there are financial and commercial consequences for them of supply interruptions but have not directly commented on current levels and expected future levels of reliability. • This is consistent with UKERC's study of domestic consumers[13], which finds that there is acceptance of additional costs among consumers for 'ensuring a reliable energy supply. There is some divergence on the trade-offs domestic consumers are making between reliability and affordability. A significant proportion of domestic consumers prefer to maintain current supply risk levels, while a slightly larger proportion prefers to pay more for more secure supply. While it could be argued that NGGT should go further to reduce reliability risk, there is limited evidence suggesting that stakeholders are unhappy with the current levels of risk.

[13] *http://www.ukerc.ac.uk/publications/paying-for-energy-transitions.html*

Appendix F – Process

6.80. The following section outlines the processes that have been used in the development of our CE-AMP.

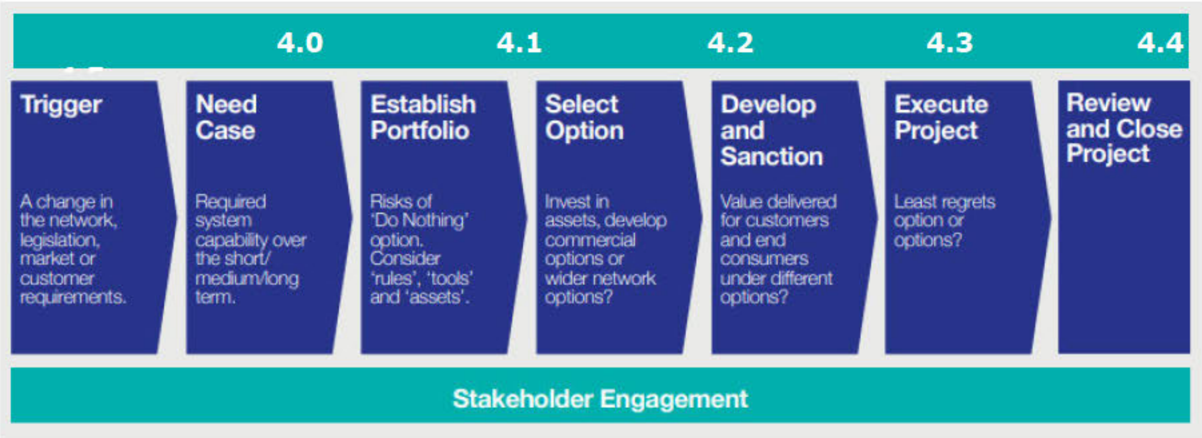
Network Development Process

6.81. The process we use for determining and managing investments is called the Network Development Process (NDP), see Figure 13.

6.82. The purpose is to manage and define the project lifecycle from inception where we establish the needs case through to closure. The aim of the process is to deliver the best value, fit for purpose solutions to identified problems or opportunities, which meet the needs of ourselves, customers, stakeholders and our RIIO-T2 outputs.

6.83. There are six stages with a "gated" progress, which provides the means for financial approval and commits the investment to time, scope and cost parameters. All options included in this document are at the 'Establish Portfolio' stage. For further information, please refer to our Gas Ten Year Statement (GTYS)[14].

Figure 13 - Network Development Process

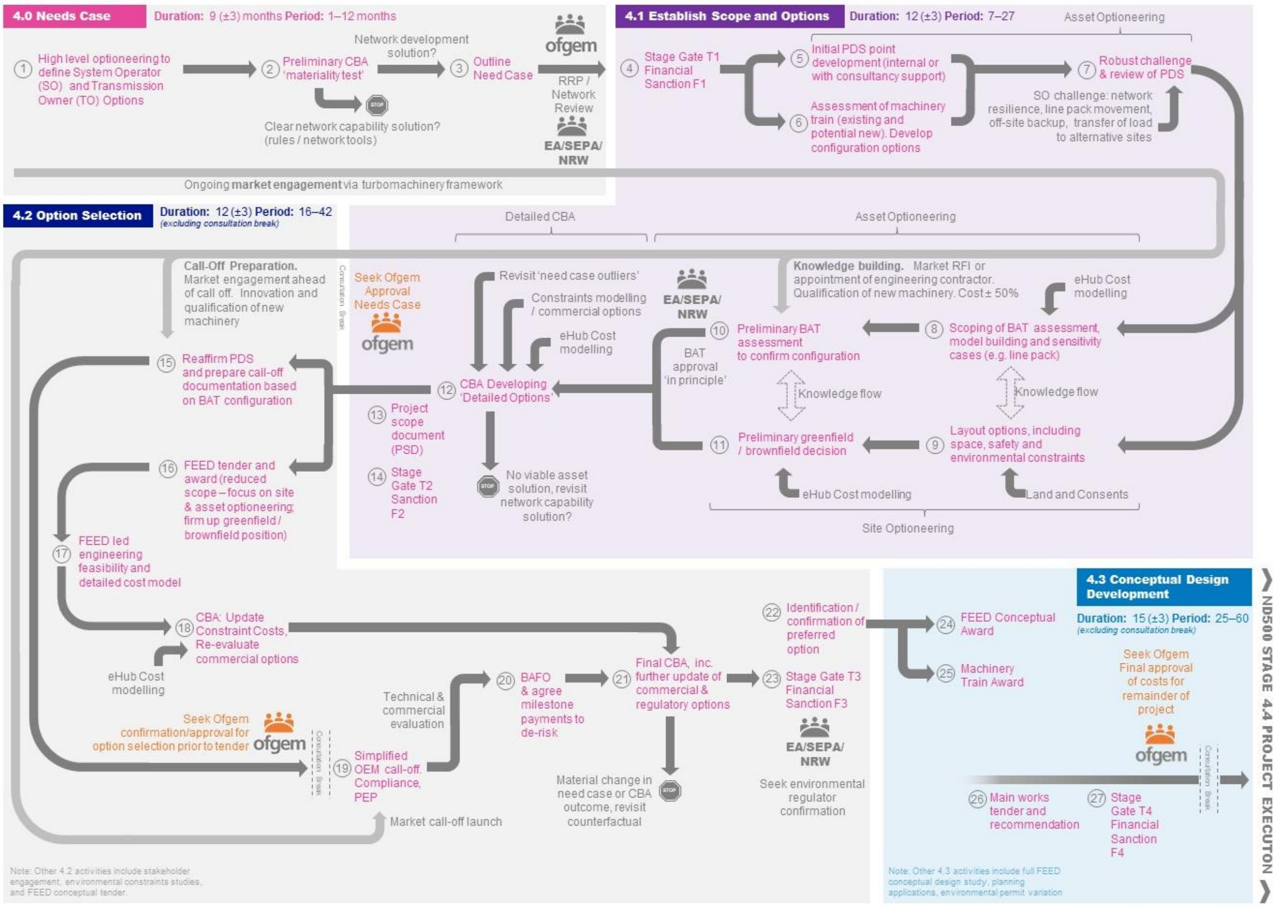


Network Development Process, Ofgem

6.84. The ND500 process, above, has been adapted specifically for our MCPD projects, highlighting our engagement with Ofgem. See Figure 14 for an overview.

[14] *https://www.nationalgrid.com/gas-transmission/insight-and-innovation/gas-ten-year-statement-gtys*

Figure 14 - ND500 MCPD process



Network Capability

6.85. The combination of compressors and other assets give a level of physical capability on the network that we can compare against stakeholder needs now and into the future. We have been carrying out stakeholder engagement to seek views on the appropriate level of network capability for the RIIO-T2 business plan. Our network capability now and into the future can be seen in our Annual Network Capability Report (ANCAR).

6.86. The risks around having too much, or too little capability are as follows:

Excess capability

- Higher network costs for consumers (building, maintaining, operating assets and having stranded assets, not being used).

Insufficient capability

- Entry constraints would impact on where and when our customers are able to bring gas onto the network, increasing wholesale gas market prices (on the assumption that cheaper constrained supplies are replaced with more expensive replacements).
- Exit constraints could impact all consumers, including large energy consumers, power generators, storage sites and interconnectors.
- Consumer exposure to the cost of constraint management actions.

- Potential inability to deliver the most effective future energy pathway by closing options down early. This includes limiting options to repurpose pipelines for transporting hydrogen transport or carbon as part of a carbon capture scheme.

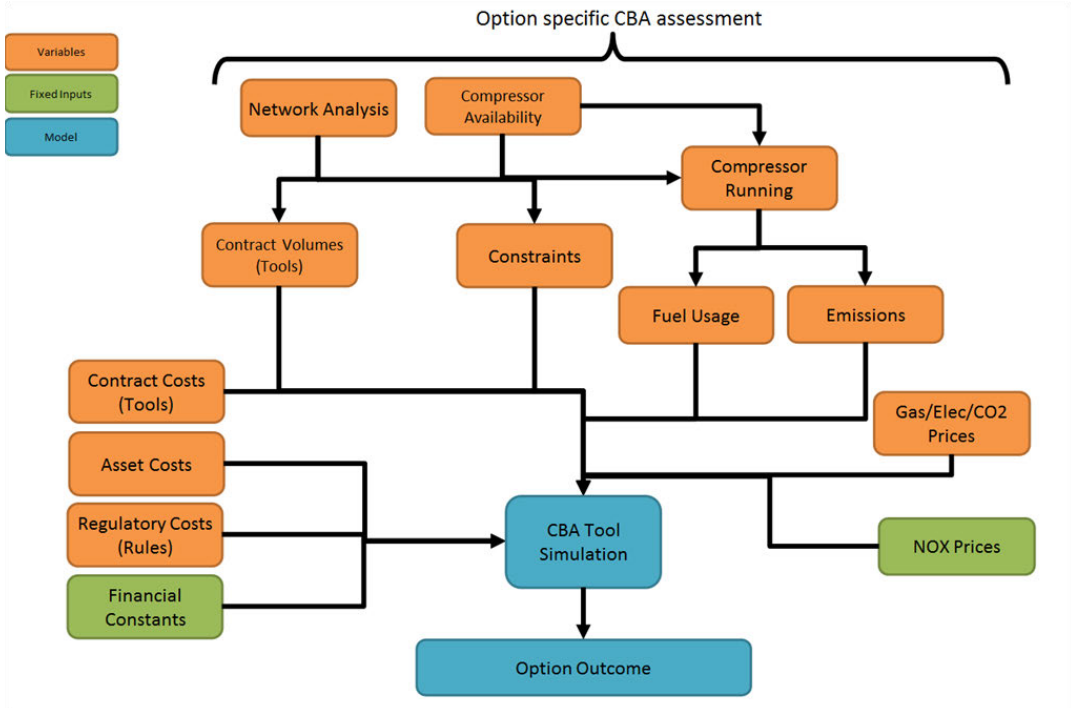
Network Capability and Resilience

6.87. To shape and demonstrate an Analytical Framework, we have developed a Proof of Concept (POC) pilot study to understand more about network resilience, see ANCAR 22, section 4[15].

Cost Benefit Analysis

6.88. We have used our CBA to quantitatively assess and compare a range of options to inform the optimal solution. The CBA was developed following feedback from the 2015 re-openers, an independent review was completed by [redacted] in 2017 and our methods have been subsequently developed to account for feedback received since our 2018 submission.

Figure 15 - Overview of the CBA tool assessment



6.89. The assessment includes costs of maintaining and replacing assets, fuel usage, emissions costs, site operating costs, the costs of managing constraints and where relevant, the cost of commercial options along with market impacts. Figure 15 and Table 11 show the data flow of the CBA model and assumptions used.

[15] *https://www.nationalgrid.com/gas-transmission/insight-and-innovation/network-capability*

Table 11 - Assumptions used in the CBA model

Element	Value
WACC	2.81%
STPR	3.5% (Years 0 – 30) / 3.0 % (30+)
Regulated Asset Life	45 Years
Assessment Period	25 Years
Depreciation method	Sum Of The Years Digits (SOTYD)
Capitalisation	75.0%

6.90. The assessment of the asset is carried out over a 25-year period. This is consistent with our assumption on the lifetime of the asset. Asset Health, constraint costs, fuel usage and emissions are calculated for 25 years after the installation of the asset.

6.91. All investment costs and any applicable operating costs are recovered through our Regulated Asset Value (RAV) over 45 years, based on the regulated asset life defined in RIIO-T2. This reflects the cost to the consumer of these elements, as this is how these costs would be recovered. Constraints, fuel usage, emissions and any contract costs are all recovered in the year they are accrued. To allow for comparison between costs occurring over different time periods, future values are discounted using rates from the government's Green Book.

6.92. The cost of constraints is calculated based on the capability of the network, the distribution of supply/demand patterns along with cost assumptions for constraint management. The network modelling that underpins our capability assessment is generated through our network modelling tool Simone. The required capability, expected flow patterns and availability of compressors determines our running expectations. These contribute both to expected fuel costs and emissions performance.

6.93. For scenarios and options where we do not have sufficient physical capability to meet our peak demand obligations, we have included commercial solutions to ensure these are met. These are typically contracts to either turn-up supply or turn-down demand. The cost of the contracts is dependent on the volumes required along with the potential providers. The initial basis for these costs are bids received as part of the Operating Margins (OM) tender process, where expert judgement is used to adjust these if the volumes required are significantly greater than those tendered.

6.94. The tool generates a Net Present Value (NPV) of the options for each FES scenario. The quoted NPV is based on 2072, 45 years after the start of the spend. We will be providing simplified CBA templates to allow Ofgem and the RIIO-T2 Challenge Group to review the outputs and the needs case.

6.95. Our CBA contains assumptions around delivery of various activities which are translated into timing profiles of expenditure. These are based on historical work programmes where possible, or otherwise advice from external experts or contractors.

Non-monetised risks and benefits

6.96. Our decision-making process is informed by the outputs of the CBA, and recognises that not all risks and benefits can be accurately quantified within the CBA. To ensure we can demonstrate the best value for the customer, we will consider these qualitative, non-monetised benefits in our final proposals.

6.97. Examples of non-monetised factors which will also contribute to the final decision are:

- Evidence of stakeholder support for one option over another
- Operational considerations such as handling within-day changes in supply or demand
- The possibility that our forecasts of the future may change
- Assumptions about the availability of existing assets may change
- Impact on consumer, wholesale energy prices from a constraint on the gas transmission network

Best Available Techniques Process

6.98. All of NGGT's gas turbine driven compressor stations are subject to regulation under the Environmental Permitting (England and Wales) and Pollution Prevention and Control (Scotland) Regulations. These Regulations place obligations on operators of permitted processes to apply BAT to the way in which an installation is designed, built, maintained, operated and decommissioned.

6.99. BAT assessment is the primary selection mechanism for all new and substantially modified or retrofitted compressor machinery trains. A detailed justification of any investment decision and how it meets the requirements of BAT is required to support an application to the relevant environmental regulator to operate a new or vary an existing facility. Following a successful determination of the application, a legally binding permit will be issued.

6.100. NGGT developed a BAT evaluation approach which supports the Compressor Machinery Train selection process for new compressor investment projects, and ensures that the relevant considerations relating to potential environmental impact, whole life costs and operating efficiency are taken into account. It also ensures that the selection is consistent with NGGT's corporate objective of ensuring that every project delivers Whole Life Value (WLV).

6.101. This process takes place during the project Feasibility Phase. The approach, which is supported by a BAT Evaluation Toolkit, utilises comparative performance and design information on candidate Compressor Machinery Train packages supplied by the OEMs.

6.102. With agreement of the UK environmental regulators, we have set out an outline stepwise approach for the assessment of BAT. This requires that NGGT should:

- Review the market to identify possible technical options that are available (candidate BAT techniques).
- Undertake a preliminary BAT assessment using the candidate BAT options to identify the preferred option.

- The results of the preliminary BAT would be used in conjunction with other tools, such as the CBA, in the decision making process to identify the final option.

6.103. Given the unique nature of the gas NTS, this approach has been refined to ensure that the operational requirements are considered, including safety, availability, reliability, flexibility and constructability and that the selection can be conducted within the constraints of a tendering exercise subject to legally binding EU procurement rules.

Preliminary BAT Assessment

6.104. The Preliminary BAT assessment was undertaken by [redacted] using a stepwise assessment process underpinned by an environmental cost-benefit analysis methodology, drawing together environmental and operational priorities to support decision making. The assessment was undertaken independently from the CBA Tool analysis using a different methodological approach. However, it incorporated common assumptions on cost, investment cases and future gas supply predictions. The preliminary BAT assessment included consideration of constraint costs. The addition of constraint costs illustrates the future significance of Wormington to the NTS and leads the assessment to indicate that the preliminary BAT solution would be two new DLE units, tying-in with the CBA outputs.

6.105. The key steps of the Preliminary BAT assessment are summarised in Figure 16. These steps include:

- Historical data analysis
- Identifying current and future usage Process Duty Specification (PDS) points
- Identifying primary sensitivities (including de-rating)
- Identifying candidate options from known market-based solutions
- Mapping load-splitting between units
- Combining options in a preliminary BAT assessment tool.

Figure 16 - Wormington 2019 Business Plan Preliminary BAT assessment method overview

6.106.The modelled period for our 2019 Business Plan was 20 years, over which total emissions and whole life operating costs (including fuel) were calculated. Options are qualitatively evaluated for the following technical and environmental criteria:

- Compressor envelope versatility
- Emissions future proofing
- Ownership
- Constructability
- Environmental hazards
- Noise

Reliability, Availability, Maintainability (RAM)

6.107 [redacted] were commissioned to develop an idealistic Reliability, Availability, Maintainability (RAM) model for the average unit of various types of compressor drivers on our network utilising our data to create representative values. For in-depth information around data sources, how the models were constructed and how different investment options varied compressor train availability see Wormington FOSR *Appendix K - NG Fleet RAM Study*. The models are designed purely around the availability of components in the compressor train and don't account for common failure modes i.e. a failure on the site incomer.

6.108.For the base data set, only units that ran for an average of more than 100 hours of operational running a year for 5 years were considered, to ensure that the sample is representative of the condition of assets. The combination of data from multiple units of a similar design and condition allows for a better model and provides a suitable volume of run hours and conditions to build a model against.

6.109.Wormington B was not considered in the RAM model, as while recent running has been high due to high LNG flows and a planned overhaul on Wormington C VSD, historically it was the second-choice unit and accrued few run hours. The central RAM model has been used as the basis for the availability of most of the components for the various compressor scenarios in the Wormington FOSR, using the mean value of the applicable sensitivity. This was based on the proposed scenario and inflight investments through all funding mechanisms that would be completed by the milestones outlined in the CBA. For the new unit availability, the P10 from our highest performing DLE Gas turbine scenario was used, which compared favourably to the availability figures for Felindre B and C units, which are the newest gas driven units on our network. There is a possibility that the availability figures of new units on the network would be higher than the highest values that the model produces. We have found through the RAM models that the equivalent OREDA and OEM provide availability figures much higher than we have seen in our experience, which could be attributed to:

- Asset age
- The intermittent nature of Grid usage
- Unmanned sites and no on-site response available to respond to developing situations or trips
- Repeated stop and starts, and low run periods
- Extensive periods of non-running standby and its associated degradation
- Low run hours leading to long intervals between overhauls and upgrades
- Variable supply and demand patterns that drive the compressors towards the extremes of their operating envelopes
- Network contamination

6.110. The highest contribution to loss of availability for all the drive types is the Safety/Protection/ESD[16] sub-units, closely followed by Control System. In the current price control RIIO-T2, there are plans to replace the control systems at Wormington on both the Avon units and there has been recent work on the motor on the VSD, with all scenarios including the counterfactual taking account of this. The forecast availability will be higher than is currently seen in (FY22) RRP.

6.111. For each driver we have designed scenarios to represent our likely investment routes on the secondary assets. They have an estimated benefit that could be accrued by a component's refurbishment for MTBF[17] and MTTR[18]. Where components are re-lifed, the model typically uses the highest value of the MTBF of a sub-unit across the three models, or uses a conservative approach of 30% on the advisement of the RAM modelling consultant that there is no solid rule set to be used. For some options, MTTR has been changed to represent having new supported systems with improved access to spares and breakdown support by implementing long term service agreements. The logic has been assigned consistently across the different engine types, using the same assumptions throughout the scenarios. The scenarios chosen for current units in the CBA result in an improvement in availability.

[16] Emergency Shut Down
[17] Mean Time Between Failure
[18] Mean Time to Repair

6.112. For the DLE retrofit options on the Avon, these are currently proof of concept works and NG have no experience of running these units and the only comparable units on the network, Aylesbury A and B have few run hours per annum and were excluded from the RAM study. Some learning from the Aylesbury units which were developments that were not reproduced anywhere else has shown that elements of the hot section of the GT have very limited useful life and that due to them being a concept are not supported in terms of ongoing spares or development. A conservative approach of a 5% availability decrease against the assumed scenario was expected based on this unproven technology. There is a long-term risk for the DLE option that it does not have the support of the OEM, is likely to have low production numbers, and could become unsupported in the medium term. There are some mitigations we can implement but they will not remove this risk. The lower value of this intervention does support taking these risks where lower availability is less restrictive, but with acceptance that mitigation may require possible follow up investments in the future if the support is not present.

6.113. As stated in *Appendix C – Compliance Options*, mitigations to the DLE development becoming unavailable include:

- NGGT to take on the Intellectual Property (IP) for the development under certain circumstance to open up support from other parties
- Work to develop and resolve further issues
- Purchase suitable volume to encourage ongoing support
- Enter into support agreement with developer (not currently being pursued)
- Support developer in trialling and in obtaining more orders from industry
- To purchase suitable spares
- The ability to retrofit a standard Avon into the berth permit allowing (This may only be suitable pre-2030)

6.114. No deterioration rate has been applied to the models, as the expectation is that units with a clear long term needs case will justify suitable investment and support to maintain the required availability level. While there will be deterioration in some secondary assets, the constant deterioration and renewal of assets would apply to all options as they have consistent secondary assets which have a set modelled deterioration rate. To account for this, we assumed that Asset health investments have been phased at the intervals identified in the NARMs[19] commentary, i.e. if a UID[20] gives a 10 year life extension, it would be conducted every ten years to ensure that the work required to maintain the availability is properly considered.

6.115. Compressor Trains are complex components with many sub-units and components that deteriorate at different rates. Experience and our NARMs methodology would suggest that new units having a larger number of investments would still be subject to the obsolescence issues and reducing OEM and aftermarket support and expertise that we are still seeing around some of the larger machinery. This is seen with our power turbines that have no original replacements if they fail, and are currently taking around 9 months to build from scratch following a failed overhaul. In this instance the OEM have delegated technical authority to a third party. The centrifugal compressors are another large mechanical element where knowledge and experience of external support is lacking due to the age of the equipment and

[19] *Network Asset Risk Metrics*
[20] *Unit Identifier*

overhaul and return to service have suffered dramatically. These cannot be overcome without a replacement of large sections of the machinery train.

6.116. Due to the nature of the RAM model, while a unit may have many trips, these generally have a low MTTR and result in a small actual loss of availability. OREDA failure proportions of minor to major failures were used to inform return to service time following rectifying a trip. A significant proportion of equipment loss comes from the minor failure’s repair time, requiring a spare part to be sourced etc.

Appendix G – Planned Innovation Projects

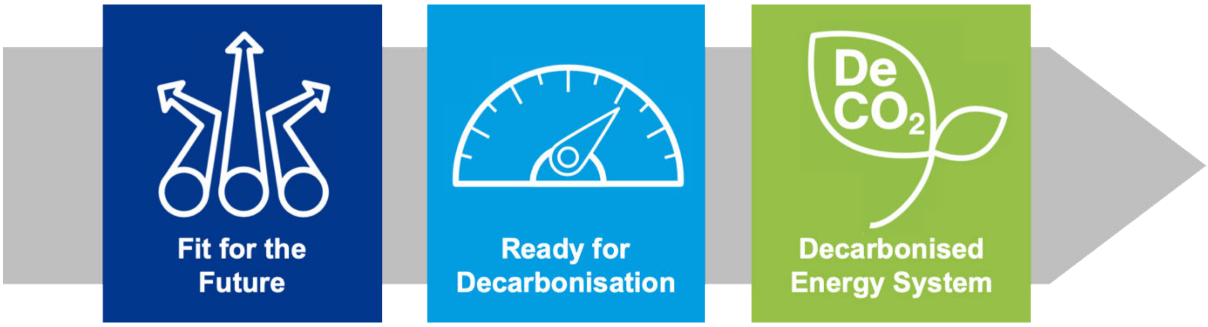
6.117. Our innovation strategy for RIIO-T2 consists of three strategic themes that take us from present day to a position when the UK Gas Industry is completely decarbonised, as seen in Figure 17. Alongside these strategic themes, five technology portfolios direct the projects and roadmaps through the RIIO-T2 period.

6.118. Fit for the Future focuses on safeguarding and preparing our assets for the challenges in operating for the next 50 years and towards a decarbonised future.

6.119. Ready for Decarbonisation focuses on how the NTS will transport a blended mix of 'green' gases and future technology to better manage the assets we own. This theme includes the development of new asset systems such as hydrogen ready compressors and metering systems.

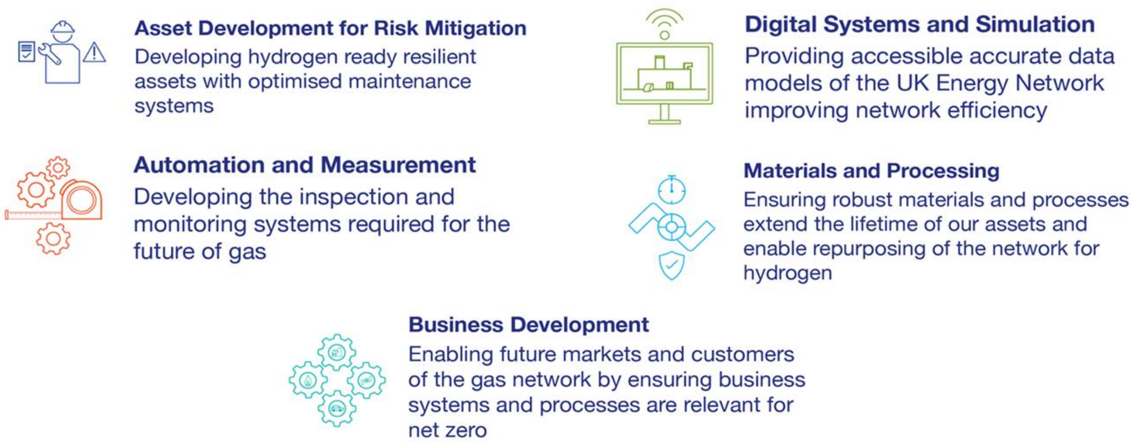
6.120. Decarbonised Energy System theme looks at how hydrogen will interact with the NTS, what new customers we may have, what novel systems such as gas separation are required, how trading could be managed and whether direct offtakes for hydrogen can support the transport and commercial market.

Figure 17 - RIIO-T2 Innovation Strategic themes



6.121. The five technology portfolios cover asset development, automation and measurement, digital systems and simulation, materials and processing and business development, as seen in Figure 18.

Figure 18 - RIIO-T2 Innovation Technology Portfolios



Asset Development for Risk Mitigation

6.122. This technology portfolio looks to ensure our core NTS assets are prepared for hydrogen, there is a focus on compression assets in the initial years of RIIO-T2 as the core cost associated with transitioning the NTS to hydrogen is due to replacement of the compressors (approx. [redacted] per compressor).

6.123. Hydrogen Fuel Gas for NTS compressors looks at the opportunity and business case around deploying green hydrogen solutions alongside compressor systems and migrate the fuel gas from natural gas to hydrogen in order to reduce emissions prior to the networks transition to hydrogen. This not only accelerates our emissions reduction activities but also positions our fleet as hydrogen ready for when the NTS transitions.

6.124. Variable hydrogen blend compression studies the opportunities for operating the compression systems when there is a level of variation in the blend of hydrogen and methane in the network. This is a likelihood with the production of green hydrogen being strongly correlated to weather conditions and customers requiring different blends at offtakes along the network. The variability of the blend accepted by a compressor could limit the options provided to customers and producers of hydrogen.

6.125. HyNTS Compression looks to take a decommissioned gas compression asset from the NTS and demonstrate the capability of existing assets with hydrogen in order to reduce the cost to the consumer of the energy transition.

6.126. Ch4RGE seeks to develop new technologies, which will allow process gas emissions from gas transmission rotating machinery operations to be captured and returned to the network, increasing efficiency, reducing heat delivery costs and associated carbon emissions. These technology solutions, identified as Best Available Techniques (BAT), are potentially suitable for installations either as a new build or can be retrofitted to existing equipment, therefore, reducing levels of investment needed.

6.127. Decarbonising Construction and decommissioning. The first aims to drive down carbon emissions during all stages of construction from design, through build to considering the operation and maintenance once completed. The second will look at innovative techniques for the safe, controlled and efficient decommissioning of redundant assets as well as potential use of decommissioned assets for innovation projects to aid in the understanding of the NTS and decision making for its future.

6.128. Carbon Capture and Storage, the process of capturing waste carbon dioxide, transporting it to a storage location and safely locking it away to prevent the release to the atmosphere.

Automation and Measurement

6.129. Leak Detection and Emissions Monitoring: the MorFE (Monitoring of real-time Fugitive Emissions) project undertaken in RIIO-T1 developed a long-term measurement solution to detect and quantify fugitive emissions on the NTS. Fugitive emissions are leaks in components caused by loss of tightness of an item (e.g. seal, valve, plug) which is designed to be tight. Any leak is a concern from both a safety and environmental perspective. A prototype system has been developed which was successful at detecting venting and estimating mass emission and likely locations of fugitive emissions. However, to roll this system out across the NTS further work is needed to refine the prototype, reduce cost and increase the level of reliability and accuracy. In RIIO-T2 we have been provided business funding to deploy MorFE. A number of alternative systems at lower costs and efficiencies have been identified and further innovation studies are underway to understand these and their capability with hydrogen and methane for future applications.

6.130. Proactively monitoring these emissions would allow faster and more targeted maintenance and asset health works to reduce emissions on site.

Digital Systems and Simulation

6.131. Collaborative Visual Data Twin: develops a digital twin of our network assets and systems including historic and live data. This could enable improvements in compressor management and control. Use cases and requirements are currently in development and will include relevant compressor needs.

Materials and Processing

6.132. NTS Materials Hydrogen Impact assessments is considering the impact of hydrogen on metallic and polymer NTS assets, this includes considerations on the lifetime and likely failure modes. The impact of temperature on the hydrogen effects will be considered later in RIIO-T2 in collaboration with OEMs of the systems.

Business development

6.133. HyNTS Deblending: this technology could be utilised in a variable blend scenario to protect the compression assets (gas turbines) from seeing variations in blend. This project is currently focussed towards protecting customers and will be demonstrated at FutureGrid alongside the HyNTS compression project.

Glossary	
1-in-20	The 1-in-20 peak day demand is the level of demand that, in a long series of winters, with connected load held at the levels appropriate to the winter in question, would be exceeded in one out of 20 winters, with each winter counted only once.
Above Ground Installation (AGI)	Above ground gas assets (including, but not limited to; pipework, valves, pigtraps, meters and regulators) located within a fence line for the safe operation and maintenance of the National Transmission System
Aggregated System Entry Point (ASEP)	A system entry point where there is more than one, or adjacent connected delivery facility; the term is of the used to refer to gas supply terminals.
Anticipated Normal Operating Pressure (ANOP)	A pressure that we may make available at an offtake to a large consumer connected to the NTS under normal operating conditions.
Assured Offtake Pressure (AOP)	A minimum pressure at an offtake from the NTS to a DN that is required to support the downstream network.
Avon	Rolls Royce (Siemens) gas turbine engine which forms part of the compressor machinery train.
BAT Reference Documents (BRef)	A series of reference documents covering, as far as is practicable, the industrial activities listed in Annex 1 of the EU's IPPC Directive. They provide descriptions of a range of industrial processes and their respective operating conditions and emission rates. EU Member States are required to take these documents into account when determining best available techniques generally or in specific cases under the Directive.
Best Available Technique (BAT)	The most effective and advanced stage in the development of activities and their methods of operation which indicates the practical suitability of particular techniques for providing the basis for emission limit values and other permit conditions designed to prevent (and where that is not practicable), to reduce emissions and the impact on the environment as a whole.
Brownfield	Construction of new units on land that is within the existing site perimeter fence.
Buyback	National Grid may request to buyback Firm capacity rights to manage a constraint on the NTS after any Interruptible/Off-peak capacity has been scaled back.
Capability	The physical limit of the NTS to flow a volume of gas under a given set of conditions; this may be higher or lower than the capacity rights at a given exit or entry point.

Glossary	
Carbon Dioxide (CO_2)	A naturally occurring chemical compound composed of two oxygen atoms and a single carbon atom. If there is not enough oxygen to produce CO_2, carbon monoxide (CO) is formed.
Carbon Monoxide (CO)	A colourless, odourless and tasteless gas produced from the partial oxidation of carbon-containing compounds. It forms when there is not enough oxygen to produce carbon dioxide (CO_2), such as when operating an internal combustion engine in an enclosed space.
Compressor Unit	Comprises of the gas generator, gas turbine and gas compressor.
Control of Substances Hazardous to Health (COSHH)	The law that requires employers to control substances that are hazardous to health.
Control System Restricted Performance (CSRP)	Technology that restricts the performance of a gas-driven compressor to limit NO_x emissions.
Cost Benefit Analysis (CBA)	A mathematical decision support tool to quantify the relative benefits of each site option.
Counterfactual	The counterfactual option represents current network with minimum interventions to comply with emissions legislation.
Dry Low Emissions (DLE)	A technology that reduces NO_x emissions from our gas-driven compressors.
Emergency Use Derogation (EUD)	Derogation provided under the IED for equipment used in emergencies and less than 500 hours per year on a rolling 5 year average, with a maximum limit of 750 hours in any one year.
Emission Limit Values (ELV)	Limits set for industrial installations by the LCP directive and IPPC under the umbrella of the IED and MCPD.
Emission Abatement	Includes technology that reduces the emissions from a gas-driven compressor.
Entry Capacity	Holdings give NTS users the right to bring gas onto the NTS on any day of the gas year. Capacity rights can be procured in the long term or through shorter term processes, up to the gas day itself. Each NTS Entry point has an allocated Baseline which represents a level of Capacity that National Grid is obligated to make available for delivery against on every day of the year.
Environment Agency (EA)	A non-departmental public body, sponsored by DEFRA, with responsibilities relating to the protection and enhancement of the environment in England.

Glossary	
Exit Capacity	Holdings give NTS users the right to take gas off the NTS on any day of the gas year. Capacity rights can be procured in the long term or through shorter term processes, up to the gas day itself. Each NTS Exit point has an allocated Baseline which represents a level of Capacity that National Grid is obligated to make available for offtake on every day of the year.
Front End Engineering Design (FEED)	The FEED is basic engineering which comes after the conceptual design or feasibility study. The FEED design process focusses on the technical requirements as well as an approximate budget investment cost for the project.
Future Energy Scenarios (FES)	An annual industry-wide consultation process encompassing questionnaires, workshops, meetings and seminars to seek feedback on latest scenarios and shape future scenario work. The Future Energy Scenarios document is produced annually by National Grid ESO and contains their latest scenarios.
Gas Distribution Network (GDN or DN)	An administrative unit responsible for the operation and maintenance of the local transmission system and <7barg distribution networks within a defined geographical boundary.
Greenfield	Construction of new units on land that is outside of the existing perimeter site boundary, where there is no need to demolish or rebuild any existing structures.
High Voltage (HV)	Electrical energy above a particular threshold.
Industrial Emissions Directive (IED)	An EU directive that came into force in January 2011. It combined 7 existing directives including the LCP directive and IPPC detailed below.
Integrated Pollutions Prevention and Control (IPPC)	An EU directive which requires industrial installations to have a permit containing emission limit values and other conditions based on the application of Best Available Techniques (BAT). It is set to minimise emissions of pollutants likely to be emitted in significant quantities to air, water or land.
Interconnector (Int)	The pipeline transporting gas between Bacton and Zeebrugge. It is capable of flowing gas in either direction and provides a strategic energy link between the UK and continental Europe.
Intrusive Outage	Significant outage works impacting the whole station and where the station cannot be returned to service until the scheduled works are completed.
Large Combustion Plant (LCP)	An EU directive to reduce emissions from combustion plants with a thermal output of 50 MW or more. Combustion plant must meet the emission limit values (ELVs) given in the LCP directive for NOx, CO, SO2, and particles.

Glossary	
Limited Lifetime Derogation (LLD)	Derogation under the IED that a combustion plant may be exempted from compliance with the ELVs for installations above 50 MW provided certain conditions are fulfilled, including the plant is not operated for more than 17,500 operating hours within the derogation period.
Linepack	The stock of gas within the gas transmission system.
Liquefied Natural Gas (LNG)	Natural gas that has been cooled to a liquid state (around -162°C) and either stored and/or transported in this liquid form.
Local Distribution Zone (LDZ)	A geographic area supplied by one or more NTS Offtakes, consisting of local transmission and distribution system pipelines.
Maximum Operating Pressure (MOP)	Maximum pressure at which a system can be operated continuously under normal operating conditions.
Medium Combustion Plant (MCP) Directive	A directive to reduce emissions from combustion plants with a net thermal input between 1-50 MW.
Mega Watt (MW)	A unit of power equal to one million watts.
Mg/Nm^3	A measurement of milligrams per normal meter cubed.
National Transmission System (NTS)	The high-pressure system consisting of terminals, compressor stations, pipeline systems and offtakes. Designed to operate at pressures up to 85 barg. NTS pipelines transport gas from terminals to NTS offtakes.
Net Present Value (NPV)	NPV is the discounted sum of future cash flows, whether positive or negative, minus any initial investment.
Network Development Process (NDP)	The process by which National Grid identifies and implements physical investment on the NTS.
Network Review	The Network Review process allows National Grid to identify the key environmental priorities with regard to ongoing operation of the compressor fleet and agree National Grid's Network Environmental Investment and Regulatory Strategy with both the EA and SEPA.
Nitrogen Oxide (NOx)	A molecule with chemical formula NO and is a by-product of combustion of substances in the air, such as gas turbine compressors.
Office of Gas and Electricity Markets (OFGEM)	The regulatory agency responsible for regulating Great Britain's gas and electricity markets.
Operating Envelope	All NTS compressors have been designed to operate within a certain range of parameters, namely maximum and minimum gas flow rates and maximum and minimum engine

Glossary	
	speeds. The limits of these ranges define the performance of a compressor and are referred to as the operating envelope.
Operationally Proven	A unit is operationally proven when it can be shown to be operating reliably and post commissioning / early life issues have been resolved.
Operations Margin (OM) Contracts	Operating Margins (OM) relate to how we use gas to manage short-term impacts of operational stresses (e.g. supply loss) where the market response is not sufficient, or during a gas system emergency. OM gas can be provided under contract by a number of operators: storage and LNG facility operators, offers for a guaranteed level of supply increase or offtake reduction (or combination thereof) from a shipper's portfolio; and offers for a site to be available for supply increase or offtake reduction.
Plant	In the context of the Limited Lifetime Derogation, plant refers to an individual compressor unit.
Proximity Outage	Significant works on a site for which safety precautions must be put in place which make the station unavailable, but the station is capable of being returned to service in a few hours if required as the works taking place are not intrusive to the operation of the station.
RB211 unit	A medium sized Rolls Royce (Siemens) gas turbine engine which forms part of the compressor machinery unit.
Re-opener	Re-openers are a type of RIIO uncertainty mechanism. Depending on their design, they allow Ofgem to adjust a licensee's allowances (in some cases up and in some cases down), outputs and delivery dates in response to changing circumstances during the price control period.
Replacement	Installing a new unit to replace the capability provided; this may not be a like-for-like replacement.
RIIO (Revenue = Incentives + Innovation + Outputs)	The new regulatory framework set out by OFGEM, building on the previous RPI-X regime. RIIO-T1 is the first transmission price control review to reflect the framework; it sets out what the transmission network companies are expected to deliver and details of the regulatory framework that supports both effective and efficient delivery for energy consumers over the eight years from 2013 – 2021. RIIO-T2 will be the second price control review.
Scottish Environment Protection Agency (SEPA)	Scotland's environmental regulator and flood warning authority.
Selective Catalytic Reduction (SCR)	A means of converting nitrogen oxides (NOx) with the aid of a catalyst into diatomic nitrogen, N2, and water, H2O. A

Glossary	
	gaseous reductant, typically anhydrous ammonia, aqueous ammonia or urea, is added to a stream of flue or exhaust gas and is adsorbed onto a catalyst. Carbon dioxide (CO_2) is a reaction product when urea is used as the reductant.
Shipper	A company with a Shipper Licence that is able to buy gas from a producer, sell it to a supplier and employ a transporter to convey gas to consumers.
System Flexibility	The ability of the gas transmission network to cater for the rate of change in the supply and demand levels which results in changes in the direction and level of gas flow through pipes and compressors and which may require rapid changes in the flow direction in which compressors operate.
Uncertainty Mechanism	Uncertainty mechanisms exist to allow price control arrangements to respond to change. They protect both end consumers and licencees from unforecastable risk or changes in circumstances.