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Peterborough & Huntingdon MCPD Compressor Emissions

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ABBREVIATIONS & GLOSSARY

Unless otherwise stated in this document, capitalised terms that appear in this document have the meaning given to them in the following table.

AC	Alternating Current
BAT	Best Available Technology
CAB	Compressor Acoustic Building
CAPEX	Capital Expenditure
CBA	Cost Benefit Analysis
CSRP	Control System Restricted Performance
DC	Direct Current
DLE	Dry Low Emissions
ERP3	Emissions Reduction Programme 3
ESD	Emergency Shutdown
EUD	Emergency Use Derogation
FEED	Front End Engineering Design
GG	Gas Generator
LV	Low Voltage
MCPD	Medium Combustion Plant Directive
NRV	Non-Return Valve
NTS	National Transmission System
OEM	Original Equipment Manufacturer
PRA	Pressure Reduction Area
PT	Power Turbine
RIIO	Revenue = Incentives + Innovation + Outputs
RIIO-T2	Second RIIO Transmission Price Control Period – From 2021 to 2026
SCR	Selective Catalytic Reduction

Executive Summary

As part of the option selection process for the Peterborough & Huntingdon MCPD project, there are six (6) emissions compliance options under review at Peterborough and four (4) at Huntingdon. These options involve the following solutions:

- Installation of one new emissions compliant gas turbine driven compressor and ceasing operation of the non-compliant Avon gas turbine from 1 January 2030
- Retaining the Avon driven compressor under limited 500 hour per year emergency use derogation
- Retaining the Avon driven compressor with the power derated such that emissions cannot exceed emissions limit values stipulated in MCPD (referred to as Control System Restricted Performance – CSRP)
- Retaining the Avon driven compressor with upgraded Dry Low Emission (DLE) combustion system. The variant of this option under consideration is Avon 1533-DLE
- Retaining the Avon driven compressor with emissions abatement provided via selective catalytic reduction (SCR)
- Decommissioning the Avon driven compressors

Each of the above options will require different levels of initial asset health investment to ensure reliable ongoing operation as summarised in Table 1 & Table 2. A conservative approach has been taken to define the minimum required initial investment taking into consideration works already funded in RIIO-T2 under separate investment themes. This report provides an overview of each scope item with detail on how the scope has been determined.

CAPEX estimates for initial and ongoing asset health scope are based on the RIIO-T2 unit cost schedule where applicable per the unit cost ID references in Table 1 & Table 2. The RIIO-T2 plan assumed at Peterborough one new unit would be installed for MCPD compliance and the remaining Avon decommissioned by 2030, and at Huntingdon one Avon unit would be retained on 500-hour Emergency Use Derogation (EUD) with the remaining Avons decommissioned by 2030. Therefore, for this option no additional spend above approved RIIO-T2 funding has been included for MCPD as shown in Table 1 and Table 2. There is no planned investment in RIIO-T2 that can be de-scoped under any MCPD compliance option.

Asset health interventions beyond 2030 have been determined based on existing maintenance philosophies and approximate forecast run-hours for each option. A similar approach has been applied for new units included in the various new build options. Due to the age of the Avon compressor machinery train and associated equipment, much of which is beyond its original design life, an increased failure rate should be expected. This is reflected in the intervention frequency for the Avon compared with new unit.

Table 1 - Initial Asset Health Scope for Peterborough

	Unit Cost ID						Intervention Frequency (Post 2030)	
		500 hour	CSRP	1533 DLE	1533 SCR	2030 Decom	Avon	New Unit
Control								
Unit control system	N/A[1]	✓	✓	✓	✓	×	15 years	
Fire and Gas Detection	N/A[1]	✓	✓	✓	✓	×	15 years	
Anti-Surge System	N/A[1]	✓	✓	✓	✓	×	15 years	
Electrical								
Distribution Boards	[redacted]	✓	✓	✓	✓	×	15 years	
Auxiliary Equipment	[redacted]	✓	✓	✓	✓	×	15 years	
LV Switchboards	[redacted]	✓	✓	✓	✓	×	15 years	
Rotating Equipment								
Gas Generator - overhaul	[redacted]	×	×	×	×	×	10 years[3]	15 years
Power turbine	[redacted]	×	×	×	×	×	10 years[3]	15 years
Compressor Impeller Refurb	[redacted]	×	×	×	×	×	30 years	40 years
Compressor - gas seal	[redacted]	×	×	×	×	×	10 years	
Upgrade Dry Gas Seal	N/A	×	✓	✓	✓	×	N/A	
Cab								
Building - CAB (Major)	[redacted]	✓	✓	✓	✓	×	40 years	
Building – CAB (Minor)	[redacted]	×	×	×	×	✓	10 years	
CAB Ventilation (Major)	[redacted]	✓	✓	✓	✓	×	10 years	40 years
CAB ventilation (Minor)	[redacted]	×	×	×	×	✓	5 years	20 years
Air intake (Major)	[redacted]	×	×	×	×	×	15 years	25 years
Air intake (Minor)	[redacted]	✓	✓	✓	✓	✓	10 years	
Exhausts (Major/Replace)	[redacted]	×	×	×	×	×	25 years	
Exhausts (Minor)	[redacted]	✓	✓	✓	×	✓	5 years	20 years
Piping & Valves								
Unit Isolation Valves	[redacted]	×	×	×	×	×	40 years	
Non-Return Valves	[redacted]	✓	✓	✓	✓	×	40 years	
Other Ancillary Systems								
Fuel Gas Skid	[redacted]	×	×	×	×	×	10 years	20 years
Oil System (GG, PT, Comp)	[redacted]	✓	✓	✓	✓	×	10 years	40 years
Fire Suppression	[redacted]	✓	✓	✓	✓	×	25 years	30 years

Note 1) *Cost based on RIIO-T2 Plan Annex 15.07 – Cyber Resilience Plan*

Note 2) *Approved RIIO-T2 scope excluded*

Note 3) *Intervention frequency of 20 years for 500-hour EUD*

Table 2 - Initial Asset Health Scope for Huntingdon

	Unit Cost ID					Intervention Frequency (Post 2030)
		500 hour	CSRP	1533 DLE	2030 Decom	Avon
Control						
Unit control system	N/A[1]	×	×	×	×	15 years
Fire and Gas Detection	N/A[1]	×	×	×	×	15 years
Anti-Surge System	N/A[1]	✓	✓	✓	×	15 years
Electrical						
Distribution Boards	[redacted]	✓	✓	✓	×	15 years
Auxiliary Equipment	[redacted]	✓	✓	✓	×	15 years
LV Switchboards	[redacted]	✓	✓	✓	×	15 years
Rotating Equipment						
Gas Generator - overhaul	[redacted]	×	×	×	×	10 years[3]
Power turbine	[redacted]	×	×	×	×	10 years[3]
Compressor Impeller Refurb	[redacted]	×	×	×	×	30 years
Compressor - gas seal	[redacted]	×	×	×	×	10 years
Upgrade Dry Gas Seal	N/A	×	×	×	×	N/A
Cab						
Building - CAB (Major)	[redacted]	×	×	×	×	40 years
Building – CAB (Minor)	[redacted]	✓	✓	✓	✓	10 years
CAB Ventilation (Major)	[redacted]	✓	✓	✓	×	10 years
CAB ventilation (Minor)	[redacted]	×	×	×	✓	5 years
Air intake (Major)	[redacted]	✓	✓	✓	×	15 years
Air intake (Minor)	[redacted]	×	×	×	✓	10 years
Exhausts (Major/Replace)	[redacted]	×	×	×	×	25 years
Exhausts (Minor)	[redacted]	✓	✓	✓	✓	5 years
Piping & Valves						
Unit Isolation Valves	[redacted]	✓	✓	✓	×	40 years
Non-Return Valves	[redacted]	✓	✓	✓	×	40 years
Other Ancillary Systems						
Fuel Gas Skid	[redacted]	×	×	×	×	10 years
Oil System (GG, PT, Comp)	[redacted]	✓	✓	✓	×	10 years
Fire Suppression	[redacted]	✓	✓	✓	×	25 years

Note 1) *Cost based on RIIO-T2 Plan Annex 15.07 – Cyber Resilience Plan*

Note 2) *Approved RIIO-T2 scope excluded*

Note 3) *Intervention frequency of 20 years for 500-hour EUD*

As shown in Table 1 and Table 2, there is minimal investment planned for existing Avon driven compressor train in the options where it will be decommissioned and replaced with the new unit prior to 2030, apart from the cab minor works. The RIIO-T2 asset health plan did not include the volume for this work to be included at Peterborough and Huntingdon.

1. Introduction

1.1. Site Background

Peterborough and Huntingdon are predominantly used for bulk transmission of gas to support extremity pressures in the South East and South West particularly during winter demand (>250mscm/d) and peak 1-in-20 demand (460 mscm/d) conditions.

At Peterborough, compression is provided by three (3) Rolls Royce (now Siemens) Avon MK1533 gas turbine driven compressor units (referred to as Units A, B and C). Huntingdon has a similar configuration to Peterborough, with compression provided by three (3) Rolls Royce (now Siemens) Avon MK1533 gas turbine driven compressor units (also referred to as Units A, B and C).

At the time of writing, four (4) Solar Titan gas driven compressors, two (2) at Peterborough (Units D and E) and two (2) at Huntingdon (Units D and E), are in the process of being installed to become lead units at each site respectively; commissioning is due to be complete mid 2023.. Installation of third Solar Titan unit was originally planned at Peterborough. However, limited construction was completed, predominately consisting of civil works.

1.2. Peterborough MCPD Shortlisted Options

Six (6) options have been shortlisted for review via CBA and BAT assessment as summarised in Table 3~~Table 3~~. CAPEX estimates at ±30% certainty have been developed for each of the shortlisted options which will be used in CBA and BAT assessments to support the selection of a single preferred option.

Table 3 - Shortlisted Options

Option	Description	Unit A	Unit B	Unit C	Unit D	Unit E	Unit F (Future)
1	500 Hr EUR	500Hr EUD	Decom	Decom	No Change	No Change	/
2	1 x CSRP	CSRP Retrofit	Decom	Decom	No Change	No Change	/
3	1 x 1533 DLE	Avon 1533 DLE	Decom	Decom	No Change	No Change	/
4	1 X SCR	Avon 1533 SCR Retrofit	Decom	Decom	No Change	No Change	/
5	1 x New GT	Decom	Decom	Decom	No Change	No Change	New GT
6	Decommission Avon	Decom	Decom	Decom	No Change	No Change	/

Note) Unit B and Unit C are planned to be decommissioned as part of RIIO-T2 Decommissioning works.

Option 5 involves installation of one new unit and ceasing operation of the remaining Avons by 1 January 2030 prior to decommissioning. Option 5 was identified as the preferred MCPD emissions compliance option in the 2019 RIIO-T2 business plan (Ref. 5) and therefore forms the basis of the RIIO-T2 asset health plans developed at the time. The asset health expenditure included in the CBA for this option is consistent with funding allowances confirmed in the final determinations of the 2019 RIIO-T2 asset health plan.

Options 1 to 4 inclusive involve the retention of the remaining Avon (assumed to be Unit A) which will require asset health spend beyond 2030. For these options additional asset health expenditure for Unit

A, which is not covered by RIIO-T2 asset health funding, have been identified as summarised in this document and are included in the CAPEX estimates and CBA.

Option 6 involves decommissioning all the remaining Avon, this would leave the site with two (2) Solar Titan T130 units with no further compressor unit to provide resilience.

1.3. Huntingdon MCPD Shortlisted Options

Four (4) Options have been shortlisted for Huntingdon, CAPEX estimates for these options have been produced and are to be reviewed via CBA.

Option	Description	Unit A	Unit B	Unit C	Unit D	Unit E
A	Counterfactual	Decom	Decom	500Hr EUD	No Change	No Change
B	Decommission	Decom	Decom	Decom	No Change	No Change
C	1 x CSRP	Decom	Decom	CSRP Retrofit	No Change	No Change
D	1 x 1533 DLE	Decom	Decom	Avon 1533 DLE	No Change	No Change

Note) Unit A and B are planned to be decommissioned as part of RIIO-T2 Decommissioning works.

Option A involves retaining Unit C on 500-hour Emergency Use Derogation. This option was identified as the preferred MCPD emissions compliance option in the 2019 RIIO-T2 business plan (Ref. 5) along with one new GT unit at Peterborough. A decommission option has been added and will be assessed as part of the CBA.

Options C and D involve retrofit technologies to be added to the Avon unit. For these options additional retrofit costs and asset health expenditure for Unit C, which is not covered by RIIO-T2 asset health funding, have been identified as summarised in this document and are included in the CAPEX estimates and CBA.

1.4. Document Purpose

The purpose of this document is to define the scope of asset health investment required for the Avon units at Peterborough and Huntingdon, and associated assets to be retained in each of the shortlisted MCPD investment options. Scope which is already funded in RIIO-T2 will be identified and excluded from MCPD cost estimates, CBA, and BAT assessment.

Funding mechanisms for various elements of scope are not discussed in this document but it is acknowledged that not all scope described herein will be included in the subsequent MCPD cost re-opener. Funding mechanisms will be confirmed once the MCPD option has been selected.

2. Control & Instrumentation

The new Solar Titan T130 units at Peterborough and Huntingdon use new unit control systems and fire and gas systems. The station control system was updated as part of the ERP3 Project. The existing unit control systems for units A to C at both sites now interface with the new station control system.

At Peterborough the unit control systems for Units A to C have not been replaced. The unit control system for Unit A is now obsolete and has been identified for replacement as part of this Asset Health

works. For the Avon units planned to be decommissioned, there are no requirements for a unit control system upgrade.

At Huntingdon, the Unit control system for Unit C was replaced in 2018 and the fire and gas system for Units A, B & C were replaced in 2017 under RIIO-T1, but no anti-surge systems were replaced. Therefore, only the anti-surge system for unit C is proposed to be replaced.

Control system scope including the following has been included in the initial CAPEX for options that involve retaining the Avon(s) beyond 2030:

- Replacement unit control system including all field instruments and cabling between instruments and unit control panel and all cabling between unit control panel and station control system for Peterborough unit A.
- Replacement anti-surge system including control system interface, valves, and actuators (excludes piping) for Peterborough unit A and Huntingdon unit C.
- Replacement fire and gas system including all sensors/detectors and cabling for Peterborough unit A.

Option with new GT units have new control systems that will tie into the recently replaced station control system. Similar scope to the above is included for all options every 15 years which is the typical design life of control systems and aligned with National Grid procedure T/PM/COMP/20.

3. Piping and Valves

At both compressor stations, the compressor suction and discharge piping between the compressor and the common header runs below grade in pits. Unit isolation is provided for each unit by a 900NB remotely operated ESD valve and a 900NB manually operated ball valve on the suction and discharge lines. There is also a 900NB non-return valve on the discharge side of each unit downstream of the ESD and manual isolation valves.

At Peterborough, a replacement non-return valve will be required. It has been assumed that the isolation valves do not require replacement and that there will be no further intervention following this initial CAPEX investment.

At Huntingdon, replacement of non-return valves and isolation valves has been identified as a requirement since their intervention interval is due before 2030. Since the intervention interval is 40 years, there are no planned interventions following this initial CAPEX investment.

New units will include installation of new suction and discharge piping and valves, and no CAPEX has been included for subsequent refurbishments in this instance.

4. Compressor Power Train

A summary of the gas generator power train assets currently installed at Peterborough and Huntingdon compressor station is shown in Table 4~~Table 4~~ & Table 5~~Table 5~~ below.

Table 4 – Peterborough Avon Compressor Train Assets

Asset	Unit	A	B	C
Gas Generator	Manufacturer	Siemens (Formerly Rolls Royce)		
	Model	Avon 1533-75G		
	Year	1973	1973	1978

	Rated Power	12.34 MW		
Power Turbine	Manufacturer	Siemens (Formerly GEC)		
	Model	EAS-133		
Compressor	Manufacturer	Siemens (Formerly Dresser-Rand)	Siemens (Formerly Dresser-Rand)	Siemens (Formerly De Laval)
	Model	36x36	36X36	PV30/30
Gas Seal	Manufacturer	Siemens (Formerly Dresser-Rand)	Siemens (Formerly Dresser-Rand)	Kaydon
	Model	Unknown	Unknown	Face Seal
	Type	Wet		
Starter	Type	Electric		

Table 5 – Huntingdon Avon Compressor Train Assets

Asset	Unit	A	B	C
Gas Generator	Manufacturer	Siemens (Formerly Rolls Royce)		
	Model	Avon 1533-75G		
	Year	1989	1989	1992
	Rated Power	12.34 MW		
Power Turbine	Manufacturer	Siemens (Formerly GEC)	Siemens (Formerly GEC)	Siemens (Formerly Cooper Rolls)
	Model	EAS-133	EAS-133	RT48S
Compressor	Manufacturer	Siemens (Formerly De Laval)	Siemens (Formerly De Laval)	Siemens (Formerly Cooper Rolls)
	Model	PV30/30	PV30/30	RFB
Gas Seal	Manufacturer	Kaydon	Kaydon	John Crane
	Model	Face Seal	Face Seal	28AT
	Type	Wet	Wet	Dry
Starter	Type	Electric		

The compressor train assets are maintained and overhauled according to the duty they have undertaken (run hours and number of starts and stops). The levels of duty are set by the manufacturers and are accepted best practice across the EU. These overhauls ensure that compression assets remain supported by the manufacturer and continue to operate safely and at an acceptable level of reliability and availability.

The overhaul of a gas generator, power turbine or compressor typically takes 13 to 26 weeks and involves isolation and removal of the equipment from site before inspection and refurbishment can be undertaken in the factory. National Grid has framework agreements with licensed and independent service providers to undertake these rotating machinery overhauls. Due to the age of the equipment,

the availability of spare parts and ongoing OEM support has been identified as a risk for retrofit options which retain Avon power trains until 2050.

4.1. Gas Generator

The Avon gas generators at Peterborough Unit A and Huntingdon Unit C were last overhauled in 2015 and 2017 respectively and no further overhauls are required in RIIO-T2. No further overhauls are included in this initial asset health CAPEX estimate.

Future overhauls beyond 2030 have been included based on an intervention frequency of 10 years for Avons with unlimited run hours and 15 years for new units. For Avon options involving 500-hour emergency use derogation an increased intervention period of 20 years has been assumed to account for the reduced run hours per annum.

Due to the age of the existing equipment, it is likely that the scope and cost of refurbishment and repairs will increase in the future due to ongoing degradation and limited spares availability. This has not been accounted for in CAPEX estimates which are based on RIIO-T2 unit costs.

4.2. Power Turbine

Power turbines are specialist items of equipment and although not operating at conditions that are as arduous as those in the gas generator, still require regular overhaul to maintain their integrity.

Power turbines are bespoke items of equipment tailored to the individual gas generator and compressor application. The EAS-133 power turbines at Peterborough and Huntingdon are no longer supported by the original OEM and spare parts can take up to 52 weeks to source as they often need to be manufactured to order.

At Peterborough Units A and B power turbines were last overhauled in 2018 and 2017 respectively and it is anticipated that, based on projected run hours, the next overhaul will be required in 2033 and then again in 2043. This overhaul has been included in the initial investment CAPEX for MCPD options where the existing assets will be retained beyond 2030. For options where the existing Avons will be replaced with new units this cost is excluded.

At Huntingdon, Unit C power turbine was last overhauled in 1992. An overhaul is planned as part of the RIIO-T2 asset health programme in 2023, therefore no further CAPEX investment has been included.

For options where the Avon will be retained under a 500 hour per year emergency use derogation the time between overhauls will be increased due to fewer run hours per annum. This results in the overhaul for Peterborough moving out to 2038. The CAPEX estimate for these overhauls is based on the RIIO-T2 unit cost schedule.

4.3. Compressor

Overhaul of the compressor impeller for the existing units are anticipated in 2043 for Peterborough and 2045 at Huntingdon, based on a 30-year intervention frequency.

For new units an intervention frequency of 40 years has been assumed meaning no overhaul will be required prior to 2050.

4.4. Seals

At Peterborough the Avon unit is currently configured with a mechanical seal oil system. This system is prone to leaks and ancillary equipment is beyond its design life. Components are obsolete and replacements are no longer available. The initial CAPEX estimates include upgrading to a 'zero loss' dry gas seal for all options that retain the Avon unit with the exception of the 500 hour EUD option.

At Huntingdon, Unit C is fitted with dry gas seals. There is no requirement to upgrade this to a 'zero loss' dry gas seal, therefore this has been excluded from the initial CAPEX estimate.

Future overhauls beyond 2030 have been included based on an intervention frequency of 10 years for dry gas seals and for original seal oil systems.

4.5. Starter Motor

Electric and hydraulic starter motors do not have a service interval and aren't expected to fail within the lifetime of a compressor unit. Starter motor costs are currently included within the Fleet Management costs for Gas Generator Assets and no costs have been included in the MCPD cost estimate for these assets.

5. Fuel Gas System

At both Peterborough and Huntingdon, process gas is taken from either in-station or outstation supply to the PRA (Pressure Reduction Area) where the gas passes through a heat exchanger or water bath heater and then filtration. Pressure is reduced by governor streams before the flow splits into dedicated streams for Units A, B & C, each with a flowmeter. The flow is then piped from the PRA to the dedicated fuel gas packages at each unit where flow to the gas generator is governed by the control system. A fuel gas analyser for each unit is also located on the unit fuel gas package.

National Grid Gas Transmission has an internal process safety action to ensure compliance with OEM service bulletins which state that fuel gas should be filtered to 5 microns and heated to 20°C above the dew point of the gas. The current set up at Peterborough and Huntingdon do not achieve this. There are planned replacements of the fuel gas conditioning skids at both sites as part of RIIO-T2 funding, therefore installation of new fuel gas conditioning skids has been excluded from this CAPEX estimate for both sites.

6. Oil System

Lube oil is supplied to the Avon compressors and power turbines from a common tank via submerged pumps (arranged as 1no. primary + 1no. standby). These pumps and associated electric motors are obsolete and spare parts are no longer available. Replacement has therefore been included in the scope for options involving the retention of the Avons beyond 2030.

There are also leaks within the oil system and inspection and repair of associated pipework is therefore included in the capital costs for Avons.

7. Compressor CAB

The Compressor Acoustic Building (CAB) Infrastructure assets are secondary assets but fundamental to ensure safe operation of the compressor train and compliance with environmental permits and safety legislation. Faults and degradation on these secondary assets will impact upon the availability of the compressor train due to inherent process safety risks. The CABs must therefore be maintained to ensure compressor train availability, preventing atmospheric conditions that could escalate to an explosion.

Compressor CABs are an essential element of our legal compliance with PM84 HSE / ISO21789 Control of Risk around Compressor Train Enclosures. They are also instrumental in maintaining our compliance with environmental legislation and permits regarding noise and exhaust emissions.

7.1. Building Structure

A major structural overhaul is expected to be carried out every 40 years on average. Major overhaul typically includes; relaying the roof membrane; replacing corroded acoustic and aesthetic panels; replacing and repairing ladders and platforms, and replacing or repairing doors.

At Peterborough, Unit A was surveyed by [redacted] in May 2022 (Ref 6.). The survey identified evidence of corrosion at many points within the void suggesting the roof has lost its weather seal and or excess moisture is being drawn in. A major overhaul has been included as part of the CAPEX estimate to address the deteriorating CAB enclosure.

[redacted] also carried out a survey on Huntingdon Unit C in May 2022 (Ref. 7). The survey did not identify any significant defects in the CAB enclosure. It states that the enclosure structure is largely sound with little signs of degradation or water ingress. A minor overhaul of the CAB enclosure has been included in the CAPEX estimate to address minor defects such as damaged oil cooler joints and defective doors.

After 2030 similar minor CAB structure overhauls have been assumed every 10 years. These overhauls will include; replacing some corroded acoustic panels, repairing some door seals that have failed, and sealing some holes that are affecting the performance of the ventilation system. A minor on Peterborough unit A has been included in 2038 and in 2040 for Huntingdon unit C.

For options looking to decommission the Avon unit by 2030, minor overhaul has been included to maintain safe operation for the remaining lifetime of the CAB building structure.

7.2. Fire Suppression

At both Peterborough and Huntingdon, fire suppression for the Avon units is provided by a HI-FOG water mist system utilising bottled nitrogen. Options which retain the existing Avons include replacement of fire suppression with an electric pump driven system which will remove the need for manual handling of nitrogen bottles which need to be replaced every time the fire suppression system is activated, thus reducing risk to personnel.

7.3. Gas Generator Air Intake

On unit A at Peterborough the survey by [redacted] did not identify any major defects with the air intake system (Ref. 6), but a minor overhaul has been included in the CAPEX estimate to allow for minor repairs. An air intake minor overhaul typically consists of replacing air filters, repairing corrosion, or replacing blow in door seals. Minor overhauls every 10 years have been included for new and existing assets.

On Huntingdon Unit C, a major overhaul has been included as part of the initial CAPEX investment. The survey carried out by [redacted] (Ref.7) identified corrosion throughout the combustion intake system in both the filter house and silencer and plenum. Large pieces of loose and corroded material were found in the plenum on the clear side of the filters which present an ingestion risk to the gas turbine.

Air intake major overhaul typically consists of a combination of the items listed in the minor overhaul and could also include an anti-icing system upgrade or installation of a second stage of filtration if the

unit only has one stage. For existing assets, major overhaul has been included every 15 years and for a new unit every 25 years.

For options looking to decommission the Avon unit by 2030, minor overhaul has been included to maintain safe operation for the remaining lifetime of the gas generator air intake.

7.4. Gas Generator Exhaust

Minor overhauls for the exhaust have been included in the CAPEX estimate for this uncertainty mechanism for all options except the SCR option at Peterborough. Exhausts are surveyed every 5 years to check external and internal corrosion, structure, joints and fasteners, and insulation. The latest condition survey identified that the exhaust stacks at Peterborough Unit A and Huntingdon Unit C to be visibly in fair condition however further internal inspections are required.

A minor exhaust overhaul would typically consist of repairing cracks, replacing the expansion joint or bellows, or replacing failed gaskets. For existing assets, a minor overhaul is required every 5 years and for new units every 20 years.

A major exhaust overhaul would typically consist of replacing the internal lining and insulation in an exhaust, or a combination of the interventions listed in the minor overhaul section. A major exhaust overhaul will be required every 25 years for new and existing units.

For options looking to decommission the Avon unit by 2030, minor overhaul has been included to maintain safe operation for the remaining lifetime of the gas generator exhaust.

7.5. CAB Ventilation

CAB ventilation systems provide airflow through the enclosure to remove the heat lost from the gas generator to prevent overheating and associated trips and equipment deterioration. On gas generator CABs, these are complex forced ventilation systems with emergency backup fans. They ensure that a safe atmosphere is always maintained and that any small gas leaks are effectively diluted to below the lower flammable limit to avoid any risk of a build-up of gas reaching flammable or explosive limits (the latter as defined by HSE Guidance Document PM84 which is now incorporated into ISO21789).

CAB ventilation assets include primary and emergency back-up ventilation fans, fan motors (usually AC for primary fans and DC for the emergency back-up fans), motor control and protection systems, cabling, ducting, filters, and louvres.

Both Avon units at Peterborough and Huntingdon have been found to have poor ventilation. Aperture tests showed that the system is providing up to 392% and 150% more exhaust air that the amount of air being drawn in from the intakes at Peterborough and Huntingdon respectively. This indicates recirculation and may be affecting dilution of flammable gases in the enclosure; some stagnant areas were visible in the cab. Therefore, a major overhaul has been included for both sites to address this issue.

A major overhaul includes repairs described in a minor overhaul and typically involves replacing failing components and iterative improvements to air flow to resolve stagnant areas through limited redesign of the system. A major ventilation overhaul will be required every 40 years for new and 10 years for existing units.

Minor overhaul of the ventilation system typically consists of localised repair of corrosion, cracking and failing seals, replacement individual elements and components. For existing assets, a minor overhaul is required every 5 years and for new units every 20 years.

For options looking to decommission the Avon unit by 2030, minor overhaul has been included to maintain safe operation for the remaining lifetime of the Gas Generator Ventilation.

8. Electrical

LV Switchboards are the first stage of power distribution following the main site supply transformer. Usually for a compressor station or large terminal there will be a main LV switchboard, a general services switchboard and unit switchboards/motor control centres. The quantity per site will vary depending on the number of compressors installed.

They are of metal clad construction with a fault rated busbar system and individual incoming and outgoing circuit breakers and/or fuse-switches plus control and instrumentation equipment as required. The boards can be either AC or DC – where the DC are fed from battery chargers for standby power/emergency back-up use. The switchboards form the first part of the LV distribution system which then feeds via electrical cables to various types of equipment and smaller distribution boards.

Switchboards, distribution boards and auxiliary equipment degrades over time and causes faults and trips. For options where the Avon units are to be retained the related LV electrical equipment will be replaced as part of the initial asset health modifications. Replacement of this equipment is included in the CBA every 15 years for new and retrofit options.

9. Decommissioning

Decommissioning costs have been included for options that remove Unit A at Peterborough and Unit C at Huntingdon, these options will cease operation of the Avon units prior to 1 January 2030.

Under a separate decommissioning project stream, two Avon units at both Peterborough and Huntingdon are planned to be decommissioned. The cost for decommissioning these units have been excluded from the CAPEX estimate for all options.

10. Other Station Assets

Assets which support the operation of the compressor station as a whole and are not dedicated to Unit A at Peterborough and Unit C at Huntingdon have not been reviewed as part of the MCPD project. These assets will be reviewed as part of the relevant asset health investment projects. Assets which have been excluded from assessment as part of the MCPD project include but are not limited to the following:

- Station inlet/outlet piping
- Above Ground Installation (AGI) / Multijunction Piping and equipment
- Compressed air
- Power actuating gas
- Nitrogen generation
- Towns water
- Site Drainage System
- Standby Power
- Uninterruptable Power Supply (UPS)

- Site Lighting
- Unit and station vent system
- Integrated Site Security
- Firewater ring main
- Cathodic Protection
- Scrubbers
- Pressure reduction area

11. Conclusions and Recommendations

The following works on the Avon units are RIIO-T2 funded and have been excluded from the CAPEX forecast.

At Peterborough on Unit A:

- Replacement of Fuel Gas System Heating System
- Vibration monitoring (control system)

At Huntingdon on Unit C:

- Replace Power Turbine
- Fuel Gas Skid Modification

The new unit option at Peterborough (option 5 – install one (1) new GT and decommission existing Avon) requires minimal initial asset health spend. Minor overhaul of the compressor CAB, including ventilation, exhaust, air intake and CAB building, has been included to ensure safe operation up to 2030, by which time the new GT will be ready for operation.

Options in which Avons are to be retained beyond 2030 include some additional initial CAPEX for asset health works required prior to 2030 but not currently funded in the RIIO-T2 plan. This scope is listed in Table 6~~Table 6~~ and Table 7. Cost for this work is based on either RIIO-T2 unit costs, where available, or supplier quotations. A detailed breakdown of the cost estimates and associated estimating methodology is described in the FOSR.

For all options, post 2030 CAPEX has been included to cover estimated asset health works required to ensure the safe and reliable asset operation to 2050 for existing assets to be retained and new assets to be installed as part of the MCPD project. This ongoing CAPEX is estimated using the same basis as initial spend (IE. RIIO-T2 Unit Costs and supplier quotations). Intervention frequencies for new and existing assets are based on; legislative and industry standards; OEM guidance; National Grid policies procedures and specifications, and previous inspection and survey results from similar NTS assets. To account for the age of existing assets, many of which are beyond their original design life, shorter intervention frequencies have been assumed than for new equipment in some instances.

Table 6 - Summary of Asset Health CAPEX at Peterborough

	Unit Cost ID						Intervention Frequency (Post 2030)	
		500 hour	CSRP	1533 DLE	1533 SCR	2030 Decom	Avon	New Unit
Control								
Unit control system	N/A[1]	✓	✓	✓	✓	×	15 years	
Fire and Gas Detection	N/A[1]	✓	✓	✓	✓	×	15 years	
Anti-Surge System	N/A[1]	✓	✓	✓	✓	×	15 years	
Electrical								
Distribution Boards	[redacted]	✓	✓	✓	✓	×	15 years	
Auxiliary Equipment	[redacted]	✓	✓	✓	✓	×	15 years	
LV Switchboards	[redacted]	✓	✓	✓	✓	×	15 years	
Rotating Equipment								
Gas Generator - overhaul	[redacted]	×	×	×	×	×	10 years[3]	15 years
Power turbine	[redacted]	×	×	×	×	×	10 years[3]	15 years
Compressor Impeller Refurb	[redacted]	×	×	×	×	×	30 years	40 years
Compressor - gas seal	[redacted]	×	×	×	×	×	10 years	
Upgrade Dry Gas Seal	N/A	×	✓	✓	✓	×	N/A	
Cab								
Building - CAB (Major)	[redacted]	✓	✓	✓	✓	×	40 years	
Building – CAB (Minor)	[redacted]	×	×	×	×	✓	10 years	
CAB Ventilation (Major)	[redacted]	✓	✓	✓	✓	×	10 years	40 years
CAB ventilation (Minor)	[redacted]	×	×	×	×	✓	5 years	20 years
Air intake (Major)	[redacted]	×	×	×	×	×	15 years	25 years
Air intake (Minor)	[redacted]	✓	✓	✓	✓	✓	10 years	
Exhausts (Major/Replace)	[redacted]	×	×	×	×	×	25 years	
Exhausts (Minor)	[redacted]	✓	✓	✓	×	✓	5 years	20 years
Piping & Valves								
Unit Isolation Valves	[redacted]	×	×	×	×	×	40 years	
Non-Return Valves	[redacted]	✓	✓	✓	✓	×	40 years	
Other Ancillary Systems								
Fuel Gas Skid	[redacted]	×	×	×	×	×	10 years	20 years
Oil System (GG, PT, Comp)	[redacted]	✓	✓	✓	✓	×	10 years	40 years
Fire Suppression	[redacted]	✓	✓	✓	✓	×	25 years	30 years

Note 1) *Cost based on RIIO-T2 Plan Annex 15.07 – Cyber Resilience Plan*

Note 2) *Approved RIIO-T2 scope excluded*

Note 3) *Intervention frequency of 20 years for 500-hour EUD*

Table 7 - Summary of Asset Health CAPEX at Huntingdon

	Unit Cost ID					Intervention Frequency (Post 2030)
		500 hour	CSRP	1533 DLE	2030 Decom	Avon
Control						
Unit control system	N/A[1]	×	×	×	×	15 years
Fire and Gas Detection	N/A[1]	×	×	×	×	15 years
Anti-Surge System	N/A[1]	✓	✓	✓	×	15 years
Electrical						
Distribution Boards	[redacted]	✓	✓	✓	×	15 years
Auxiliary Equipment	[redacted]	✓	✓	✓	×	15 years
LV Switchboards	[redacted]	✓	✓	✓	×	15 years
Rotating Equipment						
Gas Generator - overhaul	[redacted]	×	×	×	×	10 years[3]
Power turbine	[redacted]	×	×	×	×	10 years[3]
Compressor Impeller Refurb	[redacted]	×	×	×	×	30 years
Compressor - gas seal	[redacted]	×	×	×	×	10 years
Upgrade Dry Gas Seal	N/A	×	×	×	×	N/A
Cab						
Building - CAB (Major)	[redacted]	×	×	×	×	40 years
Building – CAB (Minor)	[redacted]	✓	✓	✓	✓	10 years
CAB Ventilation (Major)	[redacted]	✓	✓	✓	×	10 years
CAB ventilation (Minor)	[redacted]	×	×	×	✓	5 years
Air intake (Major)	[redacted]	✓	✓	✓	×	15 years
Air intake (Minor)	[redacted]	×	×	×	✓	10 years
Exhausts (Major/Replace)	[redacted]	×	×	×	×	25 years
Exhausts (Minor)	[redacted]	✓	✓	✓	✓	5 years
Piping & Valves						
Unit Isolation Valves	[redacted]	✓	✓	✓	×	40 years
Non-Return Valves	[redacted]	✓	✓	✓	×	40 years
Other Ancillary Systems						
Fuel Gas Skid	[redacted]	×	×	×	×	10 years
Oil System (GG, PT, Comp)	[redacted]	✓	✓	✓	×	10 years
Fire Suppression	[redacted]	✓	✓	✓	×	25 years

Note 1) *Cost based on RIIO-T2 Plan Annex 15.07 – Cyber Resilience Plan*

Note 2) *Approved RIIO-T2 scope excluded*

Note 3) *Intervention frequency of 20 years for 500-hour EUD*

12. References

1. RIIO-T2 Business Plan, Annex A14.08 – CAB Infrastructure Engineering Justification Paper, December 2019
2. RIIO-T2 Business Plan, Annex A14.10 – Compressor Train Engineering Justification Paper, December 2019
3. RIIO-T2 Business Plan, Annex A14.14 – Valves Engineering Justification Paper, December 2019
4. RIIO-T2 Business Plan, Annex A16.08 – Redundant Assets Engineering Justification Paper, December 2019
5. RIIO-T2 Business Plan, Annex A16.12 – Peterborough and Huntingdon Compressor Engineering Justification Paper, December 2019
6. PH20621-12-DDR-002 Issue A, Report of Unit A at Peterborough Gas Compressor Station, [redacted] 25th May 2022
7. PJ20621-12-DDR-006 Issue A, Report of Unit C at Huntingdon Gas Compressor Station [redacted] 30th May 2022