Final Option Selection Report

Uncertainty Mechanism Submission

# Peterborough and Huntingdon Compressor Stations

January 2023

[redacted]

nationalgrid

## Executive Summary

**Project Snapshot**

National Grid Gas Transmission (NGGT) is committed to reducing the impact of its activities on the environment. Critical to this is ensuring that our compressor fleet meets emissions limits as set out in the Medium Combustion Plant Directive (MCPD), while meeting our 1-in-20 peak demand obligation and maintain the accessibility of energy security and necessary resilience for Security of Supply.

Peterborough and Huntingdon Compressor Stations both utilise three Siemens (formerly Rolls-Royce) Avon gas compressors, two of which are being replaced with new Solar Titans, under IPPC[1] regulations to improve local air quality. The remaining Avon unit on each site is not compliant with MCPD legislation, requiring investment. This project aligns with our RIIO-T2 stakeholder priorities “I want you to care for the environment and communities” and “I want to take gas on and off the transmission system where and when I want”.

Peterborough and Huntingdon Compressor Stations provide critical roles in meeting multiple supply and demand conditions. These include meeting South-East and South-West demand, meeting South Wales demand in the event of low imports from Milford Haven LNG terminal and moving gas away from Bacton into the West of the network. Due to their central location on the network, they also provide overall operational flexibility for the National Transmission System. Long-term secure, flexible and reliable solutions need to be implemented at the sites that meets MCPD emissions legislation and aligns with meeting our 1-in-20 peak demand obligations.

NGGT have undertaken a full optioneering process, costing the most applicable options to achieve MCPD emissions legislation by 2030. Given the identified limitations with using FES 2021 to identify the right investment case, we have developed an options assessment process to determine our Final Preferred Option. This process compares shortlisted options against a number of key investment criteria and evaluation models to arrive at a Final Preferred Option which provides emissions compliant compression capability that the network needs via the most cost-effective means for consumers.

Taking into consideration compressor investment planned at other sites per CE-AMP and following evaluation of a range of options this report recommends the installation of a new gas-driven compressor unit at Peterborough and installation of DLE Emission Abatement technology on the Avon at Huntingdon. Decommissioning of the Peterborough Avon will be assessed after operational acceptance of the new unit. This will achieve emissions compliance while ensuring robust and capable compression at Peterborough and Huntingdon, ensuring resilient long-term operation. The indicative value of investment across both sites is [redacted][1] (±30%).

## Introduction

1. The purpose of this Final Option Selection Report (FOSR) is to seek Ofgem's approval of National Grid Gas Transmission's (NGGT) proposed Final Preferred Option for Peterborough and Huntingdon Compressor Stations to comply with Medium Combustion Plant Directive (MCPD) emissions legislation deadline while ensuring that the network is resilient and able to meet a wide range of likely future supply/demand patterns, ensuring UK Security of Supply. This report will provide a detailed view of the project, its associated timings and set out the different options considered.

2. As part of NGGT's RIIO-T2 submission in December 2019, we proposed to install one new gas-driven compressor unit at Peterborough to replace the existing Avon unit, and to derogate the remaining Avon unit at Huntingdon. Due to the uncertainty in this decision and the early stages of the options selection, it was requested that this project would be included within an Uncertainty Mechanism, enabling further option development to be undertaken.

3. This FOSR is submitted as part of a Compressor Emissions Price Control Deliverable (PCD) as detailed within the Gas Transporter Licence Special Condition 3.11 Compressor Emissions Re-opener and Price Control Deliverable, Part C, and as per Price Control Deliverable Reporting Requirements and Methodology Document[1] and RIIO-T Re-opener Guidance and Application Requirements Document[2].

4. Our Compressor Emissions Asset Management Plan (CE-AMP), in support of this FOSR, details our approach for how the whole of our compressor fleet will comply with emissions legislation, while meeting the required network resilience and customer needs.

## Investment Driver

5. NGGT is committed to reducing the impact of its activities on the environment while operating with the required network resilience and capability. Critical to this is ensuring that our compressor fleet meets emissions limits as set out in the MCPD. MCPD requires that our existing compressor fleet, between 1 MW and 50 MW net thermal input, must not exceed a Nitrogen Oxide ($NO_x$) emissions limit of 150 mg/m³ by 1 January 2030.

6. In addition to meeting emission legislation, NGGT must ensure the right level of network capability and resilience is maintained to meet our obligations, fulfil our customers' needs and deliver our operational requirements. This ensures we efficiently minimise network constraints, meet our 1-in-20 peak demand obligation scenario[3], provide Security of Supply to the UK and have the necessary assets to maintain market stability. We must ensure that the National Transmission System (NTS) is safe, reliable, and that it delivers value for its consumers and stakeholders, while minimising the impact on the environment.

[1] Version 2, published by Ofgem on 17 March 2021
[2] Version 2, published by Ofgem on 3 February 2022
[3] National Grid (2021), Transmission Planning Code, Standard Special Condition A9: Pipe-Line System Security Standards

7. Peterborough and Huntingdon Compressor Stations perform essential roles on the National Transmission System (NTS), moving high volumes of gas into the South of the network to meet our customer's needs and 1-in-20 peak demand obligation. Peterborough's central location on the network means that it is also used to support King's Lynn to move gas away from Bacton and into the West of the network. Reliable parallel operation of these sites is paramount, where restriction or unavailability of compression capabilities at the sites could result in network constraints and failure to meet our customer's needs.

8. Peterborough and Huntingdon both utilise Avon compressor units which are beyond their original design life, (Peterborough A commissioned 1973 and Huntingdon C commissioned 1992). Failure to meet emissions legislation means that, without intervention, the units will be limited to 500-hour running per year from 2030. Given that both sites are critical for NTS zonal transfer, line-pack management, 1-in-20 peak demand obligation and network capability, it is essential that the required level of site reliability and availability is achieved.

## Optioneering

9. NGGT, with the support of Option Selection Consultant [redacted] considered the full suite of solutions to enable Peterborough and Huntingdon to comply with MCPD including:

- Building new low-emission, high-efficiency compressor(s) (gas or electric-driven)
- Retrofitting the Avon's with Emissions Abatement technology (Control System Restricted Performance, Selected Catalytic Reduction or Avon Dry Low Emissions retrofit)
- Investing the absolute minimum to enable MCPD compliance (counterfactual), where the Avon's operate under Emergency Use Derogation from 2030
- Decommissioning the Avon's
- Delaying our investment decision, to account for uncertainties in the energy landscape

10. An options shortlist was derived where each of the main solutions (new build, abatement, derogation, decommissioning, etc.) at Peterborough and Huntingdon sites are represented across eight options. These options and detail on unit status can be seen in **Table 1** and **Table 2.**

| Peterborough Costed Option Shortlist | Unit A | Unit B | Unit C | Unit D | Unit E | Unit F |
|---|---|---|---|---|---|---|
| 1 – Counterfactual | 500Hr EUD | Removed | Removed | No Change | No Change | / |
| 2 - 1 x CSRP | CSRP Retrofit | Removed | Removed | No Change | No Change | / |
| 3 - 1 x 1533 DLE | 1533 DLE Retrofit | Removed | Removed | No Change | No Change | / |
| 4 – 1 x SCR | SCR Retrofit | Removed | Removed | No Change | No Change | / |
| 5 - 1 x New Unit | Decom. | Removed | Removed | No Change | No Change | New Unit (Brownfield) |

**Table 1 - Peterborough Option Shortlist**

| Huntingdon Costed Option Shortlist | Unit A | Unit B | Unit C | Unit D | Unit E | Unit F |
|---|---|---|---|---|---|---|
| A – Counterfactual | Removed | Removed | 500Hr EUD | No Change | No Change | / |
| B - 1 x CSRP | Removed | Removed | CSRP Retrofit | No Change | No Change | / |
| C - 1 x DLE | Removed | Removed | DLE Retrofit 1533 | No Change | No Change | / |

**Table 2 - Huntingdon Option Shortlist**

## Option Evaluation Process

11. During the development of the Peterborough and Huntingdon Needs Case, it was determined that the National Grid ESO Future Energy Scenarios (FES) are not adequate to determine the future requirements of the sites. Therefore, FES 2021 could not be used to highlight the consequences of a loss of capability. The option evaluation process used within this report considered the outputs of the CBA process along with other investment drivers and assessments to provide a diverse evaluation of Peterborough's and Huntingdon's future requirements.

12. A decision tree was used to help guide investment decisions through a number of logical steps, including definition of the investment need and its timeline for implementation. This helped us to assess costed shortlisted options against key investment criteria, evaluation models such as CBA and BAT and consider solution technical maturity and total installed cost within our decision making.

13. This ensured that our Final Preferred Option achieves our core investment requirements and network needs, as well as providing value for money for consumers and avoids over-investment which can lead to asset stranding. This roadmap can be seen in **Figure 1**. These essential criteria were evaluated in an option assessment matrix to discount options until a Final Preferred Option remained.

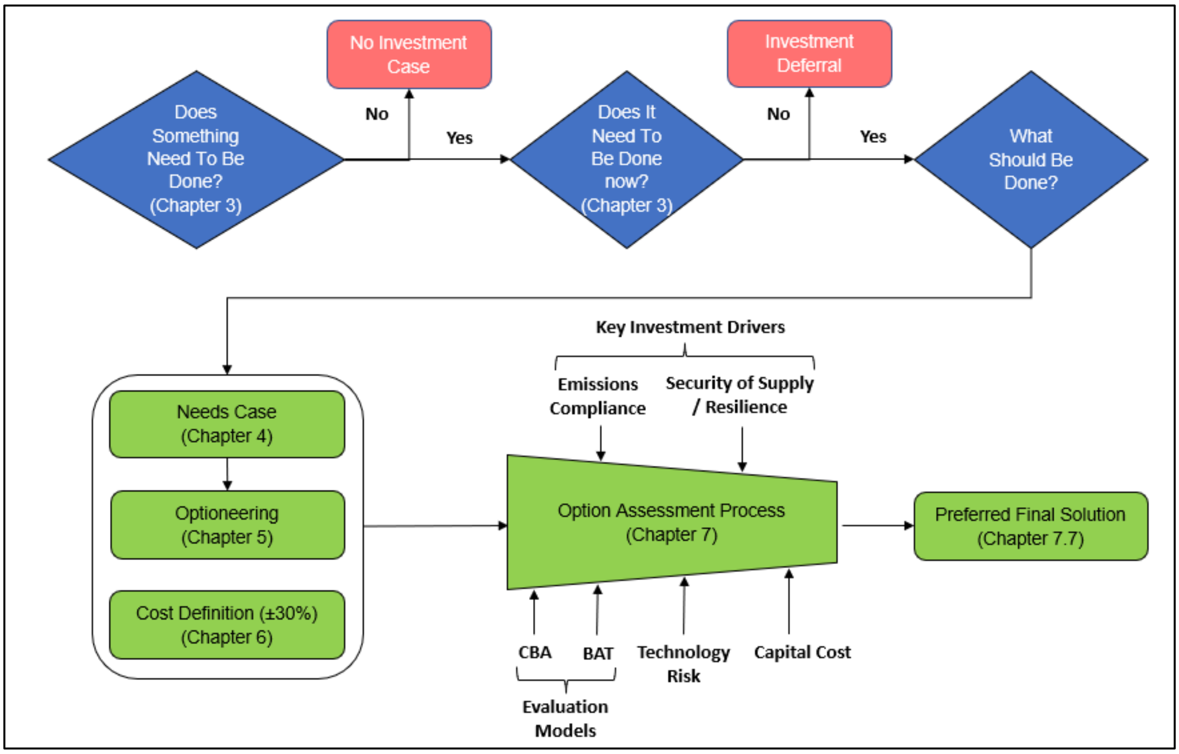


**Figure 1 - Option Assessment Process**

## Assumptions

14. Capability boundary analysis[4] and assessment has been updated from our RIIO-T2 submission with FES 2021 data[5], producing option constraint costs. However, the uncertainty and limitations of FES gives a poor representation of scenarios for the sites, forecasting low constraint costs. Investment based on this data gives a significant risk of underinvestment, leading to network constraints and failure to meet our customers' demands, and meeting our 1-in-20 peak demand obligation.

15. To enable GB's national transmission network to be resilient and meet our obligations, any site required for 1-in-20 peak demand obligation requires sufficient back-up. Any restriction to compressor and/or site utilisation must be carefully assessed to ensure risks are appropriately considered. See CE-AMP[6] for more information.

## Final Preferred Option

16. To maintain parallel operation at Peterborough and Huntingdon sites, the third unit requires a high level of availability and reliability during periods of planned and unplanned outage. Multiple assessments have been completed to determine the Final Preferred Option, including considerations for emissions compliance, BAT assessment, cost benefit analysis, impact to Security of Supply, case study assessment, technology maturity and capital investment assessment.

[4] For more information on how capability boundaries are produced, refer to ANCAR 2022.
[5] This FOSR has used the 2021 FES data. FES 2022 was published on 18 July 2022, but elements of our analysis had already commenced and therefore we have progressed the FOSR using FES 2021. See Sect. 4.1 for more context.
[6] Compressor Emission Asset Management Plan v2.0

17. The option assessment matrix used to determine our Final Preferred Option can be seen in **Table 3** and **Table 4** below.

| Option Assessment Matrix Peterborough | Emissions Compliance | BAT Assessment | CBA | Security of Supply / Resilience | Technology Risk | Capital Investment |
|---|---|---|---|---|---|---|
| 1 – Counterfactual | | | | | | |
| 2 - 1 x CSRP | | | | | | |
| 3 - 1 x 1533 DLE | | | | | | |
| 4 – 1 x SCR | | | | | | |
| 5 - 1 x New Unit | | | | | | |

**Table 3 - Option Assessment Matrix (Peterborough)**

| Option Assessment Matrix Huntingdon | Emissions Compliance | BAT Assessment | CBA | Security of Supply / Resilience | Technology Risk | Capital Investment |
|---|---|---|---|---|---|---|
| A – Counterfactual | | | | | | |
| B - 1 x CSRP | | | | | | |
| C - 1 x 1533 DLE | | | | | | |

**Table 4 - Option Assessment Matrix (Huntingdon)**

18. Following the evaluation process outlined above, this report recommends the installation of a new gas-driven compressor unit at Peterborough and installation of DLE Emission Abatement technology on the Avon at Huntingdon[7]. This solution provides sufficient resilience for parallel operation for both sites, accommodating a wide range of demand and market requirements.

## Justification for our Final Preferred Option

19. Peterborough Option 5 scored highest in terms of network versatility, future proofing against changes in energy legislation, maintainability and emissions in the BAT assessments. New GT compressors also offer fuel efficient operation, long-term reliability, high availability and low emission compression. Modern compressor units feature the most up-to-date technology and support packages, which provides a degree of future proofing against future changes in energy legislation ahead of the UK's commitment to achieve Net Zero by 2050.

20. Peterborough Option 5 is the highest performing solution from an emissions reduction perspective and received the highest overall technical rating within the BAT assessment compared to the alternative investment options. New units also offer higher levels of availability compared to existing Avon's after asset health investment has been competed (90% compared to 79%). This higher level of availability, along with the other benefits of a new unit give Peterborough the correct levels of resilience and availability.

21. Peterborough Option 5 enables us to operate a safe, efficient, and economic network. This will ensure that Peterborough can continue to be the lead site for the UK in resolving supply and demand imbalances between the different network zones. It can

[7] If trials determine DLE retrofit is successful. If DLE is unsuccessful in trials, then this shall be reassessed.

continue to ensure line-pack levels are maintained within operational ranges, minimising the risk of entry and exit constraints, while ensuring we can continue to maintain our 1-in-20 security standard.

22. Implementation of innovative retrofit DLE technology at Huntingdon has the potential to enable significant $NO_x$ emission reduction on the existing Avon. This would support unrestricted operation of the unit, at reduced CAPEX spend compared to a new unit. If retrofit DLE isn't available, then other Emission Abatement technology, or derogation is an acceptable solution for the site.

## Conclusion and Next Steps

23. Ofgem are invited to assess and approve the proposed Final Preferred Option for Peterborough and Huntingdon Compressor Stations in line with Special Condition 3.11, Part C, 3.11.9. Following Ofgem's decision on the Final Preferred Option, NGGT will use the received Baseline allowances to develop our preferred option further and submit a Re-opener application in line with Special Condition 3.11, part D and appendix 2 for Ofgem's consideration in June 2025. We welcome the engagement with Ofgem throughout the option selection process and intend to keep engaging with the regulator at all relevant project development stages, so they remain informed throughout and ensure we successfully deliver our proposed solution at Peterborough and Huntingdon Compressor Stations.

## Table of Contents

# 1. Introduction

## Background

24. NGGT is committed to reducing the impact of its activities on the environment. Critical to this is ensuring that our compressor fleet meets emissions limits as set out in the MCPD. MCPD requires that our existing compressor fleet, between 1MW and 50MW net thermal input, must not exceed 150mg/m³ Nitrogen Oxide ($NO_x$) by 1 January 2030. Units can also be restricted to 500-hours over a five-year rolling average with a maximum of 750 hours per individual year under EUD[8], this can be classed as Essential or Emergency Use for our operating strategies. This removes the use of the compressors for standard operation, where they can only be run to prevent commercial constraints (Essential Use) or exit constraints (Emergency Use) on the network.

25. The purpose of this FOSR is to seek Ofgem's approval of NGGT's proposed Final Preferred Option for Peterborough and Huntingdon Compressor Stations to comply with MCPD emissions legislation while ensuring that the network is resilient and able to meet a wide range of likely future supply/demand patterns, ensuring UK Security of Supply and the operational 1-in-20 peak demand obligation of the sites.

26. By assessing the options available to make Unit A (Peterborough) and Unit C (Huntingdon) emissions compliant we have considered the long-term capability and resilience requirements for both sites, these include the impact on UK Security of Supply and meeting our 1-in-20 peak demand obligations which is supported by case studies analysing the GVA impact. As part of the process to select our Final Preferred Option we have taken results from CBA and BAT assessment as well as technology risks into consideration.

## Site Overview

27. The three compressors at both Peterborough and Huntingdon Compressor Stations, Units A, B and C, are non-MCPD compliant. Two of these units on each site, Peterborough Unit B and C, and Huntingdon Unit A and B, are being replaced with new units, under Industrial Pollution Prevention and Control (IPPC) Directive, with decommissioning already funded to take place in RIIO-T2. This FOSR is referring to Peterborough Unit A and Huntingdon Unit C as the non-MCPD compliant Avon's that require intervention by 2030. **Section 2** provides further detail on the site layouts and assets considered as part of the Final Preferred Option.

[8] Units can be run for up to 500-hours per year, on a five-year rolling average, up to 750 hours in a single year. This derogation currently has no end date.

| Unit | Engine | Fuel Type | Power Base (MW) | Installation Date | Minimum Operational Flow (mscm/d) | Nominal Capacity (mscm/d) |
|---|---|---|---|---|---|---|
| **Peterborough** | | | | | | |
| **A** | Avon | Gas | 12.34 | 1973 | 14 | 73 |
| **B** | Avon | Gas | 12.34 | 1973 | 16 | 73 |
| **C** | Avon | Gas | 12.34 | 1978 | 7 | 73 |
| **D** | Solar Titan | Gas | 15.3 | TBC | - | - |
| **E** | Solar Titan | Gas | 15.3 | TBC | - | - |
| **Huntingdon** | | | | | | |
| **A** | Avon | Gas | 12.34 | 1989 | 12 | 55 |
| **B** | Avon | Gas | 12.34 | 1989 | 12 | 55 |
| **C** | Avon | Gas | 12.34 | 1992 | 17 | 55 |
| **D** | Solar Titan | Gas | 15.3 | TBC | - | - |
| **E** | Solar Titan | Gas | 15.3 | TBC | - | - |

**Table 5 – Existing Assets Summary**

## Ofgem FOSR Pre-Engagement

28. Robust and regular engagement is essential to bring internal and external stakeholders along on the investment journey. We have prioritised monthly touchpoints with Ofgem to update them on our investment progress, outline the next steps and seek their feedback on any gaps or technical challenges we have discovered. The following is a series of Ofgem engagements which have influenced the Options Selection process for Peterborough and Huntingdon:

- 9 December 2022: Peterborough and Huntingdon Final Preferred Option Update and Security of Supply overlay
- 18 October 2022: Peterborough and Huntingdon need case key messages update and preliminary CBA results
- 20 September 2022: Peterborough and Huntingdon need case key messages and option shortlisting
- 7 June 2022: General compressor $NO_x$ emissions
- 3 May 2022: CBA/BAT interface presentation
- 1 April 2022: Reliability, Availability and Maintainability (RAM) model
- 22 March 2022: Avon DLE/CSRP initial results

## Document Structure

29. This FOSR follows the structure of Ofgem's Engineering Justification Paper Guidance for RIIO-GD2 and RIIO-GT2 (published 20 September 2019[9])). The FOSR is supported by the CE-AMP, which also contains reports regarding CSRP, Avon DLE retrofit and the RAM Model for the NTS fleet.

30. The current status of the project describes the work we have completed on site to date and a summary of the request for Ofgem of NGGT's Final Preferred Option, which is summarised in **Section 2**.

[9] RIIO-2 final data templates and associated instructions and guidance | Ofgem

31. **Section 3** states the problem which is present at Peterborough and Huntingdon regarding future emissions compliance and provides context regarding interactions with industry, related NGGT projects and identifies the criteria for a successful delivery.

32. **Section 4** confirms the needs case for future investment at Peterborough and Huntingdon Compressor Stations, which has been approved by Ofgem as part of the RIIO-T2 Final Determinations in December 2020. The section details the expected flow and site operations as well as define the supply and demand scenarios. This section also describes the key network operational needs for both sites and details the network capability. **Section 4** provides the compressor unit availabilities and compressor utilisation, which provide inputs into **Section 5 and 7**.

33. The option selection process is used to identify credible solutions and is described in **Section 5** alongside detailed analysis of all short-listed options. The section also includes summary tables to aid in cross-comparison of options in terms of cost, schedule and BAT assessment scoring.

34. **Section 6** describes the cost methodology used to produce estimates to ±30% accuracy. This section together with **Section 4 and 5** provide the inputs into the option evaluation and final recommendation of the Final Preferred Option.

35. **Section 7** describes the option assessment process (including a decision tree using information provided in **Section 3, 4, 5 and 6**), which defines the selection of the Final Preferred Option. The section summarised the key investment drivers including emissions compliance, BAT, capability, CBA, Security of Supply, resilience, technology risks and total installed costs (capex). Security of Supply and resilience considerations include the analysis of the GVA impact. Each investment driver is described in detail, then summarised in our final option justification and recommendation of our Final Preferred Option. The result of our recommendation is summarised in an option evaluation matrix.

36. **Section 8** summarises the arguments for the Final Preferred Option including estimated delivery programme, risks and opportunities identified and reiterates how the project has been funded to date.

37. **Section 9** concludes our justification for the Final Preferred Option and identifies the next steps to option delivery.

38. The FOSR appendices contain detailed engineering back-up material and documentation including the models for site availability and the CBA for all considered FES, engineering and asset health reports (incl. execution programmes and risk registers), Emissions Abatement technology testing studies for SCR and the preliminary BAT assessment report. In addition to these technical documents, we also provide a data assurance letter and a mapping of Ofgem requirements. For ease of reference, a data book of all tables used in this report is also provided within **Appendix K**.

## 1.1. Summary Table

| | | | |
|---|---|---|---|
| **Name of Project** | Peterborough & Huntingdon MCPD | | |
| **Scheme Reference** | PAC1051191 | | |
| **Primary Investment Driver** | Compliance with MCPD legislation | | |
| **Project Initiation Year** | 2019 | | |
| **Project Close Out Year** | 2029 | | |
| **Total Installed Cost Estimate (£)** | [redacted] (does not include spend to date) | | |
| **Cost Estimate Accuracy (%)** | ±30% | | |
| **Project Spend to date (£)** | [redacted](until end of December 2022) | | |
| **Price Base** | 2018/19 prices | | |
| **Current Project Stage Gate** | 4.2 - Option Selection | | |
| **Reporting Table Ref** | RRP Table 6.2 (Projects) and Table 6.1 (CAPEX_Summary) | | |
| **Outputs included in RIIO-T1** | No | | |
| **Outputs included in RIIO-T2** | <u>Compressor Emissions PCD:</u><br>PCD to ensure NGGT delivers a Final Options Selection Report, long lead items and Re-opener submission[10].<br><br>Final Option Selection Report: January 2023[11]<br>Re-opener application window: June 2025<br>Baseline allowances: [redacted] (excl. RPEs) | | |
| **Spend Apportionment** | **RIIO-T1** | **RIIO-T2**[12] | **RIIO-T3**[13] |
| | [redacted] | [redacted] | [redacted] |

**Table 6 - FOSR Summary Table**

[10] Detailed in Special Condition 3.11 Compressor emissions Re-opener and Price Control Deliverable
[11] FOSR submission date updated in line with Ofgem Consultation of 1 August 2022
[12] Spend profile does not include previous spend, only forecast spend associated with the Final Preferred Option.
[13] As per project spend profiles for Peterborough and Huntingdon; See **Section 6.3**

## 2. Project Status and Request Summary

### Overview

40. As part of NGGT's RIIO-T2 submission in December 2019, we proposed to install one new gas-driven compressor unit at Peterborough to replace the existing Avon unit, and to derogate the remaining Avon unit at Huntingdon. Due to the uncertainty in this decision and the early stages of the options selection, it was requested that this project would be included within an Uncertainty Mechanism, enabling further option development to be undertaken. This additional option development takes the format of a two-step process whereby this Final Option Selection Report is submitted in January 2023, followed by a cost submission in June 2025 once the project has gone through a full Front-End Engineering and Design (FEED) phase for the preferred option and tender process.

41. This FOSR has been created through our Option Selection (Stage 4.2 of the Network Development Plan (NDP); overview in CE-AMP[14]) process to assess credible options aimed at meeting MCPD legislative compliance while meeting customer and stakeholder needs.

### Project Status

42. Since 2019, NGGT have selected an Option Selection Consultant, [redacted] to support in further evaluating the available options to achieve MCPD compliance by 2030. All options proposed as part of the RIIO-T2 submission have been further evaluated, along with new Emission Abatement technology and decommissioning options.

43. A preliminary BAT assessment undertaken by [redacted] ([redacted]) was also completed, feeding into the decision-making process. BAT analysis is an assessment of the available techniques best placed to prevent or minimise emissions and impacts on the environment. Options that were considered in the preliminary BAT assessment are aligned to those described in **Section 5** and include abatement options identified since the previous assessments included in our 2019 RIIO-T2 business plans. The preliminary BAT Assessment report can be found in **Appendix G**.

44. The required initial and ongoing Asset Health expenditure applicable for each of the shortlisted options described in **Section 5** has been investigated, see **Appendix D** for the Asset Health Report.

45. A qualitative risk assessment has been undertaken for all options with a focus on risks that may differentiate between options for concept selection purposes. As part of the risk assessment process, significant areas of risk requiring onward management and opportunities to be further investigated as part of value engineering were also identified. Risks relating to specific options can be found within **Appendix F**.

46. Network operating scenarios have been assessed as part of this FOSR.

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[14] CE-AMP Appendix F - Process

## Request Summary

47. To achieve MCPD legislative compliance at Peterborough and Huntingdon Compressor Stations, NGGT's Final Preferred Option recommends the installation of a new gas-driven compressor unit at Peterborough and installation of DLE Emission Abatement technology on the Avon at Huntingdon. Decommissioning of the Peterborough Avon will be assessed after operational acceptance of the new unit. This has an associated cost of [redacted], funded through the Re-opener following submission in June 2025. Funding to decommission the non-MCPD compliant unit has been included in this total cost, where actual decommissioning will be considered after operational acceptance of the new unit, and not included within the Re-opener funding request. The total project cost includes the already received Baseline funding of [redacted] (excl. Real Price Effects (RPEs)). The Baseline funding will be subject to true up following our Re-opener submission in June 2025.

48. Our Final Preferred Option supports the fleets operational and availability requirements. Assessments have shown that the third unit at Peterborough will be operated in excess of 500-hours a year to prevent network constraints. Peterborough and Huntingdon parallel operation is required at both sites to enable our 1-in-20 peak demand obligations. Restricting the Avon at Peterborough (Unit A) to 500-hours poses a significant risk to the site meeting its operational requirements. Due to Huntingdon's location on the network, a 500-hour restriction could be accommodated if DLE isn't available.

49. The Final Preferred Option provides the right level of network capability and delivers a reduction in greenhouse gas emissions and fuel usage. This option has been selected from a wide range of potential options that have been evaluated against a range of potential future operating scenarios to identify a solution with an appropriate risk exposure to maximise benefit to consumers.

50. Ofgem are invited to assess and approve our proposed Final Preferred Option for Wormington in line with Special Condition 3.11, Part C, 3.11.9. NGGT's view is that the PCD should be viewed as fully delivered once we have submitted our Re-opener application at which point the PCD will be revised to reflect the outputs and allowances related to the delivery of our preferred option. NGGT is reporting on our PCD progress and spend as part of the annual Regulatory Reporting Pack (RRP).

51. Following Ofgem's decision on the Final Preferred Option, NGGT will use the received Baseline allowances to develop our preferred option further and submit a Re-opener application in line with Special Condition 3.11, part D and appendix 2 for Ofgem's consideration in April 2025. We welcome engagement with Ofgem throughout the Option Selection process and intend to keep engaging with them at relevant project development stages, so they remain informed throughout and ensure we successfully deliver our proposed solutions at Peterborough and Huntingdon Compressor Stations.

## 3. Problem/Opportunity Statement

### Why are we doing this work and what happens if we do nothing?

52. NGGT is legally obligated to have its compressor fleet compliant with MCPD legislation[15] by the deadline of 1 January 2030. The three compressors at both Peterborough and Huntingdon Compressor Stations, Units A, B and C, fall within the MCPD category and can breach the $NO_x$ limits imposed. Two of these units on each site are being replaced with new units, under IPPC, and funded for decommissioning in RIIO-T2.

53. Once decommissioning of these units has been completed, there will be a total of three operational units at both Peterborough and Huntingdon. The new units that have replaced the four Siemens (formerly Rolls-Royce) Avon compressors, are Solar Titan T130s. See **Figure 2, Figure 3** and **Table 7** for site overviews.

[redacted]

**Figure 2 - Peterborough Compressor Station overview**

[15] https://www.gov.uk/guidance/medium-combustion-plant-mcp-comply-with-emission-limit-values

[redacted]

**Figure 3 – Huntingdon Compressor Station overview**

| Site | Current operational units | Under construction | Funded decommissioning | Operational units post decommissioning | Post 2030 operational units |
|---|---|---|---|---|---|
| Peterborough | A, B, C | D, E | B, C | A, D, E | D, E, F |
| Huntingdon | A, B, C | D, E | A, B | C, D, E | C, D, E |

**Table 7 - Summary of site investments**

54. Utilisation of the compressors at Peterborough and Huntingdon is primarily to move large volumes of gas into the south of the network, to meet South-West and South-East demand.

55. Peterborough's two T130s will operate in parallel to meet high flow requirements. In order to maintain the required level of site resilience, an unrestricted unit with a high level of availability is required as backup, to maintain parallel operation. This is required to uphold our 1-in-20 peak demand obligation.

56. Huntingdon's two T130s will operate in parallel to meet high flow requirements. In order to maintain the required level of site resilience, a backup unit is required, preferably without restriction to maintain parallel operation when required. This is required to uphold our 1-in-20 peak demand obligation.

57. Due to the sites forming a chain to move gas into the south, they are able to load share to an extent between them. For this reason, although having a restricted unit at Huntingdon isn't preferable, the risk could be mitigated by Peterborough having high resilience.

58. The location of Peterborough and Huntingdon is illustrated in **Figure 4**.

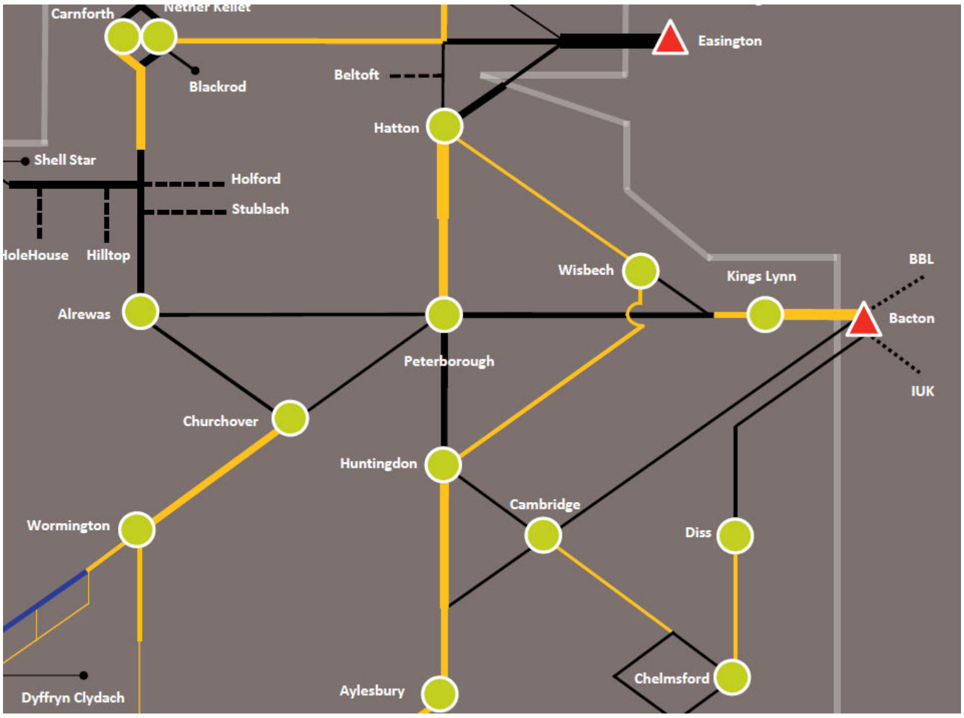


**Figure 4 - Location of Peterborough, Huntingdon Compressor Stations and Bacton Terminal**

59. The age of the compressors is a key consideration in the option evaluation process due to both Avon's being beyond their design life. Peterborough A was commissioned in 1973 and Huntingdon C was commissioned in 1992.

60. Doing nothing for this project is defined as the 'Counterfactual' within this FOSR. This is where only asset health works are completed on the Avon's, which would be operated under 500-hour derogation. Derogation limits the unit to 500-hours per year over a five-year rolling average, with a maximum of 750 in a single year, with no reduction in emissions from the units during operation.

61. Limiting the available run hours of the unit at Peterborough will impact the ability to maintain network capability, preventing us from meeting our customers' requirements and impacting our 1-in-20 peak demand obligation. Commercial contracts would not be cost effective in minimising the impact of constraints to the consumers.

62. This FOSR has considered and compared multiple options, to ensure that the Final Preferred Option, installing a new compressor at Peterborough and Emissions Abatement technology at Huntingdon, meets the MCPD and network resilience requirements.

## Under what circumstances would the need or option change for this project?

63. Any increase in the net gas supply at Bacton will increase the requirement for a new unit at Peterborough, operating to move gas away from the terminal. A new unit will increase the site's resilience and availability, increasing its versatility to respond to more

operational requirements and support the UK's Security of Supply. Below is a list of changes that could increase net gas supply at Bacton:

- Closure of storage sites on the NTS, resulting in additional gas being supplied to the network, increasing supplies from Europe.
- Changes in the interconnectors' operating models or services that increase import to the UK.
- Requests from interconnectors to increase import flows (through a PARCA submission).
- Changes in world markets resulting in a reduction of LNG coming to the UK, requiring increase supplies from the interconnectors to meet the shortfall.
- Increase of UKCS supply at Bacton.
- Reduction of industrial / power station demand near Bacton.

64. Any increase in the net gas demand in the South of the network will increase the requirement for a new unit at Peterborough, and DLE retrofit at Huntingdon. A new unit will increase the site's resilience and availability, therefore increasing its versatility to respond to more operational requirements. Below is a list of changes that could increase net gas demand in the South of the network:

- Closure of gas storage in the south, resulting in additional gas being supplied to the area.
- Reduction in Grain LNG supplies, for any reason, resulting in additional gas being supplied to the area.
- Domestic consumers increase gas demand, not transitioning to heat pumps.
- Increase of industrial / power station demand in the South.
- Reduction in net Bacton supply, which would have been used to meet the demand.

65. Any changes in legislation could impact the preferred option for a new unit. Below is a list of changes that could impact the Final Preferred Option:

- Unilateral change in the UK environmental legislation to rescind or alter the conditions of MCPD. Lowering the required $NO_x$ levels and/or including CO limits would favour new more efficient units over existing units that just meet the current legislative levels.
- Introduction of legislation that defines the required energy efficiency of our compressors would favour new units, and disfavour DLE retrofit due to the increase in fuel usage.
- Changes in Gas Safety (Management) Regulation's requirements allowing entry of different quality gas from suppliers and the blending of Hydrogen.-This has the potential to alter the gas supply mix due to lower processing requirements.

66. Any other changes that could impact the preferred option for a new unit, are listed below:

- Increasing energy costs would favour new units that are more efficient than the existing ones.
  - Increasing material costs is less favourable to new units due to the larger material quantities required when compared with retrofit options.
  - Unforeseen maintenance and/or failure of the existing Avon resulting in increased asset health costs would favour new units.
  - Reduction in the availability of spares for the existing Avon could result in increased down time, favouring new units.
  - Reduction in OEM support for the existing Avon would favour new units.

## What are we going to do with this project?

67. To achieve MCPD legislative compliance at Peterborough and Huntingdon Compressor Stations, NGGT's Final Preferred Option recommends the installation of a new gas-driven compressor unit at Peterborough and installation of DLE Emission Abatement technology on the Avon at Huntingdon. Decommissioning of the Peterborough Avon will be assessed after operational acceptance of the new unit. More detail on our Final Preferred Option can be found within **Section 8.1.**

## What makes this project difficult?

68. Uncertainties around the UK's energy landscape and the wide range of averaged demand led energy scenarios detailed within FES has led to a non-representative CBA. If FES, and the CBAs produced from it are the main drivers for investment, there is a very high risk to consumers of underinvestment, leading to network constraints.

69. Construction of new units on our network takes approximately six years from confirmation of preferred option to operational acceptance. To ensure that the Final Preferred Option is operationally accepted by the 2030 deadline, construction cannot be delayed. **Section 8.2** contains the execution programme for our Final Preferred Option.

70. This project has been initiated through MCPD, however there is a strong requirement to assess solutions from a wider network resilience to meet our 1-in-20 peak demand obligation. These are separate drivers that follow different funding mechanisms. The Option Selection stage of this project has bundled the compression requirements at Peterborough and Huntingdon with the aim of ensuring efficient spend to meet MCPD legislation and the required levels of network resilience.

71. The current national and international geopolitical situation is creating significant uncertainty in prices and availability of materials and labour which makes estimating project delivery costs more challenging. This will need to be a consideration when finalising the delivery strategy after confirmation/approval of the preferred option.

72. Risks and opportunities associated with the preferred option can be found in **Section 8.2** and details of risks and opportunities of all shortlisted options can be found in **Appendix F**.

## What are the key milestone dates for project delivery?

73. The project aims to have the new unit commissioned in 2029, allowing time for it to become operationally accepted prior to the 2030 deadline. Milestone dates have been informed by scheduling of this project against other planned investment work. This has identified that the opportune time to begin the design and build phase at Peterborough is in 2025 with operational acceptance and project closure in 2029 as summarised in **Figure 5**.

| ND500 – Network Development Stage Gates & Key Milestones | | | |
|---|---|---|---|
| **ND500 Phase** | **Key Activities** | **Sanction** | **Indicative** |
| 4.0 Needs Case<br>4.1 Establish Scope and Options | • Identification of Needs Case<br>• Define strategic approach and outputs required to deliver<br>• F1 Sanction – Optioneering | T0 | N/A |
| | | T1 | April 2019 |
| | | F1 | April 2019 |
| 4.2 Option Selection | • F2 Sanction - Feasibility<br>• BAT Assessment and Compressor Machinery Train selection<br>• Final Option Selection Report Submission<br>• Agreement to Proceed to Conceptual Design<br>• F3 Sanction - Conceptual Design and Long Lead Items | T2 | April 2021 |
| | | F2 | April 2021 |
| | | T3 | March 2024 |
| | | F3 | March 2024 |
| 4.3 Concept Design & Development | • UM Cost Reopener Submission<br>• Scope Freeze | T4 | September 2025 |
| 4.4 Project Execution | • F4 Sanction – Detailed Design & Build<br>• DDS Challenge, Review and Sign off<br>• Maintenance Requirements Identified | F4 | September 2025 |
| | | T5 | January 2027 |
| 4.5 Acceptance/Closure | • Post Commissioning Handover to GT<br>• Operational Acceptance<br>• Project Closure | T6 | January 2029 |
| | | F5 | December 2029 |

**Figure 5 - Key Project Milestones**

74. The stage gates within our NDP process ensure minimum requirements are met for each phase of investment development.

75. Decommissioning of the Peterborough Unit A will be reassessed after operational acceptance of the new unit.

## How will we understand if the project has been successful?

76. Overall project success will be confirmed by operational acceptance of the preferred option, meeting customer demands throughout the construction period, compliance with MCPD requirements as well as the project completed safely and to time, quality and cost.

77. For this Option Selection stage, the project will be deemed a success if the PCD set out in Special Condition 3.11 will be deemed as fully delivered. The PCD entails the FOSR

being submitted to Ofgem by January 2023 and the Re-opener submission in June 2025 following Ofgem’s review of the preferred option that provides the best value for consumers.

## 3.1. Related Projects

78. There are key interactions with other significant investments, both at Peterborough, Huntingdon and across the National Transmission System (NTS):

- **King's Lynn MCPD:** A FOSR for King's Lynn Compressor Station has been submitted alongside this submission. King's Lynn is located to the East of Peterborough and will form part of a compressor chain under certain scenarios when moving large volumes of gas away from Bacton. The investments aren't linked; however project alignment will be carried out for efficiency.
- **Other MCPD Projects:** The option evaluation and recommendations made in this report are predicated on the investment in the Final Preferred Options at other MCPD impacted sites being undertaken prior to 2030 as indicated in CE-AMP. Should any of the Final Preferred Options change, then option evaluation would need to be revisited.
- **IPPC investment:** Installation and commissioning of two T130 units at both Peterborough and Huntingdon to replace the two of the Avon's is in progress. Decommissioning of the two Avon units has been funded and scheduled to take place during RIIO-T2. There is no planned impact between this project and the installation, commissioning and decommissioning taking place. Project shall be aligned for efficiency if appropriate.
- **Control System replacement:** Peterborough A and Huntingdon C's control systems are scheduled to be replaced in 2029/30. This shall be factored into this project and assessed for efficient spend based on the approval of our Final Preferred Option.
- **CH4RGE:** 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 Technique (BAT), are potentially suitable for installations either as a new build or can be retrofitted to existing equipment.
- **RIIO-T2 Funded Asset Health Scope**: For the purpose of this submission, we have assumed that any asset health scope at Peterborough and Huntingdon that has already been funded in RIIO-T2 will be complete prior to the MCPD project site mobilisation. Opportunities for synergies and delivery efficiency will be reviewed during the MCPD FEED

79. To increase the options available to comply with MCPD legislation, NGGT are trialling Emissions Abatement technologies to determine their viability and legal acceptance. Trials are ongoing, and yet to be operationally accepted. These technologies are:

- Control System Restricted Performance (CSRP). This involves permanently derating or reducing the power output of an Avon through modification of the control system relative to the Exhaust Cone Temperature. A CSRP proof-of-concept trial was conducted at Huntingdon and Chelmsford

Compressor Stations in winter 2021, successfully confirming a correlation between Exhaust Cone Temperature and $NO_x$ emissions. More information can be found within a dedicated CSRP report included as an appendix in CE-AMP.

- Dry Low Emissions (DLE). An Avon DLE retrofit modifies the combustion system within the Avon engine so that air and fuel are premixed before combustion. This reduces the peak combustion temperature, which in turn reduces the amount of $NO_x$ produced. NGGT have funded development of a DLE retrofit 1533 Avon in partnership with [redacted] beginning with combustor can trials in early 2022. A full engine test bed performance trial to determine $NO_x$ reduction, and operational trial on an NTS unit to determine unit availability has been planned. As the performance trials are ongoing, an interim summary report is provided as an appendix to CE-AMP**.**
- Selective Catalytic Reduction (SCR). Exhaust gas $NO_x$ levels are reduced through the use of ammonia injection and a catalyst. A report on the feasibility of the use of SCR technology across the NGGT compressor fleet was produced by [redacted] in 2017, which was updated and revised by consultant [redacted] in June 2022, see **Appendix I**.

80. This project has no impact on planned investments at other compressor stations on the network. However, the delivery strategy across the MCPD projects shall be aligned to increase efficiencies.

81. To support our Option Selection process, we have developed a detailed Reliability Availability Maintainability (RAM) model which has evaluated unit availability across the entire NGGT fleet. This study was developed in collaboration with [redacted] An overview of the RAM Model and how it has been applied and used in the CBA can be found in CE-AMP. More detail on this can be found in our Annual Network Capability Assessment Report (ANCAR) 2022[16].

82. An updated version of our Compressor Emission Compliance Strategy (CECS), that was released to support our 2019 RIIO-T2 Business Plan, has been produced. CE-AMP (Compressor Emissions Asset Management Plan) supports this and our other MCPD FOSR submissions. CE-AMP outlines our approach to how our compressor fleet will comply with the emissions legislation, including units to be decommissioned, derogated, retrofitted with Emissions Abatement technology, and replaced with new units.

[16] https://www.nationalgas.com/insight-and-innovation/network-capability

## 3.2. Project Boundaries

83. The scope of this project is delivery of emissions compliant compression which meets forecast network capability requirements. For Peterborough, these are costs associated with construction of a new compressor unit, and at Huntingdon these are costs associated with asset health and the installation of DLE Emission Abatement technology. Funding for other costs, such as ongoing asset health costs and operational running costs for the existing units and site, will not be included in the planned Re-opener submission in April 2025.

84. Decommissioning costs for Peterborough Avon compressor Unit A, is included within this option selection report. However, a request for decommissioning funding will not be included within the 2025 cost Re-opener, as the decommissioning investment will be reassessed once the new unit has been operationally accepted, and if required requested as part of the RIIO-T3 decommissioning business plan.

# 4. Project Definition

## Expected Flows and Site Operation

86. The details in the following section are drawn from the Needs Case which is based on the analysis undertaken in support of our 2019 RIIO-T2 business plan submission to Ofgem. The information within the needs case has been updated and refined to support the FOSR. Ofgem accepted the Needs Case to retain compression capacity at Peterborough and Huntingdon as part of their RIIO-T2 Final Determinations in December 2020. As such the Needs Case was established in our RIIO-T2 Business Plan and has not been issued in a separate Needs Case document.

## Supply and Demand Scenario Discussion and Selection

87. To fully assess the scope and options for the project, a network assessment to define the capability boundaries was completed. The output from this was used in a risk and constraint assessment to define any associated constraint costs. For more information on how capability boundaries are produced, refer to ANCAR 2022[17].

88. This FOSR has used FES 2021 data. The FES 2022 (published on 18 July 2022) framework is consistent with 2021, however there are concerns with how heat has been decarbonised in the Falling Short (previously Steady Progression (SP)) scenario and the potential source of hydrogen in the System Transformation (ST) scenarios, reinforcing our decision to use FES 2021 data for consistency during this planning cycle. Full details of the review and differences are detailed in **CE-AMP Section 3**.

89. The gas landscape has changed considerably in the last 20 years. With the continued decline of UK Continental Shelf (UKCS) supplies and the need to decarbonise, NGGT expects gas supply and demand patterns and the need for flexibility in the operation of our assets to continue to change going forward. There are many factors which create uncertainty on the extent and speed of change. Given this uncertainty, it is impossible to forecast a single energy future over the long term. FES is currently updated and published annually by National Grid ESO in July. These scenarios are created using National Grid ESO's own analysis and input from stakeholders across the energy industry.

90. For FES 2020 the published scenario framework was updated (see **Figure 6**), with Net Zero targets included. This framework was continued for FES 2021.

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

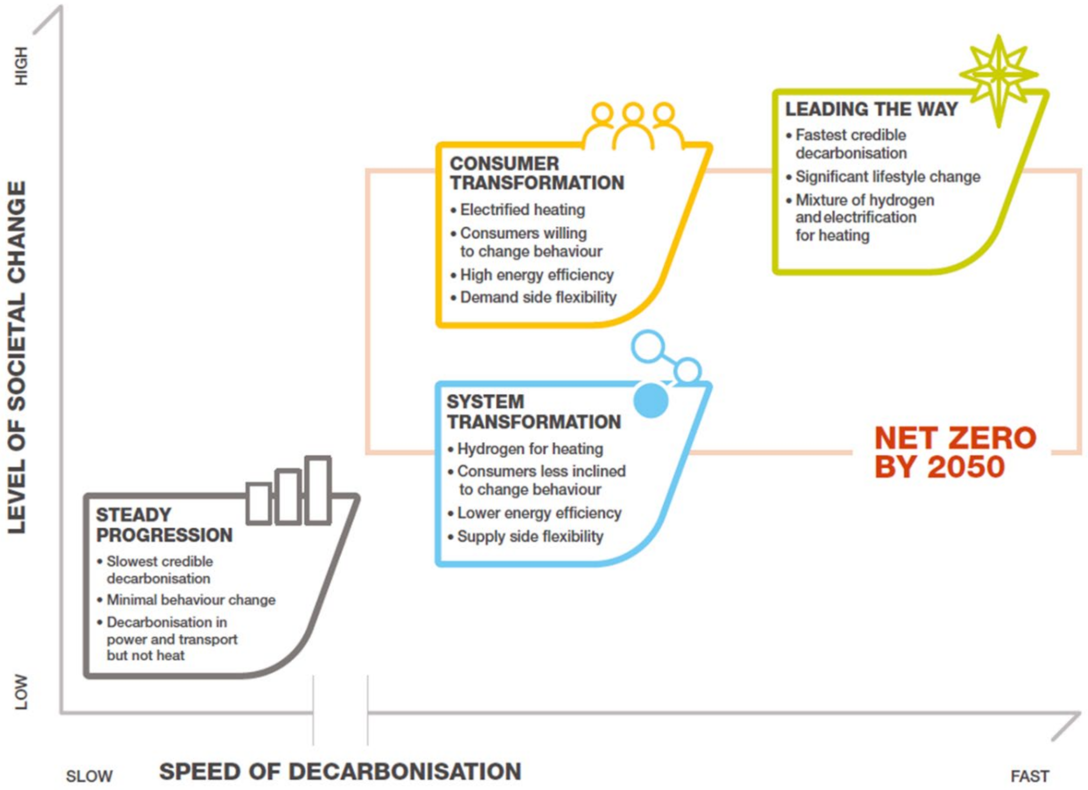


**Figure 6 - FES 2021 Framework**

91. The four scenarios as described in the National Grid ESO Future Energy Scenarios[18] provide different pathways to a Net Zero future. These range from the SP scenario, which falls just short of the Net Zero target, to Leading the Way (LW) which achieves Net Zero ahead of 2050. Each scenario is dependent to varying degrees on a series of changes and industry responses to, government policy and legislation, energy delivery and consumption, consumer behaviour, technological change and government incentives and investment. In many ways these different pathways also represent different potential extremes of energy industry change. As such, FES on its own intentionally provides no validation of the most appropriate investment option, instead it provides a broad envelope of energy backgrounds against which the merit of alternative investments may be appraised.

92. The two low natural gas scenarios (Consumer Transformation (CT) and LW) meet the targets via electrification either at a transmission or distribution level and involve changes in consumer behaviour and high improvements in energy efficiency. The use of hydrogen is considered in LW and ST scenarios. With LW hydrogen is produced from green sources only and with ST from a combination of green and blue sources, which is the reason for the high long term natural gas need for ST. In many ways, ST is the most balanced scenario with a mixture of electrification, conversion to hydrogen and increased energy efficiency and demand lead consumption. The CT scenario features

[18] https://www.nationalgrideso.com/future-energy/future-energy-scenarios

a supply led consumption. With ST, there is less consumer behaviour change and lower energy efficiency with hydrogen providing significant space heating energy. This is leading to NGGT having higher confidence in the ST scenario when compared with LW and CT. A detailed comparison of the four scenarios can be found in **Section 3** of the CE-AMP document.

### Key Flows and boundaries

93. **Figure 7** shows the peak 1-in-20 diversified demand for each of the FES 2021 scenarios, demonstrating that there are a wide range of potential demand scenarios between now and 2050. The SP scenario has the highest gas flows, but there are also very significant gas flows for the ST scenario.

94. Gas flows are much lower in the CT and LW scenarios, as there is a move away from natural gas use in achieving the Net Zero target in 2050. These are the most ambitious scenarios with the reductions seen between now and 2030 driven by reductions in heat and power generation demand. For the last 5 years the level of reduction characterised in these scenarios has not happened and is unlikely to occur until suitable incentives are in place. A more detailed review of FES 2021 can be found in CE-AMP.

95. To see the level of peak demand reduction forecast in the CT and LW scenario you need to believe that by 2030:

- Over 2 million consumers will have replaced their gas boilers with heat pumps in the CT scenario
- This is over 6 million consumers in the LW scenario
- There will a 45% reduction in peak gas fired power generation demand in the CT scenario
- And a 75% reduction in the LW scenario.

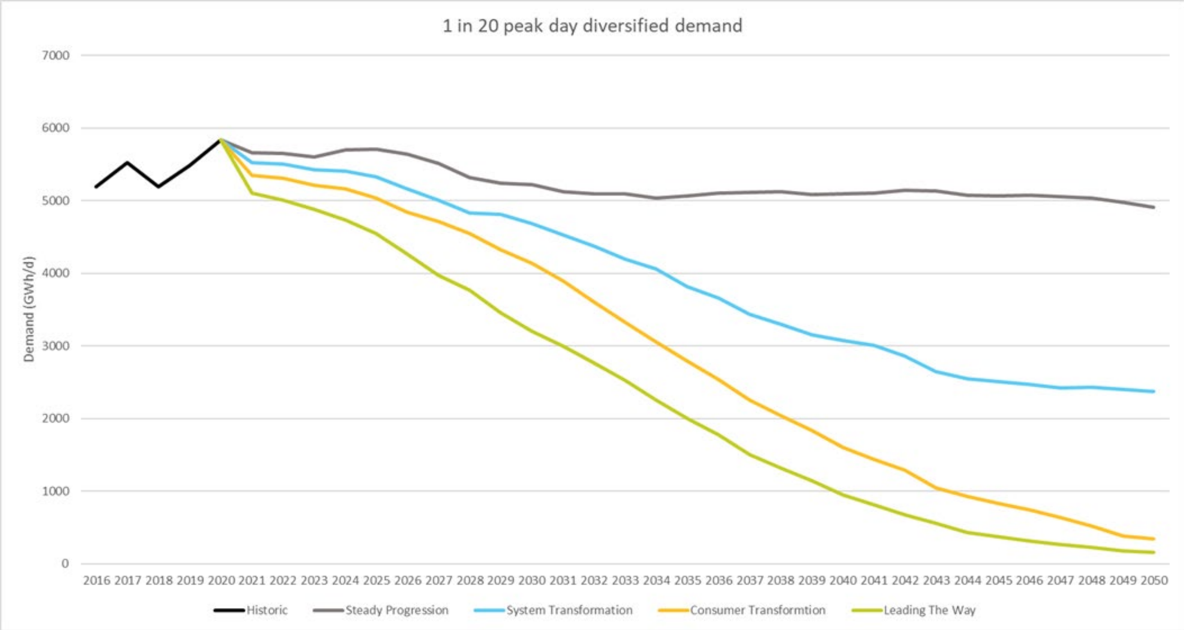


**Figure 7 - Peak 1-in-20 diversified demand for each of the FES 2021 scenarios**

## 4.1. Network Need

### Network Operational Need

96. Peterborough and Huntingdon are two of the most important compressor stations on the National Transmission System (NTS). Peterborough is located at a strategic multi-junction that conveys gas in multiple directions to meet geographical and national demand. Huntingdon is located at a key multi-junction supporting demands in the South-East and west of the network. The key network operational need of these sites can be summarised to:

- **Zonal Transfer:** The location of Peterborough compression and the flexibility of the multi-junction enables the site to balance supply and demand imbalances in multiple zones. Its capability is for bulk transmission from North to South, East to West, West to East/South and towards the North-West. Without Peterborough the efficiency of the network is reduced with multiple stations required to compensate. Huntingdon enables supply and demand to be balanced from North to South, East to West and towards the East Midlands.

- **Line-pack management:** Peterborough and Huntingdon compression, with two-units operating in parallel, are key in maintaining sufficient Line-pack stocks (volume of gas) in the south of the network. This ability to replenish line-pack stocks with the use of Peterborough and Huntingdon is important due to limited line-pack capability and high demand levels seen in these zones.

- **Network Capability:** Peterborough and Huntingdon play a crucial role in meeting our Exit capability requirements in the south of the network. They are required to maintain our compliance with the 1-in-20 security standard in both the South-East and South-West and to minimise our risk of constraints at demands away from peak.

- **Operational Strategy and efficiency:** The flexibility of Peterborough and Huntingdon to support several different roles on the network mean that they are two of the most important sites on the network. If they are not available alternative strategies are less efficient due to multiple sites being required to complete the same role.

### Zonal transfer

97. For a gas system to remain balanced all inputs must be matched with corresponding outputs. On the NTS, terminal supplies volatile, out of the direct control of NGGT and are not perfectly matched with demand within each zone, therefore zonal transfer is necessary to maintain the correct safe pressures on the network.

98. The imbalance between a zonal supply and demand will cause areas with either:

- A supply surplus (net supply zones) thereby having higher pressures than areas with a demand surplus (net demand zones), this difference in pressure will cause gas to flow from the net supply zones towards the net demand zones.

- A supply shortfall (net demand zones) thereby having lower pressures than areas with a supply surplus (net supply zones), this difference in pressure will cause gas to flow from the net supply zones towards the net demand zones.

99. **Figure 8** below shows forecasts for 2021/22 average supply and demand balances within each zone, across three different national demand levels.

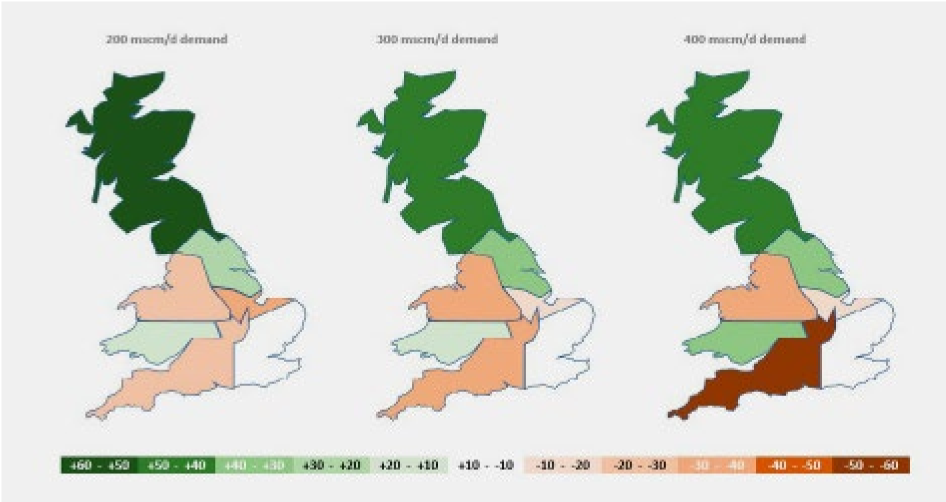


**Figure 8 - Average zonal supply balance on a low, medium and high national demand levels**

100. For the system to remain balanced, in terms of line-pack distribution, any zone with a supply surplus (green) must have the amount of gas indicated transferred out of it into an adjoining zone over the gas day, conversely any area with a supply deficit (orange) must have that amount of gas transferred into it.

101. If these imbalances are not correct areas of oversupply could result in entry constraints and areas of undersupply could result in exit constraints. It is therefore essential we move gas into areas of under supply and away from areas of over supply to give them a pressure cover. This pressure cover gives us an insurance policy against any asset failures or sudden changes in supply or demand.

102. On average the Scotland and The North, North-East and South Wales zones are over supplied. With the North-West, South-West and East Midlands in deficit. The site that is best positioned to support the movement of line-pack between these zones is Peterborough with much of that capability supported by Huntingdon.

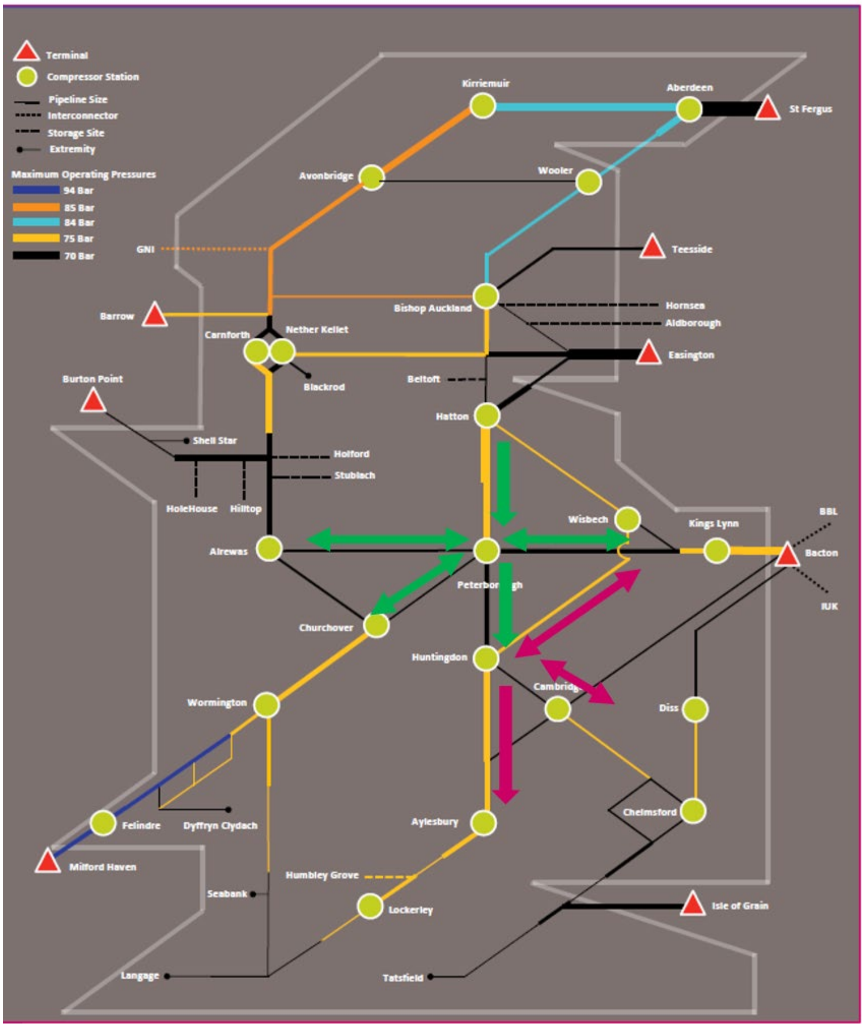


**Figure 9** - Schematic of the National Transmission System (NTS) indicating potential multi-junction configurations for Peterborough and Huntingdon compression

103. **Figure 9** shows a simplified schematic of the NTS. It shows that Peterborough Compressor Station is located at the heart of the network. The arrows on the map indicate how different configurations on the multi-junctions at Peterborough and Huntingdon can facilitate different flows on the network. These different configurations enable Peterborough to be able to support the zonal transfer from areas of over supply to areas of deficit. For Peterborough these are:

- From the North – working with the compression at Hatton, Peterborough is able to support the movement of line-pack from the over supplied Scotland and the North and North East zones into the rest of the network.

- To and from the East Midlands – enabling Entry Capability at Bacton and supporting demand in the East Midlands when supplies are either low or Bacton is exporting to Europe through the interconnectors

- To and from the North-West - enabling the refill and emptying of North-West storage as well as providing an alternative or additional capability for the bulk transmission of the over supplied North.

- To and from South Wales - enabling Entry capability at Milford Haven and supporting demand in South Wales at times of low supply from Milford Haven.

- To the South – ensuring we are able to maintain pressures in the South-East and South-West

104. Huntingdon Compressor Station located just below Peterborough Compressor Station can work with or provide resilience for some of what Peterborough does. These are:

- From the North – working with compression at Peterborough, two units operating in parallel at Huntingdon is key in meeting the 1-in-20 security standard in the South-East and South-West of the network. Away from peak they can either work together or provide resilience to each other in the movement of line-pack into the South.

- To and from the East - Huntingdon compression can be configured to either move flows into the South-East, when there is a supply deficit, or out of the South-East when there is a surplus.

- To and from the East Midlands - Huntingdon compressor can also be used to send gas to the East Midlands (towards Wisbech Junction) to provide some additional capability for Bacton Exit. It can also be used to move gas away from the East Midlands to increase bulk transmission from the North and increase Bacton entry capability.

## Line-pack Management

105. Line-pack management is the practice of adjusting the amount of line-pack (gas held within the pipeline) in a Zone for operational or risk management reasons, which may require the use of compression. There are several risks which cause an unexpected or larger variance in the amount of line-pack within a zone. These risks include asset failure and Supply and Demand volatility.

106. Each zone has the capability to store line-pack. If the line-pack within a zone goes too high, it will eventually result in pressures reaching their Maximum Operating Pressure and flows from an entry terminal having to be reduced. If pressure drops to low customers may not be able to operate or have to be disconnected. The difference between the highest and lowest amount of line-pack a zone can hold can be referred to as line-pack capability.

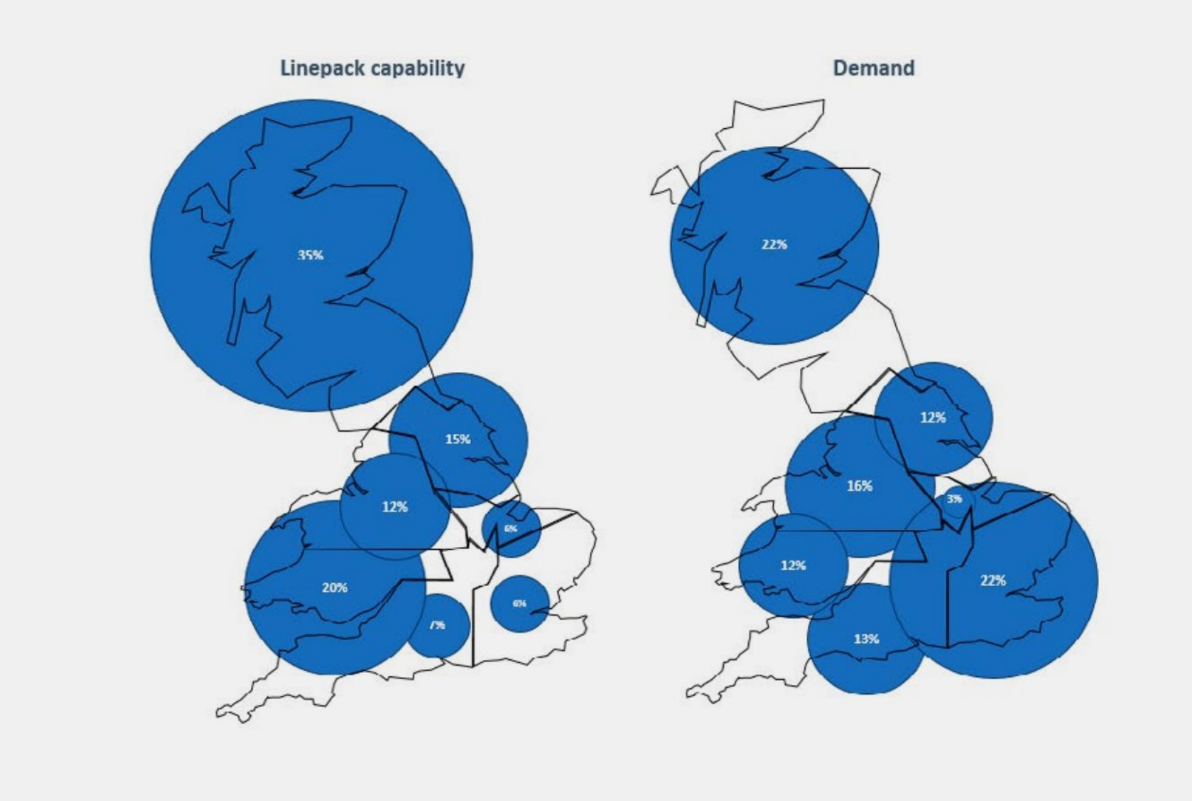


**Figure 10 - Shows a comparison of NTS operational Line-pack capability vs Demand on a zonal basis**

107. **Figure 10** illustrates line-pack capability within each zone on an average forecast demand day (Day150), alongside a view of demand levels within each zone. The high demand areas are not correlated with the areas which can facilitate large Line-pack swings. This forms the basis of active line-pack management. Line-pack changes within day are inevitable with supply not matching demand at all times during the day. Therefore, we use line-pack management to ensure that each zone stays within its operational limits to ensure customers can continue to take gas on and off the system without interruption.

108. The South-East of the network has a very high demand (22%) with very low line-pack capability (6%). This is similar in the South-West with the demand (13%) being higher than the line-pack capability (7%). This leads us to rely on compression to ensure line-pack levels within each zone is maintained within operational limits. The location of compression at Peterborough and Huntingdon makes them the most effective and efficient sites at maintaining line-pack levels in the South.

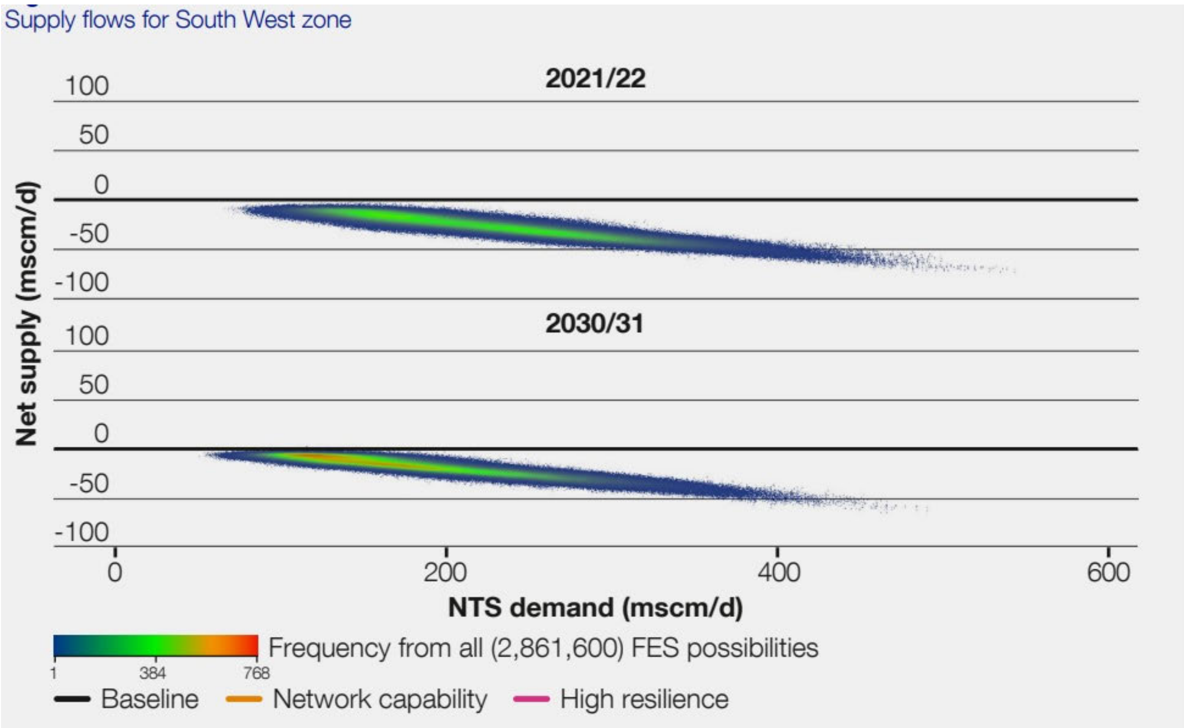


**Figure 11 – Shows supply for South-West Zone**[19]

109. **Figure 11** illustrates the net supply flows in the South-West, this zone has one relatively small storage site with no other supplies. Consequently, the zonal demand is strongly correlated with national demand, and as showing in **Figure 11** it is always expected to be in a supply deficit. When the deficit is high, compression at Peterborough and Huntingdon is required to ensure line-pack levels can be replenished. This ensures we have an adequate pressure cover at the extremity of the network to limit the impact of asset failures or sudden changes in supply or demand. This ensures our customers can continue to take gas on and off the network without interruption.

[19] ANCAR 2022, page 51, figure 50 https://www.nationalgas.com/insight-and-innovation/network-capability page

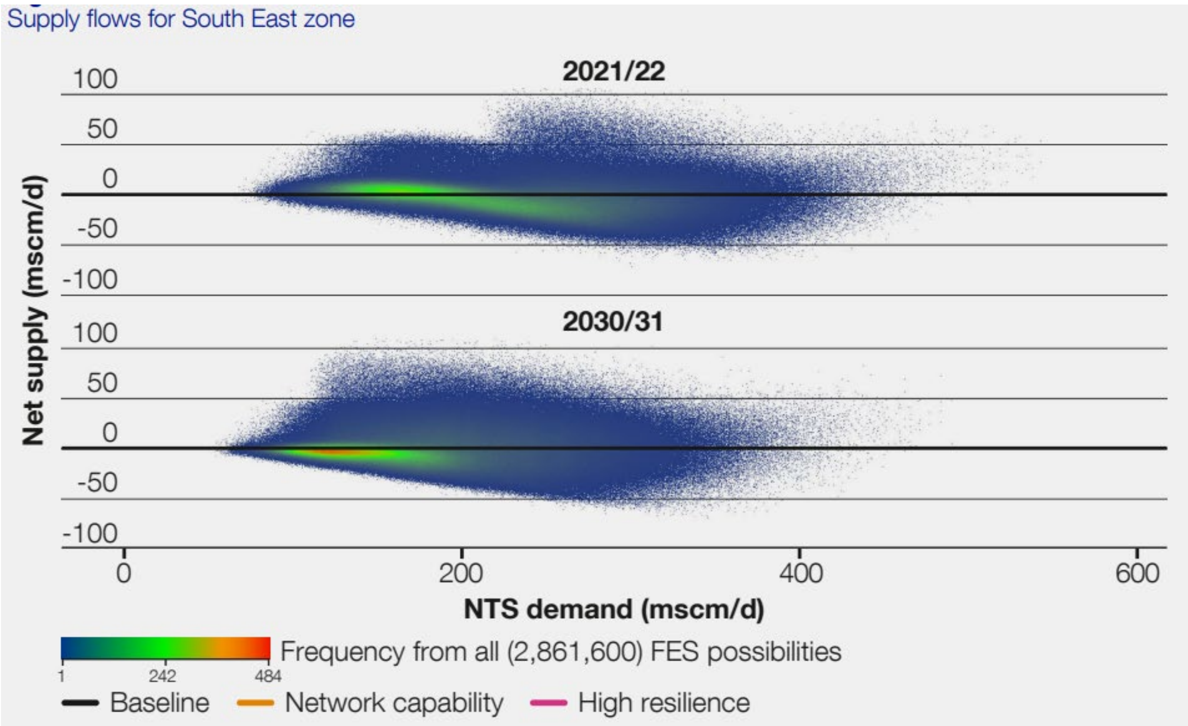


**Figure 12 – Shows supply for South-East Zone**[20]

110. **Figure 12** illustrates the net supplies flows for the South-East zone. This zone has two supply terminals, Bacton and the Isle of Grain. Most of these supplies from these terminals are imports and subject to market conditions. For that reason, we see periods when the zone is over supplied and periods of deficit. To avoid constraints, NTS operations must be able to deal with both extremes that could be realised in the zone. When the zone is in deficit, compression at Peterborough and Huntingdon will be used to move necessary line-pack into the zone. Due to the deficit occurring at the same time as in the South-West, two units will be needed to move the required volumes.

## Network capability - meeting 1-in-20 demand requirements

111. Peterborough and Huntingdon play a crucial role in meeting our Exit capability requirements in the south of the network. The previous sections have shown that Peterborough and Huntingdon are used for zonal transfer to ensure supply and demand is balanced as far and efficiently as possible in each zone, as well was managing line-pack levels in the South due to the large differences in demand and line-pack capability. They are also critical in maintaining exit pressures in the South when demand/flow levels are high, and pressure drops in the feeders increases. In the South-East, Peterborough and Huntingdon operate in combination with Cambridge, Diss and Chelmsford compressors as demand increases. Similarly, in the South-West as demand increases, they work with compression at Lockerley, Wormington and Aylesbury to ensure we can maintain the required exit pressures for our customers and to ensure safe operation of the NTS.

112. **Figure 13** to **Figure 16** show the peak 1-in-20 South-East demands level in each of the FES out to 2030 (blue line). They also show the level of network capability provided

[20] ANCAR 2022, page 51, figure 51 https://www.nationalgas.com/insight-and-innovation/network-capability page

by different compressor combinations. The orange line represents no compression, the yellow line shows the capability with just Peterborough operating (in parallel) and the grey line represents both Peterborough and Huntingdon (both in parallel) working in series. **Figure 17** to **Figure 20** shows the same lines for the South-West. These charts show how long we will need compression at Peterborough and Huntingdon under the different scenarios. For compression to no longer be required at both sites the orange (no compression) line would need to move above the blue line. For only one of the sites to be required the yellow line would need to cross the blue line. And while the grey line is below the blue line additional compression will be required to support Peterborough and Huntingdon in meeting South-East demand and ensuring the safe operation of the network.

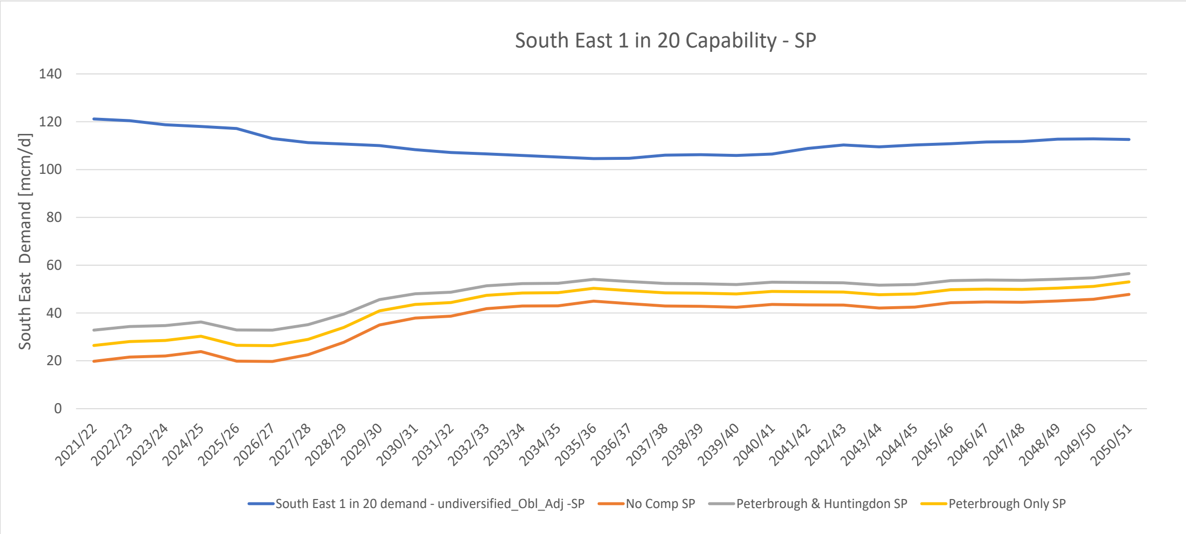


**Figure 13 - South-East 1-in-20 demand forecast along with network capability provision for the SP scenario for various compressor options**

113. **Figure 13** shows that there is continued requirement for Peterborough and Huntingdon beyond 2050 to maintain 1-in-20 compliance under the SP scenario.

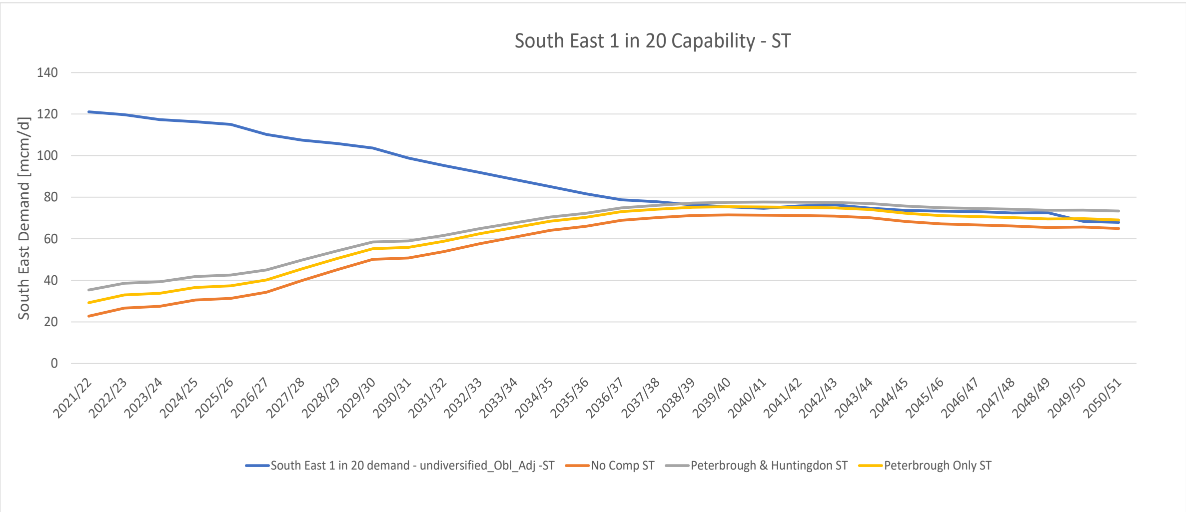


**Figure 14 - South-East 1-in-20 demand forecast along with network capability provision for the ST scenario for various compressor options**

114. **Figure 14** shows that both Peterborough and Huntingdon will be required until the late 2040's to maintain 1-in-20 compliance under the ST scenario. After this date Huntingdon may still be required to provide resilience to Peterborough and provide the necessary flexibility and resilience customers require or the supply/demand mix dictates.

115. **Figure 15** and **Figure 16** show the 1-in-20 peak demand capability required for the LW and CT scenarios. However, we believe the rate of decarbonisation of heat and the move away from methane is overestimated in these scenarios and has little substantiation. Therefore, they underestimate how long we will need compression at Peterborough and Huntingdon to maintain 1-in-20 compliance. For more information see **Section 3** of the CE-AMP document.

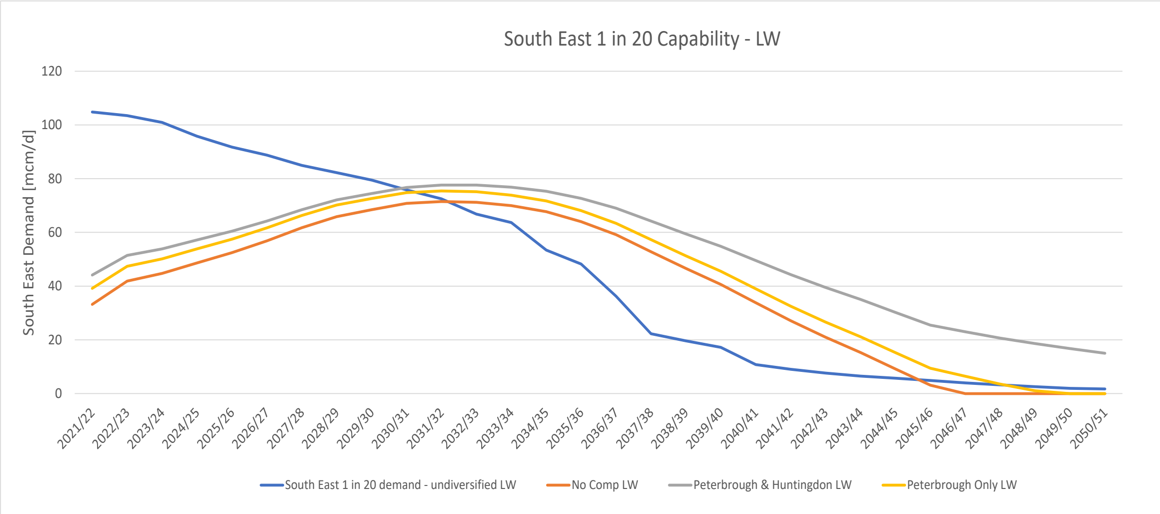


**Figure 15- South-East 1-in-20 demand forecast along with network capability provision for the LW FES scenario for various compressor options**

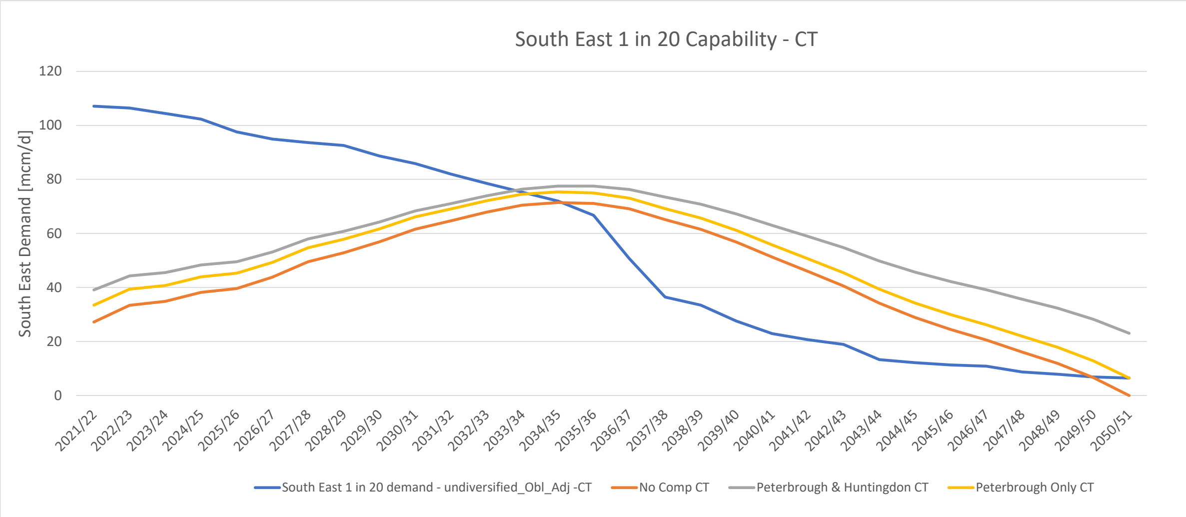


**Figure 16 - South-East 1-in-20 demand forecast along with network capability provision for the CT FES scenario for various compressor options**

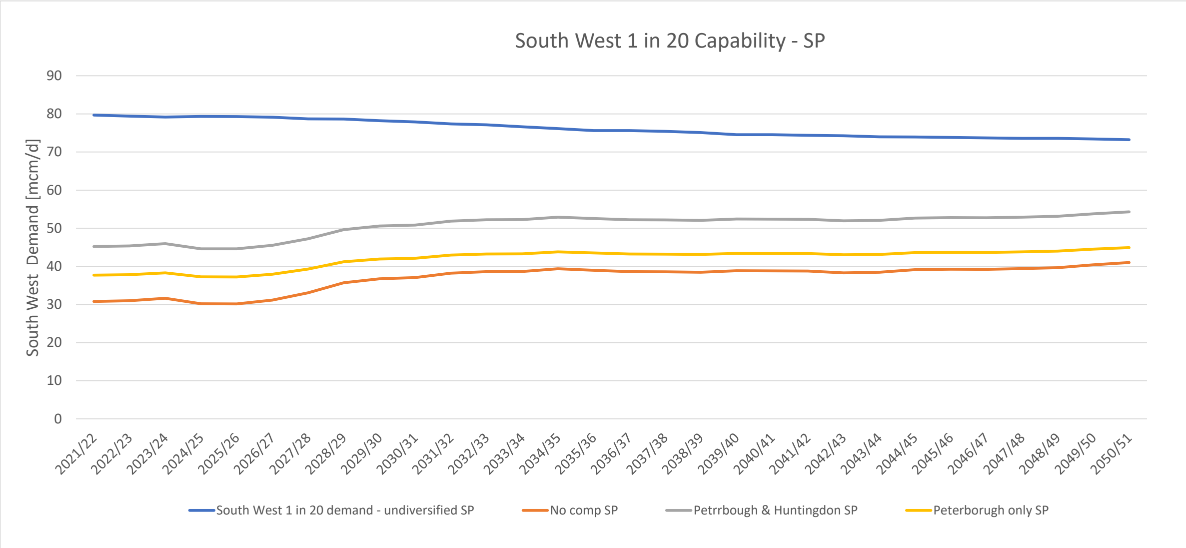


**Figure 17 - South-West 1-in-20 demand forecast along with network capability provision for SP FES scenario for various compressor options**

116. **Figure 17** indicates that there is continued requirement for Peterborough and Huntingdon beyond 2050 to maintain 1-in-20 peak demand capability in the SP scenario.

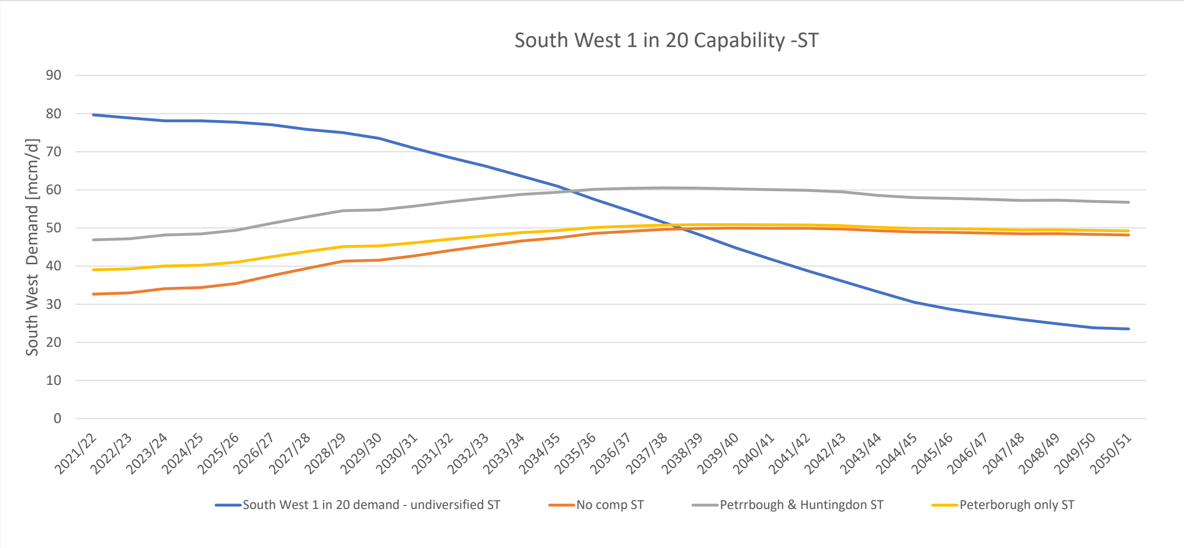


**Figure 18 - South-West 1-in-20 demand forecast along with network capability provision for ST FES scenario for various compressor options**

117. **Figure 18** indicates that Peterborough and Huntingdon will be required until at least 2037 in the South-West to maintain the 1-in-20 peak demand obligation.

118. **Figure 19** and **Figure 20** show the 1-in-20 peak demand capability required for the LW and CT scenarios. However, we believe the rate of decarbonisation of heat away from fossil fuels is overestimated in these scenarios and has little substantiation. Therefore, they underestimate how long we will need compression at Peterborough and Huntingdon to maintain 1-in-20 compliance. For more information see **Section 3** of the CE-AMP document.

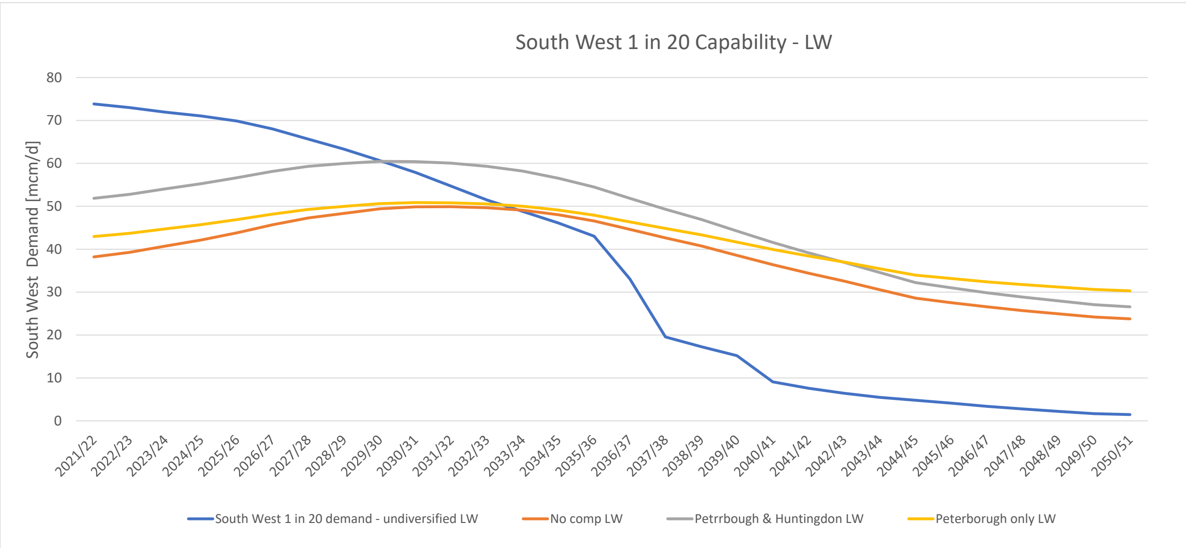


**Figure 19 - South-West 1-in-20 demand forecast along with network capability provision for LW scenario for various compressor options**

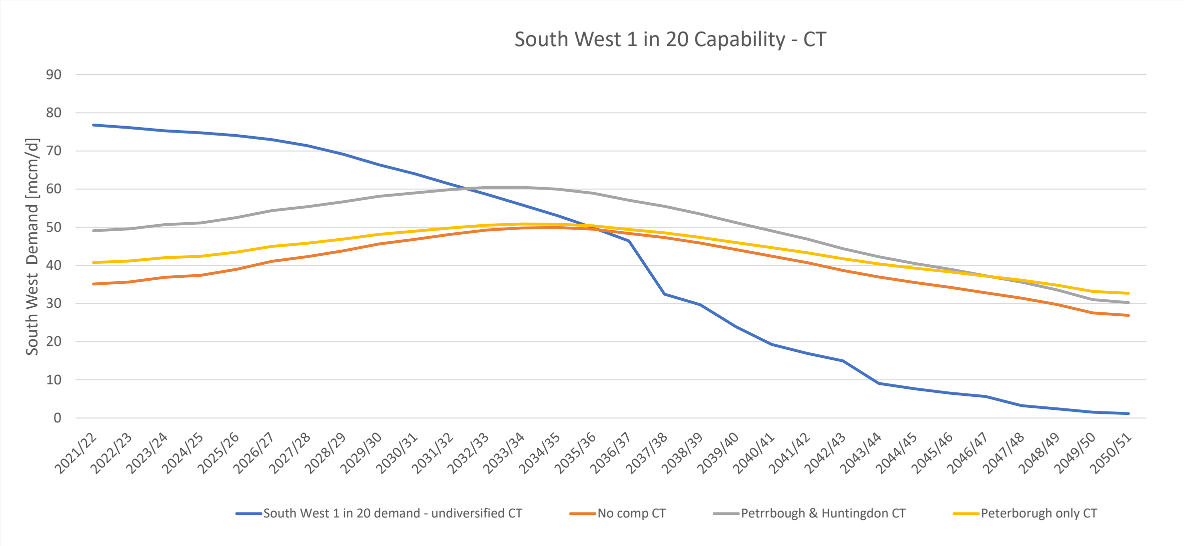


**Figure 20 - South-West 1-in-20 demand forecast along with network capability provision for CT scenario for various compressor options**

## Network Capability and Constraint Risk View

119. Network capability analysis has been carried out using the established process documented in the ANCAR to define the capability of the NTS. The capability analysis results are shown in the form of 'Flame Charts' in **Figure 21** and **Figure 22**. Further details of the capability analysis process and the creation of the Flame Charts are given in our annual publication Gas Ten Year Statement (GTYS) 2021[21], and in our annual ANCAR[22] statement.

120. The Flame Charts contain dots plotted onto the chart where one dot is associated with one day in that year, and for every day there are 7840 alternative supply and demand patterns across the four FES and associated high and low LNG sensitivities[23]. The frequency of a particular flow point is represented by the colouring on the chart, as defined in the chart key. Charts are shown for years 2030 and 2040 showing how we expect supply and demand patterns to change over time, covering the period of focus for the CBA.

[21] https://www.nationalgas.com/insight-and-innovation/gas-ten-year-statement-gtys
[22] https://www.nationalgas.com/insight-and-innovation/network-capability
[23] Within each FES scenario, sensitivities for high continental and high LNG imports are also included, and these are included in the flame charts in this section.

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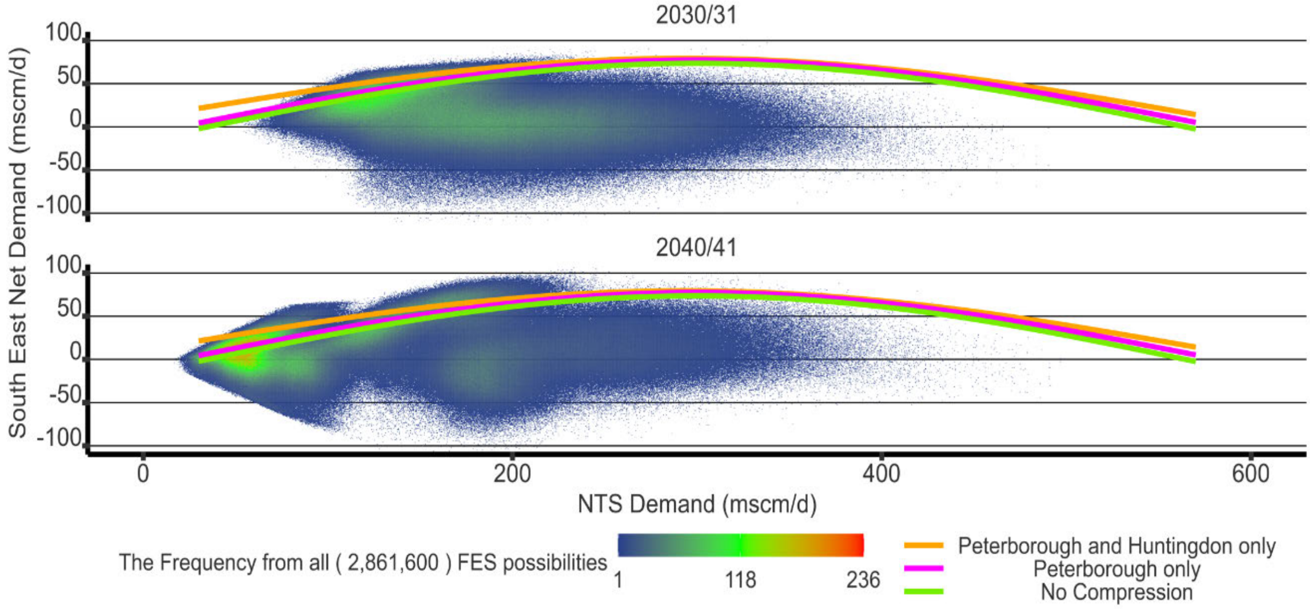
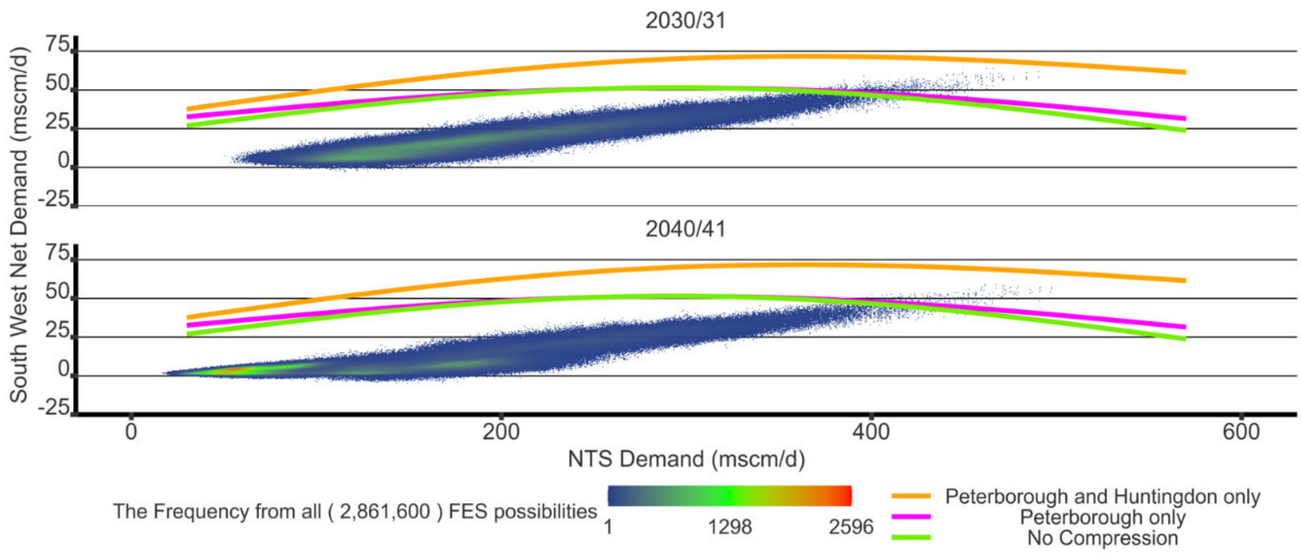



| Constraint Days | 2030/31 P10◄-Avg-►P90 | 2040/41 P10◄-Avg-►P90 |
|---|---|---|
| Peterborough and Huntingdon only | 4 ◄- 7 -► 10 | 20 ◄- 27 -► 34 |
| Peterborough only | 22 ◄- 29 -► 36 | 69 ◄- 80 -► 92 |
| No Compression | 39 ◄- 48 -► 57 | 99 ◄- 113 -► 127 |

**Figure 21 - Net South-East Exit demand capability flame charts for the years 2030/31 and 2040/41- FES 2021 Flows**

121. **Figure 21** shows our network capability in the South-East with different levels of compression based on FES 2021. The lower green line shows our network capability without any compression (other compression outside of the zone being assessed is being operated). The middle pink line shows our network capability with just Peterborough operating and the upper orange line shows our network capability with Peterborough and Huntingdon in operation. The table shows that there is an increasing number of scenarios between 2030 and 2040 when compression is required to support demand and that compression at other sites like Cambridge, Diss and Chelmsford would also be required to support.




| Constraint Days | 2030/31 P10◄-Avg-►P90 | 2040/41 P10◄-Avg-►P90 |
|---|---|---|
| Peterborough and Huntingdon only | 0 ◄- 0 -► 0 | 0 ◄- 0 -► 0 |
| Peterborough only | 0 ◄- 0 -► 0 | 0 ◄- 0 -► 0 |
| No Compression | 0 ◄- 0 -► 0 | 0 ◄- 0 -► 0 |

**Figure 22 - Net South-West Exit demand capability flame charts for the years 2030/31 and 2040/41- FES 2021 Flows**

122. **Figure 22** shows the flame chart with the same compressor combination for the South-West based on FES 2021. This chart shows only a small number of scenarios above the no compression and Peterborough only line at demand levels above 400 mscm/d. This does not mean we no longer need compression, the need at high demand levels being showing in **Figure 17** to **Figure 20**, just that it is unlikely we will see any constraints in terms of not being able to deliver gas to consumers in an average year.

## Compressor Operational strategy and efficiency

123. The flexibility of Peterborough and Huntingdon to support several different roles on the network mean that they are two of the most important sites on the network. In the previous sections we have detailed how they support zonal imbalances and replenish line-pack in multiple different directions and scenarios. As well as being critical to supporting very high demands when they work in combination with compression downstream to ensure 1-in-20 peak demand obligation. For these reason within the operation strategy for the South-East and South-West zones they are the first and second of our priority sites.

124. **Table 8** shows the priority order for compression in the South-East and their zones of influence that the compressors can directly impact. The operational strategy considers the optimal approach for managing zonal imbalances and line-pack and our ability to meet the required network capability. Compression at Peterborough is the first site in operation as it is able to complete multiple roles at the same time. For example, it could be reducing the oversupply in the north of the network, while increasing the line-pack level in the South-West and supporting the refill of storage sites in the North-West. If Peterborough was not available, no other site could complete all those roles resulting

in multiple sites and a less efficient operating strategy being required (see **Section 7.4** for further detail).

| South-East Compressor Priority and Zones of Influence | | |
|---|---|---|
| Priority | Station | Zones of influence |
| Priority 1 | Peterborough (parallel operation) | South-East, South-West, South Wales, North-West, East Midlands |
| Priority 2 | Huntingdon (parallel operation) | South-East, South-West, East Midlands |
| Priority 3 | Cambridge (series operation) | South-East and South-West |
| Priority 4 | Diss (Series operation)<br>Chelmsford (Single) | South-East |

**Table 8 – Shows the Priority order of starting compression based on South-East Compressor Operating Strategy**

125. **Table 9** shows the priority order for compressor in the South-West and their zones of influence. Again, Peterborough is the priority site because of the number of roles it is able to fulfil. Wormington is lower in the South-West strategy with other sites having a bigger impact on network capability and ability to manage line-pack in the South-West zone. Whereas in the South Wales strategy it would be the priority 1 Site.

| South-West Compressor Priority and Zones of Influence | | |
|---|---|---|
| Priority | Stations | Zones of influence |
| Priority 1 | Peterborough (parallel operation) | South-East, South-West, South-Wales, North-West, East-Midlands |
| Priority 2 | Huntingdon (parallel operation) | South-East, South-West, East-Midlands |
| Priority 3 | Lockerley (single) | South-West |
| Priority 4 | Wormington (parallel operation) | South-West, South-Wales, North-West |
| Priority 5 | Aylesbury (single) | South-West |

**Table 9 - Shows the Priority order of starting compression based on South-West Compressor Operating Strategy**

## Compressor Availability

126. The compressor availability, **Table 10** below, used in our assessment has been based on the RAM Model developed in collaboration with [redacted] An overview of the RAM Model and how it has been applied can be found in CE-AMP.

| Unit Availability | Train Type | Availability used in CBA | Aligns with RAM Scenario |
|---|---|---|---|
| Avon 500 Hours with enhancement | Avon | 79.50% | A3 |
| Avon CSRP | Avon | 79.50% | A3 |
| Avon SCR | Avon | 79.50% | A3 |
| Avon DLE | Avon | 74.50% | A3 |
| SGT | SGT-400 | 80.00% | S2 |
| New Unit | TBC | 90.00% | N/A |

**Table 10 - Compressor Availability**

127. [redacted]

128. The CSRP option uses the same scenario and investments (A3) as this is limiting peak temperature and $NO_x$ emissions on the same unit so expect no operational reduction.

129. Avon DLE assumes a 5% reduction on the same A3 scenario reducing availability to 74.5%. It would undertake the same investments, but the technology is unproven in operation and is likely to see commissioning and design issues in the short to medium term. [redacted]

130. For each option, the site availability is defined based on the compressors required to meet the required capability and the availability of the compressors on site for that option. This availability is then adjusted to account for any 500-hour restrictions which may apply, these are calculated for each scenario every five years. These are detailed further in **Appendix B**.

131. Units D and E at Peterborough and Huntingdon which have been installed as part of the ERP3 project and are due for commissioning in 2023 are Solar Titan 130 compressor trains with an assumed availability of 90%. The same availability has been assumed for new units in relevant MCPD options.

## Compressor Utilisation

132. The annual (financial year) running hours of the units at Peterborough and Huntingdon Compressor Stations are shown in **Table 11** below. Due to the partial outage of Peterborough and Huntingdon compressors units in 2019/20, 2020/21 and 2021/22 the runs hours are lower as compared to the previous five years.

133. As indicated in the sections above there are some alternatives that can be used in the absence of Peterborough and Huntingdon compressors in some circumstances, but

those options are less efficient and once the new units are commissioned the run hours will return to the levels seen before 2019.

| Individual Unit Running Hours (Financial Year) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2013/14 | 2014/15 | 2015/16 | 2016/17 | 2017/18 | 2019/20 | 2020/21 | 2021/22 | 2022/23 |
| Peterborough A | 2911 | 2370 | 522 | 30 | 2143 | 827 | 134 | 569 | 1812 |
| Peterborough B | 2186 | 1443 | 1426 | 2451 | 3417 | 1096 | 2 | 1813 | 201 |
| Peterborough C | 2077 | 1576 | 482 | 3221 | 1558 | 466 | 182 | 1897 | 425 |
| Total | 7174 | 5388 | 2430 | 5701 | 7118 | 2389 | 318 | 4279 | 2438 |
| | | | | | | | | | |
| Huntingdon A | 1800 | 865 | 238 | 1635 | 1892 | 595 | 459 | 613 | 449 |
| Huntingdon B | 1237 | 295 | 451 | 1381 | 1082 | 864 | 266 | 1068 | 986 |
| Huntingdon C | 195 | 1116 | 376 | 33 | 9 | 249 | 90 | 146 | 316 |
| Total | 3233 | 2276 | 1065 | 3049 | 2982 | 1708 | 815 | 1827 | 1751 |

**Figure 23 - Run Hours – as reported in the Regulatory Reporting Pack**

134. The predicted hours seen in **Figure 24** are based on the ST scenario in FES 2021 and linked to changes in southern demand. These are used primarily to calculate fuel and emissions in our CBA and do not highlight the full risk of limitations to the hours. In the near term these hours are in line with the levels seen historically with about 7000 hours split between the two sites. These fall off in the 2030s, primarily due to falling demands in the South-East and South-West. The scale of the reduction in demand will depend on future heating strategies and the location of some key large users, such as Hydrogen production facilities and CCUS power stations – changes to these assumptions could increase demand and the need for greater running of Peterborough and Huntingdon.

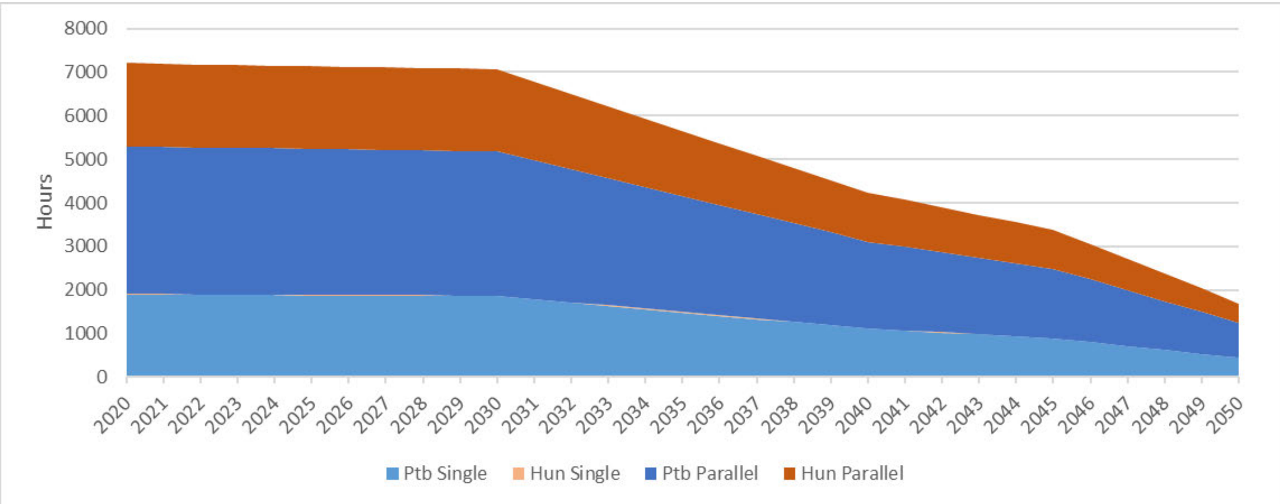



**Figure 24 - Predicted Running Hours ST**

## Summary

135. The Needs Case to retain compression capacity at Peterborough and Huntingdon was established in our RIIO-T2 Business Plan, using FES 2018 data. Updates for this FOSR based on FES 2021 data and associated scenarios, confirms the continued need for Peterborough and Huntingdon Compression until at least 2050. Peterborough and Huntingdon compressors form a vital part of the current and future efficient NTS compressor operational strategy and for maintaining flexibility and reliability in order to respond effectively where the capability requirements may change in the future.

136. Peterborough compressor site is located at the centre of the network and can complete multiple roles at the same time. This flexibility makes it a critical site on the network and critical for us to operate effectively and efficiently.

137. Peterborough and Huntingdon compressors are the starting points for our South-East and South-West compressor operational strategies. Given the flexibility and versatility of the outputs from the compression at Peterborough it is the first site on and the last one off in our operational strategy. If Peterborough was not available, no other single site could complete the same range of roles resulting in multiple sites and a less efficient operating strategy.

138. This flexibility is why the historic run hours are so high and why it is important to ensure sufficient resilience is maintained at the site so that we can continue to operate the system efficiently.

139. Compression will be required at Peterborough and Huntingdon until 2050 in the SP and ST scenarios to ensure effective and efficient operation of the NTS and 1-in-20 peak demand obligation with high utilisation well into the 2040's.

## 4.2. Project Scope Summary

140. Our Final Preferred Option is for one new gas-driven compressor unit at Peterborough and a DLE retrofit at Huntingdon. This will achieve emissions compliance while enabling robust and capable compression at Peterborough and Huntingdon, ensuring resilient long-term operation. **Table 11** provides a summary of the project scope.

| **Location** | Peterborough Compressor Station (Brownfield) | Huntingdon Compressor Station (Brownfield) |
|---|---|---|
| **Final Preferred Option** | One New GT Unit | DLE Retrofit |
| **Unit Detail** | Unit F | Unit C |
| **Year of Commission** | 2029 | 1992 |
| **Number & Size of units** | One medium sized GT compressor (circa 15 MW) | 12.3 MW |
| **Type of unit** | Gas Turbine (GT) | Gas Turbine (GT) |
| **Scope Boundaries** | The scope of this project is for costs associated with the implementation of MCPD emissions compliance.<br><br>At Peterborough, these costs are associated with building one new unit on a brownfield site location and decommissioning one existing Avon compressor. | The scope of this project is for costs associated with the implementation of MCPD emissions compliance.<br><br>At Huntingdon, these costs are associated with upgrading one existing Avon unit to use DLE retrofit technology. |
| **Station Design Discharge Pressure** | 70 barg | 75 barg |
| **Station Suction Trip Pressure** | 37.9 barg | 39 barg |
| **Availability Required** | The optimum level of availability is determined by the cost benefit analysis. | |
| **Supply & Demand Scenario**[24] | All four supply and demand scenarios, from FES 2021, were detailed as part of the scope to examine the effectiveness of each investment option against a wide envelope of future energy outcomes. | |

**Table 11 – Peterborough & Huntingdon Project Scope Summary**

[24] It should be noted that investment business case is driven by ensuring Security of Supply/1-in-20 licence obligation and as such CBA is not a defining factor in preferred final option decision.

# 5. Option Selection

## 5.1. Options Considered

### Introduction

142. As part of NGGT's RIIO-T2 Business Plan submission in December 2019, we proposed to install one new, gas-driven compressor unit at Peterborough and to decommission the existing Avon unit ahead of 2030, following operational acceptance of the new unit. At Huntingdon we proposed to derogate one of the existing units and to decommission the remaining two units. However, due to the uncertainty in this decision and the early stages of the options selection, it was requested that this project be included within our Uncertainty Mechanisms, enabling further option development to be undertaken.

143. The options described within the Peterborough-Huntingdon Engineering Justification Paper (EJP) that supported the RIIO-T2 business plan have been investigated in more detail as part of this Option Selection process including previously discounted options and new Emission Abatement solutions. As outlined within **Section 3,** NGGT have considered the full suite of solutions to achieve the required emissions compliant compression capability that the network is likely to require in the future.

144. This section focuses on the engineering options and commercial rules and tools available to solve the problem described in **Section 3.1** and uses the project scope in **Section 4** to generate plausible engineering solutions. This section will describe the option selection process used to identify the Final Preferred Option for this investment, starting from option identification, through option development to option selection. **Figure 25** below serves to identify the various stages involved in a typical option selection process.

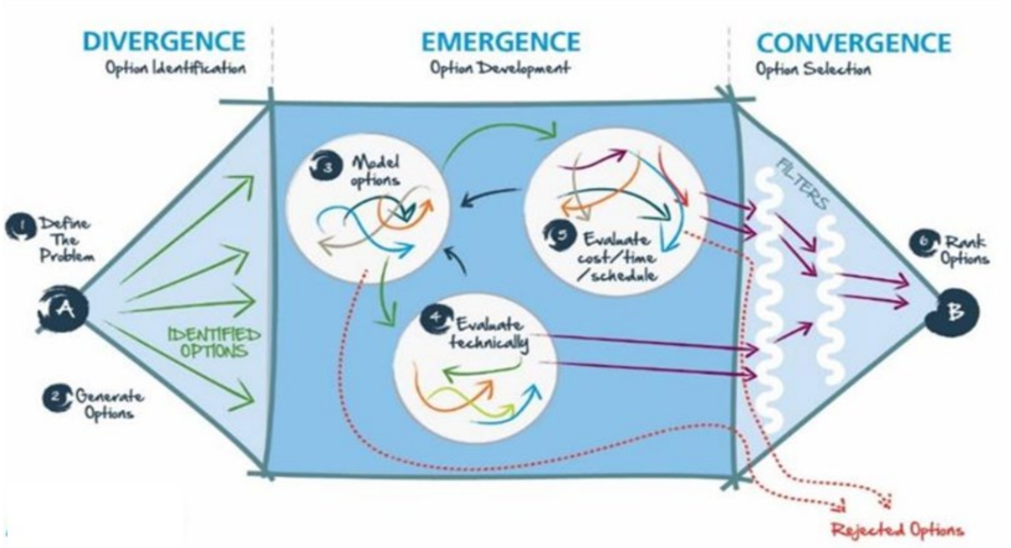



**Figure 25 - Generic Options Selection Process**

### Options Interaction with CBA & BAT

145. The options considered for MCPD compliance are evaluated in a CBA and also via preliminary BAT assessment. Our CBA tool is used to conduct whole life cost benefit analysis using a consistent methodology across all of our investments. The CBA aims to determine the option with the lowest cost to consumers which is represented by the option with the highest NPV.

146. NGGT is legally bound under the Industrial Emissions Directive (IED) to comply with the requirements of BAT in respect of its GT compressor installations on the NTS. The BAT assessment methodology, which was developed by NGGT in discussion with the EA and SEPA, is a stepwise process underpinned by an environmental cost-benefit analysis methodology, which draws together environmental and operational priorities to support decision making. The Preliminary[25] BAT assessment, led by [redacted] ([redacted]), was undertaken separately from the CBA using a different methodology. However, it does incorporate common assumptions on cost (incl. constraint costs) and future gas supply predictions. For more information on the BAT process and result, see **Appendix G**.

147. This section identifies the range of options first considered and outlines the logic used to refine this list into an options shortlist for efficient and robust detailed evaluation and costing. The CBA and BAT are used in conjunction with key investment criteria, technology risks and consideration for capital investment cost to help determine our preferred final option. An option assessment process is used to bring all of these considerations together, please refer to **Section 7** for more detail.

[25] Final BAT will be part of the permit variation submission. For new units, the BAT is also part of the tender process for new units under T/SP/ENV/21 and the Strategic Sourcing Process

## Initial Option Selection & Justification

148. In January 2022, we selected an Option Selection Consultant, [redacted] to support us in identifying and evaluating the feasibility of potential investment solutions. In consultation with [redacted] we have considered the full suite of solutions to enable Peterborough-Huntingdon to comply with MCPD including:

- Investing in a "do minimum" option to improve the site (counterfactual), where the retained units are derogated to run only 500-hours per year from 2030
- delaying our investment decision, to account for uncertainties in the energy landscape
- retrofit or modification of our existing compressors with Emissions Abatement technology to ensure compliance with the MCPD
- building new low-emission, more efficient gas-driven compressors or VSD units

149. NGGT assessed the full range of options above via an engineering study led by [redacted] and supported by other specialist contractors. The complete list of all solutions considered is provided in **Table 12**. This table also includes detail on the solutions which have been discounted from further investigation and the solutions that have been shortlisted. Further detail on how each investment solution has been considered during option selection is provided in the following pages. Please see **Appendix C** for more information on the option evaluation methodology used.

| Investment Solutions | Assessed | Option & Compressor Unit Reference Or Option Discounting Justification | |
|---|---|---|---|
| | | **Peterborough** | **Huntingdon**[26] |
| Derogation<br><br>500-hours Derogation | ✓ | Option 1 "Counterfactual" (Unit A) | Option A "Counterfactual" (Unit C) |
| Emissions Abatement<br><br>Control System Restricted Performance | ✓ | Option 2 (Unit A) | Option B (Unit C) |
| Emissions Abatement<br><br>Selective Catalytic Reduction (SCR) | ✓ | Option 4 (Unit A) | Based on option assessment at Peterborough, SCR was not found to be a favourable option and instead alternative abatement solutions were prioritised for costing at Huntingdon. |
| Emissions Abatement<br><br>Dry Low Emissions (DLE) technology retrofitted to Avon | ✓ | Option 3 (Unit A – 1533) | Option C (Unit C – 1533) |

[26] No technical assessment or evaluation was performed by [redacted] on the Huntingdon Compressor Station. Huntingdon options have been costed only in order to form part of the CBA options.

| | | | |
|---|---|---|---|
| Decommissioning<br><br>Disconnect & Decommission Avon | ✓ | Decommissioning of the remaining Avon has been costed but ruled out of further evaluation based on the requirement for the site to run two units in parallel to achieve 1-in-20 licence obligations. | Decommissioning of the remaining Avon has been costed but ruled out of further evaluation based on the requirement for the site to run two units in parallel to achieve 1-in-20 licence obligations. |
| New Build – Single GT Unit<br><br>New Gas Turbine Compressor, decommission Avon once new unit are operational. | ✓ | Option 5 (Unit F) | New unit investment was not assessed at Huntingdon. Peterborough was prioritised due to its strategic importance and following outcome of 2019 business case. |
| Commercial Actions<br><br>Commercial contracts to manage constraints and to ensure compliance with 1-in-20 licence obligations | ✓ | Contracts not required to ensure 1-in-20 licence obligation. Value of entry constraint calculated for all options. | |
| New Build – Single VSD<br><br>One new 15 MW Electric Drive Compressor, decommission Avon once new unit is operational. | ✓ | Assessed but discounted during Option Selection consultation due to high development costs and schedule risk due to requirement for new high voltage (HV) incomer | New unit investment was not assessed at Huntingdon. Peterborough was prioritised due to its strategic importance and following outcome of 2019 business case. |
| Emissions Abatement Mixing<br><br>Combinations of abatement technology (SCR + CSRP, etc.) | ✓ | Assessed through combination of Peterborough and Huntingdon options within CBA | |
| Deferral<br><br>Delaying option investment | ✗ | No opportunities for investment deferral have been identified. See below for additional context. | |

**Table 12 - Full List of Investment Solutions**

150. In order to evaluate the impact of no further investment at Peterborough & Huntingdon, NGGT have included the “counterfactual” or “do minimum” investment option in our CBA **(Option 1; Table 14 and Table 15)**. It should be noted that while the counterfactual option considers no additional capital investment, asset health investment is still necessary to ensure reliable unit operability beyond 2030. Should no investment be made to achieve MCPD compliance by 1 January 2030, both existing Avon’s will fall into Emergency Use Derogation (EUD) where they will be limited to 500-hours run time per year.

151. We have considered several Emission Abatement innovation technologies, which can be used in isolation or in combination with new build units, to reduce $NO_x$ emissions. Control System Restricted Performance (CSRP), Dry Low Emissions (DLE) and Selective Catalytic Reduction (SCR) Emission Abatement technologies have been investigated through dedicated external studies and performance trials. All three abatement solutions have been evaluated in detail at Peterborough. Based on option assessment at Peterborough, SCR was not found to be a favourable option and instead alternative abatement solutions were prioritised for costing at Huntingdon.

152. It should be noted that, as DLE retrofit has not yet been technically proven on the NTS, there are risks surrounding its selection and implementation. It is discussed in **Section 3.1** that NGGT are currently running controlled performance trials on DLE technology with a view to permanently installing a unit on the NTS for more established operational running. Once 10,000 operational hours have been built up (including a full review and inspection) the technology will be recommended for utilisation at high run hour sites across the NTS. Please see **Appendix F** for further context surrounding risk identification for this and other technologies.

153. Similarly, CSRP is an innovative control system modification which has not been implemented on the NTS previously. Solution implementation is dependent on gaining environmental permit approval from the Environment Agency (EA). Due to the uncertainty of achieving permit approval based on CSRP implementation, permit pre-application discussions are currently in progress with the EA to understand their acceptance of the solution. These discussions will help define the likelihood of CSRP permit approval although, as CSRP implementation is very unit-specific, permit approval at one compressor station won't guarantee permit approval at all compressor stations, therefore the solution carries inherent risk.

154. Peterborough and Huntingdon compression is currently provided by 3 Avon driven compressor trains at each site. Two of the three compressors (B and C at Peterborough and A and B at Huntingdon) will be decommissioned following successful commissioning of the Solar Titan 130s currently being installed as part of the ERP3 project. Costs for this decommissioning is included in the RIIO-T2 allowances under the "redundant assets" theme.

155. Consideration for the decommissioning of the remaining non-compliant units at both sites has been considered in optioneering however, a back-up third unit is required based on the requirement for the site to run two units in parallel to achieve 1-in-20 licence obligations. Therefore, options considering the reduction of the site to just two running units have been discounted from further evaluation. In the case of options featuring new unit installation, the timing of decommissioning works is likely to be post-2030 once new units have been commissioned ahead of the MCPD legislation deadline.

156. We have not considered investment deferral as part of our options selection evaluations. Both sites contain one non-MCPD compliant unit each and delay past 2030 would place both of these units under 500-hours derogation. Peterborough and Huntingdon need to provide parallel running to achieve 1-in-20 peak demand licence obligations and deferring this investment to a later date has not been considered within the optioneering scope of this project. Additionally, any deferral analysis would assess the economic impact of delaying the construction of a new compressor. Given that the provision of an unrestricted third unit is critical to provide resilience, for which an economic argument cannot be easily defined, Real Option Analysis is not considered to be an appropriate tool.

157. Partial or complete investment deferral could be beneficial where short term solutions can be implemented to maintain minimum required capability until further certainty of long-term capability requirements is known. However, delaying investment may result

in higher overall spend and/or unacceptable levels of capability in the short term. The relatively long investment programme durations, particularly for new unit installation also need to be factored into any deferral considerations.

158. At Peterborough and Huntingdon any delay in investment would result in a reduction in compression capability/resilience from the 2030 MCPD legislative deadline and therefore no deferral options have been evaluated.

159. **Section 4.2** outlines the continued importance of Peterborough and Huntingdon to providing network capability and flexibility now and into the future. Due to its multi-directional compression capabilities and central network location, Peterborough is considered an important strategic site which, in tandem with Huntingdon, enables efficient transmission of gas to South-East and South-West zones. Given the importance of Peterborough, this investment report has prioritised option evaluation at the site and for simplicity and cost-effectiveness has not considered new unit investment at Huntingdon. Please see Section 7 for additional context.

160. A single new build brownfield option was considered at Peterborough site (Option 5). New unit to be installed on Plinth F which was developed for the third unit originally planned for installation as part of the ERP3 construction project in 2021/22. Plinth F is located immediately alongside units D & E, see **Figure 26**. For additional information on the selection of site location for the new build unit and engineering layout drawings, please see the Engineering Report, **Appendix C**.

[redacted]

**Figure 26 – Selected Location for New Compressor (Peterborough)**

161. All options have included consideration of rules and tools which may be available as an alternative to proposed capital investment. In this context, amendments to rules relate to code changes. With these being relevant to all sites, no code rule changes have been identified for Peterborough or Huntingdon which would also be appropriate to all other sites. Regarding available tools, in all options there are no commercial contracts required to ensure compliance with the 1-in-20 design standard. Network Entry constraints would be managed using existing tools.

162. Replacement of Avon Unit A with new electric driven compression has been considered for Peterborough. The cost for an electric VSD compressor was c.25% more than for an equivalent GT driven compressor installation at Peterborough (based on ±50% cost estimates. There were also additional schedule risks associated with the provision of an HV supply. Therefore, at this stage a GT driven compressor is preferred for new unit options at Peterborough. However, further review will be conducted during FEED to confirm driver selection including more accurate costs for the HV connection which contribute a significant proportion of the cost for the VSD option. For the purposes of option selection described in this report the new unit option at Peterborough is based on a GT driven compressor but this can be considered broadly representative of a GT or VSD driven compressor.

163. To understand existing unit condition (availability) and how specific asset health interventions impact unit availability, we evaluated site-specific asset health interventions for both Peterborough and Huntingdon. The asset health scopes are aligned to the recommendations of the Reliability Availability Maintainability (RAM) model, which we commissioned [redacted] to develop, which evaluated unit availability across the entire NGGT fleet. These unit availability statistics are a key CBA input, see **Appendix B** for the site-specific availability model, which ultimately influences network capability, constraint cost and informs the NPV for each particular option.

## Final Option Selection & Short-Listing

164. Following on from the analysis performed on the full list of investment solutions, a shortened options list was derived where each of the main solutions (derogation, abatement, new build, etc.) is represented. These key options and detail on which units they have been applied across can be seen in **Table 13** (Peterborough) and Table **14** (Huntingdon) below. Additional sensitivities were assessed as part of the CBA case studies and are described in **Section 7**.

| Peterborough Costed Option Shortlist | Unit A | Unit B | Unit C | Unit D | Unit E | Unit F |
|---|---|---|---|---|---|---|
| **1 – Counterfactual** | 500Hr EUD | Removed | Removed | No Change | No Change | / |
| **2 - 1 x CSRP** | CSRP Retrofit | Removed | Removed | No Change | No Change | / |
| **3 - 1 x 1533 DLE** | 1533 DLE Retrofit | Removed | Removed | No Change | No Change | / |
| **4 – 1 x SCR** | SCR Retrofit | Removed | Removed | No Change | No Change | / |
| **5 - 1 x New Unit** | Decom. | Removed | Removed | No Change | No Change | New Unit (Brownfield) |

**Table 13 – Costed Option Shortlist Peterborough**

| Huntingdon Costed Option Shortlist | Unit A | Unit B | Unit C | Unit D | Unit E | Unit F |
|---|---|---|---|---|---|---|
| **A – Counterfactual** | Removed | Removed | 500Hr EUD | No Change | No Change | / |
| **B - 1 x CSRP** | Removed | Removed | CSRP Retrofit | No Change | No Change | / |
| **C - 1 x DLE** | Removed | Removed | DLE Retrofit 1533 | No Change | No Change | / |

**Table 14 - Costed Option Shortlist Huntingdon**

### Option Descriptions

165. Option 1/Option A is the counterfactual which considers no future emissions related capital investment. By 1 January 2030, the non-MCPD compliant unit(s) will be placed under limited run time (500-hours EUD) for the rest of its remaining life. This option contains asset health investment to ensure unit reliability from 2030.

166. Option 2/Option B considers control system modifications or restriction (CSRP) on the non-MCPD compliant unit.

167. Option 3/Option C considers modifying the existing unit with DLE technology.

168. Option 4 considers SCR system modification to Peterborough A only.

169. Option 5 involves a new emissions compliant gas-driven compressor unit on a brownfield location. The existing Unit A is recommended to be decommissioned once the new unit is operational.

## Option Assessment Criteria

170. Detailed descriptions of each considered option can be found in **Section 5.2**. Within this section, each option is discussed according to the following criteria:

- Option Description
- Cost Breakdown
- Commercial Actions
- Option BAT Assessment Scoring
- Option Risks

171. Option description provides context on the main features of the option.

172. Each option is provided with a cost breakdown table where total installed cost, asset health cost, operating cost, decommissioning and constraint costs are defined. Additional detail on the cost basis for each option can be found in **Section 6.2.**

173. The presence of any commercial contracts available to manage constraints and ensure compliance with 1-in-20 peak demand obligation is detailed within "commercial actions".

174. A breakdown of the option preliminary BAT[27] assessment scores is also provided to give the reader additional context on the technical and environmental benefits & limitations for each option. The BAT assessment consists of a series of importance weighted technical and environmental criteria, against which each option is scored, see **Table 15**. BAT assessment scores and weighting were qualitatively determined by representative business stakeholders. Scores are not intended to be used to determine the Final Preferred Option but to support the decision-making process in parallel with cost benefit analysis. For detailed information on the BAT assessment, please see **Appendix G**.

| Technical Criteria: | 65% |
|---|---|
| Versatility | 15% |
| Future Proofing | 15% |
| Ownership | 13% |
| Constructability | 7% |
| Environmental Amenity | 10% |
| Hazard | 5% |
| Environmental Criteria: | 35% |
| Emissions (NOx = 20%; CO2 = 10%; CO = 5%) | 35% |

**Table 15 - BAT Assessment Technical & Environmental Comparison Criteria**

175. The technical and environmental criteria are defined as follows:

[27] National Grid is legally bound under the Industrial Emissions Directive (IED) to comply with the requirements of BAT in respect of its gas turbine compressor installations. Beyond this, National Grid made a policy decision in 2013 that BAT would be the primary selection mechanism for all new and substantially modified compressor machinery trains. The BAT assessment methodology has been developed by National Grid in consultation with the Environment Agency (EA) and Scottish Environment Protection Agency (SEPA).

- **Versatility** refers to the extent and usability of the MCPD emissions compliant compressor envelope. This criterion is a combination of unit capability and availability to meet the pre-defined Process Duty Specification (PDS) points.
- **Future Proofing**[28] is defined as the headroom above current emission limits and performance against anticipated energy efficiency levels which may be contained in a future BAT Reference (BREF)[29] Document.
- **Ownership** refers to maintenance complexity and the availability of spares for the compressor unit(s).
- **Constructability** refers to the ease of construction and potential for disruption to existing site operations. Also considers number of outage periods required.
- **Environmental Amenity** refers to the potential for visual impact and noise concerns resulting from the selected option.
- **Hazard** refers to perceived risk to the environment.
- **Emissions** criteria refers to predicted $NO_x$, $CO_2$ & CO emissions for each technology solution.

176. A breakdown for option technical (65%) and environmental (35%) scores across all options can be found in Figure 27 as well as a consolidated score breakdown in *Table 32.*

177. A semi-quantitative risk assessment methodology has been used to provide an indication of the relative level of risk associated with each option. Each identified risk is quantified in terms of probability of occurrence and severity of impact in order to determine an overall risk classification. Risks were classified as; Negligible, Minor, Significant, Major or Critical. Within **Section 5.2** only the highest risks are referenced within the discussion. The Peterborough risk report and project risk register can be found in **Appendix F**. Discussion on risks associated only with the Final Preferred Option can be found in **Section 8.3**. It should be noted that the cost estimate has not been adjusted based on the output of the risk assessment process.

178. Level 2 delivery programmes have been used to determine deliverability within outage constraints and estimate capital spend profile for each option. All investments are planned to meet the legislative deadline of 1 January 2030. These programmes were also used to estimate capital spend profile for each option. The cost Re-opener planned for June 2025 will be supported by a more detailed delivery programme for the selected option based on an appropriate delivery strategy. The Level 2 programme for the Final Preferred Option can be found in **Section 8.2** while the project programme report can be found in **Appendix E**.

179. For information on the CBA and sensitivities used, please see **Section 7.3.**

180. Regarding considerations for solution design life within option selection, unit design life varies depending on the asset element in question. **Figure 27** below outlines the

[28] Future Proofing does not contain consideration for future unit hydrogen compatibility due to the lack of defined requirements associated with future hydrogen compression on the NTS and targets for blend composition.
[29] The UK environment agencies have indicated that any forthcoming BAT Reference (BREF) document may contain energy efficiency targets

design life requirements for each new compressor asset on the NTS. For example, Protection and Control Systems have a design life of 15 years and therefore replacement will be required and has been considered during the CBA period. All other new assets installed as part of the MCPD project will have a design life greater than the CBA period and replacement cost has therefore not been included. Routine maintenance and estimated ad-hoc repairs have also been included in cost estimates included in the CBA.

| Asset | Life (years) |
|---|---|
| Compressors | 40 |
| Gas Generators | 20 |
| Power Turbines | 25 |
| Pipework and Valves | 30 |
| Protection and Control Systems | 15 |
| Enclosures and Buildings | 60 |

**Figure 27 - T/PM/Comp/20 Asset Design Life[30]**

## Option Summary Tables

181. Summary tables of the main options considered, including costs and BAT scores can be found within **Section 5.3**.

[30] Section 11; T/PM/COMP/20 - Management Procedure for Compressor Installations for the National Transmission System

## 5.2. Main Option Breakdown

### Option 1 – Counterfactual (1 x 500-Hours Derogation)

**Option Description**

182. This option maintains Avon Unit A until 31 December 2029 and places it on 500-hours EUD from 1 January 2030.

**Cost Breakdown**

183. The cost breakdown of the option is given in **Table 16.**

| Option Cost Comparison Table (18/19 Prices) | Project Start Date | Project Finish Date | Total Installed Cost (£m) | Initial Asset Health Cost (£m) | Ongoing Asset Health Cost (£m) | Operating Cost (£m/pa) | Decom. Cost (£m) | Capex Cost Accuracy |
|---|---|---|---|---|---|---|---|---|
| 1 – Counterfactual | 2019 | 2027 | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | ±30% |

**Table 16 - Option 1: Cost Breakdown**

**Cost Basis**

184. Initial asset health costs consider investments which are required to ensure units are of sufficient reliability to operate effectively from 1 January 2030. Ongoing asset health costs concern investments necessary to ensure future running from 2030 to 2050. More detail can be found in the **Appendix D**.

185. Please see **Section 6** for commentary on how the cost estimate for this option was developed.

**Option Programme**

186. The project start date is the NGGT 2019 RIIO-T2 business plan submission to develop the final preferred investment option. Project finish date represents the year commissioning activities are planned to take place. Level 2 delivery programmes can be found in **Appendix E** for more details on option timeline.

**Commercial Actions**

187. There are no commercial contracts required to ensure compliance with the 1-in-20 design standard for this option. Network Entry constraints would be managed using existing tools, and these constraint costs would be expected to be significant once the derogations start in 2030.

**BAT Assessment Scores**

188. A high-level view of how the option was scored from a technical, environmental and emissions perspective is summarised in **Table 18**. A full table describing the BAT scores across all options can be found in **Section 5.3** to enable comparison across options. See **Appendix G** for how the BAT scores were established.

189. The lead configuration for all options would be one fully compliant DLE unit (new unit or Solar T-130) either operating singularly or in parallel with another fully compliant DLE unit (new unit or Solar T-130). As such there is negligible difference in performance

between options in the lead configuration and therefore BAT assessment has been conducted based on the back-up configuration. It should be noted that overall performance of the site must take into consideration the availability of compressors and number of run hours that the site would operate in back up configuration. This is considered in the CBA and business case assessment discussed in **Section 7**. For further detail please see the BAT Report (**Appendix G**).

190. In this option the lead configuration would involve operation of one or both T-130s with back-up provided by the Avon on a 500-hour per year derogation to be utilised when parallel operation is required and one of the T-130s is unavailable. The scores below represent backup parallel operation (i.e. 1 off T-130 and 1 off Avon).

| Investment Option BAT Assessment Scores | Versatility | Future Proofing | Ownership | Constructability | Environmental Amenity | Hazard | Emissions (NOx, CO2, CO) | Total Score |
|---|---|---|---|---|---|---|---|---|
| **1 – Counterfactual (1 x T130 + 500 Hrs)** | 3% | 0% | 10% | 4% | 10% | 4% | 13% | 44% |
| **Score Sub-Total** | **15/65%** | **15/65%** | **13/65%** | **7/65%** | **10/65%** | **5/65%** | **35/35%** | **100%** |

**Table 17 - Option 1: BAT Score Breakdown**

191. **Versatility:** This solution was scored 3% out of 15% as it is critically constrained by the 500-hours limitation.

192. **Future Proofing**: This solution was scored 0% out of 15% as it achieves current emissions limits but with no headroom for future increases in legislation (emissions or energy efficiency).

193. **Ownership**: This solution was scored 10% out of 13% as the Avon's have acceptable service agreements in place for maintenance and there is a medium availability of spares. However, score has been discounted due to the age of the Avon units and the likelihood for increased maintenance intervention.

194. **Constructability**: This solution was scored 4% out of 7% as it involves the following two outage periods:

- Outage A: Unit A compressor overhaul & refurbishment
- Outage B: Unit A control system installation

195. **Environmental Amenity**: This solution was scored 10% out of 10% as the solution was determined unlikely to introduce a new amenity risk.

196. **Hazard**: This solution was scored 4% out of 5%. Oil containment is to National Grid standards and asset health investment will upgrade system to use dry gas seals. However, solution cannot effectively design out all significant environmental risks.

197. **Emissions**: This solution was scored 13% out of 35% (3/20 $NO_x$; 10/10 $CO_2$; 0/5 CO) for emissions compliance due to the fact that $NO_x$ emissions are not curtailed through

system modification or power reduction, but a limitation placed on run hours. The Avon unit in this solution still has the potential to exceed $NO_x$ emissions limits.

198. **Emissions**: This solution was scored 13% out of 35% (3/20 $NO_x$; 10/10 $CO_2$; 0/5 CO) for emissions compliance due to the fact that $NO_x$ emissions are not curtailed through system modification or power reduction, but a limitation placed on run hours. The Avon unit in this solution still has the potential to exceed $NO_x$ emissions limits.

**Risks**

199. Please see **Appendix F** for more detail on the risks defined for this option. The highest rated risks are identified below.

200. **Major**: The existing Avon units are over 30 years old. This brings increased asset health maintenance exposure and higher probability of unavailability due to technical issues (CM-1)

201. **Major**: Re-use of existing underground production piping. As no underground piping survey has been carried out, there is potential for more extensive damage or lower integrity of pipework than currently expected. Potential for capex increase. (CM-4)

202. **Major**: Country specific and worldwide geopolitical issues affecting the supply & cost of equipment, materials and workforce. (CPO-11)

203. **Opportunity**: Opportunity for future change to hydrogen production. (CPO-5)

204. **Opportunity**: Opportunity to utilise existing ERP3 construction area to save on mob/demob costs before land is sold back to the farmer (CPO-3A)

## Option 2 – One Derated (CSRP) Avon

### Option Description

205. This option considers restricting high power running of Avon Unit A through control system modifications to limit its performance and thereby reduce $NO_x$ emissions to within acceptable limits.

206. This option would necessitate a control system software modification to limit Exhaust Cone Temperature which has been proven, via a CSRP performance trial, to correlate with $NO_x$ emissions. This control system software update is controlled by the G/35 management of change process which ensures that the governor controller setpoints cannot easily be returned back to their original settings.

207. Solution implementation is dependent on gaining environmental permit approval from the Environment Agency (EA). See **Section 5.1** for additional context.

### Cost Breakdown

208. The cost breakdown for the option is given in **Table 18 -** Option 2: Cost Breakdown.

| Option Cost Comparison Table (18/19 Prices) | Project Start Date | Project Finish Date | Total Installed Cost (£m) | Initial Asset Health Cost (£m) | Ongoing Asset Health Cost (£m) | Operating Cost (£m/pa) | Decom. Cost (£m) | Capex Cost Accuracy |
|---|---|---|---|---|---|---|---|---|
| 2 - 1 x CSRP | 2019 | 2027 | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | ±30% |

**Table 18 - Option 2: Cost Breakdown**

### Cost Basis

209. Initial asset health costs consider investments which are required to ensure units are of sufficient reliability to operate effectively from 1 January 2030. Ongoing asset health costs concern investments necessary to ensure future running from 2030 to 2050. More detail can be found in the **Appendix D.**

210. Please see **Section 6** for commentary on how the cost estimate for this option was developed.

### Option Programme

211. The project start date is the NGGT 2019 RIIO-T2 business plan submission to develop the final preferred investment option. Project finish date represents the year commissioning activities are planned to take place. Level 2 delivery programmes can be found in **Appendix E** for more details on option timeline.

### Commercial Actions

212. There are no commercial contracts required to ensure compliance with the 1-in-20 design standard for this option. Network Entry constraints would be managed using existing tools, and these constraint costs would be expected to be significant once the derogations kick in from 2030.

**BAT Assessment Scores**

213. A high-level view of how the option was scored from a technical, environmental and emissions perspective is summarised in **Table 19 - Option 2: BAT** Assessment Breakdown**).** A full table describing the BAT scores across all options can be found in **Section 5.3** to enable comparison across options. See **Appendix G** for how the BAT scores were established.

214. The lead configuration for all options would be one fully compliant DLE unit (new unit or Solar T-130) either operating singularly or in parallel with another fully compliant DLE unit (new unit or Solar T-130). As such there is negligible difference in performance between options in the lead configuration and therefore BAT assessment has been conducted based on the back-up configuration. It should be noted that overall performance of the site must take into consideration the availability of compressors and number of run hours that the site would operate in back up configuration. This is considered in the CBA and business case assessment discussed in **Section 7**. For further detail please see the BAT Report (**Appendix G**).

215. In this option the lead configuration would involve operation of one or both T-130s with back-up provided by the Avon updated with CSRP to be utilised when parallel operation is required and one of the T-130s is unavailable. The scores below represent backup parallel operation (i.e. 1 off T-130 and 1 off CSRP Avon).

| Investment Option<br>BAT Assessment Scores | Versatility | Future Proofing | Ownership | Constructability | Environmental Amenity | Hazard | Emissions (NOx, CO2, CO) | Total Score |
|---|---|---|---|---|---|---|---|---|
| 2 - 1 x CSRP<br>(1 x T130 + CSRP) | 9% | 0% | 10% | 4% | 10% | 4% | 13% | 50% |
| Score Sub-Total | 15/65% | 15/65% | 13/65% | 7/65% | 10/65% | 5/65% | 35/35% | 100% |

**Table 19 - Option 2: BAT Assessment Breakdown**

216. **Versatility:** This solution was scored 9% out of 15% as it contains sufficient power to meet all the PDS points but is not as versatile as a new compressor unit.

217. **Future Proofing**: This solution was scored 0% out of 15% as it achieves current emissions limits but with no headroom without further significant performance restriction implications for future increases in legislation (emissions or energy efficiency).

218. **Ownership**: This solution was scored 10% out of 13% as the Avon has acceptable service agreements in place for maintenance and there is a medium availability of spares. However, solution has been discounted due to the age of the Avon unit and the likelihood for increased maintenance intervention.

219. **Constructability**: This solution was scored 4% out of 7% as it involves the following two outage periods:

- Outage A: Unit A compressor overhaul & refurbishment
- Outage B: Unit A control system installation

CSRP software modification is targeted to take place during control system installation to minimize the impact on site operation.

220. **Environmental Amenity**: This solution was scored 10% out of 10% as the solution was determined unlikely to introduce a new amenity risk.

221. **Hazard**: This solution was scored 4% out of 5%. Oil containment is to National Grid standards and asset health investment will upgrade system to use dry gas seals. However, solution cannot effectively design out all significant environmental risks.

222. **Emissions**: This solution was scored 13% out of 35% (3/20 $NO_x$; 10/10 $CO_2$; 0/5 CO) for emissions compliance due to the fact that $NO_x$ emissions are reduced through restricting power output and not curtailed through more efficient unit running.

**Risks**

223. Please see **Appendix F** for more detail on the risks defined for this option. The highest rated risks are identified below.

224. **Critical:** Coordination and alignment between internal stakeholders. Potential for delay in gaining alignment on a preferred option (CPO-8)

225. **Major:** The existing Avon units are over 30 years old. This brings increased asset health maintenance exposure and higher probability of unavailability due to technical issues (CM-1)

226. **Major**: Re-use of existing underground production piping. As no underground piping survey has been carried out, there is potential for more extensive damage or lower integrity of pipework than currently expected. Potential for capex increase. (CM-4)

227. **Major**: Country specific and worldwide geopolitical issues affecting the supply & cost of equipment, materials and workforce. (CPO-11)

228. Significant: Potential that CSRP is not approved by Environment Agency (EA), resulting in rejection of permit request (HSSE-11)

229. **Opportunity**: Opportunity for future change to hydrogen production. (CPO-5)

230. **Opportunity**: Opportunity to utilise existing ERP3 construction area to save on mob/demob costs before land is sold back to the farmer (CPO-3A)

## Option 3 – One Avon DLE Retrofit (1533)

### Option Description

231. This option involves retrofitting Avon Unit A with DLE technology.

232. Unit A modification with DLE technology involves replacement of the combustion system in the gas generator with DLE combustors, a modified engine casing and modifications to the fuel supply system and associated controller

233. It should be noted that, as DLE retrofit has not yet been technically proven on the NTS, there are risks surrounding its selection and implementation. See **Section 5.1** for additional context.

### Cost Breakdown

234. The cost breakdown of the option is given in **Table 20.**

| Option Cost Comparison Table (18/19 Prices) | Project Start Date | Project Finish Date | Total Installed Cost (£m) | Initial Asset Health Cost (£m) | Ongoing Asset Health Cost (£m) | Operating Cost (£m/pa) | Decom. Cost (£m) | Capex Cost Accuracy |
|---|---|---|---|---|---|---|---|---|
| 3 - 1 x 1533 DLE | 2019 | 2027 | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | ±30% |

**Table 20 - Option 3: Cost Breakdown**

### Cost Basis

235. Total Asset Health Cost is a combination of “initial” & “ongoing” asset health. Initial asset health costs consider investments which are required to ensure units are of sufficient reliability to operate effectively from 1 January 2030. Ongoing asset health costs concern investments necessary to ensure future running from 2030 to 2050. More detail can be found in the **Appendix D**.

236. Please see **Section 6** for commentary on how the cost estimate for this option was developed.

### Option Programme

237. The project start date is the NGGT 2019 RIIO-T2 business plan submission to develop the final preferred investment option. Project finish date represents the year commissioning activities are planned to take place. Level 2 delivery programmes can be found in **Appendix E** for more details on option timeline.

### Commercial Actions

238. There are no commercial contracts required to ensure compliance with the 1-in-20 design standard for this option. Network Entry constraints would be managed using existing tools, and these constraint costs would be expected to be significant once the derogations kick in from 2030.

### BAT Assessment Scores

239. A high-level view of how the option was scored from a technical, environmental and emissions perspective is summarised in **Table 21**. A full table describing the BAT scores

across all options can be found in **Section 5.3** to enable comparison across options. See **Appendix G** for how the BAT scores were established.

240. The lead configuration for all options would be one fully compliant DLE unit (new unit or Solar T-130) either operating singularly or in parallel with another fully compliant DLE unit (new unit or Solar T-130). As such there is negligible difference in performance between options in the lead configuration and therefore BAT assessment has been conducted based on the back-up configuration. It should be noted that overall performance of the site must take into consideration the availability of compressors and number of run hours that the site would operate in back up configuration. This is considered in the CBA and business case assessment discussed in **Section 7**. For further detail please see the BAT Report (**Appendix G**).

241. In this option the lead configuration would involve operation of one or both T-130s with back-up provided by the Avon retrofitted with DLE technology to be utilised when parallel operation is required and one of the T-130s is unavailable. The scores below represent backup parallel operation (i.e. 1 off T-130 and 1 off DLE Avon).

| Investment Option<br>BAT Assessment Scores | Versatility | Future Proofing | Ownership | Constructability | Environmental Amenity | Hazard | Emissions (NOx, CO2, CO) | Total Score |
|---|---|---|---|---|---|---|---|---|
| 3 - 1 x 1533 DLE<br>(1 x T130 + DLE) | 12% | 6% | 8% | 4% | 10% | 4% | 24% | 68% |
| Score Sub-Total | 15/65% | 15/65% | 13/65% | 7/65% | 10/65% | 5/65% | 35/35% | 100% |

**Table 21 - Option 3: BAT Assessment Breakdown**

242. **Versatility:** This solution was scored 12% out of 15% as it contains sufficient power to meet all the PDS points but is not as versatile as a new compressor unit**.**

243. **Future Proofing**: This solution was scored 6% out of 15% as it achieves current emissions limits, but the existing Avon limits the solution with no headroom for future increase in legislation increase (emissions or energy efficiency).

244. **Ownership**: This solution was scored 8% out of 13% as the Avon DLE retrofit is a new application on the NTS, still currently being technically validated and there are potential limitations on the availability of spares. Solution has been discounted due to the age of the Avon units and the likelihood for increased maintenance intervention.

245. **Constructability**: This solution was scored 4% out of 7% as DLE modifications are expected to be completed in one summer outage however constructability is more complex when compared to other options. Two outage periods have been determined for:

- Outage A: Unit A compressor overhaul & refurbishment
- Outage B: Unit A control system installation & DLE retrofit

246. **Environmental Amenity**: This solution was scored 10% out of 10% as the solution was determined unlikely to introduce a new amenity risk.

247. **Hazard**: This solution was scored 4% out of 5%. Oil containment is to National Grid standards and asset health investment will upgrade system to use dry gas seals. However, solution cannot effectively design out all significant environmental risks.

248. **Emissions**: This solution was scored 24% out of 35% (13/20 $NO_x$; 9/10 $CO_2$; 2/5 CO) for emissions compliance. Through DLE abatement, $NO_x$ emissions will be reduced to within existing MCPD limits but is not as effective a new compressor unit.

**Risks**

249. Please see **Appendix F** for more detail on the risks defined for this option. The highest rated risks are identified below.

250. **Critical:** Coordination and alignment between internal stakeholders. Potential for delay in gaining alignment on a preferred option (CPO-8)

251. **Major:** The existing Avon units are over 30 years old. This brings increased asset health maintenance exposure and higher probability of unavailability due to technical issues (CM-1)

252. **Major**: Re-use of existing underground production piping. As no underground piping survey has been carried out, there is potential for more extensive damage or lower integrity of pipework than currently expected. Potential for capex increase. (CM-4)

253. **Major**: Country specific and worldwide geopolitical issues affecting the supply & cost of equipment, materials and workforce. (CPO-11)

254. **Major**: While DLE technology is well established within the UK & European gas network, the retrofit of DLE technology to Avon gas turbines is not yet technically proven or commercially available. NGGT are working with [redacted] to develop an Avon DLE retrofit solution. A full engine performance trial on the NTS is currently being planned. For this reason, there are inherent risks associated with selecting an unproven technical solution (which supports the lead unit) at Peterborough (CM-14)

255. **Opportunity**: Opportunity for future change to hydrogen production. (CPO-5)

256. **Opportunity**: Opportunity to utilise existing ERP3 construction area to save on mob/demob costs before land is sold back to the farmer (CPO-3A)

## Option 4 – One SCR Retrofitted Avon

### Option Description

257. This option considers adding a Selective Catalytic Reduction (SCR) system to Unit A to reduce $NO_x$ emissions to within MCPD limits. SCR technology enables conversion of $NO_x$ to Nitrogen ($N_2$) and water ($H_2O$) by reacting $NO_x$ with Ammonia ($NH_3$).

258. The SCR system consists of a number of critical components such as a self-supporting exhaust stack and silencer, ammonia storage and pumping system, ammonia vaporisation system, ammonia tanker unloading system, control system modifications and a Continuous Emissions Monitoring System (CEMS) to verify that $NO_x$ emissions have been sufficiently limited to within MCPD limits.

### Cost Breakdown

259. The cost breakdown of the option is given in **Table 22 - Option 4: Cost Breakdown.**

| Option Cost Comparison Table (18/19 Prices) | Project Start Date | Project Finish Date | Total Installed Cost (£m) | Initial Asset Health Cost (£m) | Ongoing Asset Health Cost (£m) | Operating Cost (£m/pa) | Decom. Cost (£m) | Capex Cost Accuracy |
|---|---|---|---|---|---|---|---|---|
| 4 – 1 x SCR | 2019 | 2027 | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | ±30% |

**Table 22 - Option 4: Cost Breakdown**

### Cost Basis

260. Initial asset health costs consider investments which are required to ensure units are of sufficient reliability to operate effectively from 1 January 2030. Ongoing asset health costs concern investments necessary to ensure future running from 2030 to 2050. More detail can be found in the **Appendix D.**

261. Please see **Section 6** for commentary on how the cost estimate for this option was developed.

### Option Programme

262. The project start date is the NGGT 2019 RIIO-T2 business plan submission to develop the final preferred investment option. Project finish date represents the year commissioning activities are planned to take place. Level 2 delivery programmes can be found in **Appendix E** for more details on option timeline.

### Commercial Actions

263. There are no commercial contracts required to ensure compliance with the 1-in-20 design standard for this option. Network Entry constraints would be managed using existing tools, and these constraint costs would be expected to be significant once the derogations kick in from 2030.

### BAT Assessment Scores

264. A high-level view of how the option was scored from a technical, environmental and emissions perspective is summarised in **Table 23 - Option 4: BAT Assessment Breakdown**. A full table describing the BAT scores across all options can be found in

**Section 5.3** to enable comparison across options. See **Appendix G** for how the BAT scores were established.

265. The lead configuration for all options would be one fully compliant DLE unit (new unit or Solar T-130) either operating singularly or in parallel with another fully compliant DLE unit (new unit or Solar T-130). As such there is negligible difference in performance between options in the lead configuration and therefore BAT assessment has been conducted based on the back-up configuration. It should be noted that overall performance of the site must take into consideration the availability of compressors and number of run hours that the site would operate in back up configuration. This is considered in the CBA and business case assessment discussed in **Section 7**. For further detail please see the BAT Report (**Appendix G**).

266. In this option the lead configuration would involve operation of one or both T-130s with back-up provided by the Avon modified with SCR to be utilised when parallel operation is required and one of the T-130s is unavailable. The scores below represent backup parallel operation (i.e. 1 off T-130 and 1 off SCR Avon).

| Investment Option BAT Assessment Scores | Versatility | Future Proofing | Ownership | Constructability | Environmental Amenity | Hazard | Emissions (NOx, CO2, CO) | Total Score |
|---|---|---|---|---|---|---|---|---|
| 4 – 1 x SCR (1 x T130 + SCR) | 12% | 9% | 5% | 3% | 6% | 2% | 26% | 63% |
| Score Sub-Total | 15/65% | 15/65% | 13/65% | 7/65% | 10/65% | 5/65% | 35/35% | 100% |

**Table 23 - Option 4: BAT Assessment Breakdown**

267. **Versatility:** This solution was scored 12% out of 15% as it contains sufficient power to meet all the PDS points but is not as versatile as a new compressor unit. It has been assumed that the increase in exhaust back pressure due to the catalyst will have negligible impact on maximum power.

268. **Future Proofing**: This solution was scored 9% out of 15% as it achieves current emissions limits. Avon SCR includes catalyst for $NO_x$ and CO reduction therefore good emissions headroom. Avon energy efficiency may not meet required targets in a future MCP BREF. Decreased headroom when compared to new GT solutions.

269. **Ownership**: This solution was scored 5% out of 13% as the Avon SCR retrofit is a new application on the NTS which introduces a number of new assets which require operations management and new maintenance procedures. There is expected to be a medium availability of spares. Solution has been discounted due to the age of the Avon unit and the likelihood for increased maintenance intervention.

270. **Constructability**: This solution was scored 3% out of 7% due to the construction complexity associated with the additional SCR exhaust stack steelwork which drives an additional construction outage compared to alternative options. There is significant risk in being able to complete this construction work within one outage. Two outage periods have therefore been determined:

- Outage A: Unit A compressor overhaul & refurbishment
- Outage B: Unit A SCR retrofit & control system upgrade

271. **Environmental Amenity**: This solution was scored 6% out of 10%. While horizontal exhaust stack will limit height impact, additional noise is likely to be introduced as well as the potential for visual impact (size, colour). Possible planning permission required due to new equipment exceeding permitted height limits of 15 m. This has the potential to cause programme delay.

272. **Hazard**: This solution was scored 2% out of 5% due to the added complexity brought by ammonia use as a reagent in SCR process. This introduces a new hazard which requires containment. Ammonia tanker deliveries require additional containment systems.

273. **Emissions**: This solution was scored 26% out of 35% (15/20 $NO_x$; 9/10 $CO_2$; 2/5 CO) for emissions compliance. Through SCR abatement, $NO_x$ emissions will be reduced to well within existing MCPD limits but is not as effective a new compressor unit.

**Risks**

274. Please see **Appendix F** for more detail on the risks defined for this option. The highest rated risks are identified below.

275. **Critical:** Coordination and alignment between internal stakeholders. Potential for delay in gaining alignment on a preferred option (CPO-8)

276. **Critical:** Risk of planning permission application taking longer than anticipated based on historic experience on ERP3 project at Peterborough & Huntingdon (CPO-12)

277. **Major:** The existing Avon units are over 30 years old. This brings increased asset health maintenance exposure and higher probability of unavailability due to technical issues (CM-1)

278. **Major**: Re-use of existing underground production piping. As no underground piping survey has been carried out, there is potential for more extensive damage or lower integrity of pipework than currently expected. Potential for capex increase. (CM-4)

279. **Major**: Country specific and worldwide geopolitical issues affecting the supply & cost of equipment, materials and workforce. (CPO-11)

280. **Opportunity**: Opportunity for future change to hydrogen production. (CPO-5)

281. **Opportunity**: Opportunity to utilise existing ERP3 construction area to save on mob/demob costs before land is sold back to the farmer (CPO-3A)

## Option 5 – One New GT (Brownfield) + One Decommission

### Option Description

282. This option involves the installation of a new GT compressor unit, approximate size 15 MW, which will be commissioned by 2028.

283. New unit is proposed to be installed on a brownfield site location on plinth F which is adjacent to the existing units D & E.

284. This option also includes the decommission of Unit A once the new GT compressor has been commissioned. The requirement for decommissioning will be reassessed following operational acceptance of the new unit.

### Cost Breakdown

285. The cost breakdown of the option is given in **Table 24 - Option 5: Cost Breakdown.**

| Option Cost Comparison Table (18/19 Prices) | Project Start Date | Project Finish Date | Total Installed Cost (£m) | Initial Asset Health Cost (£m) | Ongoing Asset Health Cost (£m) | Operating Cost (£m/pa) | Decom. Cost (£m) | Capex Cost Accuracy |
|---|---|---|---|---|---|---|---|---|
| 5 - 1 x New GT | 2019 | 2029 | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | ±30% |

**Table 24 - Option 5: Cost Breakdown**

### Cost Basis

286. Initial asset health costs consider investments which are required to ensure units are of sufficient reliability to operate effectively from 1 January 2030. Ongoing asset health costs concern investments necessary to ensure future running from 2030 to 2050. More detail can be found in the **Appendix D**.

287. In the case of existing units which are targeted for decommissioning, initial asset health spend will be subject to a risk assessment to ensure only the most essential components are upgraded given the expected short lifespan of the asset.

288. Please see **Section 6** for commentary on how the cost estimate for this option was developed.

### Option Programme

289. The project start date is the NGGT 2019 RIIO-T2 business plan submission to develop the final preferred investment option. Project finish date represents the year commissioning activities are planned to take place. Level 2 delivery programmes can be found in **Appendix E** for more details on option timeline.

### Commercial Actions

290. There are no commercial contracts required to ensure compliance with the 1-in-20 design standard for this option. Network Entry constraints would be managed using existing tools, and these constraint costs would be expected to be significant once the derogations kick in from 2030.

**BAT Assessment Scores**

291. A high-level view of how the option was scored from a technical, environmental and emissions perspective is summarised in **Table 25**. A full table describing the BAT scores across all options can be found in **Section 5.3** to enable comparison across options. See **Appendix G** for how the BAT scores were established.

292. The lead configuration for all options would be one fully compliant DLE unit (new unit or T-130) either operating singularly or in parallel with another fully compliant DLE unit (new unit or T-130). As such there is negligible difference in performance between options in the lead configuration and therefore BAT assessment has been conducted based on the back-up configuration. It should be noted that overall performance of the site must take into consideration the availability of compressors and number of run hours that the site would operate in back up configuration. This is considered in the CBA and business case assessment discussed in **Section 7**. For further detail please see the BAT Report (**Appendix G**).

293. In this option the lead configuration would involve operation of a new unit with back-up provided by the second T-130 to be utilised when parallel operation is required and the first T-130 is unavailable. The scores below represent backup parallel operation (i.e. 1 off new unit and 1 off T-130).

| Investment Option<br>BAT Assessment Scores | Versatility | Future Proofing | Ownership | Constructability | Environmental Amenity | Hazard | Emissions (NOx, CO2, CO) | Total Score |
|---|---|---|---|---|---|---|---|---|
| 5 - 1 x New GT<br>(1 x T130 + New GT) | 15% | 15% | 13% | 3% | 8% | 4% | 35% | 93% |
| Score Sub-Total | 15/65% | 15/65% | 13/65% | 7/65% | 10/65% | 5/65% | 35/35% | 100% |

**Table 25 - Option 5: BAT Assessment Breakdown**

294. **Versatility:** This solution was scored 15% out of 15% as the new unit is expected to meet the required PDS points (if adequately sized) in combination with the existing T-130 compressor.

295. **Future Proofing**: This solution was scored 15% out of 15% as the T-130 and new GT compressors provide for maximum headroom for $NO_x$ and CO emissions in the event the lead T-130 unit is unavailable. Both of these units are more energy efficient than existing Avon unit so maximum energy efficiency headroom is also achieved. Energy efficiency constraints are not applicable to a new unit.

296. **Ownership**: This solution was scored 13% out of 13% as the T-130's has existing service agreements and there is long-term availability of spares. New compressor should have excellent new maintenance/service arrangements in place.

297. **Constructability**: This solution was scored 3% out of 7% as there is moderate complexity associated with the installation of a new GT on a brownfield location. Three outage periods have been determined for:

- Outage A: Hook-up of new compressor

298. **Environmental Amenity**: This solution was scored 8% out of 10%. While there is a new noise source and a tall exhaust stack for the new unit, planning permission is unlikely to be required due to historic ERP3 project works in 2021/22.

299. **Hazard**: This solution was scored 4% out of 5% as it is expected that the new compressor unit will comply with new and future standards for oil containment.

300. **Emissions**: This solution was scored 35% out of 35% (20/20 $NO_x$; 10/10 $CO_2$; 5/5 CO) for emissions compliance. Through the use of the low-emission new units, $NO_x$ emissions will be reduced to well within existing MCPD limits. New units represent the most environmentally friendly solution in the NGGT suite of emissions reduction options.

**Risks**

301. Please see **Appendix F** for more detail on the risks defined for this option. The highest rated risks are identified below.

302. **Critical:** Coordination and alignment between external stakeholders. Potential for delay in gaining alignment on a preferred option (CPO-7)

303. **Critical:** Risk of planning permission application taking longer than anticipated based on historic experience on ERP3 project at Peterborough & Huntingdon (CPO-12)

304. **Critical**: Country specific and worldwide geopolitical issues affecting equipment supply and workforce (greater impact for new build unit). (CPO-11)

305. **Opportunity**: Opportunity for future change to hydrogen production. (CPO-5)

306. **Opportunity**: Opportunity to coordinate decommissioning works with other projects. (CPO-6)

307. **Opportunity**: Opportunity to reduce the steelwork associated with the operation and maintenance of the unit to reduce cost. (CM-12A)

308. **Opportunity**: Opportunity to utilise existing ERP3 construction area to save on mob/demob costs before land is sold back to the farmer (CPO-3A)

309. This option considers decommissioning of the existing Avon Unit A as the entirety of the MCPD work scope. No specific decommissioning related risks have been identified in advance of detailed asset surveys which are normally performed as part of the associated FEED study. However, there is one associated opportunity which has been identified with this option:

310. **Opportunity**: Opportunity to coordinate decommissioning works with other projects. (CPO-6)

## Option A – Counterfactual (1 x 500-Hours Derogation)

### Option Description

311. This option maintains Avon Unit C until 31 December 2029 and places it on 500-hours EUD (Emergency Use Derogation) from 1 January 2030.

### Cost Breakdown

312. The cost breakdown of the option is given in **Table 26.**

| Option Cost Comparison Table (18/19 Prices) | Project Start Date | Project Finish Date | Total Installed Cost (£m) | Initial Asset Health Cost (£m) | Ongoing Asset Health Cost (£m) | Operating Cost (£m/pa) | Decom. Cost (£m) | Capex Cost Accuracy |
|---|---|---|---|---|---|---|---|---|
| A - Counterfactual | 2019 | - | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | ±30% |

**Table 26 - Option A: Cost Breakdown (Huntingdon)**

### Cost Basis

313. Initial asset health costs consider investments which are required to ensure units are of sufficient reliability to operate effectively from 1 January 2030. Ongoing asset health costs concern investments necessary to ensure future running from 2030 to 2050. More detail can be found in the **Appendix D**.

314. Please see **Section 6** for commentary on how the cost estimate for this option was developed.

### Option Programme

315. No specific option programmes have been developed for Huntingdon. The corresponding option programme at Peterborough will give comparable detail in terms of activity timeline and outage expectations. Please see **Section 5.1** for additional context on the reduced option assessment conducted at Huntingdon.

### Commercial Actions

316. There are no commercial contracts required to ensure compliance with the 1-in-20 design standard for this option. Network Entry constraints would be managed using existing tools, and these constraint costs would be expected to be significant once the derogations start in 2030.

### BAT Assessment Scores

317. A BAT assessment was not performed for this option. Huntingdon option assessment can largely be taken from the Peterborough BAT results due to the similarity of both sites in terms of asset type, age and complexity.

### Risks

318. While a dedicated risk workshop has not been performed for Huntingdon, the corresponding risks identified against the Peterborough options can also be applied for Huntingdon due to the similarity of both sites.

319. While a dedicated risk workshop has not been performed for Huntingdon, the corresponding risks identified against the Peterborough options can also be applied for Huntingdon due to the similarity of both sites.

320. **Major**: The existing Avon units are over 30 years old. This brings increased asset health maintenance exposure and higher probability of unavailability due to technical issues (CM-1)

321. **Major**: Re-use of existing underground production piping. As no underground piping survey has been carried out, there is potential for more extensive damage or lower integrity of pipework than currently expected. Potential for capex increase. (CM-4)

322. **Major**: Country specific and worldwide geopolitical issues affecting the supply & cost of equipment, materials and workforce. (CPO-11)

323. **Opportunity**: Opportunity for future change to hydrogen production. (CPO-5)

324. **Opportunity**: Opportunity to utilise existing ERP3 construction area to save on mob/demob costs before land is sold back to the farmer (CPO-3A)

## Option B – One Derated (CSRP) Avon

### Option Description

326. This option considers restricting high power running of Avon Unit C through control system modifications to limit its performance and thereby reduce $NO_x$ emissions to within acceptable limits.

### Cost Breakdown

327. The cost breakdown of the option is given in **Table 27.**

| Option Cost Comparison Table (18/19 Prices) | Project Start Date | Project Finish Date | Total Installed Cost (£m) | Initial Asset Health Cost (£m) | Ongoing Asset Health Cost (£m) | Operating Cost (£m/pa) | Decom. Cost (£m) | Capex Cost Accuracy |
|---|---|---|---|---|---|---|---|---|
| B - 1 x CSRP | 2019 | - | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | ±30% |

**Table 27 - Option C: Cost Breakdown (Huntingdon)**

### Cost Basis

328. Initial asset health costs consider investments which are required to ensure units are of sufficient reliability to operate effectively from 1 January 2030. Ongoing asset health costs concern investments necessary to ensure future running from 2030 to 2050. More detail can be found in the **Appendix D**.

329. Please see **Section 6** for commentary on how the cost estimate for this option was developed.

### Option Programme

330. No specific option programmes have been developed for Huntingdon. The corresponding option programme at Peterborough will give comparable detail in terms of activity timeline and outage expectations. Please see **Section 5.1** for additional context on the reduced option assessment conducted at Huntingdon.

### Commercial Actions

331. There are no commercial contracts required to ensure compliance with the 1-in-20 design standard for this option. Network Entry constraints would be managed using existing tools, and these constraint costs would be expected to be significant once the derogations start in 2030.

### BAT Assessment Scores

332. A BAT assessment was not performed for this option. Huntingdon option assessment can largely be taken from the Peterborough BAT results due to the similarity of both sites in terms of asset type, age and complexity.

### Risks

333. While a dedicated risk workshop has not been performed for Huntingdon, the corresponding risks identified against the Peterborough options can also be applied for Huntingdon due to the similarity of both sites.

334. **Critical:** Coordination and alignment between internal stakeholders. Potential for delay in gaining alignment on a preferred option (CPO-8)

335. **Major:** The existing Avon units are over 30 years old. This brings increased asset health maintenance exposure and higher probability of unavailability due to technical issues (CM-1)

336. **Major**: Re-use of existing underground production piping. As no underground piping survey has been carried out, there is potential for more extensive damage or lower integrity of pipework than currently expected. Potential for capex increase. (CM-4)

337. **Major**: Country specific and worldwide geopolitical issues affecting the supply & cost of equipment, materials and workforce. (CPO-11)

338. **Significant:** Potential that CSRP is not approved by Environment Agency (EA) resulting in rejection of permit request (HSSE-11)

339. **Opportunity**: Opportunity for future change to hydrogen production. (CPO-5)

340. **Opportunity**: Opportunity to utilise existing ERP3 construction area to save on mob/demob costs before land is sold back to the farmer (CPO-3A)

## Option C – One Avon DLE Retrofit (1533)

### Option Description

342. This option involves retrofitting Avon Unit C with DLE technology.

343. Unit C modification with DLE technology is based on the existing 1533 Avon powertrain.

### Cost Breakdown

344. The cost breakdown of the option is given in **Table 28.**

| Option Cost Comparison Table (18/19 Prices) | Project Start Date | Project Finish Date | Total Installed Cost (£m) | Initial Asset Health Cost (£m) | Ongoing Asset Health Cost (£m) | Operating Cost (£m/pa) | Decom. Cost (£m) | Capex Cost Accuracy |
|---|---|---|---|---|---|---|---|---|
| C - 1 x 1533 DLE | 2019 | - | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | ±30% |

**Table 28 - Option C: Cost Breakdown (Huntingdon)**

### Cost Basis

345. Initial asset health costs consider investments which are required to ensure units are of sufficient reliability to operate effectively from 1 January 2030. Ongoing asset health costs concern investments necessary to ensure future running from 2030 to 2050. More detail can be found in the **Appendix D**.

346. Please see **Section 6** for commentary on how the cost estimate for this option was developed.

### Option Programme

347. No specific option programmes have been developed for Huntingdon. The corresponding option programme at Peterborough will give comparable detail in terms of activity timeline and outage expectations. Please see **Section 5.1** for additional context on the reduced option assessment conducted at Huntingdon.

### Commercial Actions

348. There are no commercial contracts required to ensure compliance with the 1-in-20 design standard for this option. Network Entry constraints would be managed using existing tools, and these constraint costs would be expected to be significant once the derogations start in 2030.

### BAT Assessment Scores

349. A BAT assessment was not performed for this option. Huntingdon option assessment can largely be taken from the Peterborough BAT results due to the similarity of both sites in terms of asset type, age and complexity.

### Risks

350. While a dedicated risk workshop has not been performed for Huntingdon, the corresponding risks identified against the Peterborough options can also be applied for Huntingdon due to the similarity of both sites.

351. **Critical:** Coordination and alignment between internal stakeholders. Potential for delay in gaining alignment on a preferred option (CPO-8)

352. **Major:** The existing Avon units are over 30 years old. This brings increased asset health maintenance exposure and higher probability of unavailability due to technical issues (CM-1)

353. **Major**: Re-use of existing underground production piping. As no underground piping survey has been carried out, there is potential for more extensive damage or lower integrity of pipework than currently expected. Potential for capex increase. (CM-4)

354. **Major**: Country specific and worldwide geopolitical issues affecting the supply & cost of equipment, materials and workforce. (CPO-11)

355. **Major**: While DLE technology is well established within the UK & European gas network, the retrofit of DLE technology to Avon gas turbines is not yet technically proven or commercially available. NGGT are working with [redacted] to develop an Avon DLE retrofit solution. A full engine performance trial on the NTS is currently being planned. For this reason, there are inherent risks associated with selecting an unproven technical solution (which supports the lead unit) at Huntingdon (CM-14)

356. **Opportunity**: Opportunity for future change to hydrogen production. (CPO-5)

357. **Opportunity**: Opportunity to utilise existing ERP3 construction area to save on mob/demob costs before land is sold back to the farmer (CPO-3A)

## 5.3. Option Table Summary

358. Option summary tables are provided for the following aspects to allow for cross comparison across the main options considered for Peterborough and Huntingdon investments:

- Option Shortlists
- Option Cost Breakdown
- Option Consolidated BAT Scores

359. Options are provided with a description and a numerical label to aid in referencing options throughout this report.

360. Both sets of option shortlists were combined for further evaluation, see **Section 7**.

### Option Shortlist (Peterborough)

| Peterborough Costed Option Shortlist | Unit A | Unit B | Unit C | Unit D | Unit E | Unit F |
|---|---|---|---|---|---|---|
| 1 – Counterfactual | 500Hr EUD | Removed | Removed | No Change | No Change | / |
| 2 - 1 x CSRP | CSRP Retrofit | Removed | Removed | No Change | No Change | / |
| 3 - 1 x 1533 DLE | 1533 DLE Retrofit | Removed | Removed | No Change | No Change | / |
| 4 – 1 x SCR | SCR Retrofit | Removed | Removed | No Change | No Change | / |
| 5 - 1 x New Unit | Decom. | Removed | Removed | No Change | No Change | New Unit (Brownfield) |

**Table 29 - Costed Option Shortlist (Peterborough)**

| Huntingdon Costed Option Shortlist | Unit A | Unit B | Unit C | Unit D | Unit E | Unit F |
|---|---|---|---|---|---|---|
| A – Counterfactual | Removed | Removed | 500Hr EUD | No Change | No Change | / |
| B - 1 x CSRP | Removed | Removed | CSRP Retrofit | No Change | No Change | / |
| C - 1 x DLE | Removed | Removed | DLE Retrofit 1533 | No Change | No Change | / |

**Table 30 – Costed Option Shortlist (Huntingdon)**

### Option Cost Breakdown

361. **Table 31** and **Table 32** below outline the cost breakdowns for each option.

362. Detail on how project start & finish dates are determined can be found within **Section 5.1.**

363. Detail on option capex cost accuracy can be found within **Section 6.2**.

364. Regarding considerations for unit design life within option selection, please see **Section 5.1** for more information.

| Option Cost Comparison Table (18/19 Prices) | Project Start Date | Project Finish Date | Total Installed Cost (£m) | Initial Asset Health Cost (£m) | Ongoing Asset Health Cost (£m) | Operating Cost (£m/pa) | Decom. Cost (£m) | Capex Cost Accuracy |
|---|---|---|---|---|---|---|---|---|
| 1 – Counterfactual | 2019 | 2027 | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | ±30% |
| 2 - 1 x CSRP | 2019 | 2027 | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | ±30% |
| 3 - 1 x 1533 DLE | 2019 | 2027 | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | ±30% |
| 4 – 1 x SCR | 2019 | 2027 | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | ±30% |
| 5 - 1 x New GT | 2019 | 2029 | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | ±30% |

**Table 31 - Option Cost Breakdown (Peterborough)**

| Option Cost Comparison Table (18/19 Prices) | Project Start Date | Project Finish Date | Total Installed Cost (£m) | Initial Asset Health Cost (£m) | Ongoing Asset Health Cost (£m) | Operating Cost (£m/pa) | Decom. Cost (£m) | Capex Cost Accuracy |
|---|---|---|---|---|---|---|---|---|
| A - Counterfactual | 2019 | - | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | ±30% |
| B - 1 x CSRP | 2019 | - | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | ±30% |
| C - 1 x 1533 DLE | 2019 | - | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | ±30% |

**Table 32 - Option Cost Breakdown (Huntingdon)**

## Option Consolidated BAT Scores

365. **Table 33** contains a summary of how the BAT assessment technical & environmental scores compare across all options. Technical scores (65%) and environmental scores (35%) are combined to provide for an overall 100% evaluation score. For detailed information on the BAT assessment, please see **Appendix G**.

366. BAT assessment scores and weighting were qualitatively determined by representative business stakeholders. Scores are not intended to be used to determine the Final Preferred Option but to support option decision-making.

367. As referenced in **Section 5.1**, a BAT assessment was not performed on the Huntingdon options. Due to the prioritisation of Peterborough investment over Huntingdon and the desire to avoid investing excessive effort and resources into detailed option evaluation, the Huntingdon options have been costed only to enable comparison against Peterborough and to facilitate cost forecasting for the wider MCPD programme. For this reason no detailed engineering, risk identification, scheduling or BAT assessment have been performed. Please see **Section 7** for additional context on the difference in approach taken between Peterborough and Huntingdon.

| Investment Option<br>BAT Assessment Scores | Versatility | Future Proofing | Ownership | Constructability | Environmental Amenity | Hazard | Emissions (NOx, CO2, CO) | Total Score |
|---|---|---|---|---|---|---|---|---|
| **1 – Counterfactual (1 x T130 + 500 Hrs)** | 3% | 0% | 10% | 4% | 10% | 4% | 13% | 44% |
| **2 - 1 x CSRP (1 x T130 + CSRP)** | 9% | 0% | 10% | 4% | 10% | 4% | 13% | 50% |
| **3 - 1 x 1533 DLE (1 x T130 + DLE)** | 12% | 6% | 8% | 4% | 10% | 4% | 24% | 68% |
| **4 – 1 x SCR (1 x T130 + SCR)** | 12% | 9% | 5% | 3% | 6% | 2% | 26% | 63% |
| **5 - 1 x New GT (1 x T130 + New GT)** | 15% | 15% | 13% | 3% | 8% | 4% | 35% | 93% |
| **Score Sub-Total** | **15/65%** | **15/65%** | **13/65%** | **7/65%** | **10/65%** | **5/65%** | **35/35%** | **100%** |

**Table 33 - BAT Assessment Consolidated Scores (Peterborough)**

# 6. Cost Definition

## 6.1. Cost Estimate Methodology

368. As the project has developed since our 2019 RIIO-T2 business plan submission, the accuracy of the scope of works and the estimate itself has improved. The current level of cost confidence (±30%) is consistent with other projects at a similar stage and reflect the inherent uncertainties due to further engineering work required to finalise the scope of works; detailed design; and the completion of tendering processes engineering, procurement and construction.

369. The level of cost certainty in our estimates is aligned with an AACE Class 4[31] estimate which the classification system defines as appropriate for project screening, feasibility, concept evaluation and preliminary budget approval. The Infrastructure Projects Association (IPA) published cost estimate guidance[32] classifies a ±30% cost estimate as suitable for "Outline Business Case".

370. The cost estimates, which are consistent between options, are appropriate to inform the option selection process including CBA and BAT assessment. As detailed in the PCD guidance, the cost Re-opener submission (planned for 2025) will be based on a finalised scope of works, Detailed Design and Build Main Works Contractor (MWC) tendered prices and order values for long lead items.

### Estimate Scope

371. We have developed estimates of total installed cost for all shortlisted options. We then determined approximate spend profiles for all options (per **Section 6.3**) so that discounting could be applied in the CBA and BAT assessment tools. All our estimates have been developed based on an assumed standard EPC delivery strategy consisting of the following main contracts: pre-FEED; FEED; EPC, and compressor machinery train equipment.

372. The total installed cost estimates are based on the following main cost elements:

- Installation of new build Compressor Machinery Train equipment including acoustic cab
- Tie-in of new equipment to existing station piping; control and protection systems, electrical, drainage and utilities connections, process vent
- Asset Health scope for existing Avon's to be retained considering planned interventions already funded via our RIIO-T2 business plans (see Asset Health Report**, Appendix D**)
- Retrofit Emissions Abatement modifications to existing Avon driven compressor trains (SCR, DLE, CSRP)
- Engine upgrades for applicable retrofit options
- Decommissioning of redundant compressor units

[31] AACE International Recommended Practice No. 18R-97 – Cost Estimate Classification System – As Applied in Engineering, Procurement and Construction for The Process Industries
[32] IPA_Cost_Estimating_Guidance.pdf (publishing.service.gov.uk)

373. Whole life cost estimates also include estimated ongoing asset health spend for new and existing GTs until 2050. These costs include asset refurbishment and replacements based on our asset management policies, procedures and specifications and they are consistent with asset health plans approved as part of our 2019 RIIO-T2 business plans.

374. Other recurring costs in our whole life cost estimates include OPEX, fuel consumption, reagent use and catalyst replacement for SCR option and network constraint cost.

## Base Data

### Compressor Machinery Train Equipment

375. Equipment costs for the new build option were provided by [redacted] based on cost models and norms by equipment type. Peterborough and Huntingdon Compressor Stations are located in an area of low background noise meaning compressor noise must be mitigated through the use of low noise compressor acoustic enclosures. Costs for these enclosures are included in the compressor machinery train equipment cost estimates and are based on costs for similar equipment purchased for other sites.

### Tie-in of New Equipment

376. New compressor machinery train equipment at Peterborough will be installed adjacent to the Solar Titan 130s installed as part of the Emissions Reduction Phase 3 (ERP3) Project, as described in the Engineering Report in **Appendix C**. Tie-in of new assets into existing site infrastructure has been priced based on Material Take Offs (MTOs) produced by [redacted] with the following allowances applied:

- **Technical Allowance –** Covers design development (e.g., Equipment specifications, changes in size and valve specifications etc)
- **Growth –** Covers increase in size/complexity of the project as engineering definition develops (e.g. Plot layout definition increase due to additional small-bore piping, valves, non-tagged minor equipment etc)
- **Cut and Waste –** bulk material off-cuts, overages and waste
- **MTO Allowance –** margin to cater for items not included MTOs (e.g., small bore piping and valves, bolts and gaskets, minor electrical and instrumentation material etc)

377. Procurement costs are based on assumed material cost data provided by [redacted] and fabrication and installation costs are based on assumed labour rates provided by [redacted] Given the prevailing national and international geopolitical conditions, labour and material rates present a risk to the project, particularly for new build options involving larger scope. This risk is noted in the risk register in **Appendix F**.

### Asset Health Interventions

378. The scope of asset health interventions required on the existing Avon compressor trains and associated equipment is defined in the Asset Health Report in **Appendix D**. Our RIIO-T2 asset health plans were based on retaining one of the three Avon's at Peterborough until 2030 when it would be replaced by a new unit installed as part of the

MCPD scope. Our 2019 Asset Health Plan for Huntingdon assumed that Unit C would be retained indefinitely on a 500-hour per year emergency use derogation.

379. Asset health costs are based on unit costs agreed as part of our RIIO-T2 business plans where available as shown in the table below. These costs are total installed cost and therefore no additional cost factors or Unallocated Provision (UAP) has been applied.

| Cost Element | Unit Cost ID | Total Installed Cost Estimate *(18/19 price base)* | Comment |
|---|---|---|---|
| **Control** | | | |
| Unit control system | N/A[33] | [redacted] | From RIIO-T2 Control System Cyber and Asset Health business plan submission |
| Fire and Gas Detection | N/A[34] | [redacted] | |
| Anti-Surge System | N/A[35] | [redacted] | |
| **Electrical** | | | |
| Distribution Boards | [redacted] | [redacted] | |
| Auxiliary Equipment | [redacted] | [redacted] | |
| LV Switchboards | [redacted] | [redacted] | |
| **Rotating Equipment** | | | |
| Gas Generator - overhaul | [redacted] | [redacted] | |
| Power turbine | [redacted] | [redacted] | |
| Compressor Impeller Refurb | [redacted] | [redacted] | |
| Compressor - dry gas seal | [redacted] | [redacted] | |
| **Compressor Acoustic Building** | | | |
| Building - CAB (Major) | [redacted] | [redacted] | |
| Building - CAB (Minor) | [redacted] | [redacted] | |
| CAB Ventilation (Major) | [redacted] | [redacted] | |
| CAB ventilation (Minor) | [redacted] | [redacted] | |
| Air intake (Major) | [redacted] | [redacted] | |
| Air intake (Minor) | [redacted] | [redacted] | |
| Exhausts (Major/Replace) | [redacted] | [redacted] | |
| Exhausts (Minor) | [redacted] | [redacted] | |
| **Piping & Valves** | | | |
| Unit Isolation Valves | [redacted] | [redacted] | |
| Non-Return Valves | [redacted] | [redacted] | |
| **Other Ancillary Systems** | | | |
| Fuel Gas Skid | [redacted] | [redacted] | |
| Oil System (GG, PT, Comp) | [redacted] | [redacted] | |
| Fire Suppression | [redacted] | [redacted] | |

**Table 34 - Asset Health Costs**

33 Cost based on RIIO-T2 Plan Annex 15.07 – Cyber Resilience Plan
34 Approved RIIO-T2 funded scope excluded
35 Intervention frequency of 20 years for 500-hour EUD

**Decommissioning**

380. We have included the cost for decommissioning existing Avon compressor units where they will be replaced with new units. These costs are based on confirmed allowances for decommissioning of similar units at other sites. However, the investment decision on decommissioning scope will be made as part of an NTS wide decommissioning plan and will not form part of the MCPD cost Re-opener. Decommissioning of two of three Avon's at each site has been funded for RIIO-T2 through our 2019 Business Plan.

**Emissions Abatement Technology**

*Selected Catalytic Reduction*

381. The SCR system consists of a replacement exhaust stack incorporating $NO_x$ and CO catalysts. Emissions must be monitored via a continuous emissions monitoring system connected to the control system. Aqueous ammonia is used as the reagent and is supplied by tanker to a storage and loading area which is connect to the injection points in the exhaust stacks via permanent piping connections. Equipment supply and installation costs were provided by [redacted] per the report included in **Appendix H**. We then estimated structural, civil and tie-in costs using a similar methodology to new build options.

382. Catalyst replacement cost and reagent costs are included in the OPEX estimate and are based on prices provided by [redacted] and forecast compressor run hours to 2050.

*Control System Restricted Performance*

383. The CSRP option involves restricting emissions through control system modifications and there are no physical asset modifications required. Therefore, option costs are assumed similar to the 500-hour EUD option and include asset health scope only. There may be some incremental costs associated with the application of the CSRP restrictions, these are assumed to be negligible in the context of the ±30% estimates.

*Dry Low Emissions*

384. The Avon DLE retrofit modification involves replacement of the combustion system in the gas generator with DLE combustors, a modified engine casing and modifications to the fuel supply system and associated controller. Cost estimates for this scope is based on negotiated prices with [redacted] which are based on our Avon 1533-75G gas generators per the scope summarised in **CE-AMP**.

**Remaining Project Cost**

385. All remaining project costs were factored based as described in the detailed estimate methodology provided by [redacted] which is included alongside the Engineering Report in **Appendix C**. These costs include the following:

- Engineering design including FEED, Detailed Design, surveys and third-party consultancy
- Client and contractor project management during design and construction
- Other client costs (overhead)

- Freight
- Certification and documentation
- Commissioning and operational spares
- Insurance
- Vendor representatives
- Third Party inspection
- First Fills
- Royalties

**Unallocated Provision**

386. Unallocated provisions are included in the estimate to account for unidentified growth and/or uncertainties in rates, etc. A [redacted] UAP factor has been applied to the base cost for all options excluding asset health and decommissioning spend. If all the assumptions on which the base estimate was made turn out to have been valid, then the base cost estimate should represent the expected cost or [redacted]

387. There are many potential sources of over-run for a project of this type, such as schedule delays, labour disputes, supplier problems, etc. There will be many such risks on the project risk register, many of which will not occur. However, as they all have a finite chance of happening, some will occur and have a cost impact, others might require mitigation to be put in place, at a cost, to ensure that either they do not occur, or they can be dealt with.

388. Moreover, not all assumptions made in the study design premise will turn out to be valid. Some will have been first guesses but there is no allowance in the base estimate for wrong assumptions. There may also be considerable uncertainty in the estimate because of work yet to be performed or finalised, e.g., flow assurance, weather or contracting strategy. Any one of these could have a significant impact on the cost estimate.

389. Because there will be problems and changes, even though we do not yet know what they will be, a provision needs to be added to the base estimate to obtain the [redacted] estimate. This provision is not a management reserve or budget contingency (such a contingency, typically included by operating companies, would be added on top of the [redacted] estimate); instead, it is an unallocated provision for project risks, weak data and inadequate scope definition.

390. UAP does not cover force majeure, major changes, political upheaval, major location change, capacity changes >10%, major / national strikes, major legislation change, major cost inflation change, major industrial disputes, bankruptcy major contractor, major exchange rate fluctuations and natural disasters.

## 6.2. Option Cost Estimate Details

391. CAPEX estimates for each option are provided per the breakdown requested in the 2019 Engineering Justification Paper (EJP) guidance document. Asset health costs are included separately as they are based on RIIO-T2 unit costs. All costs are provided in 2018/19 price base year and should be considered accurate to ±30%. An unallocated provision of [redacted] is included as detailed within **Section 6.1**. A detailed cost breakdown in accordance with PCD guidance is provided for Peterborough and Huntingdon in **Table 35** and **Table 36** respectively.

| Cost Element | Description | 1 - Counterfactual 1off 500-hours Avon | 2 - 1 Derated CSRP Avon | 3 - 1 Retrofit DLE 1533 | 4 - 1 SCR | 5 - 1 New GT + Decommission Avon |
|---|---|---|---|---|---|---|
| **Engineering Design** | studies/FEED/Detailed design as appropriate. | - | - | [redacted] | [redacted] | [redacted] |
| **Project Management** | costs attributed to project management, not direct or indirect company costs. | - | - | [redacted] | [redacted] | [redacted] |
| **Materials** | Bulk materials, breakdown preferred | - | - | [redacted] | [redacted] | [redacted] |
| **Main Works Contractor** | Project construction contractor costs. | - | - | [redacted] | [redacted] | [redacted] |
| **Specialist Services** | any additional services used to support the project i.e., surveys, data procurement etc | - | - | - | - | - |
| **Vendor Package costs** | Compressor Machinery Train Equipment procurement | - | - | [redacted] | [redacted] | [redacted] |
| **Direct Company Costs** | Refer to Regulatory Instructions and Guidance for definition | - | - | [redacted] | [redacted] | [redacted] |
| **Indirect Company Cost** | Refer to Regulatory Instructions and Guidance for definition | - | - | [redacted] | [redacted] | [redacted] |
| **Contingency** | Contingency included in base cost estimate | - | - | - | - | - |
| **Total Installed Cost** | **Cost excluding asset health and UAP** | **-** | **-** | [redacted] | [redacted] | [redacted] |
| **Unallocated Provision (UAP)** | | - | - | [redacted] | [redacted] | [redacted] |
| **Asset Health** | Total installed costs for asset health scope required prior to 2030 | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] |
| **Overall Total** | | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] |

**Table 35 - Option Cost Breakdown (Peterborough)**

| Cost Element | Description | A – 500-hours | B - CSRP | C - DLE Avon |
|---|---|---|---|---|
| **Engineering Design** | studies/FEED/Detailed design as appropriate. | - | - | [redacted] |
| **Project Management** | costs attributed to project management, not direct or indirect company costs. | - | - | [redacted] |
| **Materials** | Bulk materials, breakdown preferred | - | - | [redacted] |
| **Main Works Contractor** | Project construction contractor costs. | - | - | [redacted] |
| **Specialist Services** | any additional services used to support the project i.e., surveys, data procurement etc | - | - | - |
| **Vendor Package costs** | Compressor Machinery Train Equipment procurement | - | - | [redacted] |
| **Direct Company Costs** | Refer to Regulatory Instructions and Guidance for definition | - | - | [redacted] |
| **Indirect Company Cost** | Refer to Regulatory Instructions and Guidance for definition | - | - | [redacted] |
| **Contingency** | Contingency included in base cost estimate | - | - | - |
| **Total Installed Cost** | **Cost excluding asset health and UAP** | **-** | **-** | [redacted] |
| **Unallocated Provision (UAP)** | | - | - | [redacted] |
| **Asset Health** | Total installed costs for asset health scope required prior to 2030 | [redacted] | [redacted] | [redacted] |
| **Overall Total** | | [redacted] | [redacted] | [redacted] |

**Table 36 - Option Cost Breakdown (Huntingdon)**

## 6.3. Project Spend Profile

| Period | Spend Forecast |
|---|---|
| FY22 | [redacted] |
| FY23 | [redacted] |
| FY24 | [redacted] |
| FY25 | [redacted] |
| FY26 | [redacted] |
| **RIIO-T2** | [redacted] |
| FY27 | [redacted] |
| FY28 | [redacted] |
| FY29 | [redacted] |
| FY30 | [redacted] |
| **RIIO-T3** | [redacted] |
| **Total** | [redacted] |

**Table 37 - Preferred Option Peterborough and Huntingdon Spend Profile**

# 7. Option Evaluation and Final Recommendation

## 7.1. Option Assessment Process

392. This section shows the reasoning behind the Final Preferred Option selection, including detailed evaluation of costed shortlisted options (defined in **Section 5 and 6**) against our Needs Case (**Section 4**). A decision tree was used to help guide investment decisions through a number of logical steps, defining why this investment is necessary and the required time frame for implementation. Our options were then assessed against our key investment criteria and evaluation models. This process is defined in **Figure 28**.

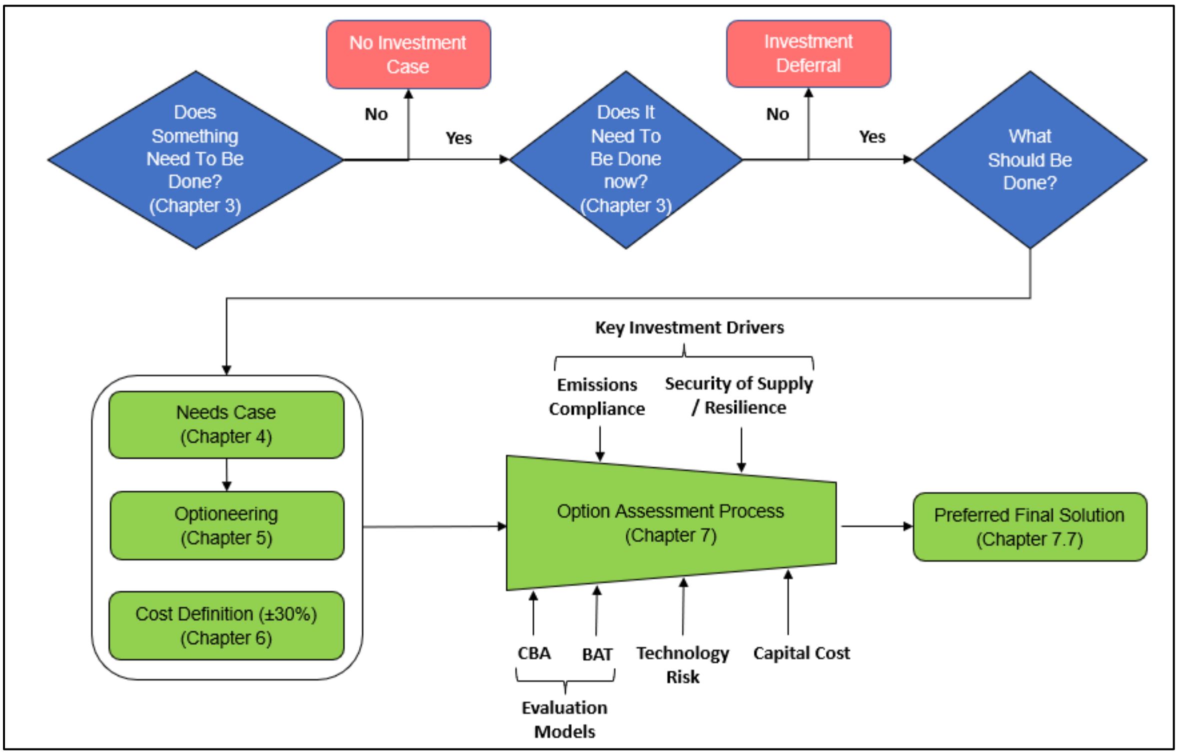



**Figure 28 - Option Assessment Process**

393. The first stage of the option assessment process was to define the investment case. This showed the needs case for future investment and that further action is required. **Section 3** outlines the need for Peterborough and Huntingdon Compressor Stations to meet MCPD emissions compliance by 1 January 2030. Failure to invest in the future of these sites will reduce site availability through restricted running or through unit unreliability by not investing in their continued health and performance.

394. Once the requirement of future investment was determined, the timeline of the investment was assessed. If near-term investment was not deemed necessary, an evaluation of investment deferral through Real Options Analysis or similar could be performed. There are benefits and drawbacks associated with deferring investment, where deferral increases the confidence in the needs case and gives awareness of future legislation changes. However, it also increases the risk of constraints due to the viable solutions not being implemented in time. Investment is required at Peterborough and Huntingdon now to ensure there is sufficient time to achieve emissions compliance

by the MCPD deadline without restricting the network's resilience, see **Section 5** for further detail.

395. Key investment drivers were used to assess options against principles which are important to the future running of the site. These aren't necessarily included in existing economic analysis e.g. CBA which relies on FES 2021. The following key investment drivers are applicable to Peterborough and Huntingdon and are covered in more detail in the sections below:

- Emissions compliance is a key investment driver for future investment at Peterborough and Huntingdon given the need to meet MCPD emissions legislation by 2030
- Peterborough and Huntingdon are both critical compressor sites to meet our 1-in-20 peak demand obligations, and as such, are required to meet N-1 design standard, see CE-AMP.

396. Evaluation models such as CBA and BAT assessments have been used, incorporating whole life cost, fuel and emissions costs, technical, environmental and emissions reduction appraisal, to best inform option selection and decision making. Technology maturity was also an important tool used to aid decision making considering the critical nature of these sites.

397. Consideration was also given for capital investment costs of the options, ensuring that the final option provides value for money for consumers and prevents over investment and potential for asset stranding as a result of changing future legislation or network capability requirements.

398. Key investment drivers, evaluation models (such as CBA and BAT), technology risk and capital investment analysis are combined in an option assessment matrix for each site to help support selection of our Final Preferred Option, see **Table 38** and **Table 39**. The option assessment criteria noted above are used to help filter out non- viable options, giving the most appropriate investment solution. Further discussion on each of these criteria is provided in the sections below.

| Option Assessment Matrix Peterborough | Emissions Compliance | BAT Assessment | CBA | Security of Supply / Resilience | Technology Risk | Capital Investment |
|---|---|---|---|---|---|---|
| 1 – Counterfactual | Achieves MCPD Compliance through **Derogation**<br><br>**Note**: No NOx emissions abatement. | Lead Configuration: BAT<br>Back-Up Score: 44%<br>Versatility: 3/15% | Modelling based on FES does not capture key use cases of the site and risks resulting from loss of capability | **Ruled Out**<br>Unrestricted backup necessary in event of parallel running | | |
| 2 - 1 x CSRP | Achieves MCPD Compliance through **Abatement**<br><br>**Note**: No NOx emissions abatement. | Lead Configuration: BAT<br>Back-Up Score: 50%<br>Versatility: 9/15% | | Provides Unrestricted Running | **Ruled Out**<br>Avon exceeds original design life which risks critical site operation.<br><br>Additional risk of CSRP permit rejection from EA | |
| 3 - 1 x 1533 DLE | Achieves MCPD Compliance through **Abatement** | Lead Configuration: BAT<br>Back-Up Score: 68%<br>Versatility: 12/15% | | Provides Unrestricted Running | **Ruled Out**<br>Avon exceeds original design life which risks critical site operation.<br><br>Additional risk that solution not yet commercially proven. | |
| 4 – 1 x SCR | Achieves MCPD Compliance through **Abatement** | Lead Configuration: BAT<br>Back-Up Score: 63%<br>Versatility: 12/15% | | Provides Unrestricted Running | **Ruled Out**<br>Avon exceeds original design life which risks critical site operation.<br><br>Requires new HSE procedures to handle ammonia on site and introduces new failure mode onto NTS. | |
| 5 - 1 x New Unit | Achieves MCPD Compliance through **New Unit Build** | Lead Configuration: BAT<br>Back-Up Score: 93%<br>Versatility: 15/15% | | Provides Unrestricted Running | New Compressor Technology proven on NTS | [redacted] |

## Table 38 - Option Evaluation Matrix (Peterborough)

| Option Assessment Matrix Huntingdon | Emissions Compliance | BAT Assessment | CBA | Security of Supply / Resilience | Technology Risk | Capital Investment |
|---|---|---|---|---|---|---|
| A – Counterfactual | Achieves MCPD Compliance through **Derogation**<br><br>**Note**: No NOx emissions abatement. | BAT Assessment not performed at Huntingdon however based on PET assessment back-up configuration would not be considered BAT compliant | Modelling based on FES does not capture key use cases of the site and risks resulting from loss of capability | Avon derogation is acceptable based on unrestricted running at Peterborough | Unit condition mitigated by asset health investment & Peterborough support | [redacted] |
| B - 1 x CSRP | Achieves MCPD Compliance through **Abatement**<br><br>**Note**: No NOx emissions abatement. | BAT Assessment not performed at Huntingdon however based on PET assessment back-up configuration could be considered BAT compliant | | Provides Unrestricted Running | Potential for EA permit rejection mitigated by reversion to derogation, up-front permit pre-application and Peterborough support | [redacted] |
| C - 1 x 1533 DLE | Achieves MCPD Compliance through **Abatement** | BAT Assessment not performed at Huntingdon however based on PET assessment back-up configuration could be considered BAT compliant | | Provides unrestricted running | Potential for unit DLE failure mitigated by reversion to derogation and Peterborough support | [redacted] |

## Table 39 - Option Evaluation Matrix (Huntingdon)

## 7.2. Emissions Compliance & BAT Assessment

### Emissions Compliance

399. MCPD compliance was assessed through the Optioneering process defined within **Section 5,** and as such, only options which were MCPD compliant were taken forward for costing and further consideration.

400. It should be noted that while all options achieve MCPD compliance, not all options can be considered equal in their ability to reduce $NO_x$ levels. Unit derogation and CSRP do not reduce $NO_x$ levels to the same level as DLE, SCR or new build options, achieving emissions compliance through reduced operation or limited power output.

401. In this regard, from a purely emissions reduction perspective, options featuring DLE, SCR or new build would be preferred over unit derogation and CSRP retrofit.

### Preliminary BAT Assessment

402. The preliminary BAT assessment outlined within **Appendix G** determined that "when the lead unit is available, there is sufficient capability available to meet all the duty requirements using a single unit or with two units in parallel. It was considered that there will be no significant difference between all options in a lead configuration". For this reason, Options 1-5 were considered BAT compliant in the lead unit configuration.

403. Option BAT scores are identified within the option assessment matrix to recognise the differing levels of BAT capability between the options (back-up configurations only). As detailed within the BAT report, unit derogation and CSRP scored lowest due to reduced versatility, poor future proofing and lack of $NO_x$ abatement. DLE and SCR were the next best performing options which feature improved emissions reduction but are limited by remnant Avon infrastructure. New units provide the most significant technical and environmental advantage over Avon based units.

404. It was defined in **Section 5** that a BAT assessment has not been performed on the Huntingdon options. Nevertheless, using the BAT scores from the Peterborough assessment we can derive that the same results would be gained from Huntingdon. All options are considered BAT compliant in the lead configuration while DLE represents the best back-up configuration option based on the potential for superior emissions reduction and future proofing compared to CSRP and derogation.

405. In summary, the preliminary BAT assessment has not been used to filter out any of the shortlisted solutions.

## 7.3. Cost Benefit Analysis (incl. key assumptions and sensitivities)

### Introduction

406. **Section 4** detailed the diverse uses of compression at Peterborough and Huntingdon and why Peterborough offers the most flexibility to the operation of the NTS and our customer's demands of it. The number of roles each site can undertake is the reason for the high historic run hours and why **Figure 23** shows this to continue and therefore three unrestricted compressors are required at Peterborough. We have also detailed that compression at Peterborough and Huntingdon, to support exit capability in the South of the network, will continue until at least the late 2040's. Without resilient compression at the sites, the network will be less efficient. Multiple alternative sites would need to be run to compensate for Peterborough or Huntingdon being unavailable. This will have consequences on downstream compression and the need for additional investment to ensure we have sufficient resilience to meet the range of future flows.

407. The importance of Peterborough and Huntingdon is not fully captured in the CBA, as it only considers the risk of constraints associated with having a single site or fewer fully unrestricted units. Due to the central location of the sites, and there being alternative ways of achieving the network capability required for the most frequently seen levels of demand, there is a small risk of exit constraints, this risk substantially increases as higher demands are experienced. The impact the sites have on managing supply and demand imbalances in different zones and ensuring suitable line-pack levels are maintained in each zone are not easily captured in the CBA. This is because these occur within day and the risk model is based on end of day values, therefore undervaluing sites like Peterborough and Huntingdon. The risk is very binary, without appropriate assets at these sites the network fails either with high pressures backing out entry points or pressure levels falling at the extremities as line-pack depletes; with these sites the NTS operates more effectively and efficiently. For these reasons the CBA alone cannot be relied upon to determine the preferred option but is included for information.

### Options in CBA

408. To refine the CBA, shortlisted options for Peterborough and Huntingdon were combined to provide a holistic approach to the investment option evaluation. The Huntingdon option assessment process determined that Avon DLE was the most appropriate solution for the site out of the short-listed options. Please see **Section 7.7** for detail on this decision. **Table 40** identifies the list of options brought forward for the CBA evaluation.

| Peterborough - Huntingdon CBA Options | Pet'boro Unit A | Pet'boro Unit B | Pet'boro Unit C | Pet'boro Unit D | Pet'boro Unit E | Pet'boro Unit F | Huntingdon Unit C |
|---|---|---|---|---|---|---|---|
| 1 – Counterfactual | 500Hr EUD | Removed | Removed | No Change | No Change | / | 1533 DLE Retrofit |
| 2 - 1 x CSRP | CSRP Retrofit | Removed | Removed | No Change | No Change | / | 1533 DLE Retrofit |
| 3 - 1 x 1533 DLE | 1533 DLE Retrofit | Removed | Removed | No Change | No Change | / | 1533 DLE Retrofit |
| 4 – 1 x SCR | SCR Retrofit | Removed | Removed | No Change | No Change | / | 1533 DLE Retrofit |
| 5 - 1 x New GT | Decom. | Removed | Removed | No Change | No Change | New Unit (Brownfield) | 1533 DLE Retrofit |

**Table 40 - Combined Option List for CBA Evaluation**

## Constraints

409. The annual constraint costs are shown in **Figure 29** for the ST scenario. The DLE unit has a 5% penalty in availability which would lead to greater constraint costs compared to Option 2 (CSRP) and Option 4 (SCR). The total constraint costs, and the difference between the options, are deemed small based on the FES 2021 data.

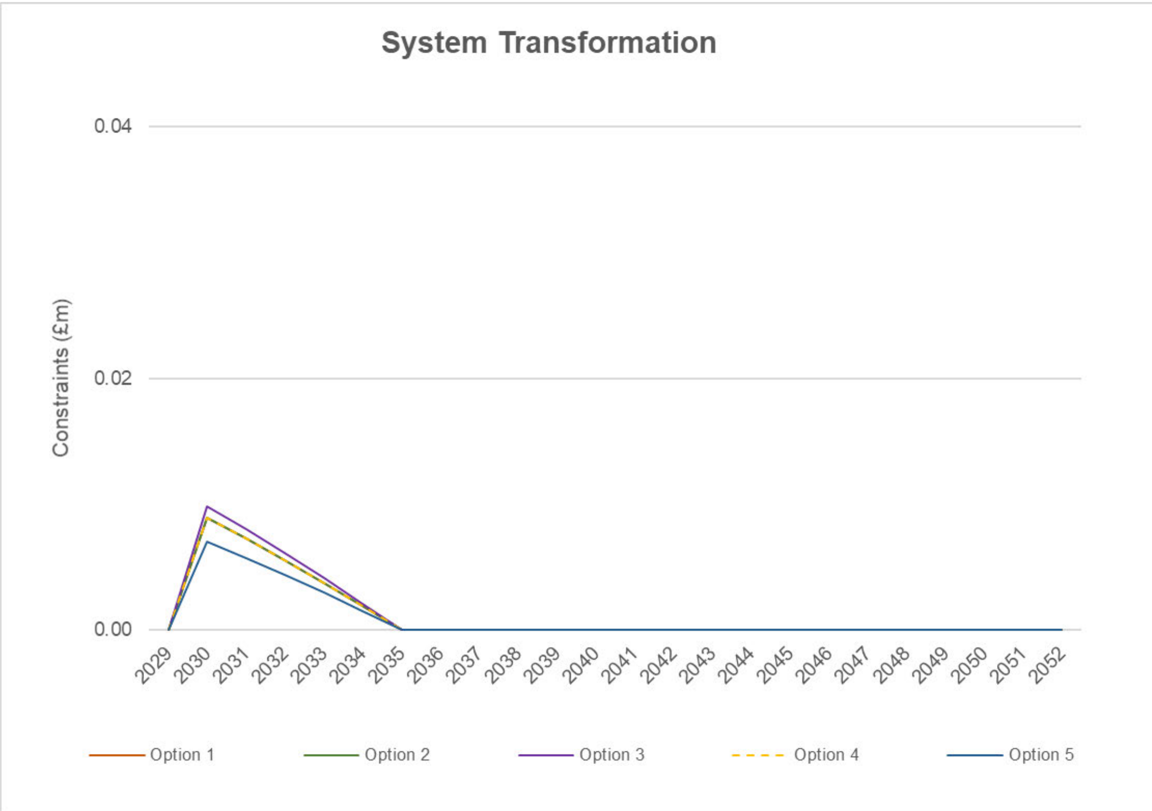



**Figure 29 – Peterborough and Huntingdon Annual Constraints**

## Operational and Investment Costs

410. **Figure 31** shows the breakdown of the investment and asset health costs included within the CBA. This allows a comparison over the relative costs in each of the options.

411. As would be expected, Option 5 with a new GT unit at Peterborough and DLE retrofit at Huntingdon, has the highest investment costs. This is followed by Option 4 with SCR at Peterborough and DLE retrofit at Huntingdon. The asset health in Option 5 with the new unit at Peterborough and DLE at Huntingdon is the lowest at [redacted]. The extra investment cost in the other 4 options is around [redacted]. These costs are covered in more detail in **Section 6.2.**

[redacted]

**Figure 30 – Peterborough and Huntingdon Asset Costs included in the CBA**

412. As shown in **Figure 31**, the fuel and emission costs in all options are very close. For example, in the ST scenario the cost difference is [redacted] in fuel usage and [redacted] in emissions.

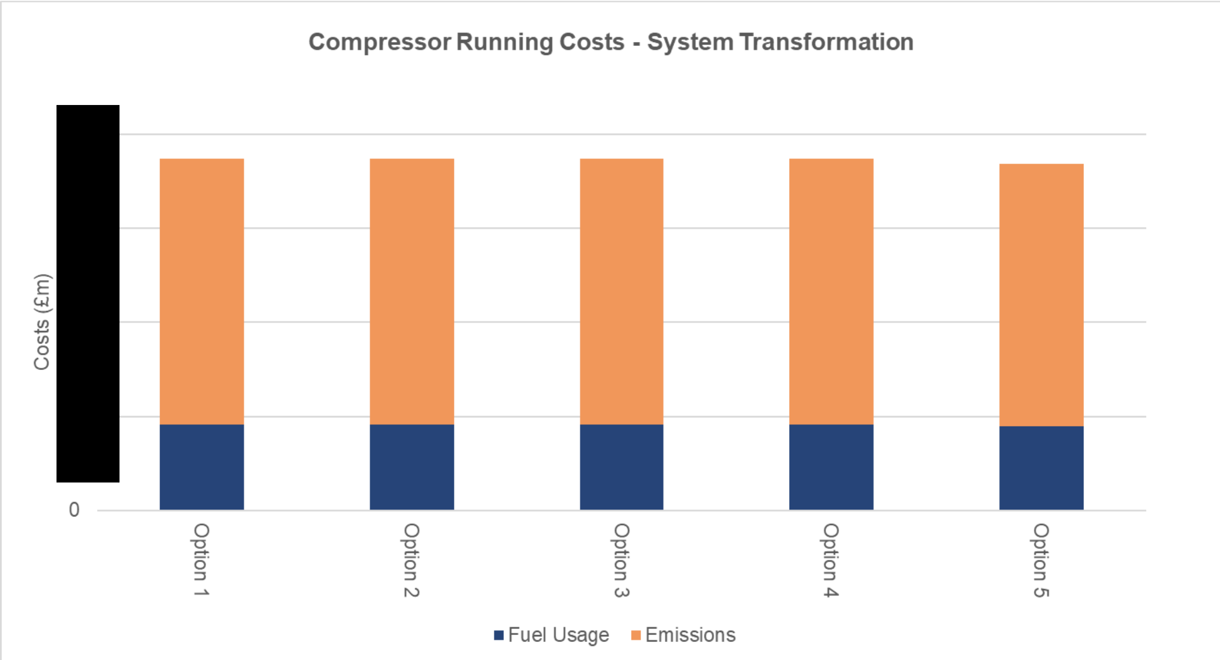



**Figure 31 – Peterborough and Huntingdon Operational Costs included in the CBA**

## Key CBA Assumptions

413. The key assumptions used in the Peterborough and Huntingdon CBA are detailed in **Table 41** below.

| Category | Assumption | Base Assumption | Rationale |
|---|---|---|---|
| CBA parameters | WACC | 2.81% | Defined in RIIO-T2 |
| | Social Time Preference Rate | 3.5% (Years 0 – 30) / 3.0 % (30+) | Defined in Green Book |
| | Regulated Asset Life | 45 years | Defined in RIIO-T2 |
| | Assessment Period | 25 years | Based on lifetime of asset |
| | Depreciation | SOTYD | Defined in RIIO-T2 |
| | Capitalisation | 75.00% | Defined in RIIO-T2 |
| Constraints and Fuel | Gas Price | Annual price 50 – 64 p/th | BEIS reference scenario |
| | Compressor Fuel Costs | Gas Price | |
| | Constraint management pricing | [redacted] | As defined by Commercial Constraint Price Methodology |
| | Constraint management method | 50% buybacks/50% locational actions | Reflective of tools available to manage constraints |
| Emissions | CO2 cost | Annual price 241 – 378 £/tonne | BEIS Valuation of greenhouse gas emissions: for policy appraisal and evaluation : Central Case |
| | NOx price | £6,199 £/tonne | DEFRA damage costs |

**Table 41 - Key Assumptions and Sensitivities**

## CBA Outputs

414. To test the sensitivity of the Peterborough and Huntingdon options against different supply and demand scenarios, we have compared the case against all four FES. The relative and absolute NPVs of these can be seen in **Table 42** and **Table 43** respectively. The highest NPV option in all FES was Option 1 (Peterborough Counterfactual and Huntingdon with DLE Avon).

| Option | Steady Progression | Consumer Transformation | Leading the Way | System Transformation |
|---|---|---|---|---|
| 1 – Counterfactual | £0 m | £0 m | £0 m | £0 m |
| 2 - 1 x CSRP | -£3 m | -£3 m | -£3 m | -£3 m |
| 3 - 1 x 1533 DLE | -£5 m | -£6 m | -£12 m | -£5 m |
| 4 – 1 x SCR | -£11 m | -£11 m | -£11 m | -£11 m |
| 5 - 1 x New Unit | -£34 m | -£34 m | -£21 m | -£36 m |

**Table 42 - CBA  Results vs. FES 2021 - Relative NPV**

| Option | Steady Progression | Consumer Transformation | Leading the Way | System Transformation |
|---|---|---|---|---|
| 1 – Counterfactual | [redacted] | | | |
| 2 - 1 x CSRP | | | | |
| 3 - 1 x 1533 DLE | | | | |
| 4 – 1 x SCR | | | | |
| 5 - 1 x New Unit | | | | |

**Table 43 - CBA Results vs. FES 2021 - Absolute NPV**

415. Based on the CBA most of the difference being a result of the investment costs. A new unit at Peterborough (Option 5) does show some benefits in terms of fuel costs and emissions, however these alone do not outweigh the higher upfront costs.

## CBA Summary

416. Due to the limitations of FES 2021, the CBA cannot fully quantify the benefits of unrestricted running at Peterborough and Huntingdon. As a result, no options can be filtered out of consideration on this basis.

## 7.4. Security of Supply and Case Studies

### Zonal Transfer and Line-pack management

418. As detailed in **Section 4.1** the central location of Peterborough and Huntingdon at strategic multi-junctions means they can move gas in multiple directions to correct zonal imbalances in supply and demand and ensure line-pack is maintained within safe operational limits. This movement of gas to strategically manage these imbalances and line-pack levels on the NTS serves two key purposes:

- Provision of pressure cover – This is essentially an insurance policy, giving headroom above the minimum or maximum offtake pressures for any unexpected changes in supply and demand or any asset failures. It gives us time to react and rectify the situation minimising interruption to system users. Peterborough and Huntingdon directly impact two system extremity points and ensure sufficient pressure cover is maintained.

- Zonal line-pack management - **Figure 10** shows that the South-East and South-West have limited line-pack capability compared to the level of demand in the zones. Active line-pack management is required to constantly ensure line-pack levels are maintained within safe limits in these zones. This ensures the system can safely accommodate the full range of potential flows under various short term/market responsive, operational scenarios.

419. The two purposes outlined above are in essence providing for the movement of strategic line-pack away from terminals to areas of demand. The consistent ability and necessity to operate this strategy provides an insurance policy to both the market (entry capability/Security of Supply) and our downstream customers (lowering risk of failure to meet minimum offtake pressures through pressure cover/constraint and emergency management). Removing or diminishing this capability does not on its own lead directly to constraints but instead, depending on the demands being placed on the network and its assets at the time, raises the risk significantly by putting the system in a position where other asset failures would immediately result in the network failing.

420. The value that these activities provide are not captured within the CBA. This is because these activities occur within day and all the risk modelling is based on end of day values. To show the importance of these activities we have estimated the economic value downstream of the compression at Peterborough and Huntingdon in the South-East and South-West.

### Gross Value Added Analysis

421. A significant proportion of economic activity in the UK is supported by the safe and effective operation of the gas network. Currently, the economic importance of the gas network is not assessed, and it is not included in the CBA for investments of the network.

422. We have assessed the scope of economic activity supported in Southern (South-East and South-West) England by the operation of the Peterborough and Huntingdon Compressor Stations, considering the economic value of larger industrial sites and gas fired power stations. This value is based on an evaluation of the economic activity

(industry and power) that are reliant on gas supplies (and therefore the gas network) using the Gross Value Added (GVA measure). This measures the value of the industry and power facilities that are downstream of Peterborough and Huntingdon, whose activity would be at risk if there was no other compression available in Southern England. This has been done using a top down and bottom-up[36] approach to verify the findings from the different approaches.

423. **Figure 32**[37] of the large industrial sites supported by the Peterborough and Huntingdon compressors. **Figure 33** shows an estimate of the economic value of electricity generation potentially at risk from an interruption to supply[38]:

| Economic value supported by the NTS | 2021 implied GVA (£m) |
|---|---|
| Industry: top down | 6,656 – 7,279 |
| Industry: bottom up | 7,370 |
| Gas fired power stations: bottom up | 1,361 |

**Figure 32 - Economic value of large industrial sites**

| Value of electricity generation at risk | | Value at risk (£m) |
|---|---|---|
| Gas fired power stations: | Value of load (VOLL) basis | 1,457 |
| | Wholesale market prices basis | 14 |

**Figure 33 - Economic value of electricity generation**

424. Compression at Peterborough and Huntingdon supports a significant proportion of the UK economy. It is imperative that the correct level of resilience and capability are maintained so that we can continue to provide active line-pack management and pressure cover in the South-East and South-West of the network. This ensures we can continue to offer Security of Supply and minimise the risk of interruptions to consumers.

## 1-in-20 Peak Demand Obligation

425. As detailed in **Section 4.1,** Peterborough and Huntingdon will continue to play a key role in managing 1-in-20 peak demand obligations into coming decades, along with other compressors in the region such as Cambridge. Modelling under the ST scenario suggests that, while the 1-in-20 peak demand obligation capability gap, seen in **Figure 34**, narrows significantly out to 2050, Peterborough and Huntingdon as the first and second sites in operation, will continue to play a significant role in managing the 1-in-

[36] For large corporations where site specific financial data is not available: assumes 10% of UK turnover is in Southern England (pending further financial research.)
[37] Figures are for 1 year.
[38] We have assumed that supplies to power stations are restored in 24 hours as a conservative assumption.

20 peak demand obligations. For example, in 2029/30, utilisation of Peterborough reduces the capability gap by approximately 5 mcm/d, and the additional utilisation of Huntingdon reduces it by an additional 3 mcm/d.

426. The modelling also indicates that there are no periods out to 2050 when Peterborough and Huntingdon are no longer required., i.e. the 1-in-20 peak demand does not declined to a point where Peterborough and Huntingdon are no longer required. This shows that the compressors will have an ongoing role in managing 1-in-20 peak demand obligation out to 2050.

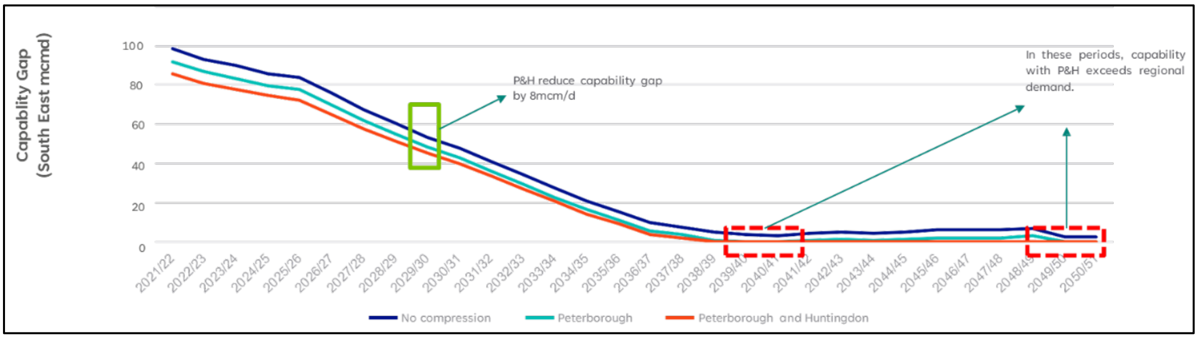



**Figure 34 – South-East Capability Gap – ST**

427. The compressors also play a role in managing 1-in-20 peak demand obligation in the South-West. Modelling under the ST scenario from FES suggests that, while the 1-in-20 peak demand capability gap seen in **Figure 35** narrows significantly out to 2050, Peterborough and Huntingdon will continue to play a significant role in managing 1-in-20 peak demand. For example, in 2029/30, deploying Peterborough reduces the capability gap by approximately 3mcm/d, and the additional deployment of Huntingdon reduces it by an additional 9 mcm/d.

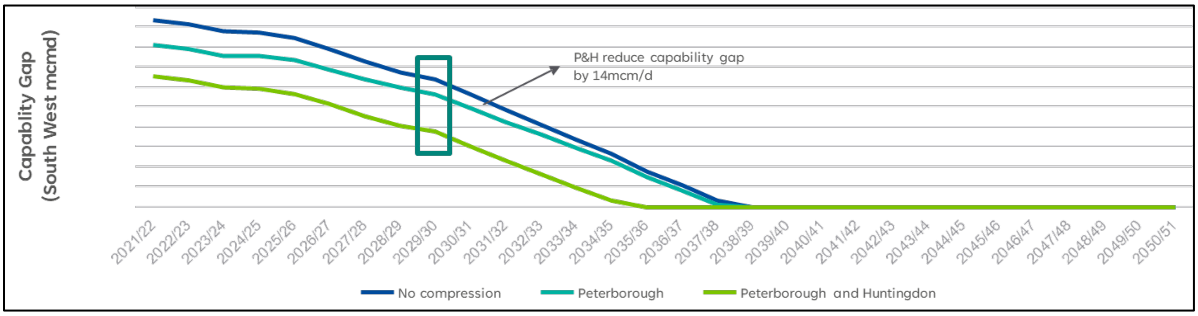



**Figure 35 – South-West Capability gap (ST)**

428. The modelling shows that both Peterborough and Huntingdon will play a key role in supporting South-East 1-in-20 peak demand capability until 2050 and supporting South-West capability until at least the late 2030s.

## Operational Strategy and Efficiency

429. The flexibility of Peterborough and Huntingdon to support several different roles and requirements on the network mean that they are two of the most important sites on the

network. If they are not available, the alternative strategies used are less efficient as multiple compressor sites are required to deliver the same level of resilience and output.

430. To demonstrate this, we have provided the following examples of common uses of Peterborough and the alternative configurations which would be required if parallel operation was not available.

431. One example is during typical winter demands with low Milford Haven supplies. The primary compressor combination to support these flows would be parallel operation at Peterborough, as shown in **Figure 36** below. In this instance, Peterborough was the only compressor in use in the South of the Network to support these flows. End of day demand was 265mcm (although instantaneous demand was higher at 297.6mcm/d), with the extract shown from 15:00, compressor configuration was similar for most of the day.

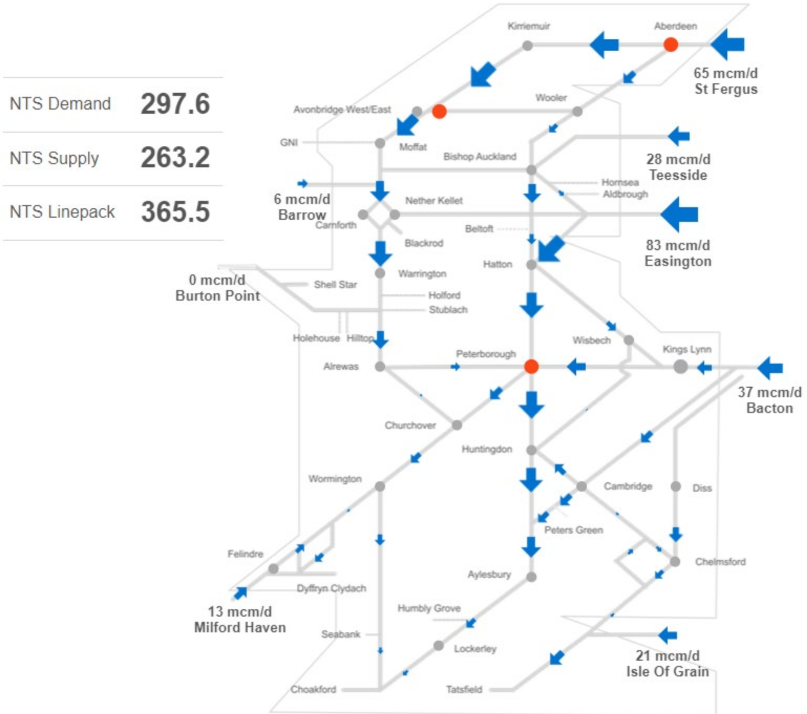



**Figure 36 - Example Configuration (27 December 2020)**

432. To meet these conditions without the use of Peterborough operating in parallel, Huntingdon would have to be run in parallel along with Churchover. As shown in **Table 44** below, this would increase running costs from about [redacted].

| | Compressor Station | Machine | Fuel Cost (£k/h) | Carbon Cost (£k/h) | Total Running Cost (£k/h) |
|---|---|---|---|---|---|
| Primary Configuration | Peterborough | D | [redacted] | [redacted] | [redacted] |
| | Peterborough | E | [redacted] | [redacted] | [redacted] |
| | | | | Total | [redacted] |
| | Compressor Station | Machine | Fuel Cost (£k/h) | Carbon Cost (£k/h) | Total Running Cost (£k/h) |
| Secondary Configuration | Huntingdon | D | [redacted] | [redacted] | [redacted] |
| | Huntingdon | E | [redacted] | [redacted] | [redacted] |
| | Churchover | E | [redacted] | [redacted] | [redacted] |
| | | | | Total | [redacted] |

**Table 44 - Running Example One**

433. Another example is when it is required to move significant volumes of gas from the North to the South of the network. Our primary configuration to meet these flows would be running Hatton, Peterborough in parallel and Huntingdon in parallel.

434. If Peterborough in parallel was not available, Carnforth and Alrewas would have to be operated along with Hatton and Huntingdon to replace the capability of Peterborough. As shown in Table 44 below, this would increase costs from [redacted].

| | Compressor Station | Machine | Fuel Cost (£k/h) | Carbon Cost (£k/h) | Total Running Cost (£k/h) |
|---|---|---|---|---|---|
| Primary Configuration | Peterborough | D | [redacted] | [redacted] | [redacted] |
| | Peterborough | E | [redacted] | [redacted] | [redacted] |
| | | | | Total | [redacted] |
| | Compressor Station | Machine | Fuel Cost (£k/h) [A] | Carbon Cost (£k/h) [B] | Total Running Cost (£k/h) [D] = [A]+[B]+[C] |
| Secondary Configuration | Carnforth | C | [redacted] | [redacted] | [redacted] |
| | Alrewas | C | [redacted] | [redacted] | [redacted] |
| | | | | Total | [redacted] |

**Table 45 - Running Example Two**

## Security of Supply Summary

435. Peterborough and Huntingdon are vital in meeting our 1-in-20 peak demand obligations in the South-East and South-West of England. Given the need for parallel running at these sites, an unrestricted third unit is required for resilience in the event of planned or unplanned lead unit outage. This is one of the fundamental criteria that supports the 1-in-20 design standard. Therefore, any option that results in a restricted third unit is deemed unacceptable due to the need to ensure the 1-in-20 design standard is maintained, as stated in CE-AMP.

436. In addition to the 1-in-20 peak demand obligation, our economic analysis shows how Peterborough and Huntingdon will play a key role in supporting overall demand in the South of the network. This demand represents significant value to the UK economy, as

demonstrated in our GVA analysis, and the most efficient way to support this is the use of Peterborough and Huntingdon.

## 7.5. Technology Risk

437. **Section 5** described a number of innovative abatement solutions which were considered as part of the Optioneering process. These solutions reflect technologies which are at various levels of technical maturity and implementation on the National Transmission System. For example, SCR is a proven technology in the European gas network however, no compressors on the NTS currently use SCR to ensure $NO_x$ compliance.

**Peterborough Assessment**

438. The technological readiness level of these technologies is an important consideration for implementation at a compressor site of critical importance such as Peterborough. The technological risk inherent in each of the abatement solutions below is described in **Section 5.2** and is also contained within the Project Risk Register (**Appendix F**).

439. Important consideration is given to the age and current condition of the Avon's. As described in **Section 3**, Peterborough A is over 50 years old (commissioned in 1973), currently operating well beyond its original design life. While we have considered an appropriate level of initial and ongoing asset health investment to achieve the unit availability targets set out in the RAM Study (see **Section 4.2** and CE-AMP). Continued reliance on 50-year-old assets remains a risk to site availability and resiliency. Reliance on the Peterborough unit beyond 2030 poses a high risk to the operation of the NTS and the UK's Critical National Infrastructure.

440. The asset health scope of the Avon has been assumed based on the recommendations of the RAM Study; visual, non-intrusive site inspection, and feedback from site Operations team. In the case of options that rely on Avon operation beyond 2030, condition assessment surveys will be conducted during FEED and there is a major risk[39] that additional scope will be identified during survey. Further risks associated with the age of the Avon include the risk that reliability will be worse than expected due to age related issues[40] and that long term support will become more problematic[41].

441. Following due consideration for the criticality of Peterborough Compressor Station as detailed in **Section 4** and **Section 7.4**, each of these abatement solutions has been filtered out of consideration due to the concerns raised above, with additional justification for ruling out these abatement solutions is described further below. This can be seen in the Option Assessment Matrix represented in **Table 35.**

**Huntingdon Assessment**

442. The approach taken at Huntingdon differs from Peterborough due to the strategic role the compressor stations have on the NTS. While both sites are critical for NTS zonal transfer, line-pack management, 1-in-20 peak demand obligation and network capability and overall operational strategy, Peterborough is prioritised due to its network location

[39] Risk Register ref. CM-1
[40] Risk Register ref. CM-6
[41] Risk Register ref. CM-7

in supporting flows North to South and East to West in particular. See **Section 4.1** for more context on network need case.

443. For this reason, derogation, CSRP and DLE are acceptable forms of investment as Peterborough can provide significant back-up compression support in most cases of planned or unplanned outages at Huntingdon. Huntingdon can't support Peterborough to the same extent due to its location on the NTS.

444. In the event of CSRP permit rejection or DLE technology failure, there remains the ability to return operation back to the original Avon compressor setup operated under derogation, given primary investments at other MCPD sites are approved. In both instances the environmental permits will require updating to align to the 500-hour derogation. Should the Avon DLE option fail in operation then reverting to a standard Avon would require some physical asset modifications, with the extent of such modifications being dependent on the severity of the failure. The risk of a catastrophic failure of the Avon DLE solution is somewhat mitigated through engine testing currently in progress and operational proving which should be partially complete prior to Avon DLE installation at Huntingdon. Additional risks and mitigations will be investigated further during conceptual and detailed design.

445. In summary, no shortlisted options are ruled out on the basis of technology risk at Huntingdon given the ability of Peterborough to provide supporting compression, along with the potential to revert to 500-hour derogation being a viable option - given primary investments at other MCPD sites are approved.

**Dry Low Emissions (DLE) Avon Retrofit**

446. The DLE retrofit solution has not yet been fully proven in commercial operation and is currently undergoing performance testing. As such, there are risks surrounding its selection and implementation, see **CE-AMP** for further detail

447. This technology risk is represented in the Project Risk Register under CM-14 as a Major risk (High Probability / Medium Impact). This risk has the potential to impact unit availability and given the future requirement for parallel running (as established within **Section 4**), site availability could be impacted in the event of planned or unplanned downtime involving the lead units on site.

448. It is discussed in **Section 3.1** and **5.1** that we are currently running controlled performance trials on DLE technology with a view to permanently installing it on units on the NTS for more established operational running. Following the accumulation of 10,000 operational hours on a single unit, and a full review and inspection the technology could be recommended for network wide installation.

449. Given the risks associated with implementation of an unproven technology at a high criticality site, DLE retrofit has been removed from future consideration at Peterborough as identified in **Table 38**.

**Control System Restricted Performance (CSRP)**

450. CSRP is an innovative control system modification which has not been implemented on the NTS previously. Solution implementation is dependent on gaining environmental permit approval from the Environment Agency (EA). Permit applications are being sought for the sites that were used for performance tests, to determine if the EA would accept it as an MCPD solution. Individual permits would have to be submitted for each unit where CSRP it the selected solution, with the relevant environment agency reviewing each one specifically.

451. This technology risk is represented in the Project Risk Register under HSSE-11 as a Significant Risk (Low Probability / High Impact). This risk has the potential to impact the execution schedule through experiencing delay due to challenges in obtaining an environmental permit from the EA.

452. In certain circumstances, CSRP would reduce the top end power of the compressor. The exact reduction in performance is specific to the particular compressor in question, taking into account multiple variables specific to its location and operation on the NTS. Installation of CSRP on compressors requiring top end utilisation could significantly impact operation, leading to constraints.

453. There is an increased risk that, due to the potential for high forecast run hours at Peterborough, the EA could deem CSRP an inadequate solution for emissions reduction compared to DLE, SCR or new unit application. If deemed “available”, CSRP is an ideal candidate for lower run hour sites which wouldn’t be impacted from performance restrictions.

454. Given the risks outlined above and the case made against continued use of compressor units which have exceeded their design life, CSRP is removed from future consideration.

**Selective Catalytic Reduction (SCR)**

455. The SCR solution uses Ammonia ($NH_3$) and a catalyst to convert $NO_x$ into Nitrogen ($N_2$) and water ($H_2O$), in turn reducing the total $NO_x$ emissions.

456. SCR represents a new technology on the NTS, as no compressors currently use SCR to reduce NOx emissions. A similar catalyst solution has been implemented at Aylesbury, but this is a passive solution which reduces CO. This solution did not use reagent – ammonia – to reduce $NO_x$. SCR requires a continuous emissions monitoring system to monitor $NO_x$ and adjust ammonia level accordingly. Implementation of a new technology on a critical site poses a risk to site availability and resiliency through the introduction of a new failure mode to the compressor system.

457. The ammonia reagent introduced by SCR is a hazardous substance which would require new procedures to be developed. For this reason, this option scores worse than alternatives in terms of “hazard” on the BAT assessment.

458. Given the concerns outlined above and the case made against continued use of compressor units which have exceeded their design life, SCR is removed from future consideration.

**New Unit**

459. New units will have some technology risk associated with their installation and operation; however this is mitigated through strict qualification requirements which must be met prior to compressor equipment being approved for use on the network. We will also look to commission new units in 2028 to allow a winter proving period prior to the legislative deadline when non-compliant units must be removed from service.

## 7.6. Capital Investment

460. As stated in **Section 7.1**, our key investment drivers are to comply with MCPD emissions legislation, while ensuring that the network is resilient and able to meet a wide range of likely future supply and demand patterns, thereby ensuring compliance with our 1-in-20 peak demand obligations.

461. By filtering options based on criteria which assess the relative merit and viability across a wide range of key considerations, we have reduced the available Peterborough options down to one single option as displayed in **Table 46** below.

462. Option 5 remains the preferred solution for the site despite its high initial investment cost. This is the only option that achieves our key investment criteria in addition this option also provides significant technical, environmental and emissions improvements.

| Option Assessment Matrix Peterborough | Emissions Compliance | BAT Assessment | CBA | Security of Supply / Resilience | Technology Risk | Capital Investment |
|---|---|---|---|---|---|---|
| 5 - 1 x New Unit | Achieves MCPD Compliance through **New Unit Build** | Lead Configuration: BAT Back-Up Score: 93% Versatility: 15/15% | Modelling based on FES does not capture key use cases of the site and risks resulting from loss of capability | Provides Unrestricted Running | New Compressor Technology proven on NTS | [redacted] |

**Table 46 - Final Option Assessment Capital Investment Filter (Peterborough)**

463. There are three viable options available for Huntingdon which comply with our investment criteria and evaluation models within an acceptable level of risk. DLE retrofit offers a low capex alternative to derogation or CSRP, provides the ability to operate unrestricted and enables superior levels of emissions reduction. Should major issues be encountered with this solution, we retain the ability to revert to CSRP or the original Avon configuration with derogation (given primary investments at other MCPD sites are approved). Therefore, we recommend investment in Avon DLE retrofit at Huntingdon as shown in **Table 47**.

| Option Assessment Matrix Huntingdon | Emissions Compliance | BAT Assessment | CBA | Security of Supply / Resilience | Technology Risk | Capital Investment |
|---|---|---|---|---|---|---|
| A – Counterfactual | Achieves MCPD Compliance through **Derogation**<br><br>**Note**: No NOx emissions abatement. | BAT Assessment not performed at Huntingdon however based on PET assessment back-up configuration would not be considered BAT compliant | Modelling based on FES does not capture key use cases of the site and risks resulting from loss of capability | Avon derogation is acceptable based on unrestricted running at Peterborough | Unit condition mitigated by asset health investment & Peterborough support | [redacted] |
| B - 1 x CSRP | Achieves MCPD Compliance through **Abatement**<br><br>**Note**: No NOx emissions abatement. | BAT Assessment not performed at Huntingdon however based on PET assessment back-up configuration could be considered BAT compliant | | Provides Unrestricted Running | Potential for EA permit rejection mitigated by reversion to derogation, up-front permit pre-application and Peterborough support | [redacted] |
| C - 1 x 1533 DLE | Achieves MCPD Compliance through **Abatement** | BAT Assessment not performed at Huntingdon however based on PET assessment back-up configuration could be considered BAT compliant | | Provides unrestricted running | Potential for unit DLE failure mitigated by reversion to derogation and Peterborough support | [redacted] |

**Table 47 - Final Option Assessment Capital Investment Filter (Huntingdon)**

## 7.7. Final Option Justification

### Our Investment Recommendation

464. Based on our option assessment and evaluation, to achieve MCPD legislative compliance at Peterborough and Huntingdon Compressor Stations, NGGT's Final Preferred Option recommends the installation of a new gas-driven compressor unit at Peterborough and installation of DLE Emission Abatement technology on the Avon at Huntingdon. Decommissioning of the Peterborough Avon will be assessed after operational acceptance of the new unit. This option provides long-term emissions compliant compression resilience.

### Justification for the Final Preferred Option

465. As detailed throughout the FOSR, Huntingdon requires a third unit to maintain parallel site operation to meet our 1-in-20 peak demand obligation. Due to its proximity and strategic operation with Peterborough, there are multiple viable solutions that can be utilised to ensure MCPD compliance and network security. A DLE retrofit is the preferred option due to the unrestricted running and emission reduction it provides compared to CSRP and 500-hour derogation, and reduced capital expenditure compared to a new unit. Therefore, all combined options include a DLE retrofit solution for Huntingdon Unit C.

466. Option 1 (500-hour derogation Unit A) isn't a viable option as detailed in **Section 7.4.** Analysis has shown that derogating the unit to 500-hours will incur the highest level of network constraints and gives insufficient resilience to the site in meeting operational requirements and operating in parallel.

467. Option 2, 3 and 4 (Emission Abatement solutions) aren't viable options for Peterborough as detailed in **Section 7.5.** DLE is currently undergoing performance trials, CSRP's acceptance by the environment agencies is being assessed, and SCR poses significant operational risks which can't be accepted on a critical site. Therefore, these are not currently available solutions for the site to meet MCPD and operational requirements by the 2030 deadline.

468. Option 1, 2, 3 and 4 (options retaining the Peterborough Avon) aren't viable options as detailed in **Section 7.5.** The Avon is currently over 50 years old, beyond their original design life. Reliance on its continued operation beyond 2030 poses significant risk to the continued operation of UK Critical National Infrastructure.

469. Option 5 (new unit) is a viable option as detailed in **Section 7.3.** This solution scored highest in terms of network versatility, future proofing against changes in energy legislation, maintainability and emissions in the BAT assessments. New GT compressors also offer fuel efficient operation, long-term reliability, high availability and low emission compression. Featuring the most up-to-date technology and support packages, which protects the investment from future changes in energy legislation ahead of the UK's aspiration to achieve Net Zero by 2050.

470. Option 5 (new unit) is the highest performing solution from an emissions reduction perspective and received the highest overall technical rating with the BAT assessment compared to the alternative investment options. New units also offer higher levels of availability compared to existing Avon's after Asset Health has been competed (90% compared to 79%). This higher level of availability, along with the other benefits of a new unit give Peterborough the correct levels of resilience and availability.

471. Option 5 (new unit) enables us to operate a safe, efficient, and economic network. This will ensure that Peterborough can continue to be the lead site for the UK in the balancing the supply and demand imbalances between the different network zones. It can continue to ensure line-pack levels are maintained within operational ranges, minimising the risk of entry and exit constraints, while ensuring we can continue to maintain our 1-in-20 security standard.

472. Deferring or delaying the investment in Option 5 (new unit at Peterborough) isn't feasible due to the high risks posed with the Avon being derogated to 500-hours beyond 2029 (Option 1).

473. Various planned investments are expected to interface with this Final Preferred Option, these are detailed within **Section 4.2**. Detail on the risks associated with the preferred option and other shortlisted options is included in **Appendix F**.

474. Specific project risks relating to the Final Preferred Option are covered within **Section 8.3**.

# 8. Additional Final Option Detail

## 8.1. Option Programme

475. Project delivery programmes for all shortlisted investment options for Peterborough have been developed to confirm the feasibility of delivery prior to the 1 January 2030 MCPD legislative deadline and to identify notable schedule related risks. These programmes have not been used to derive any elements of the CAPEX estimates, but they have been used to determine basic spend profiles.

476. For simplicity at this stage, separate project delivery programmes for Huntingdon have not been produced and the same programmes have been assumed as for Peterborough. Actual delivery programmes will be developed during FEED and will be dependent on the contract strategy and construction outages which will be scheduled across the two sites such as to minimise the impact on network operation.

477. The delivery programme for the preferred option including the key assumptions and constraints is described below. Delivery programmes for the other shortlisted option are provided in **Appendix E**.

478. The project delivery programme is based on a standard EPC delivery approach including the following main contracts:

- Pre-FEED
- FEED
- Compressor machinery train equipment supply
- Engineering, Procurement, Construction and Commissioning

479. Pre-FEED stage will be initiated immediately following confirmation/approval of the Final Preferred Option via the Re-opener planned for completion February 2023. During this pre-FEED stage the delivery strategy will be confirmed and tender documentation for the FEED stage produced.

480. During the subsequent FEED phase the selected investment option will be defined to an appropriate level of detail to support the Re-opener to confirm remaining project costs and to allow the EPC phase.

481. The EPC phase will include development of tender package for the compressor machinery train equipment which will be purchased by NGGT and free issued to the EPC contractor. Site works will commence once detailed design has been sufficiently progressed and two years has been allowed for all site works up to operational acceptance. The new unit installation will be conducted in a separate CDM area to minimise impact on site operations but there will still be a degree of SIMOPs to manage and some short outages on the adjacent unit may be required. A summer station outage will be required to allow tie-in and commissioning of the new unit.

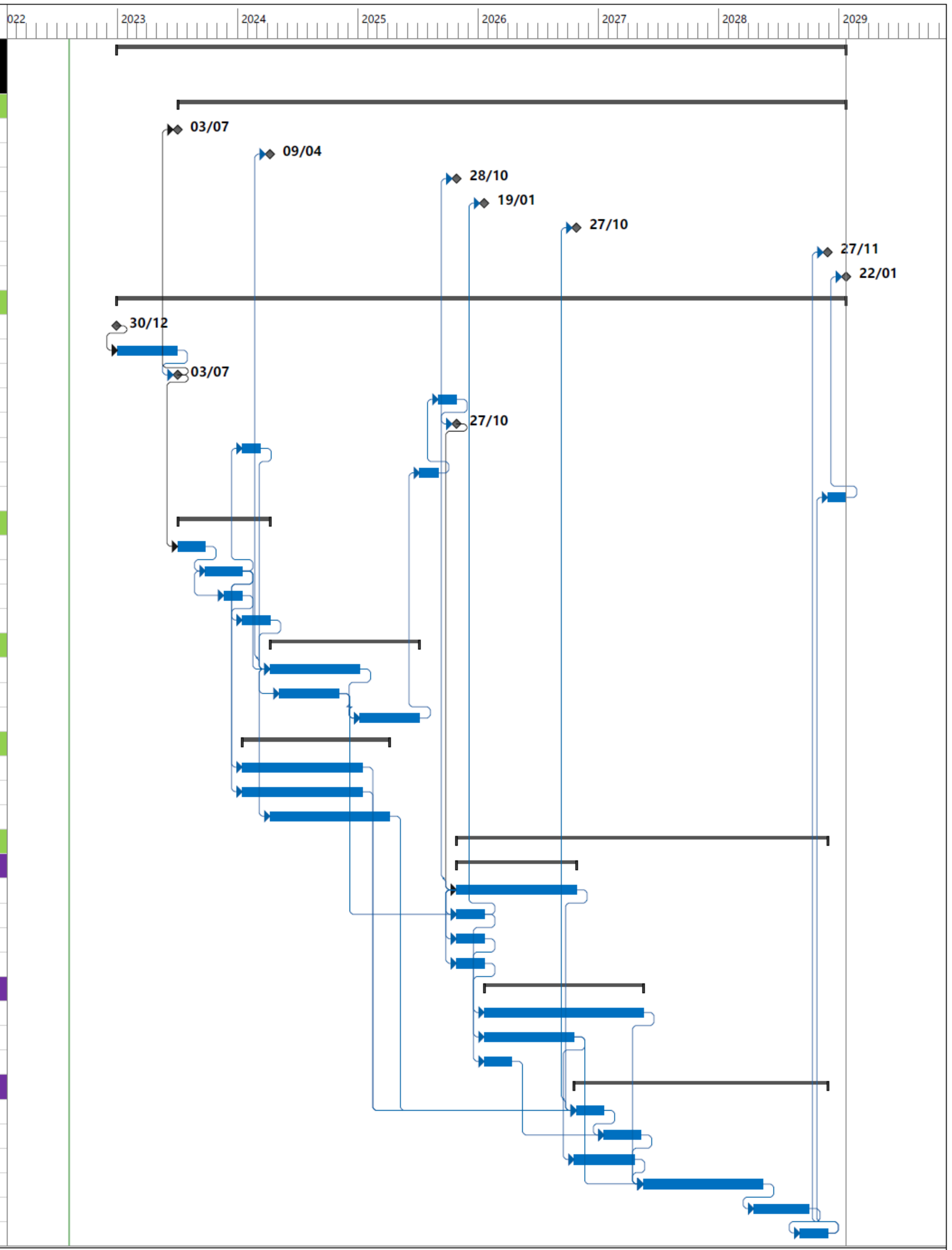
482. Potential schedule refinement and optimisation will be reviewed in the FEED stage once the scope has been refined and delivery approach. During this refinement process

a holistic view of works to be delivered across Peterborough and Huntingdon will be taken to ensure an efficient delivery with minimal impact on network operation.

483. After operational acceptance a winter running period has been allowed to operationally prove the new unit prior to the 2030 legislative deadline when any non-compliant units will be removed from service.

484. **Figure 37** shows the execution programme for the preferred option for Peterborough. The Huntingdon works will follow the same programme through design phases through to construction. At this stage the Huntingdon works will be scheduled around an outage in summer of 2027 followed by operational acceptance later that year. This will ensure full capability of one of the two sites is maintained throughout the construction phase.

| ID | Task Name | Duration | Start | Finish | Predecessors |
|---|---|---|---|---|---|
| 1 | **Option A GT Driven Compressor Machinery Located in Vacant Plinth F** | **316.4 wks** | **Fri 30/12/22** | **Mon 22/01/29** | |
| 2 | **Milestones** | **290 wks** | **Mon 03/07/23** | **Mon 22/01/29** | |
| 3 | NG Option Selection Complete | 0 wks | Mon 03/07/23 | Mon 03/07/23 | 13 |
| 4 | Commence FEED | 0 wks | Tue 09/04/24 | Tue 09/04/24 | 25SS |
| 5 | Commence Execute | 0 wks | Tue 28/10/25 | Tue 28/10/25 | 34SS |
| 6 | Place Oder for Compression Train | 0 wks | Mon 19/01/26 | Mon 19/01/26 | 35 |
| 7 | Site Mobilisation | 0 wks | Tue 27/10/26 | Tue 27/10/26 | 43SS |
| 8 | Commissioning Complete | 0 wks | Mon 27/11/28 | Mon 27/11/28 | 48 |
| 9 | Project Complete | 0 wks | Mon 22/01/29 | Mon 22/01/29 | 18 |
| 10 | **Ofgem Approvals & National Grid Governance** | **316.4 wks** | **Fri 30/12/22** | **Mon 22/01/29** | |
| 11 | Select Study Complete | 0 wks | Fri 30/12/22 | Fri 30/12/22 | |
| 12 | Ofgem Re-opener Window #1 Peterborough | 26 wks | Mon 02/01/23 | Fri 30/06/23 | 11 |
| 13 | Option Approved | 0 wks | Mon 03/07/23 | Mon 03/07/23 | 12FS+1 day |
| 14 | Ofgem Re-opener Window #2 Peterborough | 8 wks | Tue 02/09/25 | Mon 27/10/25 | 17 |
| 15 | Funding Approved | 0 wks | Mon 27/10/25 | Mon 27/10/25 | 14 |
| 16 | National Grid F3 Sanction (FEED) | 8 wks | Tue 16/01/24 | Mon 11/03/24 | 21 |
| 17 | National Grid F4 Sanction (EPC) | 8 wks | Tue 08/07/25 | Mon 01/09/25 | 27 |
| 18 | National Grid T6 Sanction (Project Completion) | 8 wks | Tue 28/11/28 | Mon 22/01/29 | 48 |
| 19 | **Pre-FEED** | **40 wks** | **Tue 04/07/23** | **Mon 08/04/24** | |
| 20 | Pre-FEED Study ITT & Award | 12 wks | Tue 04/07/23 | Mon 25/09/23 | 13 |
| 21 | Pre-FEED Study | 16 wks | Tue 26/09/23 | Mon 15/01/24 | 20 |
| 22 | FEED ITT Package | 8 wks | Tue 21/11/23 | Mon 15/01/24 | 21SS+8 wks |
| 23 | FEED ITT & Award | 12 wks | Tue 16/01/24 | Mon 08/04/24 | 22 |
| 24 | **Define** | **65 wks** | **Tue 09/04/24** | **Mon 07/07/25** | |
| 25 | FEED Study | 39 wks | Tue 09/04/24 | Mon 06/01/25 | 23,21,16 |
| 26 | Vendor Engagement | 26 wks | Tue 07/05/24 | Mon 04/11/24 | 25SS+4 wks |
| 27 | Execute ITT & Award | 26 wks | Tue 07/01/25 | Mon 07/07/25 | 25,26 |
| 28 | **Consents** | **64 wks** | **Tue 16/01/24** | **Mon 07/04/25** | |
| 29 | Environmental Assessment | 52 wks | Tue 16/01/24 | Mon 13/01/25 | 21 |
| 30 | Planning Consents and Approvals | 52 wks | Tue 16/01/24 | Mon 13/01/25 | 21 |
| 31 | Construction Camp Lease Agreement | 52 wks | Tue 09/04/24 | Mon 07/04/25 | 25SS |
| 32 | **Execute** | **161 wks** | **Tue 28/10/25** | **Mon 27/11/28** | |
| 33 | **Engineering** | **52 wks** | **Tue 28/10/25** | **Mon 26/10/26** | |
| 34 | Detailed Engineering | 52 wks | Tue 28/10/25 | Mon 26/10/26 | 15 |
| 35 | Compressor Purchase Order Placement | 12 wks | Tue 28/10/25 | Mon 19/01/26 | 34SS,26 |
| 36 | Piping / Instruments / Electrical / Structural Bulks Orders Placement | 12 wks | Tue 28/10/25 | Mon 19/01/26 | 34SS |
| 37 | Civils Bulks Orders Placement | 12 wks | Tue 28/10/25 | Mon 19/01/26 | 34SS |
| 38 | **Procurement** | **69 wks** | **Tue 20/01/26** | **Mon 17/05/27** | |
| 39 | Compression Train and Associated Equipment | 69 wks | Tue 20/01/26 | Mon 17/05/27 | 35 |
| 40 | Piping / Instruments / Electrical /Structural Bulks | 39 wks | Tue 20/01/26 | Mon 19/10/26 | 36 |
| 41 | Civils Bulks | 12 wks | Tue 20/01/26 | Mon 13/04/26 | 37 |
| 42 | **Construction** | **110 wks** | **Tue 20/10/26** | **Mon 27/11/28** | |
| 43 | Site Set-Up & Mobilisation | 12 wks | Tue 27/10/26 | Mon 18/01/27 | 29,30,31,34 |
| 44 | Civil Work for New Compressor | 16 wks | Tue 19/01/27 | Mon 10/05/27 | 43,41 |
| 45 | Pre-Fabrication of Piping Spools / Structures | 26 wks | Tue 20/10/26 | Mon 19/04/27 | 40 |
| 46 | Install New Compressor | 52 wks | Tue 18/05/27 | Mon 15/05/28 | 44,39,45,40 |
| 47 | Site Shutdown for Hook-up of New Compressor | 24 wks | Tue 18/04/28 | Mon 02/10/28 | 46FS-4 wks |
| 48 | Pre-comm and Commissioning of New Compressor | 12 wks | Tue 05/09/28 | Mon 27/11/28 | 47FS-4 wks |




Project: J25231 NG MCPD King
Date: Tue 09/08/22

Task | Split | Milestone | Summary | Progress

Page 1

**Figure 37 - Project Delivery Programme (Peterborough)**

## 8.2. Option Risks and Opportunities

485. Key risks and opportunities for all shortlisted options for Peterborough have been reviewed using a semi-quantitative approach. This risk methodology is described fully in the Risk Report & Register contained within **Appendix F**. This section of the FOSR concerns risks & opportunities associated with the Final Preferred Option only.

486. For the preferred option much of the value erosion is associated with the risk of CAPEX increase and schedule delay which will therefore be a focus area for onward risk management.

487. The highest rated risks & opportunities associated with the preferred option for Peterborough are identified below. Significant, Minor and Negligible risks are summarised within **Appendix F**.

### Key Option Risks & Mitigation

488. There is a critical risk associated with UK specific and worldwide geopolitical issues which has the potential to impact equipment supply and labour rates and availability leading to CAPEX increase and schedule delay. This risk will be a key focus area during development of the delivery strategy and lessons learnt from other similar projects will be applied appropriately.

489. Progression to the next phase of the project relies on agreement between NGGT and Ofgem on the preferred option. There is a critical risk that alignment will not be gained at the end of the 6-month Re-opener window allowed for in the project delivery programme causing schedule delays. To mitigate this risk we have held regular engagement meetings with Ofgem through the option selection phase. The output of these engagement sessions has informed this option selection process described in this submission.

490. Planning permission will be required for the preferred option and there is a critical risk that this may take longer than planned particularly considering lessons learnt from the ERP3 project.

### Huntingdon Preferred Option

491. A site-specific risk assessment for Huntingdon has not been undertaken but the following major risks identified in the Peterborough Risk Workshop apply for the preferred option at Huntingdon.

492. At this stage no detailed condition assessment surveys on the existing Avon's and associated underground pipework have been undertaken and so there is a risk that the scope and therefore CAPEX will increase. Surveys will be carried out during FEED to mitigate this risk where possible.

493. The Avon DLE retrofit technology is still under development and is not operationally proven which poses a risk of operational issues and reduced availability during initial operation. This risk will be mitigated where possible through test bed trials and NTS

trials planned for 2023. Should unresolvable issues be identified during these trials then a fallback to unit derogation is the assumed back-up strategy.

## Option Opportunities Identified

494. There is an opportunity to utilise the existing ERP3 construction area to save on mobilisation / demobilisation costs before land is sold back to the landowner.

495. There is also an opportunity to coordinate with other projects and bundle scope to provide potential CAPEX savings across this and other investments. This will be reviewed with the development of the delivery strategy.

496. The opportunity to align the design to a future hydrogen strategy will also be reviewed early in the engineering design development process.

497. The steelwork design associated with the new unit is considered conservative and there are opportunities for optimisation which will be explored during FEED.

## 8.3. Efficient Cost

498. CBA and BAT assessments are based on ±30% CAPEX estimates developed according to the methodology described in **Section 6.1**. These cost estimates were based on engineering inputs, including material quantities and equipment lists provided by [redacted] the engineering consultant used for the option selection phase. Asset Health costs were based on relevant funding allowances agreed for RIIO-T2.

499. Following confirmation of the Final Preferred Option we will develop the delivery strategy, engineering design and cost estimates through pre-FEED and FEED stages ahead of the cost Re-opener. As part of the development of the preferred option, value engineering and delivery efficiencies will be reviewed including consideration of opportunities discussed in the previous section.

500. Cost efficiencies will be incorporated into the updated cost estimates which will form the basis of the funding allowance request to be submitted in our cost Re-opener submission.

501. As noted in the programme for the preferred option described in **Section 8.2**, we plan to defer placement of the purchase order for compressor machinery train equipment until after the cost Re-opener in 2025. This decision is based on lessons learnt from the Hatton LCPD project and improves the CAPEX spend profile by moving the significant cost associated with this equipment later in the delivery programme.

502. An investment decision regarding decommissioning of non-compliant compressor trains will be taken after operational acceptance and a winter proving period for the new assets at Peterborough and Huntingdon to be installed as part of the MCPD scope. This decommissioning investment will be reviewed alongside other similar scope on the wider NTS and will form part of a separate NTS wide decommissioning specific funding request in RIIO-T3. This will allow decommissioning scope to be assessed against the network capability requirements at the time and allow scope to be prioritised and bundled to ensure efficient spend.

## 8.4. Outputs and Allowances in RIIO-T2

503. In RIIO-T1 NGGT we received baseline funding for emissions mitigation for IPPC phase 3 (or ERP phase 3). Under this allowance we are delivering two new gas-driven compressor units on each site (see further detail in **Section 3**). As a result of this investment we have received decommissioning funding to decommission two Avon's on each site following the successful commissioning of the new compressor units[42]. As detailed in the summary table, **Table 6**, we have spent [redacted][43] in RIIO-T1, which was to initiate the feasibility study and options selection process as well as the development of our RIIO-T2 business plan submission for MCPD compliance for Peterborough and Huntingdon Compressor Station. For further detail on RIIO-T1 outputs related to emissions compliance, please see CE-AMP.

504. In RIIO-T2 NGGT has a Compressor Emissions PCD detailed in Special Condition 3.11 Compressor emissions Re-opener and Price Control Deliverable, Appendix 2. The PCD is to ensure NGGT delivers a Final Options Selection Report, long lead items and a Re-opener submission for Peterborough and Huntingdon Compressor Stations. Through pre-application engagement we agreed with Ofgem the most appropriate timing for submission of the Final Option Selection Report is January 2023 and the Re-opener application window is in June 2025. The received Baseline allowances are [redacted] (excl. RPEs).

505. The PCD follows the GT Project Assessment Process (GTPAP), which is a two-step process whereby we submit the FOSR as part of the first step, and a cost submission once the project has gone through a FEED for the preferred option and tender process, as a second step. The outcome of the second step (Re-opener submission in June 2025) will be to amend the licence to incorporate the PCD outputs associated with delivery of the selected option set by Ofgem's Final Determinations in December 2020.

506. NGGT's Baseline allowance covers development costs and deposits on long-lead items, subject to a true-up during the associated Re-opener (cost submission). In RIIO-T2 (up to December 2022) we have spent [redacted] of our Baseline allowance. Please see **Table 6** for further detail of spend to date. We are reporting on spend and progress against our Baseline allowance and PCD as part of our annual RRP.

507. Following Ofgem's review and approval of our Proposed Final Option for Peterborough and Huntingdon Compressor Stations MCPD compliance, we will continue working to develop our preferred option further in readiness for our Re-opener submission in June 2025 at which date we will propose a revised PCD to be included in the Gas Transporter Licence to reflect the delivery of our preferred option as detailed in **Section 8.2**.

[42] Baseline allowances include [redacted] per site (this excludes ongoing efficiencies as well as capitalised Opex adjustment).
[43] This does not include spend related to the ERP 3 projects.

# 9. Conclusions and Next Steps

508. This FOSR has detailed the Needs Case for parallel compressor operation at both Peterborough and Huntingdon to meet our 1-in-20 peak demand obligation, Security of Supply, our customers' needs and minimise network constraints. Investment is required to ensure the site is MCPD complaint by the 2030 legislative deadline, while having sufficient reliable and emission compliant compressor capability to accommodate a wide range of forecasted flows.

509. Multiple assessments have been completed to determine the Final Preferred Option, including CBA, BAT, technology readiness, case study assessment, technology risk, Security of Supply, capital investment and emissions compliance, as detailed in **Section 7**.

510. To achieve MCPD legislative compliance at Peterborough and Huntingdon Compressor Stations, NGGT's Final Preferred Option recommends the installation of a new gas-driven compressor unit at Peterborough and installation of DLE Emission Abatement technology on the Avon at Huntingdon. Decommissioning of the Peterborough Avon will be assessed after operational acceptance of the new unit. This has an associated cost of [redacted], funded through the Re-opener following submission in June 2025. Funding to decommission the non-MCPD compliant unit has been included in this total cost, where actual decommissioning will be considered after operational acceptance of the new unit, and not included within the Re-opener funding request. The total project cost includes the already received Baseline funding of [redacted] (excl. Real Price Effects (RPEs)). The Baseline funding will be subject to true up following our Re-opener submission in June 2025.

511. Following Ofgem's decision on the Final Preferred Option, NGGT will use the remaining baseline allowances confirmed in 2020 to develop our preferred option up to the cost Re-opener currently forecast for June 2025. We intend to initiate a pre-FEED stage immediately following preferred option confirmation where the delivery strategy will be confirmed, and tender documentation produced for the FEED stage. During the subsequent FEED phase, the selected investment option will be refined to support the cost Re-opener and confirmation of remaining project cost. The EPC phase will include development of tender package for the compressor machinery train equipment. Site works will commence once detailed design has been sufficiently progressed which allows for a maximum of three years for all site works up to operational acceptance. After operational acceptance in 2028, a winter running period is provided for the new units prior to the 2030 legislative deadline when Peterborough Unit A will be subject to MCPD legislation.

# 10. Appendices

- Appendix A – CBA
- Appendix B – Site Availability Model
- Appendix C – Engineering Report and Appendices
- Appendix D – Asset Health Report
- Appendix E – Project Programmes and Report
- Appendix F – Project Risk Register and Report
- Appendix G – Preliminary BAT Report Summary
- Appendix H – [redacted] SCR Technical Feasibility Study
- Appendix I – Assurance Letter
- Appendix J – Mapping of Ofgem Requirements
- Appendix K – FOSR Databook

| 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. |
| **AGI** | **Above Ground Installation:** Above ground gas assets (including, but not limited to; pipework, valves, pig traps, meters and regulators) located within a fence line for the safe operation and maintenance of the National Transmission System |
| **ASEP** | **Aggregated System Entry Point:** 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. |
| **Avon** | Rolls Royce (Siemens) gas turbine engine which forms part of the compressor machinery train and is subject to MCPD. |
| **Barg** | Bar gauge is the pressure gauge reading. |
| **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. |
| **BAT** | **Best Available Technique:** 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 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. |
| **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 $CO_2$ during combustion, 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. |
| **CE-AMP** | Compressor Emission Asset Management Plan |

| Glossary | |
|---|---|
| **Compressor Unit** | Equipment used to compress gas to high pressure for transport through the NTS. Each compressor station consists of one or more compressor units as well supporting equipment such as meters, filters, valves and pipework. Compressor units can be driven by gas turbines or electric drives. |
| **CSRP** | **Control System Restricted Performance:** Technology that restricts the performance of a gas-driven compressor to limit $NO_x$ emissions. |
| **CBA** | **Cost Benefit Analysis:** 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. |
| **DLE** | **Dry Low Emissions:** An Avon DLE retrofit modifies the combustion system within the Avon engine so that air and fuel are premixed before combustion. This reduces the peak combustion temperature, which in turn reduces the amount of $NO_x$ produced |
| **EUD** | **Emergency Use Derogation:** Compressor unit derogated under the MCPD limited to run 500-hours per year on a rolling 5-year average, with a maximum limit of 750-hours in any one year. This removes the use of the compressor from standard operation, where they can only be run to prevent commercial constraints (Essential Use) or exit constraints (Emergency Use) on the network |
| **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. |
| **EA** | **Environment Agency:** A non-departmental public body, sponsored by DEFRA, with responsibilities relating to the protection and enhancement of the environment in England. |
| **ERP3** | **Emissions Reduction Phase 3** – Project to install two new Solar Titan 130 driven compressor trains at Peterborough and Huntingdon as part to replace the capability of two of the three Avon’s at each site under and IPPC emissions driver |
| **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. |
| **FOSR** | Final Option Selection Report |

| Glossary | |
|---|---|
| **FEED** | **Front End Engineering Design:** The FEED is basic engineering which comes before the detailed design stage. The FEED design process focusses on the technical requirements as well as an approximate budget investment cost for the project. |
| **FES** | **Future Energy Scenarios:** 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. |
| **DN** | **Gas Distribution Network:** 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 on land that is outside of the existing perimeter site boundary, where there is no need to demolish or rebuild any existing structures. |
| **GVA** | **Gross Value Added:** The measure of the value of goods and services produced in an area, industry or sector of an economy. |
| **IED** | **Industrial Emissions Directive:** An EU directive that came into force in January 2011. |
| **IPPC** | **Integrated Pollution Prevention and Control:** A regulatory system that employs an integrated approach to control the environmental impacts of certain industrial activities. |
| **Intrusive Outage** | Significant outage works impacting the whole station and where the station cannot be returned to service until the scheduled works are completed. |
| **LCPD** | **Large Combustion Plant Directive:** 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 $NO_x$, CO, $SO_2$, and particles. |
| **LNG** | **Liquefied Natural Gas:** Natural gas that has been cooled to a liquid state (around -162°C) and either stored and/or transported in this liquid form. |
| **MCPD** | **Medium Combustion Plant Directive:** A directive to reduce emissions from combustion plants with a net thermal input between 1-50 MW. |
| **MTO** | Material Take Offs |
| **MWC** | Main Works Contractor |
| **NTS** | **National Transmission System:** 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. |

| Glossary | |
|---|---|
| **NPV** | **Net Present Value:** NPV is the discounted sum of future cash flows, whether positive or negative, minus any initial investment. |
| **NDP** | **Network Development Process:** The process by which National Grid identifies and implements physical investment on the NTS. |
| **NGGT** | National Grid Gas Transmission |
| **Nitrogen Oxide** ($NO_x$) | Oxides of nitrogen which are a by-product of combustion of substances in the air, such as gas turbine compressors. |
| **Ofgem** | **Office of Gas and Electricity Markets:** 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 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. |
| **PARCA** | Planning and Advanced Reservation of Capacity Agreement |
| **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** | A Rolls Royce (Siemens) gas turbine engine which forms part of the compressor machinery unit and is subject to LCPD. |
| **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:** RIIO-T2 is the second 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. |
| **RPE** | Real Price Effects |
| **RRP** | **Regulatory Reporting Pack:** Annual submission to Ofgem on 31 July as per RIIO-T2 reporting requirements Standard Special Condition A40: Regulatory Instructions and Guidance |
| **SEPA** | **Scottish Environment Protection Agency:** Scotland's environment regulator and flood warning authority. |

| Glossary | |
|---|---|
| **Selective Catalytic Reduction** (SCR) | A means of converting nitrogen oxides ($NO_x$) with the aid of a catalyst into diatomic nitrogen, $N_2$, and water, $H_2O$. A 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. |
| **UAP** | Unallocated Provision |
| **Uncertainty Mechanism** | Uncertainty mechanisms exist to allow price control arrangements to respond to change. They protect both end consumers and licensees from unforecastable risk or changes in circumstances. |
| **Unit Outage** | Significant outage works impacting one or more compressor units on a compressor station, the unit cannot be returned to service until the scheduled unit works are completed, however, the station can still operate with other available units. |
| **United Kingdom Continental Shelf** (UKCS) | The region of waters surrounding the United Kingdom, in which the country claims mineral rights. |