Asset Health EJP Wormington Compressor Emissions Re-Opener

December 2025

Version: 1.0

Official-Sensitive Commercial

Version control

Version/revision number	Date of issue	Notes
0.1	October- 25	NGT First Draft (without cost estimates)
0.2	December-25	NGT Second Draft (with cost estimates)
1.0	December-25	Ofgem Submission

Contents

1 Summary Table

1.1.1 The summary table below sets out key information about the Wormington Asset Health Investment project.

Name of Project	Wormington Asset Health
Scheme Reference/ Mechanism Category	PAC1204852
Primary Investment Driver	Compliance with MCPD legislation
Project Initiation Year	FY19
Project Close Out Year	FY31
EAC (£m 2018/19)	[redacted]
Funding Request (CEPOt)[1], £m	[redacted]
Price Base	[redacted]
Cost Estimate Accuracy (%)	[redacted]
Project Spend to date as of 31 October 2025 (£m)	[redacted]
Current Project Stage Gate	ND500 (4.4) Project Execution
Relevant Investment Code	COMP1073085-4 COMP1073085-5
Outputs/ PCDs	See Table 3
Reporting Table Reference	RRP Table 6.2 (Projects) and Table 6.1 (CAPEX Summary)
Spend Apportionment for EAC (£m)	[redacted]

Table 1: Summary table for Wormington Asset Health

[1] For RIIO-T2 the direct costs aligned to CEPOt represent the allowances requested, as this project is subject to the Opex Escalator (Special Condition 3.18 of the Licence). For RIIO-GT3 and RIIO-GT4 our funding request under CEPOt includes direct and indirect cost.

2 Executive Summary

Whilst the investments proposed in this submission have been developed to a 25-year Asset Health re-life strategy, given the cost increase as set out in the provided Cover Letter we will explore a phased approach for critical Asset Health investments to ensure the best outcomes for consumers while improving unit availability across this critical site by March 2026.

2.1.1 This submission seeks funding to address Asset Health needs on Unit A at Wormington Compressor Station. The proposed interventions are necessary to ensure the continued safe, secure, and reliable operation of the UK Gas National Transmission System (NTS).

2.1.2 National Gas Transmission (NGT) is submitting this funding request under the RIIO-T2 Compressor Emissions Re-opener and Price Control Deliverable Uncertainty Mechanism, in accordance with Licence Special Condition 3.11, Part D and E, as per the Re-opener Guidance and Application Requirements Document[2] and as per Price Control Deliverable Reporting Requirements and Methodology Document.

2.1.3 This Engineering Justification Paper (EJP) details the scope, delivery plan, efficient costs and requested regulatory allowances for Asset Health interventions on Wormington Unit A. Our cost submission objective was to identify and provide the most cost-efficient Asset Health interventions to enable the Unit to provide efficient service under the 500-hour Emergency Use Derogation (EUD) allowed for in the Medium Combustion Plant Directive (MCPD) and support the site when Unit C or the new unit (Unit D) is not available.

2.1.4 Due to investment in the West Import Resilience Project, the average flow and the peak flow will increase placing differing demand on the site. In turn, this will increase the compressors run hours which further explain the importance of the site to security of supply.

2.1.5 NGT submitted the Wormington Compressor Emissions Final Options Selection Report (FOSR) in August 2022 following which Ofgem approved Option 7 which entails the installation of a new gas turbine compressor unit and retention of one of the existing Avon units under the 500-hour EUD allowed for in the Directive, with significant asset health investment to improve unit availability. Further investigation was needed to decide which unit would be kept ahead of submission. Remnant Life Study (Appendix I) did not identify a case for retaining either of the units in preference of the other.

2.1.6 We conducted studies to inform consideration of whether Unit A or unit B should be nominated for 500-hour EUD. The studies indicated that both units A and B require near term intervention to stay in service in the period prior to commissioning of the new unit. However, the studies did not identify a preference for which unit ought to be retained beyond that time. We have elected for Unit A to be nominated for 500-hour EUD retention and be the subject of significant asset health intervention described in this EJP. We have included minor asset health interventions on Unit B in our RIIO-GT3 business plan recently approved by Ofgem. We will consider the case for decommissioning Unit B after the significant asset health investment is complete on Unit A and the new unit (Unit D) has been commissioned.

2.1.7 This paper describes costs to implement Asset Health interventions on Unit A to extend the life of the Unit and ancillary systems for an additional 25-years as well as improving its operational reliability up to 2050 (net zero target). The costs to install a new unit as part of the approved FOSR option will be presented in separate EJP documents.

2.1.8 GT request a re-opener direction from Ofgem to modify outputs, delivery dates and associated allowances (CEPOt) o [redacted] across the RIIO-T2 and RIIO-GT3 price control periods. Delivery of this project by 2031 will ensure that our customers continue receiving gas at volumes and pressures required. Once this project is delivered, Unit A will be able to support Units C (VSD) and D (new unit to be installed under this re-opener) when they are not available and therefore provide the necessary level of site resilience.

[2] Version 4, published in October 2025

2.1.9 After carefully considering options, we propose a mixture of minor refurbishment, major refurbishment and replacement of mechanical assets and complete replacement of all electrical assets in scope. The recommended intervention for each asset is largely determined by its asset health condition, operational risk exposure to personnel and well as legislative compliance. These details are shown in the portfolio document (Appendix C). The holistic recommended interventions will increase Unit A availability from a baseline of [redacted]

2.1.10 The delivery programme is contingent upon NGT achieving financial supply chain commitments and contract award by June 2026. As internal governance requires clarity of the regulatory position prior to such commitment, NGT request that Ofgem assess this application in line with its Standard Assessment Tier, with an estimated time from point of submission to decision of 3-6 months. Accordingly, NGT request Ofgem target Draft Determinations (DD) by 31 May 2026 and Final Determinations (FD) by 31 August 2026. This is aligned with Ofgem's re-opener guidance, para A11.21. As such, NGT are keen to support Ofgem in their review process to permit a timely decision.

2.1.11 The project is at Network Development (ND500) project Stage 4.4 (Project Execution) with surveys recently completed to define scope and project boundaries to further support the needs case and puts cost confidence in the range of [redacted] This EJP is submitted, together with the New Unit EJP, with an overarching document covering details common to both papers. Hence, it should be read in conjunction with the Wormington MCPD Re-opener Overarching document.

3 Introduction and Request Summary

3.1.1 Wormington compressor station plays a critical role on the NTS as it is the primary compressor station to support Milford Haven supplies, whilst its bi-directional flow capabilities support offtakes in South Wales when demands are higher than Milford Haven inputs.

[redacted]

3.1.3 The location of Wormington compressor station relative to Milford Haven Terminal and the other compressor stations referenced is shown in Figure 1. Overall, the site ensures high LNG imports can be achieved and enables the movement of large volumes of gas, up to a third of Great Britain's daily demand, away from Milford Haven into the rest of the network.

[redacted]

3.1.4 Figure 2 further shows a site overview of Wormington Compressor Station indicating the locations of the three existing units relative to each other.

[redacted]

3.1.5 This submission follows Ofgem's decision[3] to proceed with the installation of a new gas turbine compressor unit and retain an existing unit with significant asset health investment to improve unit availability. The FOSR provided a summary of all the work performed to evaluate, cost and analyse a suite of feasible options available to maintain current levels of network capability and availability for customers.

3.1.6 This EJP covers asset health interventions on the existing Unit A to address defects, obsolescence and safety/compliance gaps to ensure the unit can continue to provide reliable, safe service under the Medium Combustion Plant Directive (MCPD) Emergency Use Derogation (EUD) from 1 January 2030.

3.1.7 To ensure the most robust and cost-effective approach for improving the operational condition of Unit A and securing reliable performance beyond 2030, NGT adopted a structured, evidence-based process. This involved commissioning a remnant life assessment (Appendix I) to understand the condition of Unit A including Reliability Availability Maintainability (RAM) studies which evaluated the unit against key performance metrics and identified measures needed to ensure the unit attains the required levels.

3.1.8 Subsequently, a targeted asset health assessment of Unit A was carried out by a Main Works Contractor (MWC) and specialist subcontractors. The scope of this aimed to categorically establish the current condition of mechanical and electrical assets associated with Unit A by undertaking detailed inspections and tests. Based on the findings which included assessing compliance with legislation and standards and supportability constraints, the MWC provided recommended interventions.

3.1.9 The MWC recommendations were reviewed by NGT Subject Matter Experts (SME) and site operators in collaboration with the MWC to determine the most effective solution to address the problems found in line with the Wormington Compressor Emissions Final Preferred Option.

3.1.10 On completion of the iterative optioneering process, interventions were further scoped and a costed portfolio of work derived.

3.1.11 This EJP requests funding to undertake the refurbishment programme to ensure Unit A is able to continue operating as required and to sustain the resilience of Wormington compressor station. It interacts with other documents to form the Wormington reopener submission pack as illustrated in Figure 3 below.

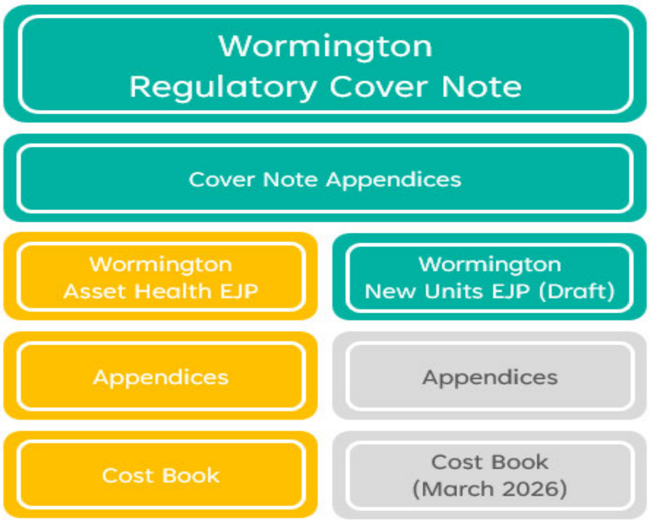

Figure 3: Wormington MCPD Reopener Submission Pack

[3] www.ofgem.gov.uk/decision/decision-wormington-compressor-emissions-final-preferred-option

Request Summary

3.1.12 This submission is made in accordance with Special Condition 3.11, Part D and requests to modify the outputs, delivery dates and allowances in Appendix 2 of the Gas Transporter Licence (the Licence), which are detailed in Table 2. Our total funding request (CEPOt) to deliver the required Asset Health works at Wormington Unit A is [redacted] Ofgem are invited to assess and approve our cost proposal in line with Special Condition 3.11, Part F.

3.1.13 Table 2 below sets out the total funding request to deliver the Asset Health scope at Wormington Compressor Station. Further details are included within the cost book (Appendix A). For RIIO-T2 the direct costs aligned to CEPOt represent the allowances requested, as this project is subject to the Opex Escalator (Special Condition 3.18 of the Licence). For RIIO-GT3 and RIIO-GT4 our funding request under CEPOt includes direct and indirect cost aligned to Ofgem's published Final Determination for RIIO-GT3.

[redacted]

Price Control Deliverable

3.1.14 Table 3 below is a summary of the proposed Price Control Deliverables (PCD) Output associated with the delivery of the proposed re-opener Asset Health scope for Unit A.

[redacted]

4 Equipment Summary

4.1.1 Commissioned in 1990, Unit A at Wormington Compressor Station is a gas-powered compressor machinery train which currently operates either independently or in parallel with Unit B when lead Unit C, an electrically driven Variable Speed Drive (VSD) unit, is unavailable during planned and unplanned outages. Unit A also operates in parallel with the VSD unit at times of high flow to mitigate NTS entry constraints. The current and future (beyond 2030) operating regimes are summarised in Table 4.

Unit	Compliance with MCPD	Current Operation Regime	Future Operation Regime beyond 2030
A	Not Compliant	Operates independently or in parallel with Unit B when Unit C is unavailable or in parallel with Unit C during high gas flow.	500-hour Emergency Use Derogation (EUD).
B	Not Compliant	Operates independently or in parallel with Unit A when Unit C is unavailable or in parallel with Unit C during high gas flow.	500-hour Emergency Use Derogation (EUD). The need for decommissioning will be reassessed following operational acceptance of Unit D (new) and derogated Unit A.
C	Compliant	Lead unit operates independently or in parallel with Unit A or Unit B during high flows.	Lead Unit supported by Unit A or Unit D (new).
New Unit	N/A	N/A	Lead Unit

Table 4: Wormington Compressor Station Units Summary

4.1.2 Figure 4 shows the Siemens[redacted] gas generator installed in Unit A.

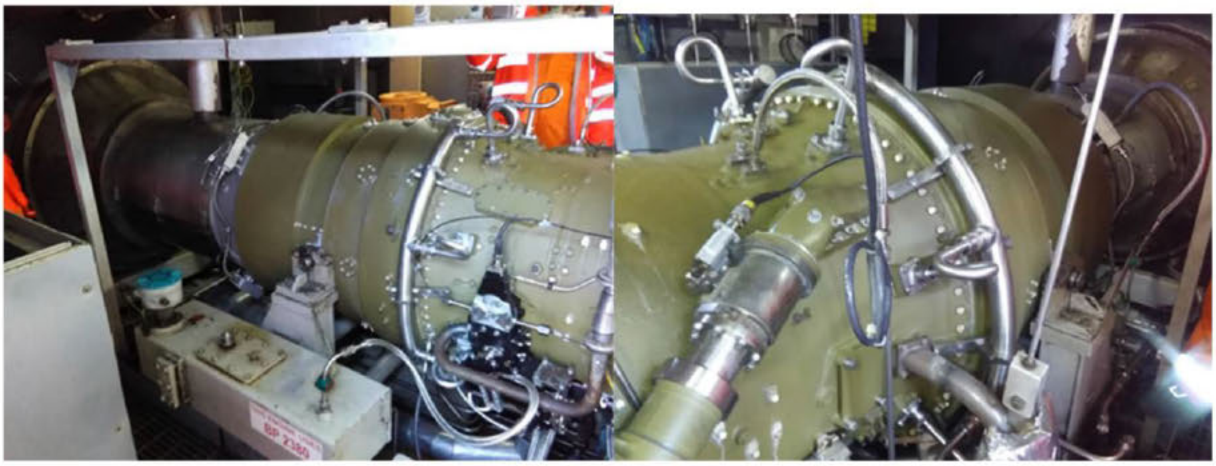

Figure 4[redacted] Gas Generator installed in Unit A

4.1.3 Table 5 summarises the technical details of Unit A which is comparable with Unit B.

Unit	Gas Generator	Power Base (MW)	Commissioning date	Nominal Capacity (mscm/d)
A	[redacted] 1533-75G (Formally Rolls-Royce Avon)	12	1990	40

Table 5: Unit A Specifications

4.1.4 Due to the close similarities between Unit A and Unit B, a comprehensive remnant life study was undertaken to inform the decision on which unit should be retained. The study (Appendix I) included asset condition assessments and a Reliability, Availability, and Maintainability (RAM) analysis. It concluded that while there were minor advantages and disadvantages for each unit in certain focus areas, there was no definitive driver to retain one over the other.

4.1.5 Based on this, combined with unique operational experience and working knowledge of both units, Unit A was selected as the preferred unit to remain operational under the 500-hour EUD.

4.1.6 The sustained safe, compliant and reliable operation of Unit A is dependent on the capability and asset health of all aspects of the compressor machinery train and the multitude of mechanical and electrical sub-assets. The following provides an overview of these assets and how they support the operation of the Unit.

Wormington Unit A Asset Health - Mechanical Sub-Assets Summary

Valves and Actuators

4.1.7 Valves are installed across Wormington Compressor Station to enable operation of plant, effective isolation of sections of the site, limit gas loss in an emergency, manage flow direction (routing), flow rate and pressure, facilitate maintenance, repair, modification, testing and commissioning.

4.1.8 The purpose and pipework configurations affect the size, type and functionality of valves in service which include locally actuated valves (LAV) and remotely operated valves (ROV). Valves can be located wholly above ground, in pits or below ground which determines their accessibility. The main groups of specific valves covered in this scope are:

- In station / out station Emergency Shutdown (ESD) valves
- Compressor isolation and vent valves
- Pressure Reduction Area (PRA) valves
- Isolation and vent valves

4.1.9 Actuators are the prime mover to operate valves. Figure 5 shows the name plate (left) and actuator of a main station inlet valve on site. The valve itself is buried underground and is only accessible after excavations. The control of actuated valves can be either from a control panel local to the valve or remotely from the site control room.

[redacted]

[redacted]

Fuel Gas Supply Systems

4.1.10 Fuel gas systems supply gas at the right temperature, pressure, flow rate and quality to the Gas Generator to ensure it operates as intended. Fuel gas systems consist of several sub-systems including:

- In Station Fuel Gas Supply.
- Outstation Fuel Gas Supply (including valve actuator cabinet).
- Station Fuel Gas – Water Bath Heater.
- Station Fuel Gas – PRA Skid.
- Unit Fuel Gas System.

4.1.11 In general, the fuel gas sub-systems are predominantly a network of pipework, valves and associated instrumentation assets for the management and control of gas flow. Figure 6 below shows the configuration of out station and in station fuel gas supply systems.

[redacted]

[redacted]

Instrument Air System

4.1.12 The instrument air system provides power for the actuation of critical valves across the site, including ESD, isolation, and process control valves. Originally, the Wormington compressor station was designed to use high-pressure natural gas from the Pressure Reduction Area for actuating gas. However, in circa. 2007, this was replaced by a dedicated instrument air supply to improve safety, reliability, and environmental performance. The upgraded system retained much of the original actuating gas pipework, repurposing it for instrument air distribution.

Lubrication and Hydraulic Oil Systems

4.1.13 Lube oil systems are essential for providing lubrication to the gas generator, power turbine and compressor. Unit A utilises the following two lube oil systems:

- Station Lube Oil System – For handling lubrication oil common to all the units. Oil can be transferred from this bulk source to the individual unit lube oil system using transfer pumps.
- Unit Lube Oil System – For handling lubrication oil dedicated for the unit.

4.1.14 The lube oil systems comprise several sub-assets such as bulk tank, heat exchangers, pumps, direct current (DC) and alternating current (AC) motors, civils structures and control and instrumentation assets.

Figure 7 below shows the lubrication system assets.

4.1.15 Lubrication systems are crucial to gas compression as a failure during compressor operation leads to excessive heat and friction, causing component wear, bearing failure, or even seizing. This results in costly repairs, unplanned downtime, decreased efficiency, increased energy consumption, and potentially irreparable damage to critical parts. In some cases, inadequate lubrication can also lead to safety hazards from equipment failure or contaminated air quality.

Figure 7: Lubrication System

Dry Gas Sealing System

4.1.16 Unit A utilises a dry gas seal system which is a non-contacting mechanical sealing arrangement which prevents gas leakage along the compressor shaft. Filtered discharge gas is directed into the seal chamber where it establishes a thin, high-pressure gas film separating the rotating shaft from the stationary seal housing faces. Failure of dry gas seals result in gas leakage which could be ignited causing a high risk of fire and explosions. It is, therefore, important to ensure the sealing mechanism is reliable to ensure the unit is available and can operate safely.

Pipework / Lines

4.1.17 Unit A pipework / lines in scope of this EJP include:

- Compressor Suction Line.
- Compressor Discharge Lines.
- Vent and Drain Lines.
- Compressor Anti-Surge Recycle Line.

4.1.18 As part of this submission, NGT and the MWC completed Ultrasonic Testing (UT), Eddy Current Crack Detection (ECCD), Long Range Ultrasonic Testing (LURT) to confirm lines integrity. Failure of compressor lines results in loss of containment which impacts on personnel safety and station capacity to compress gas.

Compressor Acoustic Building (CAB)

4.1.19 Unit A is housed in a CAB which is made up of a weather-tight and noise attenuating enclosure, an air intake for the combustion air into the gas turbine, a ventilation system to maintain safe and operable conditions within the enclosure and an exhaust system to compliantly remove combustion gases and attenuate noise. Each system comprises multiple mechanical and electrical components which must be suitable for the operational conditions of the CAB. The general arrangement of a CAB and its major sub-assets is shown in Figure 8.

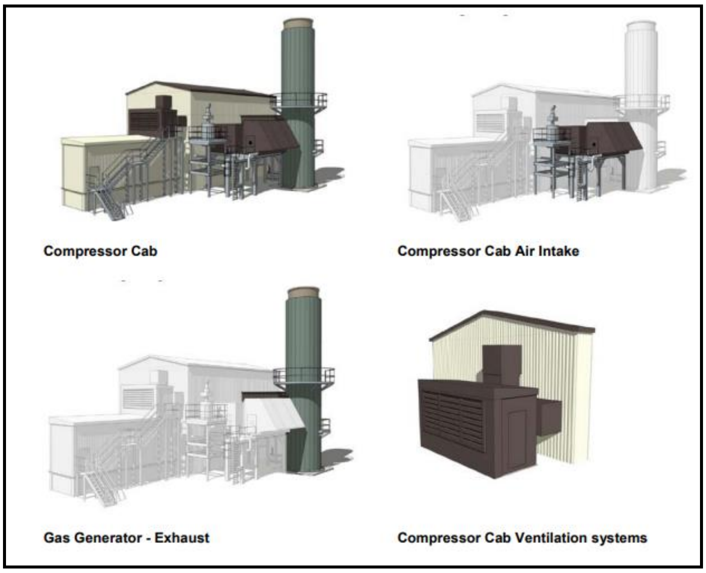

Figure 8: Compressor CAB Sub-assets

Fire Suppression System

4.1.20 Unit A CAB has a Fire Suppression System (FSS) to extinguish fires within the enclosure to prevent fire escalation and minimise risk of injury to personnel and damage to plant, equipment, and environment. The existing FSS on Unit A CAB is a HI-FOG water mist system which utilises water and nitrogen cylinders as shown in Figure 9. If the FSS is not available, the Unit cannot be operated.

Figure 9: Water Mist Kiosk and Cylinders

Wormington Unit A Asset Health - Electrical Sub-Assets Summary

Low Voltage (LV) Switchboards

4.1.21 The first stage of the electrical reticulation system is the LV switchboard which is fed from the main site supply transformer. The LV2 switchboard was originally installed to supply power to the 415V AC MCCs, the AC Unit Services Distribution Boards (via DB14 and DB15) and the 110V DC charger system. It has several cubicles with outgoing circuits to different auxiliaries as shown in Figure 10.

Figure 10: LV Switchboard (LV2)

Motor Control Centres (MCC)

4.1.22 MCCs are used for downstream distribution to LV loads, mainly electric motors. Typically, these MCCs are indoor, metal-clad, air-insulated equipment incorporating Air Circuit Breakers (ACB), Moulded Case Circuit Breakers (MCCB), fuse switches and motor starters. The scope of this paper covers 415V AC and 110V DC MCCs.

4.1.23 MCCs are critical for the operation and maintenance of all electrical motors installed within the unit. Failure of MCCs would cause loss of critical motive power to motors and pumps required to safely and effectively operate the Unit. Figure 11 shows the Wormington Compressor Station AC and DC MCCs which supply power to downstream AC and DC motors respectively.

Figure 11: AC MCC (Left) and DC MCC (Right)

Motors

4.1.24 AC and DC motors are installed on auxiliary systems which are fundamental to Unit A operations including lube oil pumps, hydraulic oil pumps and vent fan motors.

Distribution Boards (DBs)

4.1.25 DBs are an important part of electricity supply systems. They split incoming electrical power into multiple secondary or subsidiary circuits. All fuses, breakers and other circuit protection devices for these secondary circuits are held within one single enclosure.

4.1.26 DBs are either AC or DC depending on the connected equipment. For instance, all DC motors receive their electrical power from DC distribution boards whilst AC motors receive their power from AC distribution boards.

4.1.27 The distributed power from the DBs enables more precise and granular control of the supply to different areas, including the ability to isolate and shut down parts of the circuit without completely isolating incoming power.

4.1.28 DBs also provide safety features (typically fuses, breakers, Residual Current Devices (RCD) and Miniature Circuit Breakers (MCB) that allow for safer use of mains power. As each branch circuit has an individual safety cut-off, the entire electrical system is better protected against overloads, short circuits, and other hazards. Figure 12 shows an AC Unit Services DB, highlighting the internal and external views.

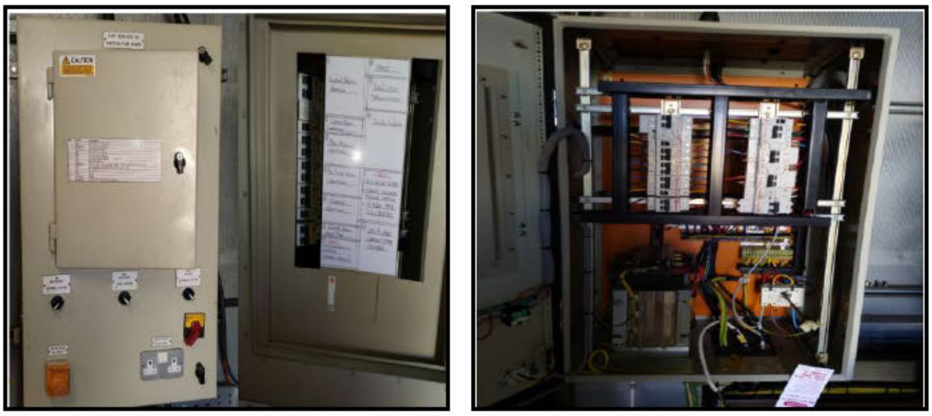

Figure 12: AC Unit Services DB External (Left) and Internal view (Right)

Electric Motors

4.1.29 AC and DC motors are installed on auxiliary systems which are fundamental to Unit A operations. AC motors include:

- Lube Oil Transfer Pump
- AC Vent Fans
- Combined Air/Oil Cooler Fan
- Lube and Hydraulic Oil Pumps
- Gas Generator Stator Motor

DC motors include:

- DC Emergency Vent Fan
- BC Lube oil emergency pump
- DC Hydraulic Oil Pump

Electrical Trace Heating and Space Heating

4.1.30 There are five space heaters within the CAB fed from the AC MCC (240V, 16A TP&N cubicle B4) via a common JB (JB3), which is mounted in the CAB. Heaters are in the Local Equipment Room (LER), Gas Turbine Area (Zone 2 area) and Compressor Area (Zone 2 area). A typical example of a heater is shown in Figure 13.

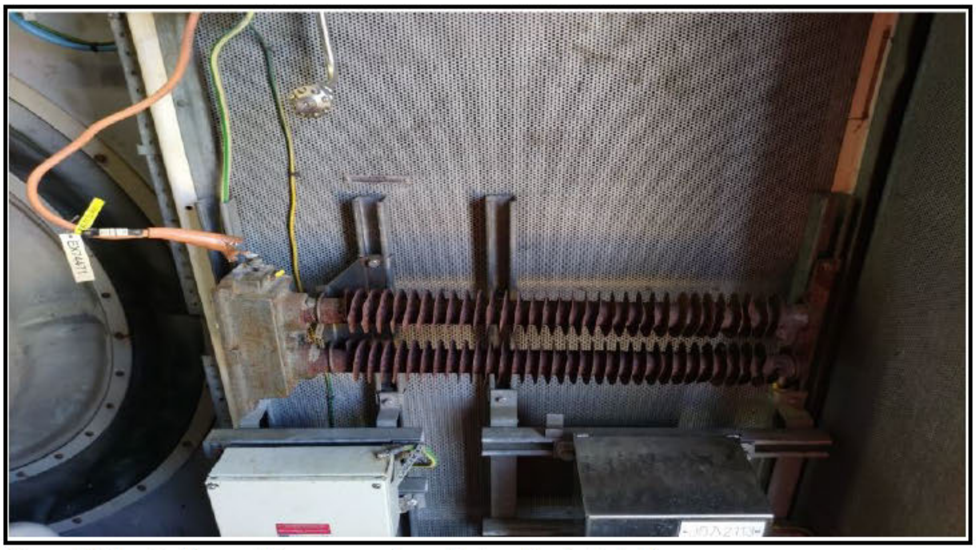

Figure 13: Gas Turbine and Compressor Area Heaters (typical of all)

CAB Lighting

4.1.31 Internal and external lighting is present on Unit A including normal and emergency fittings. These assets were installed during the installation of the Unit before its full commissioning and operation in 1990. The only exception is the external stairway lighting which was recently replaced with LED energy efficient alternatives as part of the stairway replacement.

4.1.32 Figure 14 shows a typical example of legacy fluorescent type lighting on the left and recently installed compliant lighting on the right.

Figure 14: Fluorescent CAB lighting (left) and LED stairway lighting (right)

5 Problem Statement

5.1.1 In line with the decision[4] to install one new gas turbine driven compressor unit and retain one existing unit with significant asset health investment to improve availability, Table 6 presents the key drivers which will enable Unit A to support the new MCPD-compliant unit and the existing VSD unit beyond 2030 under its Emergency Use Derogation (EUD) role.

Driver Category	Description
Legislation and Standards	All systems, processes, assets and equipment associated with Unit A must comply with applicable legislation, standards and specifications. Examples include, but are not limited to: Primary legislation such as Health and Safety at Work etc Act 1974 and specific regulations including Pressure Systems Safety Regulations (PSSR), Electricity at Work Regulations (EAWR) 1989 and Management of Health and Safety at Work Regulations 1999 are all directly applicable to Unit A. NGT standards and policies stipulate maintenance regimes and equipment specifications such as T/PM/COMP/23 (specification for mechanical equipment on compressor installations) which, in turn, incorporates wider industry standards including API, ASME, IGEM, ISO, IEC and BS EN standards to ensure adoption of best practice from recognised industry bodies. For example, it defines that certain assets are required to be certified (i.e., ATEX certification) for equipment and protective systems intended for use in potentially explosive atmospheres as per Directive 94/9/EC.
Asset Deterioration	Without intervention, assets will continue to deteriorate, increasing the likelihood of failure with multifaceted consequences. Unit A has been in operation since 1990 and has been sustained through routine maintenance, overhauls, modifications, and upgrades - measures that have been vital to its continued service. Given the ongoing need for Unit A, it is essential to maintain this approach by addressing known defects and demonstrable deterioration to restore its condition to support functionality and capability in line with future strategy. Due to the complex interactions between Unit A and its associated assets and sub-assets, interventions must be considered as an integrated package of work.
Reliability and Availability	Unit A must remain reliable to meet required availability levels and support Wormington Compressor Station resilience. Performance issues and defects directly impact availability and, therefore, require timely intervention. The Reliability, Availability, and Maintainability (RAM) study referenced in this EJP modelled the unit's performance under various scenarios to identify targeted investments needed across the compressor machinery train package.
Age and Obsolescence	Assets and sub-components installed on Unit A continue to become obsolete resulting in longer lead times for spares and repairs. In turn, this increases the risk of adversely impacting availability and therefore must be managed through intervention which is further highlighted by the RAM study.
Safety and Environment	The safety of people, plant and equipment must be managed appropriately in accordance with our Safety Case and as part of the absolute need to comply with HSE legislation. Assets, systems and processes must be assessed and action taken where necessary to ensure risks are understood and reduced to As Low as Reasonably Practicable (ALARP) across all aspects of Unit A. Furthermore, Unit A is required to operate in full compliance with environmental permits and adopt practices that minimise environmental impact.

Table 6: Investment Drivers Summary

[4] https://www.ofgem.gov.uk/decision/decision-wormington-compressor-emissions-final-preferred-option

5.1.2 Considering these drivers, a remnant life assessment study was conducted in 2023 which aimed to evaluate asset condition, supportability, and remaining life of both Units A and B with checks against applicable standards and specifications. This is provided in Appendix I.

5.1.3 Following this, United Infrastructure (UI) undertook a targeted survey of Unit A within the Regional Asset Health Framework to carry out inspections and tests in collaboration with competent subcontractors. The asset health survey report is provided in Appendix B which includes a list of the standards and specifications the assessments were made against.

5.1.4 The asset health assessment approach integrated multiple data sources and techniques to provide robust evaluations including:

- **Photographic Documentation** - High-resolution images were captured across the plant to visually document the current condition of equipment and infrastructure. These photographs provide a detailed record of visible signs of wear, corrosion, and deterioration.
- **Non-Destructive Testing (NDT**) - Advanced inspection techniques were utilised to detect flaws, cracks, corrosion, or structural issues that could compromise safety or performance.
- **Failure Impact and Criticality Analysis** - Assessing the impact of potential equipment failures on system reliability, safety, and overall plant operations.
- **Arc Flash Assessment using the Electrical Transient Analyser Program (ETAP)** - Arc flash hazard analysis was conducted to evaluate potential personnel safety risks on existing electrical equipment and ensure that appropriate protective measures were in place to mitigate safety concerns.
- **Insulation Resistance and Continuity Testing –** Specialist contractors conducted a range of electrical testing to ensure operational reliability and compliance with safety standards.

RAM Model

5.1.5 As part of the remnant life assessment (Appendix I), RAM analysis was undertaken to evaluate the reliability and availability performance of Units A and B and the potential performance improvements following asset health interventions. This was conducted in accordance NGT management procedure T/PM/COMP/20. The primary objectives of the RAM analysis were:

- To determine the operational availability of the system over the anticipated remnant life against a targeted 95% availability including a maximum of 14-days planned maintenance outage.
- To ensure that an aggregated Mean Time Between Failure (MTBF) for the Unit of at least 2000 running-hours.
- To ensure that failure-to-start occurs in less than one-in-200 operations.

5.1.6 The RAM analysis also aimed to:

- Identify key critical components in the system and events responsible for reduction of the overall operational availability of the system.
- Quantify the potential improvements to operational availability in a CAPEX/OPEX balance between asset health investment and availability gain.

5.1.7 [redacted]

5.1.8 Figure 15 summarises the most common contributors to Unit unavailability, with outage events presented with their relative loss of availability in percent.

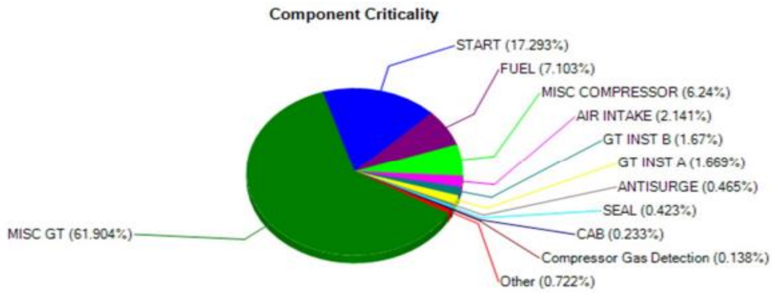

Figure 15: Top Unavailability Contributors, Reference Case, Unit A

5.1.9 The RAM study revealed aspects of Unit A which need asset health improvements to meet the required availability level. Recommended scope within this paper, therefore, targets the specific, areas which can improve the performance of Unit A.

Mechanical/Structural Sub-Asset Health Survey Report Summary and Real-life Examples

5.1.10 This sub-section presents a summary of the findings of the mechanical and structural aspects of the asset health surveys including examples to illustrate the current condition of Unit A. The full survey report included in Appendix B provides detailed findings.

5.1.11 **Station Fuel Gas System** – PRA Skid (Valves, filters, pipework)

- **Valves –** There is excessive surface corrosion on valves and fittings. All Manual Isolation and Slam-shut valves (MD-type) are obsolete, with no spare parts available. Beyond obsolescence, the configuration of manual isolation valves also restricts individual equipment isolation to a non-compliant single valve isolation.
- **Filters –** Filters have a cast body design and over 30 years in service, resulting in material deterioration and future re-certification. The cast construction precludes reliable thickness monitoring, increasing failure risk.
- **Pipework -** There is localised coating degradation on governing streams. Due to the service length of pipework, the current coating system is ageing with forecasted long-term adhesion and durability based on sound engineering principles.

5.1.12 **In Station Fuel Gas Supply system** – the prevalent defects on this fuel gas system are:

- Active crevice corrosion and coating failure at the U-bolt cradle support.
- Surface corrosion under deteriorated coatings at flange faces.
- Degraded coating and environmental-associated wear at pipe bends and supports.
- Minor damage to the vertical pipe-to-soil sealing collar, which based on expected service will compromise long-term protection.
- Surface corrosion on valves, particularly at bolting and flange interfaces.
- Evidence of hydraulic oil staining on the actuator reservoir, indicating an early-stage leak or seal failure.

5.1.13 **Out Station Fuel Gas Supply Pipework** – Ultrasonic Testing (UT) readings identified low wall thickness. The valve actuator cabinet and oil reservoir show visible deterioration of coating, requiring refurbishment to prevent further degradation. An uncoated blind valve flange was observed in the outstation pipework which represents a vulnerability requiring inclusion in the recoating programme.

5.1.14 **Station Fuel Gas (Water Bath Heater)** – There is a single-point failure risk across both Units A and B, preventing engine restart if the heater fails. Low fuel gas temperatures are being experienced with the current configuration which is a major risk factors for gas generator blade failure. Other major findings are:

- Coating failure and localised corrosion at vent lines, outlet nozzles, and relief components.

- Missing vessel ID on nameplate, breaching regulatory requirements (PSSR 2000).
- Cracked plinth and missing anchor bolt at saddle support, affecting mechanical stability.
- Instrument panel joint corrosion and gas odour, requiring resealing and follow-up inspection.
- Unresolved solenoid valve reliability due to frequent open and closure and lack of modular replacement logic.

5.1.15 **Unit Fuel Gas System**- The existing fuel gas system is largely comprised of pit and external pipework which are predominantly corroded with coating failures. Pit pipework has small-bore branches within the pit which are in poor condition, especially at flange-to-flange interfaces. The gaskets are heavily degraded and at risk of failure. External pipework between the pit and the CAB wall showed heavy external corrosion and pitting, with effective remaining wall thickness (ERWTs) as low as 4.7mm as a compared to a normal thickness of 7.5mm. This is significant thickness loss which will result in sudden failure. The pipework transitions to stainless steel only immediately before penetration of the CAB wall, however, T/SP/COMP/33 Section 7.7.7 recommends stainless steel after the filter to prevent any internal pipe corrosion products from being carried forward into the gas turbine. Figure 16 shows the level of corrosion on the Unit fuel gas system.

Figure 16: Unit fuel Gas system coating failure

5.1.16 **Instrument Air System** - Surface corrosion and pitting of up to 1.0mm deep at elbows, flanges, and tee branches is a major concern as it will result in pipe failure without intervention. Branch valves, though visually intact, are located in a confined, moisture prone area and are of a similar age to the original pipework.

5.1.17 **Station Lube Oil System** - Major asset health findings of the station Lube Oil System includes:

- Localised Corrosion Under Insulation (CUI) and internal thinning, particularly on the east dished end, with thickness readings as low as 4.7mm. The minimum required wall thickness is 6mm.
- The presence of corrosion, pitting at multiple nozzles, and degraded coatings indicate ongoing deterioration.
- Saturated insulation, degraded coatings, and light atmospheric corrosion at soil-to-air interfaces. This drastically reduces its ability to insulate resulting in energy loss and structural damage.
- The pipework system, constructed from carbon steel (API 5LB), has extensive surface corrosion, particularly in the pit and local to the Lube Oil Tank. Figure 17 shows the general condition of lube oil pipework. This ultimately results in pipe failure, loss of lube oil and environmental incidences.

Figure 17: General condition of lube oil pipework (left) and Flanges (right)

5.1.18 **Unit Lube Oil System** – Main findings associated with the Unit Lube Oil System include:

- Water ingress due to poor vent design and low operating temperatures continues to result in elevated moisture levels in oil samples, posing a threat to lubrication quality and equipment longevity.
- Lack of maintenance spares for critical pressure control components further compound system vulnerabilities.
- Recurring trend of oil contamination, elevated acid levels, water ingress, and associated component reliability issues.

5.1.19 **Hydraulic Oil System** - Most notably, the submerged AC and DC hydraulic oil pumps, which are critical to system function are obsolete. The associated motors are no longer serviceable as maintenance spares were confirmed to be obsolete, thus affecting maintainability. The Hydraulic Oil Tank lacks a manufacturer nameplate, constituting a compliance gap under relevant pressure system legislation (PSSR). There is also significant coating degradation.

5.1.20 **Dry Gas Seal System** –Equipment such as filter vessels is now difficult to maintain and inspect because of its original design and manufacturer. These issues must be addressed to maintain regulatory compliance and ensure continued assurance over the asset's operating life.

5.1.21 **Compressor Suction Line (Common Header)** –The manual isolation valve has a known sealing problem when required to isolate. Overhauling this valve would require intrusive cutting, dismantling, re-welding, and recertification activities which, due to age and uncertainty over internal condition, may not provide sufficient assurance of future performance.

5.1.22 **Compressor Suction Line (Pit)** - Branch pipework, which is largely uncoated, particularly within the pit area exhibits widespread surface corrosion. Without appropriate intervention, this degradation could advance to more serious metal loss. Overhauling the isolation valve would require intrusive cutting, dismantling, re-welding, and recertification activities which, due to age and uncertainty over internal condition, may not provide sufficient assurance of future performance.

5.1.23 **Compressor Suction Line** – Acoustic Enclosure (Lobster Back) - localised coating breakdown was observed near a flanged joint and on a small-bore branch connection (**Error! Reference source not found.**). Without intervention, continued coating breakdown will occur with subsequent corrosion.

Figure 18: Coating breakdown on Acoustic Enclosure Flange

5.1.24 **Compressor Anti-Surge Recycle Line** - Carbon steel line connects the discharge line to the suction line, via an anti-surge recycle valve which ensures a minimum flow through the compressor to prevent the compressor from surging. The inspection included visual assessment, UT, and ECCD on selected welds. Grit contamination observed in several flanged joints, poses a risk of crevice corrosion and bolt degradation. Surface corrosion is present on some holding down bolts, which affects long-term support integrity if not addressed. Surface-breaking linear defect is present at a critical stress concentration point on a pressure-retaining nozzle of the anti-surge recycle valve actuator reservoir which is an imminent point of failure. This is a threat to the pressure integrity and operational safety of the vessel.

5.1.25 **Fire Suppression System** - The fire suppression system was assessed by a specialist, and a detailed report is provided as part of the Asset Health Survey report (Appendix B). In summary, survey findings revealed that:

- [redacted] which does not comply with NFPA750 (Standard on Water Mist Fire Protection Systems).
- Refurbishment of the existing system is not recommended as this would require a significant increase in the number of cylinders to achieve the required discharge time. Additional cylinders cannot be accommodated in the existing HI-FOG cabinet. This does not address several other asset health defects found on the existing system design.
- In addition, the survey concluded that the existing skid location, combined with the method of suppression using water mist cylinders, has an inherent manual handling risk due to the requirement to manoeuvre cylinders in and out of the cabinet.
- The recommended solution by the specialist is to replace the current system with an Electric Pump system, inclusive of a 4 m^3 break tank which will meet the requirements of NFPA750. This is in line with the same principles adopted for all other compressor units with legacy nitrogen-based Fire Suppression Systems on the NTS. Elsewhere, a replacement programme to replace them with electric based system commenced in RIIO-T2 which will continue throughout RIIO-GT3.

5.1.26 **Vent Line (Pit) and Drain Line** - This line has been in operation for approximately 36 years and external visual inspection and Non-Destructive Testing (NDTs) were carried out on the Unit A vent line and several localised deterioration mechanisms were identified. Most notably, Long Range Ultrasonic Testing (LRUT) conducted at the soil-to-air interface identified significant material loss along the vent line. This finding, although localised, was highlighted as a concern given the pipe's age and duty. External corrosion is evident at exposed locations where the protective coating system had failed, particularly around a flanged joint. These exposed locations have become weak points on which the lines will eventually fail. The majority of this line has operated beyond typical design life for carbon steel vent systems operating in partially exposed environments.

5.1.27 **CAB sub-assets findings**

- **Plenum Chamber**: Multiple areas within the plenum cavity exhibited significant corrosion, particularly around drainage trenches, splitter supports, and internal structural flanges. Observed failures included cracked paint, rust scale at stitched welds, and deterioration around starter motor bracketry. The internal paint system has largely failed in floor-level drainage zones, leaving bare metal exposed to corrosion and failure.
- **Internal Structural Supports Behind Acoustic Panels**: Corrosion was identified primarily along lower wall regions, especially behind the acoustic panel bases. Supporting members near floor level and panel interfaces exhibited advanced paint failure and surface rust. Cable pass-throughs showed sealing integrity, and welded brackets (e.g. for limit switches) displayed rust streaking and flaking paint. Bracket fixings and drainage-associated structures were common corrosion points, indicating long term moisture exposure at base levels.
- **Vent Intake Blister**: Corrosion was visible along base interfaces and damper supports. Pneumatic clamps securing control-air lines were in place, but backing structures and damper plate seams showed rust initiation, particularly beneath the flange seams and around lower damp zones. All these compromised areas will result in metal failure and collapse of the blister.
- **Exhaust Blister**: Internal inspection revealed heavier corrosion than at the vent blister. The support angle frames and structural fixings beneath the damped wall cladding were affected by long-term moisture exposure. Areas near floor contact showed consistent paint failure, and accumulated debris was present near the internal corner seams.

Electrical Assets Survey Report Summary and Real-life Examples

Motor Control Centre (MCC)

5.1.28 The MCC switchgears were supplied with the original plant and are showing signs of ageing. Due to the age of equipment, the form of construction does not meet the requirements of present Form 4 Type 7 as well as BS EN 61439-1:2011.

5.1.29 Form 4 Type 7 specifies the need for internal separation of busbars and functional units from one another when installing electrical control systems for safety reasons. Terminals for external conductors should not be located in the same compartment as the associated functional unit, but in individual separate, enclosed protected spaces, or compartments. The termination for each functional unit has its own integral glanding facility which avoids electrical faults and most importantly improves the safety of personnel.

Distribution Boards

5.1.30 The AC Unit Services Distribution Board has no identifiable OEM and was custom-built, from an earlier generation Schneider Electric Prisma enclosure.

5.1.31 It was noted that there is lack of 'finger proof terminals' or 'shrouds', particularly on the panel backplane around the 230V / 110V AC transformer. This does not align with the requirement for protection over live terminals, as per BS 7671:2018.

5.1.32 Spare parts are no longer being supported by the OEM, and the installed Merlin Gerin breakers are not supported by with maintenance spares.

5.1.33 Some internal components, e.g. relays and switches, were noted onsite as heat damaged and contacts / housings were brittle with age.

5.1.34 Does not comply with BS 7671:2018, which requires that live terminals be adequately protected to prevent accidental contact.

5.1.35 **Arc Flash** -An arc flash is a dangerous release of energy produced by an electrical fault that ionises the air, allowing current to flow through it. Problems include:

- During an arc flash event, temperatures can rise to tens of thousands of degrees Celsius in an instant. This immense heat vaporises surrounding metal, generates a powerful shock wave, and emits intense light. Together, these hazards pose serious risks to personnel, including burns, flying debris, and potential hearing or vision damage. A summary of this
- A key measure of arc flash severity is the incident energy, expressed as the energy per area in cal/cm². The higher incident energy, the greater the level of personal protective equipment (PPE) required.
- An Arc Flash Study was conducted for Unit A which involved analysing electrical systems to determine the incident energy level which quantifies the potential thermal energy exposure from an arc flash event and the required personal protective equipment (PPE) required.
- The study identified arc flash hazards and estimated the likelihood of severe injury. The study determined where additional protections are needed. Arc flash hazards must be reduced to as low as reasonably practicable (ALARP). Electrical assets such as DBs should comply to BS EN 61439 and tested to TR 61641 which states requirements and tests for an arc ignition protected zone.

5.1.36 **Lube Oil Transfer Pump/Motor set -** There is one transfer pump for 100% duty which is in an open space subjecting the motor to rain and adverse weather condition. The pump-motor assembly was installed in 1989 and it now exhibits discolouration and a weathered appearance. Both assets are obsolete with no OEM support.

5.1.37 **Lube oil tank Heater –** The major investment driver for this asset is maintainability due to the unavailability of spares. The heater has been energised since installation and has surpassed its design life.

5.1.38 **AC Vent Fans –** The major asset health issue is that the enclosure seals are damaged allowing water ingress into the cabinet.

5.1.39 **AC Main Lube Oil Standby Pump** - The OEM advised that the motor has a life expectancy of 20,000hrs with adequate maintenance. However, the current running hours are 34,902hrs and considering the criticality of the pump in lubricating the gas turbine shaft, it is critical to reduce the risk of failure.

5.1.40 **AC Gas Generator Hydraulic Oil Pump** - Engagement with the OEM confirmed that this motor is have no maintenance spares. Failure of the pump would result in a long procurement and replacement time.

5.1.41 **Gas Generator (GG) Starter Motor** – This motor is a custom-built, two-speed motor designed to start the heavy GG Avon turbine. The motor is 36+ years old against a standard design life of circa 25 years. There are visual signs of damage in the current state, stripped out of gland. This motor has non-standard winding configuration and will likely require a special order for replacement. The motor has been subjected to a high number of starts, running under heavy load conditions in rotating the GG shaft. The OEM confirmed this motor is obsolete, with no spares available. This potentially significant Mean Time to Repair (MTTR) if the motor fails. Starter motors are fundamental to achieving compliance with Unit Start Probability requirements.

5.1.42 **DC Main Lube Oil Pump** - This motor was manufactured in 1974 and has undergone major refurbishments in the past. Major findings include:

- Carbon brushes on the motor are approaching their maximum permissible wear limit and replacement brushes could not be sourced as they are no longer supported by the manufacturer. The asset is also custom made with no alternative brushes from other suppliers
- Excessive brush wear increases the risk of electrical arcing and sparking, which may lead to overheating, accelerated commutator damage, and eventual motor failure. Such deterioration can compromise system reliability, increase maintenance costs, and pose potential safety risks.
- OEM of this motor has since dissolved; therefore, the motor is obsolete, and any replacements will not be like-for-like creating significant risk for compatibility and lengthy MTTR.

5.1.43 **DC Emergency Vent Fan**

- It was identified during the inspection that the cable to the fan had been snagging within the gland collar.
- The OEM confirmed that this unit is now obsolete, and no spares are available, risking lengthy MTTR.

5.1.44 **DC Hydraulic Oil Pump** – Failure of the motor in operation could result in significant mechanical damage to the gas turbine unit due to loss of hydraulic oil supply. Carbon brushes on the motor are approaching their maximum permissible wear limit and replacement brushes have become difficult to source. The OEM has since been acquired by another manufacturer, ATB Morley, who no longer support the legacy design, therefore this motor has no maintenance spares support. The motor is configured in a 1x100% arrangement, performing the function of an emergency back-up. Therefore, there is a single point of failure and operational reliability of these motors is critical which requires addressing.

5.1.45 **Electrical heat tracing (EHT)** - The defects listed below were identified:

- Originally installed EHT has started to short to earth, across both the Air Filter Bypass Doors and the Thrust Unloader Tank, indicative of service life.
- The Electrical Heat Tracing (EHT) thermostat has already been disconnected because it is shorted to earth.
- Temperature cannot be regulated, and the EHT temperature is set to a constant temperature which is inefficient and could cause temperatures to fall outside of required parameters leading to failure of equipment and Unit trips.

5.1.46 **Electrical Space Heaters** – Major asset health issues found with space heaters are listed below:

- All the electrical space heaters in the gas turbine and compressor areas have bent and rusty cooling fins and heater bodies.
- All space heaters are non-complaint with T/SP/EL/50 specifications.
- The heaters have been in service for 36 years which is beyond their recommended design life. Furthermore, inefficient space heaters result in increased electricity usage during operation and has consequential impacts to Unit availability and asset deterioration.

5.1.47 **CAB Lighting** – Asset health and compliance issues have been identified during CAB lighting surveys. These are listed below:

- Maintainability and Obsolescence – The current internal and external CAB lighting assets utilise fluorescent tubes which have been discontinued from manufacturing under the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (2012) (the RoHS regulations).
- Corrosion Issues – Corrosion observed at the electrical connections affects the Ex-rating fittings, increasing safety risks in hazardous areas.
- High energy consumption - fluorescent lights consume significantly more energy compared to LED alternatives, leading to higher operational costs.
- Existing Defects – there are numerous defects on lighting systems related to several lights within the main machinery module of the CAB which do not function.
- Low Lux levels - In certain areas of the Turbine Room and Compressor Room Lux Levels are below recommended industry guidelines, due to defective lamps.

5.1.48 **Cables and Auxiliaries** – Surveys revealed compliance issues listed below:

- Cables are designed to outdated BS 6346 PVC Insulated Cables, 600/1000V with a solid or braided aluminium and are only Flame Retardant to IEC60332 part 1, BS4066 part 1. Current cable certification should comply to BS5467 cable specification and covers the requirements for low voltage armoured cables, both galvanised steel wire armoured (multi-core), and non-magnetic aluminium wire armoured (single core).
- The outer sheaths of cables do not have reduced flame propagation characteristics in accordance with current IEC 60332 [31] and are not anti-vermin impregnated or provided with suitable mechanical means of anti-vermin protection.
- Emergency escape lighting and emergency standby lighting circuits are not segregated from other power cables by the required 300mm in accordance with BS 5266.
- The current earthing system does not comply with BS EN 60079-14 or BS 7671:2018 requirements for Equipotential Bonding of differing equipment.
- The existing LV cables do not comply with current fire safety standards. Specifically, they are not constructed using flame-retardant, low smoke, zero halogen (LSZH) materials with cross-linked polyethylene (XLPE) insulation and steel wire armour (SWA).

What the investment seeks to achieve

5.1.49 The problems identified in the remnant life study, RAM model and asset health assessment clearly demonstrate the need to invest in Unit A for the ongoing safe and compliant operation in support of Wormington Compressor Station resilience required for the NTS.

5.1.50 Overall, this investment seeks to address these problems by efficiently delivering an integrated package of works across the whole of Unit A in line with the strategic aims of the programme.

5.1.51 Should the proposed interventions not be performed, impacts of failure become more likely and drive an increasing probability of unplanned unit outages which could adversely affect UK security of supply.

How will we understand if the project has been successful?

5.1.52 The project will be deemed successful when all asset health works are completed, the unit is returned to service and demonstrates reliable service as a back-up unit to Units C (VSD) and D (new unit). Furthermore, once the scope has been delivered, the asset will comply to the relevant technical specifications, safety, and engineering standards.

5.1.53 Success will also be measured based on programme delivery including management of risks, budgets and schedules.

5.1.54 Additionally, NGT Management Procedure (T/PM/G/35) incorporates the philosophy and general principles outlined in the Institution of Gas Engineers & Managers (IGEM) standard IGEM/GL/5 Edition 2 'Managing new works, modifications and repairs' and serves to adopt its principles. Adherence to this will be demonstrated prior to the issuing of a commissioning certificates as per NGT Policy (RE/18) and the asset being handed back to the operator

Spend Boundaries

5.1.55 This paper only covers Asset Health interventions which affect the operation of compressor Unit A at Wormington Compressor Station.

5.1.56 The proposed investments are directly linked to defects and improvements identified as part of Asset Health survey reviews conducted by NGT and its MWC.

5.1.57 The scope covered under this re-opener submission has been assessed against the RIIO-GT3 business plan to ensure no duplication of scope. Appendix C provides further detail on the interaction between this EJP and the RIIO-GT3 business plan submission.

5.1.58 There are also significant interactions between in-flight and planned projects such as the Western Import Resilience Programme (WIRP) and station cyber control system replacement projects. The funding of these projects remains separate from the scope of this EJP.

6 Options Considered

6.1.1 Figure 19 provides a high-level summary of the steps taken to derive and assess options to address the issues presented in the Problem Statement section in this paper.

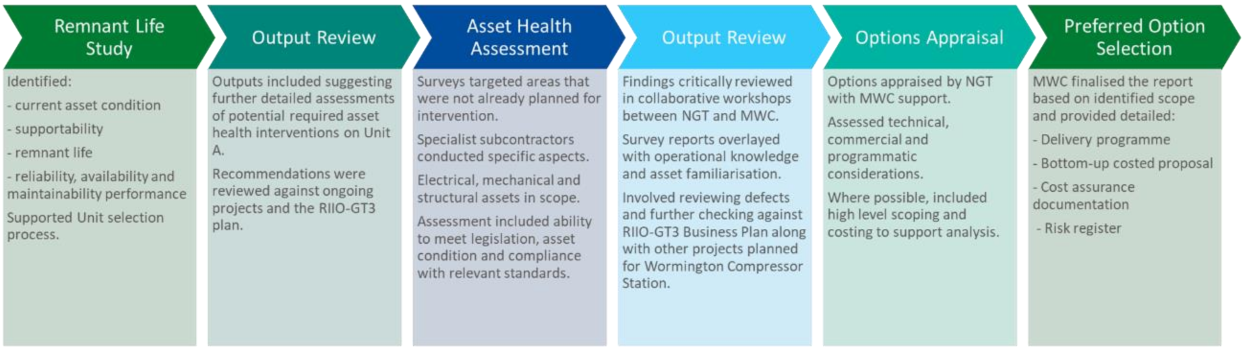

Figure 19: High Level Optioneering Process

6.1.2 NGT adopted a rigorous and structured optioneering process to ensure that multiple potential solutions were explored within the constraints of the project. This multi-staged approach aimed to ensure that decisions were technically sound and strategically aligned with the project objectives and site strategy.

6.1.3 The process involved:

- Comprehensive issue analysis at asset-level detail based on detailed surveys.
- Leveraging the expertise of specialist contractors and delivery partners, combined with operational knowledge from site personnel and subject matter experts across NGT.
- Collaborative workshops between NGT and the Main Works Contractor (MWC) to critically review recommendations against both technical and commercial criteria.
- Integration of defect data, gap analysis, and equipment supportability constraints to ensure robust decision-making.

6.1.4 By exploring multiple methods to address key drivers such as legislative compliance, adherence to standards, and mitigation of HSE risks, the optioneering process also considered system interactions, process dependencies, and alignment with ongoing projects.

6.1.5 For each candidate option considered, further analysis was undertaken to assess the advantages and disadvantages and what the scope of interventions would likely entail.

6.1.6 The outcome is captured in the intervention portfolio document (Appendix C) which provides a transparent evaluation framework detailing why certain options were selected and others discounted, along with clear linkage between proposed interventions, known issues, and long-term strategic objectives.

6.1.7 The intervention portfolio provides rationale based on criteria including:

- Intervention drivers
- Dependencies
- Survey findings and SME inputs
- Site intelligence and Computerised maintenance management system (CMMS) defect data

6.1.8 This structured methodology demonstrates that multiple options were appraised across a range of drivers to ensure that the final recommendations represent the optimum balance of safety, compliance, cost-effectiveness, and strategic fit.

6.1.9 The tables below provide a high-level summary of the options taken forward for the assets in scope. Specifically, intervention options included the counterfactual, minor refurbishment, major refurbishment or replacement. Appendix C provides a holistic document covering all factors considered during option selection. Table 7 and Table 8 below indicate the selected option for each intervention.

MECHANICAL ASSETS	Do nothing	Minor Refurbishment	Major Refurbishment	Replacement
[redacted]	No	No	Yes	No
[redacted]	No	No	Yes	No
[redacted]	No	No	Yes	No
[redacted]	No	No	No	Yes
[redacted]	No	No	No	Yes
[redacted]	No	No	No	Yes
[redacted]	No	No	Yes	No
[redacted]	No	No	No	Yes
[redacted]	No	No	Yes	No
[redacted]	No	No	No	Yes
[redacted]	No	No	Yes	No
[redacted]	No	No	Yes	No
[redacted]	No	Yes	No	No
[redacted]	No	No	Yes	No
[redacted]	No	No	Yes	No
[redacted]	No	No	Yes	No
[redacted]	No	Yes	No	No
[redacted]	No	No	Yes	No
[redacted]	No	No	Yes	No
[redacted]	No	No	No	Yes
[redacted]	No	No	Yes	No
[redacted]	No	No	No	Yes
[redacted]	No	No	Yes	No
[redacted]	No	No	Yes	No
[redacted]	No	No	Yes	No
[redacted]	No	No	Yes	No
[redacted]	No	No	Yes	No
[redacted]	No	No	No	Yes

[redacted]

ELECTRICAL ASSETS	Do Nothing	Minor Refurbishment	Major Refurbishment	Replacement
[redacted]	No	No	No	Yes
[redacted]	No	No	No	Yes
[redacted]	No	No	No	Yes
[redacted]	No	No	No	Yes
[redacted]	No	No	No	Yes
[redacted]	No	No	No	Yes
[redacted]	No	No	No	Yes
[redacted]	No	No	No	Yes
[redacted]	No	No	No	Yes
[redacted]	No	No	No	Yes
[redacted]	No	No	No	Yes
[redacted]	No	No	No	Yes

[redacted]	No	No	No	Yes
[redacted]	No	No	No	Yes
[redacted]	No	No	No	Yes
[redacted]	No	No	No	Yes
[redacted]	No	No	No	Yes
[redacted]	No	No	No	Yes
[redacted]	No	No	No	Yes

[redacted]

7 Preferred Option and Project Plan

7.1.1 The option selection process identified candidate interventions and evaluated them using a comprehensive methodology to address survey findings and ensure compliance with relevant legislation and standards. Based on these findings and recommendations from collaborative workshops, the preferred option is to deliver a programme of works across mechanical and electrical assets supporting Unit A. This aligns directly with the Wormington Compressor Emissions – Final Preferred Option, which highlighted the need for significant asset health investment to improve unit availability.

7.1.2 Implementing targeted interventions - ranging from minor refurbishment to full replacement - will restore equipment integrity, maintain operational efficiency, and ensure safety standards are met in accordance with our obligations as a responsible operator. Together, this integrated package of works has been structured as a portfolio of activities that accounts for interdependencies, delivery constraints, and operational considerations.

7.1.3 Across the mechanical asset base, major refurbishment was the most preferred intervention selected which will involve returning the asset to safe, operable states. Alongside these major refurbishments, minor refurbishment and replacement interventions will ensure the complex sub-systems associated with Unit A will be sustained for continued use. The interactions between these systems have been considered to ensure efficient work delivery and mitigate compatibility and process safety issues. Appendix C details why options were selected in detail.

7.1.4 Similarly, electrical works must be aligned to ensure successful delivery. For example, cabling modifications will be required to support electrical asset interventions. It was evident from the optioneering process that replacement of electrical equipment was generally the preferred option.

7.1.5 This approach will ensure that investment is delivered at the most efficient overall cost, however the need to deliver work within specific outage windows, procure specialist items from the supply chain, and coordinate with in-flight and upcoming projects creates a complex programme with substantial risk. Close collaboration with contractors will be essential to implement mitigation measures as necessary and maintain careful management throughout.

7.1.6 Overall, the preferred option is to deliver a programme of interventions to resolve known failures, performance deficiencies, and non-conformances across Unit A. This will enable continued safe and reliable operation, maintain network resilience, and minimise unplanned outages and whole-life costs.

Project Scope

7.1.7 The project scope follows the preferred option, with the interventions forming the basis of the volumes detailed in this section. The work scope includes:

- Design, specification, and procurement of appropriate replacement sub-assets in accordance with NGT and relevant standards.
- Programming and coordination of works with coinciding site activities.
- Temporary works including civils and groundworks.
- Removal and replacement of life expired and defective sub-assets.
- Refurbishment of defective assets and systems.
- Welding and NDT activities.
- Site Acceptance Testing.
- Commissioning works.
- Reinstatement works.
- Collation and archiving of handover spares and records.
- Records and asset data updates.

Asset Health Investment IDs

7.1.8 NGT proposes the new investment codes shown in Table 9 and Table 10 for specific deliverables. It is important to note that some similar interventions in scope and cost are grouped under one investment code. For instance, AC and DC motors are all covered under Investment Code C-430. This shows how the cost will be apportioned at delivery stage.

Investment Title	InvID
[redacted]	

[redacted]

Investment Title	InvID
[redacted]	

[redacted]

Project Timescales

7.1.9 The project was sanctioned at ND500 Stage 4.2 (F2/T2) (Option Selection) in November 2024 and detailed Asset Health surveys were completed in May 2025 (with a day visit in September 2025 to double check information concerning the 3D scan for the Computational Fluid Dynamics modelling).

7.1.10 The project progressed detailed to ND500 Stage 4.4 (F4/T4) (Project Execution) in November 2025 to ratify the outcome of the Asset Health scoping, cost estimation ([redacted] and delivery programme which forms the basis of this submission.

7.1.11 Following Ofgem's determination, a contract will be awarded in a two-stage Early Contractor Involvement (ECI) type approach on the Regional Asset Health Framework.

7.1.12 Stage 1 will be tendered on a direct award bases to the MWC covering feasibility detailed engineering and procurement of long-lead items.

7.1.13 The second stage of contract will be tendered for the construction stage at the end of detailed engineering. The MWC will be required to revalidate the construction cost following the completion of the detailed engineering.

7.1.14 Project closure is anticipated in June 2031 based on the extensive and time-consuming records update and financial reconciliation associated with this large-scale project

7.1.15 Details of the project delivery program, excluding operational acceptance and Project closure are shown in Appendix E

7.1.16 Table 11 provides the outline milestone plan, with the high-level schedule presented in Table 12.

7.1.17 Table 12 is also showing the timeline for delivering the project across regulatory periods. Further details are included in the outage plan in Appendix G.

	Activity Name	Indicative Completion Dates
[redacted]		

[redacted]

Final Costs

7.1.18 To ensure robustness of the final costs, NGT employed the use of a Designer / MWC to validate scope, understand some of the engineering challenges associated and to help refine details as well as building up an externally priced estimate showing how the market would cost works of this nature. Further details are highlighted in the Overarching document. [redacted]

7.1.19 Table 13 provides a breakdown of the final EAC costs for the project split by required categories.

	Cost Category	Costs (£m) 2018/2019 Price Base	% of EAC
[redacted]			

[redacted]

7.1.20 The cost accuracy at this stage of the project is estimated [redacted] in accordance with the Infrastructure and Projects Authority (IPA) cost estimating guidance. The investment and works will span across the RIIO-T2 and RIIO-GT3 periods and RIIO-GT4.

Key Business Risks and Deliverability Challenges

7.1.21 As expected with a project of this nature – characterised by complex interdependencies, operational constraints, and supply chain interactions – there are significant risks involved with delivering this portfolio of work. To ensure risks are understood and controlled appropriately, NGT utilise a robust management framework and programme governance methods as described in Appendix H. Furthermore, details of MWC risk management is provided in the Contractor Cost Methodology Report (Appendix D).

7.1.22 The total risk value for asset health is [redacted] Table 13 summarises the top three key risks for the Asset Health scope. The complete risk register including qualitative and quantitative assessments and mitigations, together with the risk profiles, probability of occurrence and three-point estimates of cost and/or time impacts are presented within the Risk Register in Appendix A (cost book).

[redacted]

[redacted]

7.1.23 The following challenges are foreseen with other activities and interactions at the Wormington Compressor Station which have been captured in the planning assumptions:

- Operationally critical maintenance activities – Maintenance activities that are undertaken at Wormington Compressor Station on fixed intervals driven by legislative requirements such as Pipeline Safety Regulations 1996 (PSR) and Pressure Systems Safety Regulations 2000 (PSSR) are fixed in the schedule as they cannot be moved.
- Interactions between projects including the Emissions New Unit and the Western Import Resilience Programme (WIRP) may have an impact to activities for this Unit A Asset Health project. Further information can be found in the overarching document.

7.1.24 Despite the challenges detailed above, NGT has completed a series of deliverability assessments to confirm the scope is deliverable within the planned schedule. Appendix F provides further details of the indicative delivery programme.

7.1.25 Deliverability has also been aligned to the RIIO-GT3 plan, other adjacent work and customer outages.

8 Cost Build up and Estimation Methodology

8.1.1 Funding was granted to undertake feasibility, a conceptual study and develop the options to determine the preferred solution. The spend to date has been quantified within the Wormington Cost Book (Appendix A).

8.1.2 To ensure robustness of costs, NGT employed the use of Designers / Main Works Contractors (MWCs) to validate scope, understand engineering challenges, and build priced estimates reflecting current market costs.

8.1.3 Following a competitive process in which various Contractors were invited to tender, the rates were negotiated for three regions across the UK. The MWC was awarded West Area (in which Wormington is located) under the Regional Asset Health Partnership Framework (RAHP). This Framework covers asset health in general across the three regions and lasts until the end of the RIIO-T2 period. The 2-stage contract award will then commence following a decision on this UM reopener.

8.1.4 The cost estimates are based on tendered prices i.e. they use a bottom-up approach provided by an experienced MWC, using tendered pricing from designers, equipment and material suppliers, and internal estimates for people, plant and machinery. The contractor's estimate confidence level is further detailed in the Contractor Cost Methodology Report (Appendix D).

Estimating Uncertainty (EU)

8.1.5 In line with the Infrastructure and Projects Authority (IPA) cost estimating framework, the cost estimate has been structured around the fundamental equation: [redacted]
The EU range selected was based on a Class 2 estimate maturity, with a range of [redacted] applied. Our Cost and Risk Report (Appendix H) further detail the methodology for calculating the EU on this project.

8.1.6 Our Cost and Risk Report also outline the cost and risk methodology used to establish a comprehensive and transparent framework for the project's financial planning and risk management. It delineates the systematic approach used to develop our cost estimates for this project.

Efficient Cost

8.1.7 The MWC produced detailed asset health surveys, which were conducted through the last stage of feasibility. Outputs from MWC, including cost estimation and delivery programme are included within our preferred option.

8.1.8 Following internal review of the MWC surveys reports and recommendations, the preferred option scope was confirmed. For some sub assets such as pipework, the initial recommended scope was revised from minor to major refurbishment due to the condition of the asset and the benefit of the initial recommendation being deemed insufficient.

8.1.9 Based on the confirmed scope, the MWC produced a bottom-up cost estimate including quotations from the supply chain for detailed engineering, equipment and materials purchase, and internal estimation for labour and plant for the construction and commissioning phases.

8.1.10 To assure the MWC cost estimates, the activity pricing schedule provided by the MWC has undergone a cost assurance exercise. Key activities included cross checking Material Take-off (MTO) quantities and rates for materials, reviewing durations and resources for both construction activities and design phases to ensure alignment with both the programme of works and project requirements.

8.1.11 Specifications of fittings and pipework to be procured by the MWC have also been checked as suitable. To ensure that all costs have been allowed for by the MWC, a Document Review Sheet (DRS) was produced by NGT and issued to the MWC highlighting areas of concern or where clarification was required. This has resulted in a revised activity pricing schedule incorporating the comments and queries raised to clarify points such as granularity of costs, scope limits and resource allocations.

8.1.12 Through this additional information, durations of activities and detail of allowances were able to be checked against scope activities. The resource forecast provided by the MWC provides additional cost assurance that sufficient project management allowances have been made. Where quantity errors have been found, these have been adjusted/reduced in alignment with resource durations. Rates have also been used from MCPD new build Short Schedule of Cost Components (SSCC), an existing set of contractor rates.

8.1.13 All quotes from the MWC have been included in the Contractor Cost Methodology Report (Appendix D)

8.1.14 NGT costs (staff and operations resourcing) required to support successful project delivery has been built-up using the Contractor's delivery programme. This programme defines when the key project delivery milestones will take place and to determine the optimum / efficient resources required to support each stage. Resourcing has been identified through several key sources:

- Assessment of governing specifications and standards (e.g. BP/133G) which define core project delivery roles and responsibilities.
- Cross comparison against the resources utilised on similar asset health projects (i.e. Bacton and St Fergus terminal asset health projects).
- Lessons learnt from historic delivery projects (i.e. Bacton and St Fergus terminal asset health projects).
- Engagement with various disciplines within across our core departments (Asset, System Operator, Construction and Operations).

8.1.15 Staff utilisation throughout key project phases (detailed engineering, construction, commissioning, documentation handover/closure) was determined by the interrogation of:

- The Contractor's programme for Formal Process Safety Assessment (FPSA) workshops such as HAZOPs (Hazard and Operability Study), HAZCON (Hazard in Construction) etc. which are resource intensive particularly for engineering subject matter experts.
- The Contractor's construction programme which identifies the number of work areas to be supervised, the number of work crews proposed by the. This helped us determine the necessary NGT resource requirement

8.1.16 Supporting narrative and granular cost details of NGT direct roles and their project responsibilities are contained within Appendix A.

Contracting Strategy

8.1.17 The Early Contractor Involvement (ECI) type approach on the Regional Asset Health Framework was selected following market consultation [redacted] to enable early collaboration and engagement with the Contractor to prioritise scope definition and cost estimate development ahead of the re-opener submission. This ECI approach reduces risk, enhances collaboration, and ensures timely delivery. Bringing the contractor into the early design and planning phases allows for their input ahead of construction which contributes to cost efficiencies through design optimisation, constructability, risk management, and stakeholder alignment.

8.1.18 The ECI model was adopted in preference to traditional procurement methods such as competitive tender on a design and build basis, which limit collaboration and hinder innovation during early stages of project development, which often leads to changes late in the design process with significant increase in cost and project delays.

8.1.19 Stage 1 involved conducting the survey, establishing the project scope and conducting the cost assurance on a cost reimbursable basis forming the basis of this submission.

8.1.20 Stage 2 will involve a tender with the same MWC for the detailed engineering and delivery phase on either an Option A firm price or Option C target price basis. Stage 2 will be divided into two phases. Phase 1 will be detailed engineering and long lead procurement. At the completion of phase 1, the contractor will reconfirm the cost for phase two, construction, commissioning and close out. Should phase two costs exceed agreed allowances, we have the option to spot tender phase 2 works.

Wormington Re-opener cost movement from FOSR

8.1.21 In the August 2022 FOSR submission, various solutions to achieve MCPD compressor emissions compliance were identified and evaluated. This included a broad range of technological, operational and commercial options to derive the shortlist of options and cost estimate to an accuracy o[redacted] The main purpose of the estimate of [redacted] (2018/19) was to support the commercial evaluation and comparison of the proposed options.

8.1.22 The FOSR costs reflected high-level assumptions of scope and costs required fo[redacted] operating under EUD post 2030. Risk was covered implicitly through [redacted] accuracy margin rather than through a formal Quantitative Risk Analysis (QRA).

8.1.23 Since the FOSR submission, the remnant life studies and asset health assessments have enabled more granular scopes to be derived. As a result, the funding requested in this EJP follows a detailed process of scope and cost development to an accuracy of [redacted] as detailed in the cost book.

8.1.24 These changes reflect the maturity of scope definition and the need to address asset condition issues to ensure safe and reliable operation of Unit A under derogated service. Key factors include:

- **Revised Scope –** Post-survey reviews between our subject matter experts and the Main Works Contractor (MWC) revealed a need to revise assumptions made at FOSR stage. For example, initial assumptions for some refurbishment interventions were changed to replacements due to the detailed survey findings as discussed in previous sections.
- **Materials –** Material costs have increased overall due to expanded scope and the transfer of procurement responsibility from NGT direct to the MWC to ensure accountability and risk management clarity. Market price escalation since RIIO-T2 baseline further compounds cost growth.
- **Main Works Contractor Costs –** These costs have increased overall as the revalidation exercise has taken place. Costs for the works in this re-opener have now been programmed after a detailed deliverability of work was undertaken looking at what can be achieved within the programme constraints. Subsequently, costs through extension of the works have increased the overall cost.
- **Direct Company Costs –** Direct costs have increased in line with the revised duration of works and the corresponding increase in MWC costs for the same reason.
- **Engineering Design –** Conceptual engineering for the defined scope of works for mechanical and electrical asset health interventions have been adjusted in line with works that have already been completed or reassigned to other related projects detailed in the overarching document.
- **Project Management –** Overall duration of the project has been indicated in Table 10.
- **Risk and contingency –** The overall risk at 8.6% of the EAC cost and within the appropriate risk coverage for this scope of work. The additional level of detailed work undertaken allowed more robust updates to be made to the Quantitative Risk Analysis (QRA) which ultimately drives this cost element.

8.1.25 This programme of works remains aligned with the original FOSR intent: ensuring Unit A can operate safely and reliably under derogated conditions to provide resilience and maintain gas supply at required volumes and pressures. The revised scope addresses critical asset health risks and compliance obligations.

9 Conclusion

9.1.1 This report has explained the approach NGT has taken to scope, review and cost the asset health interventions required for Unit A at Wormington Compressor Station to enable it to operate reliably beyond 2030 and the implications of not completing these works.

9.1.2 Furthermore, it has detailed the safety, environmental and operational risk concerns NGT has regarding the defective and life expired mechanical and electrical sub-assets and the implications of these on the reliability of Unit A. The interventions are necessary to ensure improved reliability and life extension of the unit.

9.1.3 The proposed scope is in line with the Ofgem's approved FOSR option and meets internal SME and external contractor engineering approval.

9.1.4 The project's agreed scope and cost have been assured for efficiency. The scope has been assessed against the current electrical and mechanical standards, while the costs have been assured by benchmarking against similar projects delivered.

9.1.5 Failure to obtain funding will put Unit A at risk of continued failure and operational stand down, potentially leaving NGT unable to meet its network wide reliability and availability commitments.

9.1.6 The interventions described will provide the best value for money and support gas delivery at pressures and volumes NGT's customers require.

9.1.7 Failure to address the issues could result not only in a loss of reliable gas supply for consumers but also in forcing NGT and site personnel to operate critical equipment that is already well beyond its design life. This significantly increases the risk of a serious incident (personnel injury, loss of containment etc.), which could expose NGT to enforcement action or prosecution by regulatory bodies such as the HSE, the Environment Agency, and others.

9.1.8 The funding request (CEPOt) for Asset Health interventions on Unit A totals [redacted]

10 Appendices

Appendix A – Wormington AH Unit A_Cost Book

Appendix B - Wormington AH Unit A_Survey Report

Appendix C - Wormington AH Unit A_Portfolio Document

Appendix D – Wormington AH Unit A_Contractor Cost Methodology Report

Appendix E - Wormington AH Unit A_Contractor Cost Estimate Report

Appendix F - Wormington AH Unit A_Programme

Appendix G - Wormington AH Unit A_Outage Plan

Appendix H - Wormington AH Unit A_Cost and Risk Report

Appendix I - Wormington AH Unit A_Remnant Life Study

11 Glossary

Glossary	
CBA	**Cost Benefit Analysis:** A mathematical decision support tool to quantify the relative benefits of each site option.
CDS	Conceptual Design Study
COMAH	Control of Major Accident Hazards (COMAH) Regulations 2015. Bacton Terminal is one of two designated NGT COMAH establishments. The other being St Fergus Terminal
DSEAR	Dangerous Substances and Explosive Atmospheres Regulations 2002
ECI	Early Contractor Involvement
EJP	Engineering Justification Paper
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 NGT is obligated to make available for delivery against on every day of the year
EPC	Engineering Procurement and Construction
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 NGT is obligated to make available for offtake on every day of the year.
FES	**Future Energy Scenarios:** An annual industry-wide consultation process encompassing questionnaires, workshops, meetings and seminars to seek Feasibility back on latest scenarios and shape future scenario work. The Future Energy Scenarios document is produced annually by National Energy System Operator and contains their latest scenarios.
FOS	Future Operating Strategy
FOSR	Final Option Selection Report
GS(M)R	**Gas Safety (Management) Regulations:** The Gas Safety (Management) Regulations 1996 (GS(M)R) apply to the conveyance of natural gas (methane) through pipes to domestic and other consumers
HSE	**Health and Safety Executive**
IPA	**Infrastructure and Projects Authority**
LNG	Liquified Natural Gas, Natural gas that has been cooled to a liquid state (around -162ºC) and either stored and/or transported in this liquid form.
LAV	Locally Actuated Valves
MWC	Main Works Contractor
(G)NDP	**Network Development Process:** The process by which NGT identifies and implements physical investment on the NTS.
NEA	Network Entry Agreement
NEC	New Engineering Contract
NGT	National Gas Transmission

Glossary	
NTS	**National Transmission System:** The high-pressure system consisting of Terminals, compressor stations, pipeline systems and offtakes. Designed to operate at pressures up to 94 barg. NTS pipelines transport gas from Terminals to NTS offtakes.
OEM	**Original Equipment Manufacturer**
Ofgem	**Office of Gas and Electricity Markets:** The regulatory agency responsible for regulating Great Britain's gas and electricity markets.
PFD	**Process Flow Diagram**
PV	**Process Valves**
PSSR	Pressure Systems Safety Regulations 2000
RAM	**Reliability Availability Maintainability**
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.
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.
ROV	**Remote Operation Valves**
SOL	**Safe Operating Limit**
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.
UKCS	**United Kingdom Continental Shelf:** The UK Continental Shelf (UKCS) is the region of waters surrounding the United Kingdom, in which the country has mineral rights. The UK continental shelf includes parts of the North Sea, the North Atlantic, the Irish Sea and the English Channel; the area includes large resources of oil and gas.
UID	Unique Identifier