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ENGINEERING JUSTIFICATION PAPER (EJP)

OFFICIAL – FOR PUBLIC RELEASE

Electrical Infrastructure: Standby Power Systems and LV Distribution

Version: 1.0

Issue: Final

December 2024

RIIO-GT3 NGT_EJP11

Contents

1 Summary Table

Table 1 Summary Table for Electrical Infrastructure Standby Power Systems and LV Distribution

Name of Project	*Electrical Infrastructure Asset Health*		
Scheme Reference	*NGT_EJP011_Electrical Infrastructure: Standby Power Systems and LV Distribution_RIIO-GT3*		
Primary Investment Driver	*Asset Health*		
Project Initiation Year	*2026*		
Project Close Out Year	*2032*		
Total Installed Cost Estimate (£m, 2023/24)	*£35.56m*		
Cost Estimate Accuracy (%)	*+-30%*		
Project Spend to date (£m, 2023/24)	*0*		
Current Project Stage Gate	*ND500 4.0*		
Reporting Table Ref	*6.4*		
Outputs included in RIIO-GT2 Business Plan	*No*		
Spend apportionment (£m 2023/24)	**RIIO-T2**	**RIIO-GT3**	**RIIO-GT4**
	£1.75	£33.43	£0.38

2 Executive Summary

2.1.1 This paper proposes £35.56m of baseline funding to address defect, obsolescence and safety related issues on 504 (16%) of the standby power and LV distribution asset population in RIIO-GT3. This is part of a wider request for £74.08m across our electrical infrastructure, measured through a non-lead asset Price Control Deliverable (PCD), (summarised in Table 2*).*

Table 2: RIIO-GT3 Electrical Infrastructure Summary (£m, 2023/24)

Engineering Justification Asset Group	Intervention Volumes	Funding Request
Associated EJP (Switchgear and Transformers)	90	19.86
This EJP (Standby Power Systems and LV Distribution)	**504**	**35.56**
Associated EJP (Site Lighting, Earthing and Lightning protection)	4,464	18.65
Total	**5,058**	**74.08**

2.1.2 5,058 interventions are required across our electrical infrastructure to ensure we maintain electrical distribution to critical operational assets, utilised to maintain efficient network operations. Any loss of compression has the potential to cause significant impact to customers, making it essential that our fleet remains available and resilient to the demands put on the NTS. Without this investment we are at increased risk from asset failures and consequential security of supply impacts. To ensure this operation we must operate in accordance with all standards and legislation. Our investment seeks to address defects and significant obsolescence issues and, for certain assets, to undertake a proactive intervention programme to avoid unmanageable levels of defects.

2.1.3 Across our electrical infrastructure investment 5,058 interventions are required to ensure stable network risk is maintained during RIIO-GT3, 504 on the assets within this Engineering Justification Paper (EJP). The Network Asset Risk Metric (NARMs) Long Term Risk Benefit (LTRB) of the interventions within this paper is £17.52m.

2.1.4 Within our electrical infrastructure investment programme we developed 70 intervention options, 18 intervention options for Standby Power Systems and LV Distribution assets within five portfolio options. In summary, we are proposing the intervention mix summarised in Table 3.

Table 3: RIIO-GT3 volumes proposed in this EJP

	Replacement	Overhauls/ Refurbishments	Total
Standby Power Systems	[redacted]	[redacted]	**264**
LV Distribution	[redacted]	[redacted]	**240**
Total	[redacted]	[redacted]	**504**

2.1.5 In RIIO-T2 we are forecasting, across our electrical infrastructure portfolio, to deliver 238 fewer interventions than in our RIIO-T2 business plan. Original intervention volumes have been re-evaluated as condition and compliance data have become available. This has resulted in a reduction in refurbishment interventions for our LV switchgear in favour of replacements.

2.1.6 The growth in proposed RIIO-GT3 intervention volumes is driven by two reasons: (1) It is a consequence of the continued deterioration of these assets shown through actual and forecast defects and widespread obsolescence challenges for which it is crucial that we deliver a stepped increase to ensure future network asset performance is not compromised which has the potential to impact on security of supply; (2) We have redefined interventions, moving away from major and minor refurbishment interventions to specific activities on our assets, e.g. Transformer coating replacement, and individual luminaire replacements compared to site lighting replacement intervention in RIIO-T2. The latter of which represents 4,253 (84%) of our proposed 5,058 volumes. This provides greater granularity on our outputs but drives the significant increase in investment volumes without the equivalent increase in investment cost. This is summarised in Table 4.

Table 4: RIIO-T2 vs RIIO-GT3 for overall Electrical Infrastructure

	RIIO-T2 Business Plan Final Determination	RIIO-T2 Forecast Delivery	RIIO-GT3 Business Plan
Interventions	452	179	5,058
Investment	£29.97m	£28.88	£74.08m
Asset Interventions	3%	1%	36%

2.1.7 The deliverability of this investment programme has been assessed, incorporating a network access assessment and supply chain capability analysis. We have high confidence that this can be delivered during RIIO-GT3. The switchgear and transformer investment profile for RIIO-GT3 is shown Table 5.

Table 5: RIIO-GT3 funding request for Standby Power Systems and LV Distribution (£m 2023/24)

	2026	2027	2028	2029	2030	2031	2032	Total	Funding Mechanism
Standby Power Systems	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	23.05	Baseline – Non Lead Asset PCD
LV Distribution	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	12.51	Baseline – Non Lead Asset PCD
Total in this EJP	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**35.56**	
Total for Electrical Infrastructure	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**74.08**	

3 Introduction

3.1.1 Site Electrical Infrastructure assets generate, convert, distribute, control or utilise electrical energy to enable the safe operation of sites across the NTS. A large proportion of National Gas Transmission (hereafter NGT) assets rely on the safe, secure and reliable supply of electricity to fulfil their function, including critical assets such as those utilised to support the operational running of Variable Speed Drive (VSD) or Gas compression units, and electrical supplies for Gas Quality and Metering systems required for ensuring compliance with GS(M)R and billing processes.

3.1.2 Compressor stations have complex electrical systems involving High Voltage Electrical connections, Transformers, Standby Generators and Low Voltage Switchgear with Low Voltage Distribution, Direct Current (DC) and Alternating Current (AC) Uninterruptible Power Supplies (UPS) and connected electrical equipment such as Site Lighting, heaters, motors etc. Above Ground Installations (AGIs) have simpler electrical infrastructure involving a Low Voltage Electrical connection, single or multiple distribution boards and small numbers of connected loads, such as Lighting.

3.1.3 In total across our network, our electrical infrastructure is composed of [redacted] assets.

3.1.4 In addition to the two associated electrical EJPs, the decisions made upon assessing the Electrical Infrastructure investments has interactions with other Investment Decision Packs (IDPs). This EJP interacts with Compressor Fleet, Civils, Valves and Site Asset IDPs, as electrical infrastructure supports asset operation within scope of those papers. There are also interactions with the NGT_EJP28_St Fergus: Electrical Assets_RIIO-GT3 around the consistency of our investment proposals.

3.1.5 The RIIO-GT3 worklist has been generated specifically for each asset theme, aligned to each of the chapters across our Electrical Infrastructure EJPs. This has included analysis of historical defect data and survey data, and an assessment of industry standards and legislation and their impact on our Electrical Infrastructure asset base.

Business plan commitments

3.1.6 The scope of this document is aligned with our Asset Management System (AMS) and relates to our Business Plan Commitments (BPCs) '*Meeting our critical obligations every hour of every day*' and '*Delivering a resilient network fit for the future*'. More information on our AMS and a description of our commitments is provided in our NGT_A08_Network Asset Management Strategy_RIIO_GT3 annex and our NGT_Main_Business_Plan_RIIO_GT3.

Document structure

3.1.7 This document has been structured into several chapters, each specific to a group of Electrical Infrastructure assets aligned to our ISO 14224 equipment taxonomy as shown in Figure.

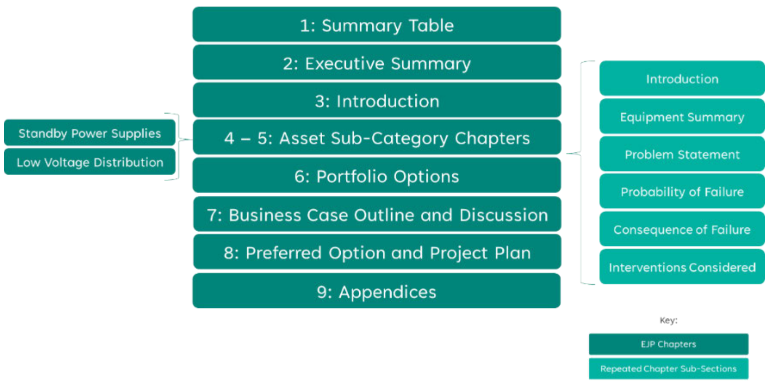

Figure : Document Structure of Standby Power Systems and LV Distribution EJP

3.1.8 Three Engineering Justification Papers are included within the investment decision pack, both covering a range of electrical assets as shown in Figure 1.

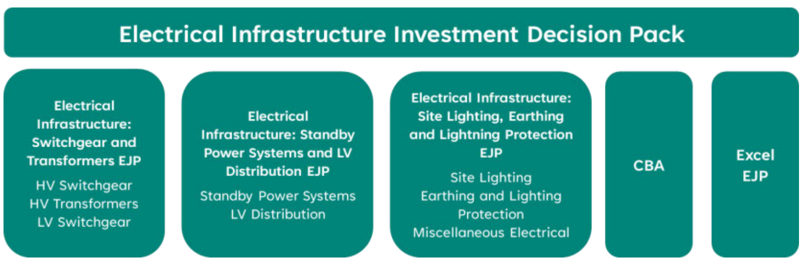

Figure 1: IDP document structure

4 Standby Power Systems (£23.05m)

4.1 Equipment Summary

4.1.1 Our Standby Power system asset grouping covers Standby Generators and Uninterruptible Power Supply (UPS) assets.

4.1.2 Standby generators are located at terminals, compressor stations and a few of the larger AGIs to provide an emergency electrical supply to maintain essential site operations in the event of mains power failures which, although rare, will cause the station to shut down and vent all compressor units and associated ancillary equipment within minutes.

4.1.3 Standby generators have also been installed at five AGI sites where enhanced security solutions have been installed. This is used to maintain the emergency electrical supply to these assets in the event of a mains power loss.

4.1.4 They consist of a diesel/gas reciprocating engine or gas turbine driving an alternator producing 400V AC electrical power, controlled by electronic control system, and switched via air circuit breakers. Connection to the site electrical system is via the main LV switchgear.

4.1.5 Most of the standby generators are powered by diesel and have an associated tank and pumping system. The generators are contained within either a permanent building or purpose built container. They are started via a battery supply and may be fitted with an automated load bank. The unit operates in island mode and cannot be connected to the electricity grid.

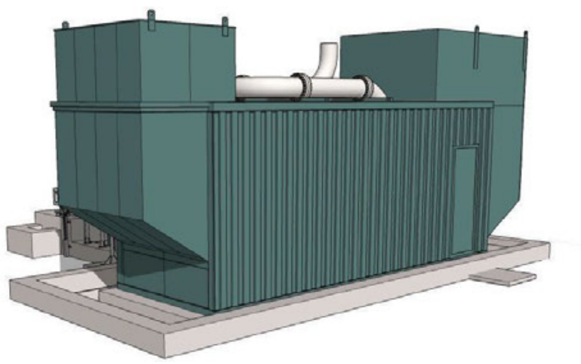

Figure 2: Typical standby generator

4.1.6 On the NTS we have 32 Standby Generators, excluding 1 at [redacted] These two sites are excluded from the assessment of investment within this EJP.

4.1.7 The graph below shows that our Standby Generators at the end of RIIO-GT3 will be mid to end lifecycle based on age expectations, with several replaced in RIIO-T2 through Compressor Emissions projects.

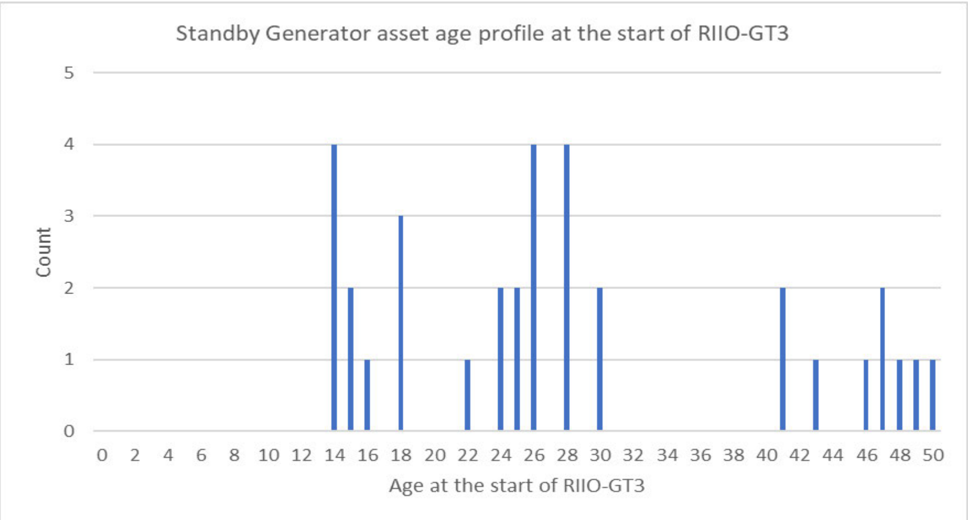

Figure 3: Standby generator age profile

4.1.8 UPS are installed across a range of site types including, Terminals, Compressor Stations, Multi-junctions and Network offtakes. They are used to:

- Provide continuous electrical supply to a range of essential or critical systems in the event of a loss of Public Electricity Supply (PES) or failure or maintenance of upstream electrical infrastructure.
- Condition the Alternating Current (AC) electrical supply from the Distribution Network Operator (DNO) to remove power disturbances that can impact on the operation of downstream connected systems.

4.1.9 At compressor stations and terminals, UPS typically have larger ratings, up to 220KV. With a loss of mains supply, the load would typically be transferred to the alternate generator supply in about 40 seconds. The UPS supports the critical equipment e.g., safety services for the time they are required to be supported, up to 24.5 hours depending on the criticality of the system.

4.1.10 Our standby generators do not meet the standards required to support safety services and should therefore be considered to be an additional level of standby support. AGIs have smaller connected loads, but do not normally have standby generator back-up, so rely on the battery autonomy from the UPS to maintain electrical supply in the event of a loss of PES.

Compressor UPS

4.1.11 Across our Compressor Stations, we utilise four types of UPS systems, as shown in Table 6, to support critical site systems. Each of the UPS have bespoke use case based on the type and load of the connected equipment. More information can be found on the type of UPS in Table 6.

Table 6: UPS System Types

Type	Quantity
Alternating Current (AC) UPS	40
Direct Current (DC) UPS	90
Rotary UPS	8
Uninterruptible Motor Drives (UMDs)	3
Total	**141**

4.1.12 Figure 4 shows the age profile of these UPS assets at the start of RIIO-GT3. UPS equipment typically has an asset life 20 years.

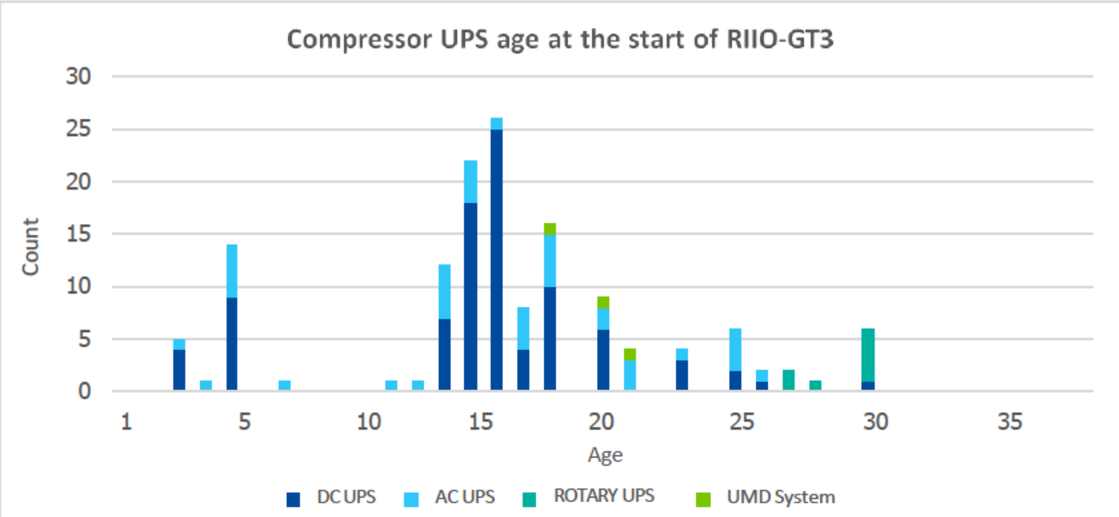

Figure 4: Compressor UPS Age at the Start of RIIO-GT3

4.1.13 Each UPS has its own associated battery typically utilising either of two battery technologies:

- **Valve-Regulated Lead-Acid (VRLA) - VRLA** batteries have a typical service life of 7 years. However, they are a lower cost technology, a high energy density (having a smaller footprint) and have a lower risk in terms of hydrogen release and chemical spills meaning they can be installed in any position and requiring less maintenance than Vented Lead Acid (VLA) batteries
- **Nickel Cadmium (NiCad)** – Nickel Cadmium batteries typically have a life of 20 years, offer a high cycle life and have good tolerance for deep discharges.

4.1.14 Small systems might have four battery blocks, with larger systems having greater than 70 battery blocks.

AGI UPS

4.1.15 On our AGIs we use either AC or DC UPS to provide backup power to critical systems including metering, telemetry and gas quality equipment. UPS are sized for the rating of that equipment and the length of time these assets need standby power supply. The table below provides the quantity of assets.

Table 7: UPS quantities

Type	Quantity	Processes
AC UPS	42	Gas Quality, Metering, Pressure Reduction
DC UPS	144	Telemetry, Metering, Enhanced security solutions & Gas Quality

4.1.16 These systems are typically smaller than those installed on our Compressors due to the reduced load from smaller process assets needing backup power supply, with ratings typically from 500VA to 10kVA.

4.1.17 Additional information on this equipment group such as the health score at the beginning and end of the price control and monetised risk are provided in the accompanying Excel EJP[1]

4.2 Problem/Opportunity Statement

4.2.1 There are four main problems with our standby power systems that our investment seeks to manage.

- **Asset deterioration** - UPS assets have a finite life of up to 20 years due to mechanical and Electrical, Control & Instrumentation (EC&I) failure modes such as corrosion and electronic component failures. An increasing number of defects are being recorded and the assets are becoming unreliable. A high proportion of standby power systems are supported by VRLA batteries which also experience age based deterioration resulting in cell failure.
- **Obsolescence** - Specific elements of our standby power systems, such as Standby Generator control systems have exceeded their original design life and are now obsolete. Additionally, some of the UPS system Inverters mid-way through their lifecycle have been declared obsolete. In Oct 2020 we were made aware that [redacted] a manufacturer of AC and DC UPS systems had discontinued two types of inverter module, [redacted]. It is estimated there are approximate [redacted] utilised in 10kVA UPS systems currently installed on the NTS. Therefore, these assets have specific challenges in reaching the expected 20 year life of a UPS system. 33 defects have been raised on these UPS since 2017 for rectifier or inverter failures, representing a failure rate in excess of 2 a year.
- **Environmental** - UPS installed on National Gas sites, particularly AGIs, are located in enclosures with basic thermal insulation and forced ventilation. Where environmental locations are not ideal (Temperature, humidity or airborne particles), the life of equipment can be significant reduced. With global temperatures increasing accelerated deterioration of UPS and battery systems is likely to be seen.
- **Full Load Testing** - Standby generators require periodic running at load to prove the operation of sub systems. Our policies specify standby generator annual on load maintenance and three yearly maintenance at full load. Site loads are typically insufficient to achieve the generators minimum load requirement to be satisfied (typically 30%) due to the baseline load needed, when utilising PES, not being able to be created. Additionally, not all generators have the facility to connect a temporary load bank due to the absence of a connection point or earthing arrangements. If a generator is regularly operated at less than 30% of its full rated output engine rating a range of concerns on the performance of the engine can be seen (High oil consumption).

4.2.2 Standby Power System assets need to have a high level of availability and reliability, as sites with standby generators are not categorised as a priority by the DNO in the event of widespread disruption to the PES, meaning they are a critical component on keeping sites operational.

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

4.2.3 Lack of investment in our Standby Generators and UPS will decrease their reliability and increase the number of failures experienced and found on inspection. Increasing defect levels are being experienced across RIIO-T2 with deficiencies identified from our RIIO-T2 National Electrical Asset health Campaign surveys . This ultimately will lead to the inability of the assets to perform their required function and increase the number of assets needing to be fixed on fail using unassigned opex funding.

[1] NGT_IDP02_Portfolio EJP Electrical Infrastructure_RIIO-GT3

4.2.4 During the RIIO-GT3 period, 182 UPS will reach an age of 20 years, representing 50% of our UPS assets; a significant asset management challenge.

4.2.5 Lack of investment to address known obsolescence issues will result in a compounding availability issue for our UPS. Whilst we have procured spares, the quantity is significantly less than our estate of affected systems. This may lead to UPS failure which could result in such consequences such as failure to measure gas parameters, or meter gas through installations.

4.2.6 Operating a compressor without the standby power supply systems would, in the event of mains power failure, cause an instantaneous stop of all the support systems. This will lead to shutdown of essential operations which would have a detrimental impact on consumers and the network.

What is the outcome that we want to achieve?

4.2.7 The outcome of this investment in Standby Power Systems is to:

- Ensure that the standby generation and UPS assets are available when required and perform their duty to provide power to the site electrical equipment in the case of loss of the Public Electricity Supply.
- Ensure Standby Power systems are not a cause affecting the availability, safety and performance of the compressors and AGIs.
- Ensure that all batteries meet the required autonomy for the systems that they support.

How will we understand if the spend has been successful?

4.2.8 The outcome of the investment shall ensure we are in a position to demonstrate our ability to robustly provide emergency electrical supply to maintain essential site operations in the event of a mains power failure to provide gas to consumers as and when they need it.

4.2.9 We are also seeking to address all known defects and obsolescence issues with these assets and ensure that we do not experience failures of our critical UPS systems.

Narrative Real Life Example of the problem

[redacted] Standby Generator

4.2.10 The standby generator is a 1,730kVA [redacted] system manufactured in May 2003. The standby generator supplies [redacted] via the main LV switchboards.

4.2.11 The control panel for the standby generator, Figure 5, is an old system with many parts that are obsolete. The [redacted] have limited asset live expectancy, circa 15 years, and this system has reached this age. This carries the risk of sudden system failure which could lead to unexpected repair and/or replacement costs including long lead time to source replacement components there by impacting operations and gas supply to consumers.

Figure 5: [redacted]

[redacted] UMD

4.2.12 [redacted] a persistent fault has been seen on the UMD system that impacts on its operation. Unavailability of this UPS could result in the unavailability of [redacted] reducing site resilience and impacting North to South gas transmission flows.

4.2.13 This UMD system is not only used in the event of a loss of Public Electricity Supplies (PES) but the system also conditions the electrical supply to avoid downstream equipment failure seen from power disturbances.

Project Boundaries

4.2.14 The investment boundary includes all components within our Standby Generator packages and Uninterruptible Power supply systems, including all components and ancillary systems, e.g., Engine, Control System, Link Box, Day tank. The investment boundary also includes assets that are utilised to maintain the ambient conditions of the enclosures UPS are installed within.

4.2.15 Inspection and maintenance activities on these assets are not included in this investment case, as they are Opex activities.

4.2.16 The investment boundary does not include the standby generator enclosure which has been included in the Civil Building investment theme, covered in the NGT_EJP19_Civils_RIIO-GT3.

4.2.17 Investment at [redacted] are outside the scope of this investment case.

4.3 Probability of Failure

4.3.1 Probability of failure (PoF) has been assessed utilising historical defects, results from surveys and utilising our Network Asset Risk Metric (NARMs) model. This model is built within our Copperleaf asset management decision support tool to assess the forward-looking probability of failure. This provides a different lens to consider in addition to looking at historically captured defects.

4.3.2 Within our NARMs model Standby Power Systems specific failure modes are associated with the loss of the systems and the consequential impact on the following failure modes. Each failure mode is presented with the failure rate, representing the rate of defects per asset per year:

Table 8: Standby Power Systems Failure Modes

Failure Mode	Average proportion of failures
Loss of standby power control impacting on station availability	0.10
Power failure that leads to a loss of control	0.47
Power failure the loss of the security system	0.52
Power failure that leads to loss of station	0.55
Power failure that leads to loss of unit.	0.55

4.3.3 When applied to the asset count with an assumption that no investment is made, a forecast of failures across the RIIO-GT3 period is produced, shown in Table 9.

Table 9 Standby Power Systems Forecast Defects

Asset Type	No. of Assets	Cumulative Average Failure Rates					Forecast Failures per Year				
		2027	2028	2029	2030	2031	2027	2028	2029	2030	2031
Standby Generators	495	0.51	0.53	0.55	0.57	0.59	8	8	9	10	11
UPS	1728	0.69	0.71	0.73	0.75	0.77	40	41	32	32	33

4.3.4 The forecast defect rate for standby generators increases by 16% over the RIIO-GT3, with the defect rate for UPS increasing by 12%.

Historic Defects

4.3.5 In total, 113 defects have been raised within our Maximo defect management system, on our UPS since 2014. Table 10 provides a summary of these issues, grouped into component categories, with the largest category of defects relating to life expired UPS systems. Failure of batteries and inverters and rectifiers have also been identified as common issues from the analysis of the defect population.

4.3.6 48 defects have been raised for inverter and rectifier failures. Of these defects, 33 have been raised on our [redacted] In each occurrence this has needed replacement; however, spares are limited with NGT having purchased all available spares to manage this risk.

Table 10: Historic defects for UPS

UPS Defect Categorisation	Volume	Standby Generator Defect Categorisation	Volume
Battery Failure	15	Asbestos Risk	1
Component Failure	9	Battery Failure	4
Equipment Failure	2	Corrosion	4
Equipment Sizing	1	Enclosure Deterioration/Repairs	9
Inverter Failure	8	Component failures	17
Life Expired	29	Obsolete Components	9
Obsolete Equipment	3	No Load Bank (20% Load testing)	4
Policy Non-Compliance	1	Control system failure	1
Rectifier Failure	40	Maintenance Corrective Actions	15
Ventilation Non-Compliance	2	Drawings/manual issues	2
Power Supply Failure	2		
Battery Configuration	1		
Total	**113**	Total	**66**

4.3.7 For Standby Generators 66 defect entries have been raised since 2009, several encompassing multiple defects (faults). The highest volume of issues is component failure where starter motors, water pumps, and instrumentation has needed to be replaced.

4.3.8 We have also experienced obsolescence challenges with obsolete control systems impacting the operation of the units and the availability of spares to rectify the issues. Figure 6, below, presents the defects by raised year for both UPS and Standby Generator assets.

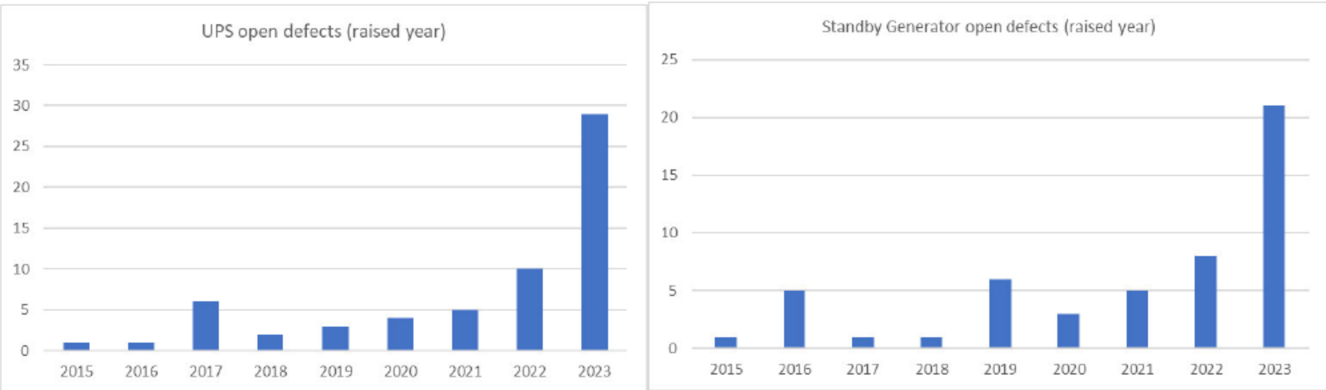

Figure 6: Standby power system historic defect profiles

4.3.9 A significant increase in the number of defects raised on both our Standby Generator and UPS systems has been seen over the RIIO-GT1 and RIIO-T2 regulatory periods, The RIIO-T2 increase is based on a survey campaign linked to our RIIO-T2 investment programme.

4.3.10 From these surveys, a range of issues have been identified including defective controllers, and obsolete control panel, life expired UPS and batteries. These issues have not all been resolved as part of our RIIO-T2 programme due to funding constraints and therefore are in need of rectifying in RIIO-GT3.

Probability of Failure Data Assurance

4.3.11 Across all probability of failure data presented in this paper historic failure has been determined based on our Defect management system. An extract from our defect management system was undertaken on the 27 June 2024, with data analysis undertaken based on the columns of data exported from the system.

4.3.12 Forecast probability of data information has been collated using the Copperleaf asset management decision support system and connected Power BI dashboards. This data was used in predicting future defects and failures of the preheating assets if no investment was made and also for conducting Predictive Analytics (PA) assessment described in further detail in Chapter 6.

4.4 Consequence of Failure

4.4.1 In the event of a failure of our Standby Power Supply assets there are a range of potential impacts to our site operations. The consequence of which as shown in Table 11., mapped against our NARMs Consequence of Failure service risk measures.

Table 11: Standby power system consequence of failure

Sub-Asset Type	Impact / Consequence				
	Availability	Environment	Financial	Safety	Societal & Company
Standby Generator	(1) Inability to operate the process e.g. station or unit during the period of loss of output (2) A Compressor unit or entire station being unavailable for an extended period. This would result in reducing the resilience of the NTS and could have potential impacts on the availability of gas or increase the potential for buy backs. (3) Damage to sensitive loads across the site (C&I equipment) that will impact on the operation of the site.	(4) Venting of gas due to Emergency Shut Down due to power disturbance if Standby Generator is unavailable following UPS autonomy period	(5) Consequential damage to site equipment at the end of the autonomy period. (6) Potential need for capacity buy-backs if loss of station and available compression creates sufficient constraint against supply & demand.	(7) Harm to personnel due to impact of consequential events, e.g. loss of lighting, loss of communications, loss of the site security systems	(8) HSE interventions or prosecution due to failing to comply with regulations such as the Health and Safety at Work regulations.
UPS – AGIs and Compressors	(9) Damage to sensitive downstream electronic equipment or control systems (10) Inability to operate the process e.g. station or unit during the period of loss of output (11) Damage to gas turbines, power turbine and compressors due to failure of lubrications systems and/or heat damage due to loss of ventilation fans, impacting unit availability.	(12) Venting of gas due to malfunction of control equipment (13) Venting of gas due to Emergency Shut Down due to power disturbance if the UPS is unavailable.	(14) Costly damage to gas turbines due to failure of lubrications and/or ventilation systems (15) Failure to maintain electrical equipment in a safe condition is a non-compliance with the Electricity at Work Regulations and may result in HSE interventions or prosecution	(16) Fire/Explosion due to malfunction of control equipment. (17) Harm to personnel due to impact of consequential events	(18) HSE interventions or prosecution due to failing to comply with regulations such as the electricity at work regulation or dangerous substances and explosive atmosphere regulations.

4.4.2 The following graphs show the level of risk, which is a combination of probability of failure and consequence of failure, for our standby generator (left) and UPS systems (right), with no investment across the RIIO-GT3 period.

Figure 7: Baseline Risk for standby power systems

4.4.1 For Standby generator assets baseline risk increases from £65k at the start for RIIO-GT3 and increases to £71k by the end of the period, an increase of 9.2%, with the largest component of risk being the financial risk of unplanned maintenance and reactive repairs which would have a negative knock-on impact on consumers.

4.5 Interventions Considered

Interventions

4.5.1 A range of interventions on our Standby Power Systems have been considered (including Standby Generators and associated assets, UPS and battery systems) to address the drivers for investment.

Counterfactual

4.5.2 Our Counterfactual intervention considers no specific intervention to be undertaken on our Standby power systems (UPS, battery and standby generators), with the exception of planned maintenance activities. Investment is deferred into future price control periods.

Battery Replacement

4.5.3 This intervention proposes the replacement of batteries within the UPS systems with equivalent batteries. These assets have a limited asset life and therefore need investment to ensure that UPS systems are available to operate should power disturbances occur. Within this intervention we have considered:

- Fix on fail replacement.
- Proactive/planned replacement.

Fix on Fail Replacement

4.5.4 UPS Batteries are replaced upon a failure being identified. Fix on fail approach would leave UPS systems non-functional whilst replacement batteries are sought and installed/commissioned. If a loss of PES or power disturbance occurs this would result in a dangerous situation, environmental incident or equipment damage at high cost.

Proactive/planned Replacement

4.5.5 UPS Batteries are replaced in a proactive/planned manner based on the expect life of these assets, (7 years VRLA, and 20 years NiCad). The complete battery group shall be replaced at the same time to maintain the availability of UPS operations.

UPS Replacement (AC/DC/Rotary/UMD)

4.5.6 This intervention proposes the replacement of the UPS System, including complete UPS and associated battery group. In this approach we would wait for the UPS failure to occur before replacing UPS systems. Replacement would be whole UPS systems, rather than individual components within the solution, given the obsolescence challenge and types of failure previously experienced.

4.5.7 UPS Systems are replaced proactively based on an age, 20 years for all AC UPS, DC UPS, UMD and Rotary UPS systems. This age is in line with Original Equipment Manufacturer (OEM) guidance and our policy. This intervention option has been split into 9 interventions for the variety of AC, DC, Rotary and UMD UPS systems, sized for different connected loads, with different sizes of battery groups.

UPS and Battery Room Heating/Cooling Enhancement

4.5.8 This intervention proposes replacement of or installation of chillers or trace heaters within the existing battery rooms, to ensure that the environment remains within the temperature range of -5ºC to +20ºC. It is important to ensure that the ambient conditions of batteries are within this range, as excursions can result in degradation of batteries and advanced failures, necessitating investment.

Temperature Risk Assessment Study - Batteries

4.5.9 This intervention proposes the completion of Temperature Risk Assessment Study on battery rooms across the NTS, to assess the impact of increased temperatures on our UPS batteries. Our intent is to assess the impact and understand whether we need to develop permanent mitigation measures to mitigate against the effects of climate change on our operation of UPS and battery systems.

Standby Generator Replacement

4.5.10 This intervention proposes the full replacement of a standby generator to address known defects, obsolescence and asset deterioration issues. This includes the replacement of the whole standby generator package, including tanks, UPS and batteries.

Installation of Load Bank / Load Bank Replacement

4.5.11 This intervention proposes the installation of load bank onto the Standby Generator Package or replacement of existing load bank to enable 20% to full load to be applied to the standby generator package through our routine maintenance. A range of sites exist where load banks are not fitted, and on-load testing of generators cannot be completed.

Standby Generator Refurbishment

4.5.12 This intervention category contains a variety of interventions to maintain the asset health of our standby generator packages, these include:

- **Replacement of the Standby Generator control system** – Control systems have limited asset lives of 15 years, and this intervention would replace the control system on the existing standby generator package.
- **SBG Link Box replacement -** Replacement of link box due to asset deterioration caused by age or environmental conditions.
- **SBG Battery replacement** – Batteries are used as part of the standby generator starter motor system. These VRLA batteries have a limited asset life of up to 7 years, and therefore require investment management.
- **SBG Switchgear replacement -** Replacement of standby generator switchgear package due to asset deterioration caused by age or environmental conditions.
- **Alternator Replacement -** Replacement of standby generator alternator due to asset deterioration caused by age or environmental conditions.

4.5.13 Individual or a combination of these interventions could be applied to ensure the continued availability of standby generators to support critical NTS sites should there be a loss of PES.

Intervention Summary

4.5.14 Table 12 presents a summary of the interventions considered.

Table 12: Interventions Considered

Intervention	Equipment Design Life	Positives	Negatives	Taken Forward
Counterfactual (Do nothing)	N/A	Lower cost solution	Increasing number of defects has been seen, which if left unmitigated will result in UPS failure and the potential loss of downstream critical assets to support the function of the NTS. Does not address known issues with ambient conditions in the battery rooms.	No
Battery Replacement- **Fix on Fail**	7 - 20 Years	Lowest Cost Capex solution	We have a large portfolio of UPS systems, using a fix on fail approach requires significant management and overheads. Unavailability of batteries would result in unavailability of UPS systems. This could result in unavailability of critical NTS asset systems impacting NTS operation	No
Battery Replacement– **Planned**	7 – 20 Years	Lowest Cost Capex solution Manages the availability of these assets in a planned manner across a large portfolio of assets.		Yes

Intervention	Equipment Design Life	Positives	Negatives	Taken Forward
		Manges peaks and troughs in delivery programmes given the large number of these systems across the NTS. Reduces the risk of battery failure upon UPS operation.		
UPS Replacement (AC/DC/Rotary/UMD) - **Fix on Fail**	20 Years	Potential for lower programme cost over RIIO-GT3 regulatory period due to lower volumes of replacement undertaken	Given the large number of UPS on the NTS a planned programme spreads the programme across regulatory periods, managing peaks and troughs and limits the potential unavailability of downstream systems. Failure of UPS could result in damage being undertaken to downstream connected assets due to electrical fluctuations, impacting on network operations and requiring increased cost to consumers to replace. Potential for higher costs to reactively fix assets quickly to avoid significant network disruptions. Potential for significant volume of investment being needed in future years due to sweating the assets, impacting on cost to consumers, increased programme costs than spreading across the period.	No
UPS Replacement (AC/DC/Rotary/UMD) – **Planned**	20 Years	Given the large number of UPS on the NTS a planned programme spreads the programme across regulatory periods, managing peaks and troughs and limits the potential unavailability of downstream systems. This approach also limits cost increases due to short notice reactive replacement is needed.	Highest cost intervention	Yes
UPS and Battery Room Heating/Cooling Enhancement	N/A	Maintains the ambient temperature that should ensure UPS and battery systems operate more reliably, meet their expected asset life, and do not experience early failures. Lower cost to install these ancillary assets that replacement of UPS systems	More costly than the counterfactual.	Yes
Temperature Risk Assessment Study - Batteries	N/A	Gathers further information on the impact of climate change on the operation of our UPS and battery systems. Low Cost intervention	N/A	Yes
Standby Generator Replacement	30 years		Based on our engineering assessment of the condition of our standby generators we do not believe that a replacement of any unit is required. The 1 remaining gas turbine generator is located at Wisbech which is proposed to be disconnected through our compressor fleet investment.	No
Installation of Load Bank / Load Bank Replacement	15 Years	Enables 20% load testing of the standby generator to undertake necessary routine maintenance activities. This shall ensure we can extend the life of our standby generator and do not observe accelerated asset deterioration and failures.	N/A	Yes
Replacement of the Standby Generator control system	15 years	Addresses known age-based deterioration specific to installations. Lower unit cost of combined intervention compared with replacement of the whole package	N/A	Yes
SBG Link Box replacement	15 years	Addresses known age-based deterioration specific to installations	N/A	Yes
SBG Battery replacement	20 years	Lower unit cost of combined intervention compared with replacement of the whole package	N/A	Yes
SBG Switchgear replacement	30 years	Addresses known age-based deterioration specific to installations	N/A	Yes
Alternator Replacement	30 years	Lower unit cost of combined intervention compared with replacement of the whole package	N/A	Yes

Volume Derivation

4.5.15 Figure 8 explains the development process for Uninterruptible Power Supplies interventions.

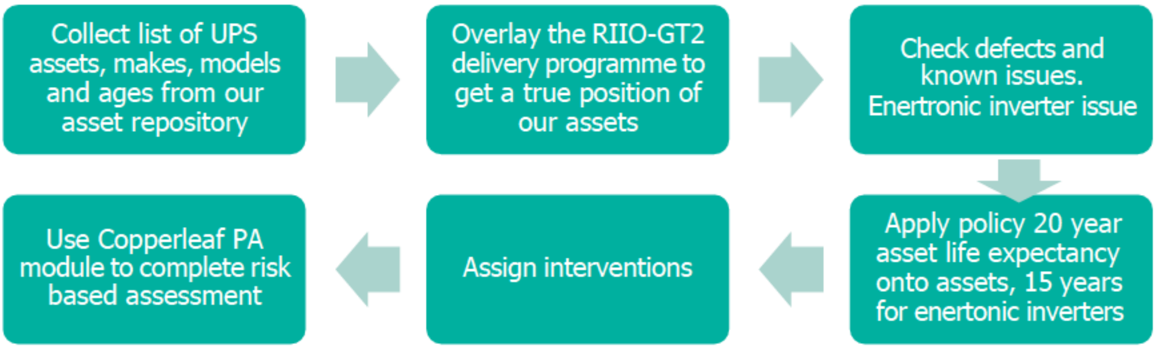

Figure 8: Volume derivation process

4.5.16 We utilised our policy T/SP/EL/50 to define the 20 year life expectation for UPS systems, and industry guidance for VRLA and NiCad battery life (7 years and 20 years respectively).

4.5.17 Asset information including makes, models, ages and defect information was sourced and validated. Known replacements undertaken in RIIO-T1 and RIIO-T2 were discounted from the list. Asset age live expectations were layered over the information to define intervention volumes for RIIO-GT3.

4.5.18 To manage the known issue with rectifiers failing on our [redacted] systems and the large portfolio of these assets[redacted]), we propose a reduced life for these assets of 15 years. 25 inverter failures have occurred, with defects raised requiring the replacement of components. A refresh life of 15 years from 20 years is proposed to manage this issue.

4.5.19 The condition of our existing standby generators was assessed through survey information completed as part of the RIIO-T2 electrical investment project. This identified deficiencies in our standby generator assets that were not proposed for rectification in RIIO-T2, hence investment has been included in RIIO-GT3. This covered refurbishment activities such as Replacement of the Standby generator batteries, link box replacement and the standby generator control system replacement.

4.5.20 Known deficiencies against policy are present on our Standby generator, such as our ability to undertake 20% and 30% load tests on our Standby Generators, a stipulation of our electrical specification. Investigations were undertaken and it was assessed that this load could normally only be applied through unavailability of the PES, without fitting a load bank.

4.5.21 A criticality assessment of the stations was undertaken and the top 33% selected for the installation of load banks. Therefore 7 load banks are proposed to be installed in RIIO-GT3 on these stations.

4.5.22 Table 13 presents a summary of the intervention volumes for our standby power systems.

Table 13 Standby Power Systems Volume Derivation

Intervention	Volume	Unit of Measure	How this volume has been developed
Replace AC UPS (Large) - Compressor Station	[redacted]	Per asset	A refresh cycle of 20 years has been utilised based on policy expectations and industry guidance, and in line with our RIIO-2 refresh cycle. Asset data was collated with installation dates, which were utilised to determine a replacement year based on this expected life. A proactive replacement regime is proposed due to the criticality of these installations. To manage the known issue with rectifiers failing on our [redacted] systems and the large portfolio of these assets ([redacted]), we propose a reduced life for these assets of 15 years. [redacted])
Replace DC UPS (Large) - Compressor Station	[redacted]	Per asset	
Replace DC UPS (Small) - AGI (Compressors)	[redacted]	Per asset	
Replace Pillar Rotary UPS (Compressors)	[redacted]	Per asset	
Replace AC UPS (Large) - AGIs	[redacted]	Per asset	
Replace AC UPS (Small) - AGIs	[redacted]	Per asset	
Replace DC UPS (Small) - AGIs	[redacted]	Per asset	
Replacement of Uninterruptible Motor Drives (UMD)	[redacted]	Per asset	
Replace Batteries (VRLA) (Large) (Compressors)	[redacted]	Per asset	A refresh cycle based on age was utilised to derive our investment volumes for the RIIO-GT3 period. An expected life, and refresh period of 7 years for VRLA batteries and 20 years for NiCad batteries was utilised. Asset data was collated with installation dates, which were utilised to determine a replacement year based on this expected life. A proactive replacement regime is proposed due to the criticality of these installations.
Replace Batteries (Nicad) (Large) (Compressors)	[redacted]	Per asset	
Replace Batteries (VRLA) (Small) (AGIs)	[redacted]	Per asset	
Replace Batteries (VRLA) (Small)	[redacted]	Per asset	
UPS & Battery Room Heating/Cooling Enhancement	[redacted]	Per Room	
New load bank installation including switchgear	[redacted]	Per asset	Information was gathered on site with and without load banks installed on

Intervention	Volume	Unit of Measure	How this volume has been developed
modification			the standby generators. [redacted]
Control System Replacement	[redacted]	Per asset	Standby Generator control systems have an expected life of 15 years, similar to other digital control systems installed across our assets. The age for each Standby generator control system was obtained and forecast forward to derive the [redacted] replacements due in RIIO-GT3 period.
Standby Generator - Battery replacement	[redacted]	Per asset	Volumes derived based on the refresh life of 7 years for VRLA batteries
Link box replacement	[redacted]	Per asset	Volumes were derived based on an engineering assessment of the condition studies undertaken as part of the RIIO-T2 National Electrical Asset Health Campaign, and where investment was not due to progress in RIIO-GT2 investment was proposed on specific assets of specific generators.
Standby Generator-Day tank replacement	[redacted]	Per asset	
Load bank replacement	[redacted]	Per asset	
Integral switchgear replacement	[redacted]	Per asset	
Integral fuel transfer system replacement	[redacted]	Per asset	
Engine heating system replacement	[redacted]	Per asset	No driver for investment identified from our engineering assessment of the standby generator assets
Standby Generator Engine replacement	[redacted]	Per asset	
Standby Generator-Alternator replacement	[redacted]	Per asset	

Unit Cost Derivation

4.5.23 In developing our RIIO-GT3 investments we have assessed our intervention options against historically completed or in delivery investments. In this assessment we have mapped RIIO-GT3 interventions to RIIO-T2 Unique identifiers (UIDs) and assessed the available historical outturn and/or in delivery forecasted completion costs.

4.5.24 Where historical outturn or tendered costs have not been available, we have undertaken estimating using first principles, including sourcing quotations from our supply chain. A breakdown of the unit costs is summarised in Table 14 and also provided in Appendix 3 – Cost Breakdown.

Table 14: Standby power systems unit cost summary table (£,2023/24)

Intervention	Unit of Measure	Unit Cost	Cost Accuracy	Number of Data Points	Source Data
Replace AC UPS (Large) - Compressor Station	Per Asset	[redacted]	[redacted]	[redacted]	[redacted]
Replace DC UPS (Large) - Compressor Station	Per Asset	[redacted]	[redacted]	[redacted]	[redacted]
Replace DC UPS (Small) - AGI (Compressors)	Per Asset	[redacted]	[redacted]	[redacted]	[redacted]
Replace Pillar Rotary UPS (Compressors)	Per Asset	[redacted]	[redacted]	[redacted]	[redacted]
Replace Batteries (VRLA) (Large) (Compressors)	Per Asset	[redacted]	[redacted]	[redacted]	[redacted]
Replace Batteries (Nicad) (Large) (Compressors)	Per Asset	[redacted]	[redacted]	[redacted]	[redacted]
Replace AC UPS (Large) - AGIs	Per Asset	[redacted]	[redacted]	[redacted]	[redacted]
Replace AC UPS (Small) - AGIs	Per Asset	[redacted]	[redacted]	[redacted]	[redacted]
Replace DC UPS (Small) - AGIs	Per Asset	[redacted]	[redacted]	[redacted]	[redacted]
Replace Batteries (VRLA) (Small) (AGIs)	Per Asset	[redacted]	[redacted]	[redacted]	[redacted]
Replace DC UPS (Small) - AGIs (ISS)	Per Asset	[redacted]	[redacted]	[redacted]	[redacted]
Replace Batteries (VRLA) (Small)	Per Asset	[redacted]	[redacted]	[redacted]	[redacted]
UPS & Battery Room Heating/Cooling Enhancement	Per Asset	[redacted]	[redacted]	[redacted]	[redacted]
Standby Generator replacement	Per Asset	[redacted]	[redacted]	[redacted]	[redacted]
New load bank installation including switchgear modification	Per Asset	[redacted]	[redacted]	[redacted]	[redacted]
Control System Replacement	Per Asset	[redacted]	[redacted]	[redacted]	[redacted]
Link box replacement	Per Asset	[redacted]	[redacted]	[redacted]	[redacted]
Standby Generator - Battery replacement	Per Asset	[redacted]	[redacted]	[redacted]	[redacted]
Standby Generator-Day tank replacement	Per Asset	[redacted]	[redacted]	[redacted]	[redacted]
Load bank replacement	Per Asset	[redacted]	[redacted]	[redacted]	[redacted]

Intervention	Unit of Measure	Unit Cost	Cost Accuracy	Number of Data Points	Source Data
Integral switchgear replacement	Per Asset	[redacted]	[redacted]	[redacted]	[redacted]
Integral fuel transfer system replacement	Per Asset	[redacted]	[redacted]	[redacted]	[redacted]
Engine heating system replacement	Per Asset	[redacted]	[redacted]	[redacted]	[redacted]
Standby Generator Engine replacement	Per Asset	[redacted]	[redacted]	[redacted]	[redacted]
Standby Generator-Alternator replacement	Per Asset	[redacted]	[redacted]	[redacted]	[redacted]
Replacement of Uninterruptible Motor Drives (UMD)	Per Asset	£[redacted]	[redacted]	[redacted]	[redacted]

4.5.25 Our cost accuracies are determined based on the type of cost data available, the quantity of this data (i.e. the number of data points), the similarity of the scope of these historical data points against our RIIO-GT3 investment programme and are in line with government cost estimating guidance[2] and IPA standard. Cost accuracies of +/-10% are defined where the scope of the historical data points directly align to the investment proposed, or estimates have been derived from 4.0 level scopes.

4.5.26 [redacted]

4.5.27 "Replace DC UPS (Large) - Compressor Station" has recently been priced utilising forecast costs from our National Electrical Asset Health Campaign from RIIO-GT2. In this forecast, we are anticipating the need to [redacted] no. DC Power Supply UPS across [redacted] no. sites.

4.5.28 It was validated by subject matter experts that the scope for future works will mirror those forecast as part of this campaign and therefore are comparable for this intervention but with two exceptions. Works at [redacted] relate to a standby generator and therefore are not applicable for the intervention and [redacted] is rationalisation which has led to higher unit costs. In these instances, it was agreed that these data points did not represent an accurate reflection of the future scope and were therefore to be excluded.

4.5.29 The final unit cost reflects an average of the remaining [redacted]).

[2] Cost Estimating Guidance - GOV.UK

5 Low Voltage Distribution (£12.51m)

5.1 Equipment Summary

5.1.1 Low Voltage (LV) Distribution equipment is used to supply power to various systems within a site. Systems on compressor stations contain several LV Distribution boards each connected to the LV Switchgear. These are used to supply power to a variety of downstream connected assets (metering, telemetry, lighting etc).

5.1.2 Systems on AGIs are generally all housed within a single enclosure where a variety of distribution boards, isolators and fuses are located. The pictures below show both an individual distribution board and an AGI system.

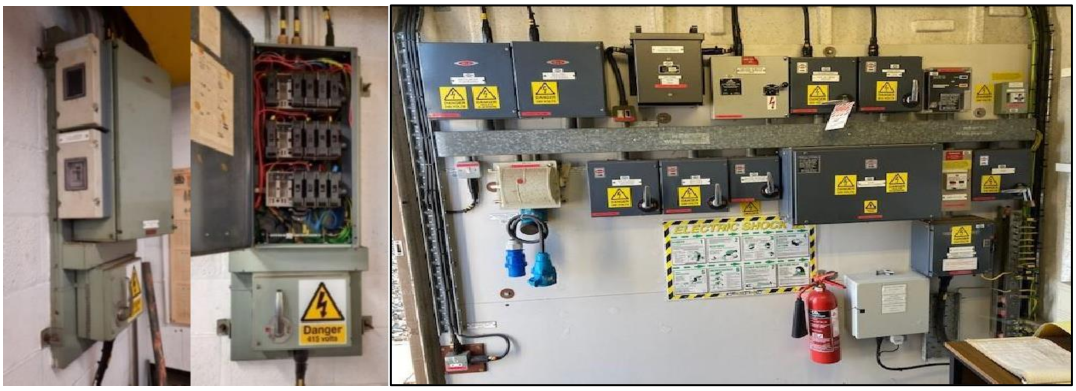

Figure 9: LV Distribution systems - Compressor Distribution board (left) and AGI Distribution system (Right)

5.1.3 Across the NTS we have 737 distribution boards across our compressor stations and 168 AGI sites (Entry Points, Offtakes and Multi-junctions) with AGI distribution systems.

5.1.4 At Compressor stations, 214 distribution boards will reach 30 years or older at the start of RIIO-GT3, which is 10 years over their design life.

5.1.5 Additional information on this equipment group such as the health score at the beginning and end of the price control and monetised risk are provided in the accompanying NGT_IDP08_Portfolio EJP Civils_RIIO-GT3.

5.2 Problem/Opportunity Statement

5.2.1 The LV Distribution systems on our sites are beyond life expectancy, with most installed at the time the site was constructed from mid 1960s to mid-1980s. They are of many varied designs from a multitude of manufacturers and therefore have widely differing standards of design and construction. Inspections and testing are finding an increasing number of defects due to Asset Deterioration and Obsolescence. There are several problems with this equipment.

- **Asset Deterioration** – Elements of the assets are deteriorating due to age, corrosion, and wear. There have been failures of fuse holders such as the GEC Red-Spot sprung contact failure which presents a fire risk.
- **Age** – Distribution boards internal componentry deteriorates with age, leading to safety concerns. Distribution boards should have an effective asset life of 20 years in accordance with Chartered Institution of Building Services Engineers (CIBSE) guidance. Several of our distribution boards are older than this with 223 distribution boards having ages greater than 30 years old at the start of RIIO-GT3.
- **Obsolescence –** 96 Distribution boards on compressor stations are no longer being supported by manufacturers and therefore spares are limited. (Eaton MEM EXEL Distribution Board, General Electric Red Spot Fuse Board). Semi enclosed fuses are used in several boards, which have low breaking capacity, and therefore are not recommended for other than small installations.
- **Health and Safety** – Some of the isolators and distribution boards have asbestos present within them at risk of being disturbed. There is no internal shrouding on some of our distribution boards, a modern safety requirement. Several Distribution boards (General Electric Red Spot Fuse Board, Federal Electric, Eaton MEM EXEL Distribution Board) do not contain Residual Current Device (RCD) protection devices, as required in the latest standards.

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

5.2.2 The overall effect of no investment on our Low Voltage distribution assets will be asset deterioration. This will result in breach of legal obligations under the Electricity at Work Regulations driven by the Health and Safety Executive (HSE). Deterioration of assets could result in the need to isolate assets to maintain safety impacting on site operations.

5.2.3 Our investment seeks to ensure that Low Voltage distribution assets meet all legal compliance requirements and operate to ensure the availability of connected equipment.

What is the outcome that we want to achieve?

5.2.4 The outcome of the investment on LV Distribution assets is to:

- Maintain the safe operational availability of compressor stations and AGIs that have electrical equipment installed.
- Ensure compliance with all legal obligations and required standards, e.g., Electricity at Work Regulations (EAWR).

How will we understand if the spend has been successful?

5.2.5 All LV Distribution assets are fully functional with all known condition, obsolescence and health and safety issues resolved. All assets are compliant to key legislation such as Electricity at Work Regulations and the Dangerous Substances and Explosive Atmospheres Regulations and British and International standards.

Narrative Real Life Example of Problem

5.2.6 At [redacted] AGI we have an AGI distribution system, shown in Figure 10, that is aged, having been installed at the time the site was installed, 1969. Equipment is unsupported with no spares availability and defects/issues have been found on the majority of equipment. Warning notices are installed to highlight the defective equipment.

5.2.7 Several assets are also experiencing corrosion including the switched fuse isolators. Deterioration in asset condition impacts the safe operation of the equipment, due to the risk of electric shock.

5.2.8 Fuse boards contain rewireable fuses with asbestos flash guards, both of which are not in line with the latest standards (BS61439-3) and increase the health and safety risk to operations personnel. There is the potential exposure to asbestos as the fuse is replaced along with the ruptured asbestos fuse wire.

Figure 10: [redacted] *Electrical Distribution equipment*

Project Boundaries

5.2.9 The spend includes all components of distribution boards, fuse boards, isolators and all internal components. On AGIs investment also includes wiring between these assets

5.2.10 Assets at [redacted] have been discounted from our assessments due to consideration being made for investment as part of prior projects.

5.2.11 Investment at [redacted] has been discounted due to investment taking place as part of the control system replacement project.

5.3 Probability of Failure

5.3.1 Probability of failure (PoF) has been assessed utilising both historical defects and utilising our NARMs model. This model is built within our Copperleaf asset management decision support tool to assess the forward-looking probability of failure. This provides a different lens to consider in addition to looking at historically captured defects.

5.3.2 Within our NARMs model Low Voltage Distribution specific failure modes are associated with the loss of the systems and the consequential impact on the following failure modes. Each failure mode is presented with the failure rate, representing the rate of defects per asset per year, as summarised in Table 15.

Table 15: LV Distribution failure modes

Failure Mode	Average proportion of failures
Loss of electrical supply to site	0.40
Loss of unit - trip	0.22
Failure to control or monitor plant on site	0.15

5.3.3 When applied across the RIIO-GT3 period, through our NARMs model embedded within our Copperleaf asset management system the defects presented in Table 16 are forecast. This forecast is generated based on the historic defect rate and the imbedded elicitation curves and assumes no investment in RIIO-GT3 and based on the asset count that make up our Low Voltage distribution assets Table 16.

Table 16: Forecast LV distribution failures

Asset Type	No. of Assets	Cumulative Average Failure Rates					Forecast Failures per Year				
		2027	2028	2029	2030	2031	2027	2028	2029	2030	2031
LV distribution	245	0.90	0.91	0.92	0.93	0.94	3	3	3	3	2

Historic Defects

5.3.4 In total, 509 defects have been raised on our LV Distribution assets, 171 on distribution boards on compressor stations and 338 on AGI LV distribution systems since 2005, Of the 174 defects on compressor stations 37 are open, with no investment proposed in RIIO-GT2. For our AGI LV Distribution Defects on LV distribution systems have been raised on a range of assets within the system isolators,

5.3.5 Of the AGI LV distribution defects 262 have been raised from DSEAR inspections, which identified glanding issues, missing equipment tags, cable ducting issues and drawing updates. These issues are resolved through Opex funded activities.

5.3.6 Of the remaining 76 AGI defects, issues raised include component failures, aged and obsolete equipment and boards that have asbestos in them (11 defects that each contain multiple assets with asbestos, e.g., 1 defect identified 6 distribution boards with Asbestos Containing Materials ACM).

5.3.7 During RIIO-T2 we have undertaken a site survey programme to support the electrical capital delivery programme. When faults or issues have been identified as part of these surveys, defects have been logged to ensure this information is captured in our centralised system. Table 17 provides a summary of some of the issues identified:

Table 17: Sample of identified problems

Site	Identified Problems
[redacted] Compressor Tee	All Distribution boards (6 in total) are OLD type MEM Fuse boards which are obsolete equipment, lack spares and some contain asbestos. DB1, DB2, DB3, DB4, DB9, DB10 all are recommended for upgrading/replacement.
[redacted] Multijunction	The distribution boards DB1, DB2 and outside services board are obsolete, and do not meet modern safety standards. The fused switches in the switchgear room are at the end of their serviceable life, contain asbestos and are no longer supported. The building distribution circuits also do not meet modern safety standards and require upgrading.

Probability of Failure Data Assurance

5.3.8 Probability of failure data presented above has been determined based on our Defect management system. An extract from the system was undertaken on the 30 April 2024, with data analysis undertaken based on the data exported from the system.

5.3.9 The NARMs Probability of Failure data was sourced from a Power BI dashboard, with data supplied from our Copperleaf asset management decision support system.

5.3.10 An engineering assessment has been undertaken by internal Subject Matter Experts (SMEs) on the ongoing risk that not rectifying the defects would have on the operation of the LV Distribution assets, and the impact on the wider network operation.

5.4 Consequence of Failure

5.4.1 LV Distribution assets are utilised to enable other systems to undertake their primary function, ultimately providing a safe and compliant operational site. Failure of a single electrical component will not generally have an immediate impact on network operations, however, can impact on the health and safety of our operatives and the efficiency of the operation of the network. Table 18 summarises the typical consequence of failures related to LV distribution assets.

Table 18: Consequence of failure

Sub-Asset Type	Impact / Consequence				
	Availability	Environment	Financial	Safety	Other
Low Voltage Distribution – Compressors & AGI	(1) Failure of a distribution board can lead to non-functionality of downstream connected assets including metering and telemetry affecting the efficient operation of the network.	(2) The failure of these assets, could lead to a subsequent venting of gas, affecting efficient NTS operations.	(3) The financial risk of non-compliance with legislation, such as DSEAR could be significant.	(4) Failure of distribution boards could lead to a loss of electrical systems, such as lighting. The failure of lighting may impact on the health and safety of personnel as safe access/egress may not be ensured.	N/A

5.4.2 Figure 11 shows a forecast of the increase in baseline risk, which is a combination of probability of failure and consequence of failure, for LV Distribution assets, with no investment across the RIIO-GT3 period.

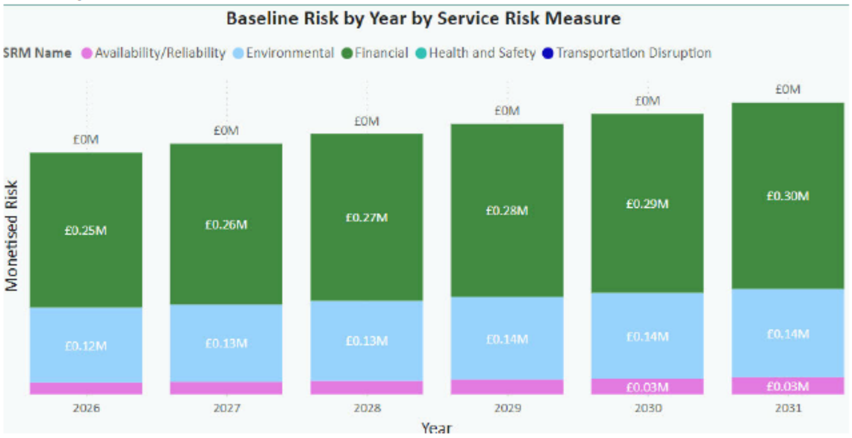

Figure 11: LV distribution baseline risk

5.4.3 The graph shows that risk starts RIIO-GT3 at £395,000 and reaches £476,000 at the end of the period, an increase of 18%.

5.4.4 The aim of our investment across our electrical assets is to address known issues on our assets and maintain stable risk over the RIIO-GT3 period.

5.5 Interventions Considered

Interventions

5.5.1 In reviewing the investment options on our LV Distribution assets (Compressors and AGIs), to address the drivers for investment a range of options have been considered.

Counterfactual

5.5.2 Our counterfactual option considers no specific intervention to be undertaken on our LV Distribution assets, with the exception of our normal inspection, maintenance and testing activities in accordance with maintenance procedures. Investment is deferred into future price control periods.

LV Distribution Individual Asset Replacement

5.5.3 This intervention proposes the replacement of an individual isolator or distribution board within an AGI LV Distribution system.

5.5.4 An assessment has been completed from surveyed condition information and the identified deficiencies against policy, industry standards, obsolescence and identifying assets that are non-functional or defective.

AGI LV Distribution Major Refurb

5.5.5 This intervention proposes the replacement of several significant assets within an LV Distribution system. Examples of significant assets are isolators, feeder cubicles, distribution boards or fuse boards.

5.5.6 Based on surveyed condition information and the identified deficiencies against policy, industry standards, obsolescence and identifying assets that are non-functional or defective an assessment has been conducted to propose the replacement of several assets, proposing the Major Refurb intervention.

Replacement of Entire AGI Distribution and Wiring Systems

5.5.7 This intervention proposes the replacement of entire AGI Distribution and Wiring Systems. This includes the replacement of all isolators, fuse boards, distribution boards and the associated cabling and wiring within an AGI electrical installation and the rationalisation of the system, where redundancy is identified based on changes to the connected site loads.

5.5.8 Based on surveyed condition information and the identified deficiencies against policy, industry standards, obsolescence and identifying assets that are non-functional or defective an assessment has been conducted to propose the replacement of several assets, proposing the replacement of entire AGI Distribution and Wiring Systems

Compressor Distribution Individual Board replacement

5.5.9 This intervention proposes the replacement of an individual distribution board located on our compressor stations with a modern equivalent.

5.5.10 We propose to proactively replace individual distribution boards that reach a life 30 years old within the RIIO-GT3 period, based on asset degradation and health and safety concerns, to ensure that the connected assets continue to provide their necessary function for safe site operations (e.g., telemetry, metering, site lighting).

5.5.11 Multiple identical interventions could be completed on a site where we are proposing to replace several individual boards on the same site.

Intervention Summary

5.5.12 Table 19 presents a summary of the interventions considered.

Table 19 LV Distribution intervention summary

Intervention	Equipment Design Life	Positives	Negatives	Taken Forward
Counterfactual (Do nothing)	N/A	Lowest Capex cost solution	Leaves a range of components within installations that are obsolete, and unsupported through OEMs and our supply chain partners, Specific defects identified shall not be resolved impacting he operation of the system, the health and safety of operatives and could result in disruption of NTS operations. This position does not align to our Specific Asset Strategy Desired states written to ensure we are complying with our Asset Management Objectives (AMOs).	No
LV Distribution Individual Asset Replacement	30 Years	Lower Capex Cost solution Where specific defects are identified for specific assets on a site, delivery of the investment ensures the availability and compliance of these assets at the lowest cost to consumers.	Applying this holistically across our sites would leave a range of components within installations that are obsolete, and unsupported through OEMs and our supply chain partners. The resultant position may impact the operation of the system, the health and safety of operatives and could result in disruption of NTS operations.	Yes
AGI LV Distribution Major Refurb	30 Years	Addresses a range of defective assets within an existing installation ensuring safe compliant operation of assets. Solution is designed within one project ensuring	Higher Cost	Yes
Replacement of Entire AGI Distribution and Wiring Systems	30 Years	Addresses all defective assets within an existing installation ensuring safe compliant operation of assets. Single project to deliver improvements offers efficiencies over protracted subsequent major refurbishment over time. Rationalises the system to ensure it is fit for purposes based on the connected assets.	Highest Cost Option	Yes

Intervention	Equipment Design Life	Positives	Negatives	Taken Forward
Compressor Distribution Individual Board replacement	30 Years	Manages Obsolescence in a planned way Addresses installation have defects affecting their operation. Ensures a safe and compliant operation of the assets.		Yes

Volume Derivation

5.5.13 For AGI LV Distribution assets, asset condition surveys were conducted across [redacted] Survey recommendations were recorded and assessed by our electrical Subject Matter Expert (SME) engineering team.

5.5.14 Intervention proposals were developed against these recommendations between individual asset replacement, our major refurbishment intervention (which looks to replace multiple LV distribution assets such as isolators, distribution boards, within a site), or a proposal to replace all LV Distribution assets within a site.

5.5.15 For compressor distribution boards, we have 534 assets across 21 sites. We have assessed the age and the obsolescence status of these assets and in line with OEM information and industry guidance and proposed a replacement intervention to [redacted]

5.5.16 Table 20 summarises the development of our engineered plan volumes.

Table 20: LV Distribution Volume Development

Intervention	Volume	Unit of Measure	How this volume has been developed
LV Distribution Individual Asset Replacement	[redacted]	Per asset	Surveys were completed across [redacted] AGIs as part of the development of our RIO-GT3 preparation. Survey recorded observed condition through the completion of site visits and assessment of maintenance results. Recommendations were proposed which were assessed by our Electrical Subject Matter Expert engineering team to propose investments based on the recorded information. No investment has been completed on our AGI electrical systems, since sites were commissioned from the mid-1960s and therefore significant volumes of condition, health and safety and obsolescence related issues were identified across the surveyed sites.
AGI LV Distribution Major Refurb	[redacted]	Per site	
Replacement of Entire AGI Distribution & Wiring Systems	[redacted]	Per Site	
Compressor Distribution Individual Board replacement	[redacted]	Per asset	Asset data on our Compressor distribution boards was collated, including make and model, the date of commissioning, and the presence of asbestos. Obsolescence status for each of the makes and models were assessed ([redacted]). Condition information was combined with the metrics above to make engineering decisions.

Unit Cost Development

5.5.17 In developing our RIIO-GT3 investments we have assessed our intervention options against historically completed or in delivery investments. In this assessment we have mapped RIIO-GT3 interventions to RIIO-T2 Unique identifiers (UIDs) and assessed the available historical outturn and/or in delivery forecasted completion costs.

5.5.18 Where historical outturn or tendered costs have not been available, we have undertaken estimating using first principles, including sourcing quotations from our supply chain to calculate the estimated cost of completion (ECC).

5.5.19 For this LV Distribution theme one option has been determined from unit costing, one utilised RIIO-2 Unit Costs and two utilised engineering judgement. A summary of the unit costs is shown in Table 21 with cost breakdowns provided in Appendix 3 – Cost Breakdown

Table 21: LV distribution unit cost summary table (£, 2023/24)

Intervention	Unit Cost	Unit of Measure	Cost Accuracy	Data Points	Source Data
Replacement of Entire AGI Distribution & Wiring Systems	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Compressor Distribution Individual Board replacement	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
LV Distribution Individual Asset Replacement	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
AGI LV Distribution Major Refurb	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

6 Options Considered

6.1 Portfolio Approach

6.1.1 In developing our plans, we focused on value for money and deliverability, while managing the risks of aging assets. We evaluated the cost-effectiveness of our investment program through a full Cost Benefit Analysis (CBA) using the NARMs Methodology within the Copperleaf decision support tool.

6.1.2 We have assessed the benefit from options across the entire electrical portfolio to meet investment drivers, business plan commitments, and consumer priorities. Therefore, a single CBA covers switchgear, transformers, standby power systems, LV distribution, site lighting, earthing and lightning protection.

6.1.3 The options considered combine the interventions discussed previously, and those in the other electrical EJPs, in varying combinations and volumes to identify the optimal investment for our electrical assets.

6.1.4 In line with HM Treasury Green Book advice and Ofgem guidance, we assessed the value of investing in Electrical Infrastructure across the RIIO-GT3 period by analysing the cost benefit over a 20-year horizon.

6.1.5 We derived bottom-up intervention volumes using the engineering assessments described in the previous chapters. Each investment was assessed via the Ofgem-approved NARMs Methodology embedded in Copperleaf, quantifying risk reduction and Long Term Risk Benefit (LTRB). Analysing this performance, Copperleaf Predictive Analytics is then able to select further NARM driven interventions to create further options to satisfy certain criteria, such as stable risk across the portfolio. A table of these intervention volumes is shown in Table 22 and Appendix 1.

Table 22: Portfolio Options Summary

Option	Option Name	Description
Option 0	Counterfactual (Do Nothing)	Maintenance and corrective repairs only
Option 1	Total Monetised Risk Stable to RIIO-T2 start	This option is a programme of investments developed to achieve risk level at the start of RIIO-T2.
Option 1A	Total Monetised Risk Stable to RIIO-T2 start – Post deliverability	This option is a programme of investments developed to achieve risk level at the start of RIIO-T2, constrained by our deliverability assessment.
Option 2	10% Additional Risk Reduction	This option is a programme of investments developed to achieve 10% lower than the risk level at the start of RIIO-T2.
Option 3	Lowest Whole Life Cost	This option is a programme of investments developed to achieve the lowest total cost of CAPEX incurred over the operational life of the assets based on unconstrained service risk measures. Our whole life cost model takes the ideal economic replacement timing into account.
Option 4	Availability and Reliability Risk Stable	This option is a programme of investments developed to maintain availability and reliability risk level to that at the start of RIIO-T2 only, without controlling the levels of other risk measures.

6.2 Options

6.2.1 Using the Predictive Analytics Optimisation Module (PA) within Copperleaf, our electrical assets have been optimised against the NARMs Methodology to ensure the portfolio achieves a variety of outcome risk levels, to satisfy stakeholder needs.

6.2.2 All the options described below have been assessed against our Option 0, Counterfactual (Do Nothing) option, which considers no investment over and above maintenance and corrective repairs.

6.2.3 In all options (except the counterfactual) we include bottom-up intervention volumes to address know defects and obsolescence issues. A table of these intervention volumes is in Appendix 1.

Option 1: Total Monetised Risk Stable to RIIO-T2 start

6.2.4 In this option we have utilised our Copperleaf Portfolio optimisation tool to constrain the overall level of NARMs risk at the end of the RIIO-GT3 period to remain consistent with the levels of risk at the start of the RIIO-T2 period. Individual NARMs service risk measures (Availability and Reliability, Environmental, Health and Safety, Financial, Societal) are not individually constrained, however overall risk outcome is.

6.2.5 The total spend of proposed interventions in this option is £75.56m (2023/24) which addresses known and forecast defects. No additional investment is proposed through our Predictive analytics model to keep overall NARMS risk stable.

6.2.6 The proposed intervention volumes and the associated spend for this option are shown in Table 23 with further detail in Appendix 1.

Table 23: Option 1 Total Monetised Risk Stable to RIIO-T2 start Intervention Summary (£, 2023/24)

Intervention	Volumes	RIIO-GT3 Value
Bottom Up Interventions (Appendix 1)	[redacted]	£75,559,820.26
Total	[redacted]	**£75,559,820.26**

Option 1A: Post Deliverability Assessment of Total Monetised Risk Table to RIIO-T2 Start

6.2.7 This is a variation of Option 1 that has been taken through a deliverability assessment which assesses the programme of works against outputs across our entire capital investment plan. It is therefore more constrained than Option 1. The deliverability assessment reduced volumes by 272 in order to meet network access, contract strategy and supply chain availability constraints.

6.2.8 The total spend of proposed interventions in this option is £74.08m (2023/24) which addresses known and forecast defects. No additional investment is proposed through our Predictive analytics model to keep overall NARMS risk stable.

6.2.9 The proposed intervention volumes and the associated spend for this option are shown in Table 24 below, with a full intervention breakdown in Table 31.

Table 24 Option 1A Post Deliverability Total Monetised Risk Stable to RIIO-T2 start Intervention Summary (£, 2023/24)

Intervention	Volumes	RIIO-GT3 Value
Bottom Up Interventions (Appendix 1)	[redacted]	£74,075,124.68
Total	[redacted]	**£74,075,124.68**

Option 2: 10% Additional Risk Reduction

6.2.10 In this option we have utilised our Copperleaf Portfolio optimisation tool to constrain the overall level of risk at the end of the RIIO-GT3 period to 10% lower than the levels of risk at the start of the RIIO-T2 period.

6.2.11 In this output we seek to ensure overall NARMS monetised risk is 10% lower but Individual service risk measures are not individually constrained, hence service risk measures achieve a blend of outcomes to overall meet the 10% lower NARMS risk.

6.2.12 The total spend of proposed interventions in this option is £80.80m (2023/24) which addresses known and forecast defects.

6.2.13 The proposed intervention volumes and the associated spend for this option are shown in Table 25.

Table 25: Option 2 10% Additional Risk Reduction Intervention Summary (£, 2023/24)

Intervention	Volumes	RIIO-GT3 Value
Bottom Up Interventions (Appendix 1)	[redacted]	£75,559,820.26
Electrical Cabling Replacement	[redacted]	£64,749.46
Integral fuel transfer system replacement	[redacted]	£ 288,725.86
Non-Hazardous Area lighting - replace luminaire and cable RIIO3	[redacted]	£3,010,191.13
Refurbishment of Earthing & Lightning Protection Systems (Large Site)	[redacted]	£51,338.51
Replace Batteries (Nicad) (Small) (AGIs)	[redacted]	£1,632,028.03
Replace Batteries (VRLA) (Small) (AGIs)	[redacted]	£194,247.35
Total	[redacted]	**£80,801,100.59**

Option 3: Lowest Whole Life Cost (WLC)

6.2.14 In this option we have utilised our Copperleaf Portfolio optimisation tool to deliver a combination of intervention options which achieves the lowest total cost of CAPEX incurred over the operational life of the assets. Individual service risk measures are not individually constrained, however overall risk outcome is.

6.2.15 The total spend of proposed interventions in this option is £82.56m (2023/24).

6.2.16 The proposed intervention volumes and the associated spend for this option are shown in Table 26.

Table 26: Option 3 Lowest Whole Life Cost (WLC) Intervention Summary (£, 2023/24)

Intervention	Volumes	RIIO-GT3 Value
Bottom Up Interventions (Appendix 1)	[redacted]	£75,559,820.26
Converter Transformer Coating Replacement	[redacted]	£37,983.30
Electrical Cabling Replacement	[redacted]	£64,749.46
Integral fuel transfer system replacement	[redacted]	£288,725.86
Non-Hazardous Area lighting - replace luminaire and cable RIIO3	[redacted]	£4,309,441.59
Replace Batteries (Nicad) (Small) (AGIs)	[redacted]	£1,687,040.21
Replace Batteries (VRLA) (Small) (AGIs)	[redacted]	£225,080.26
Replacement of LV Switchgear Installation	[redacted]	£385,257.49
Total	[redacted]	**£82,558,098.42**

Option 4: Availability and Reliability Risk Stable

6.2.17 In this option we have utilised our Copperleaf Portfolio optimisation tool to constrain our Availability and reliability service risk measure to achieve a stable risk at the end of RIIO-GT3 to the start of RIIO-T2. No other service risk measures have been constrained and they have been left un-optimised.

6.2.18 The total spend of proposed interventions in this option is £81.62m (23/24).

6.2.19 The proposed intervention volumes and the associated spend for this option are shown in Table 27.

Table 27: Availability and Reliability Risk Stable (£, 2023/24)

Intervention	Volumes	RIIO-GT3 Value
Bottom Up Interventions (Appendix 1)	[redacted]	£75,559,820.26
Electrical Cabling Replacement	[redacted]	£64,749.46
Integral fuel transfer system replacement	[redacted]	£224,564.56
Non-Hazardous Area lighting - replace luminaire and cable RIIO3	[redacted]	£4,309,441.59
Replace Batteries (Nicad) (Small) (AGIs)	[redacted]	£1,118,581.01
Replace Batteries (VRLA) (Small) (AGIs)	[redacted]	£200,413.93
Replacement of LV Switchgear Installation	[redacted]	£385,257.49
Total	[redacted]	**£81,862,828.29**

6.3 Options Summary

6.3.1 Table 28 presents the technical summary table comparing our Portfolio Options 1 to 4.

Table 28: Options technical summary table (£m, 2023/24)

Description	First Year of Spend	Last year of spend	Volume of Interventions	Equipment or investment design Life	% of assets intervened on	Total Spend Request
1. Total Monetised Risk Stable to RIIO-T2 start	2027	2031	[redacted]	15-40 years	33.96%	£75.56
1A. Total Monetised Risk Stable to RIIO-T2 start Post Deliverability	2027	2031	[redacted]	15-40 years	32.23%	£74.08
2. 10% Additional Risk Reduction	2027	2031	[redacted]	15-40 years	47.28%	£80.80
3. Lowest WLC	2027	2031	[redacted]	15-40 years	52.65%	£82.56
4. Availability and Reliability Risk Stable	2027	2031	[redacted]	15-40 years	52.39%	£81.86

7 Business Case Outline and Discussion

7.1 Key Business Case Drivers Description

7.1.1 Electrical assets deteriorate over time through their operation and through age-based asset deterioration mechanisms. This in turn can result in immediate and unplanned failures which results in the loss of function of downstream assets, non-compliance with current legislation and industry standards and can result in an environment that is unsafe.

7.1.2 In developing our investment proposals, a range of investment drivers have been identified:

- Legislative requirements.
- Health and Safety – unsafe working conditions (e.g., access to live electricity, presence of asbestos).
- Asset deterioration, linked to our ageing asset base and asset type.
- Obsolescence.

7.1.3 Specific outcomes associated with this investment are:

- To maintain compliance and safe operation of electrical infrastructure assets across the NTS, through interventions that balance cost, risk and performance outcomes.
- To ensure that electrical infrastructure assets with high consequence of failure do not reach the point of failure, and result in impact to network operations, network constraints or contribute to the failure to supply gas to our customers and stakeholders.

7.2 Business Case Summary

7.2.1 In developing our plans and making our decision we have been fully cognisant of the need to develop plans that are value for money, acceptable, affordable, and deliverable, whilst achieving a suitable level of risk of our aging assets.

7.2.2 In considering the most effective combination of efficient interventions, we have challenged whether our preferred programme of investments is the most cost-beneficial by carrying out a full CBA utilising our Copperleaf Portfolio Optimisation tool.

7.2.3 We have appraised these portfolio options through completing a cost benefit analysis, the results of which are shown in Figure 12 and Table 29, including the post deliverability option.

Figure 12: Graphical representation of option payback periods

Table 29: Option summary of headline business case metrics (£m, 2023/24)

Option	Total Volume of Interventions	Total Spend Request	Outcome Risk End of RIIO-GT3	% change in comparison to start of RIIO-T2	Present Value (PV) Costs	PV Benefits	NPV	Payback Period (from 2031)	% change in service risk measures compared to start of RIIO-T2				
									Financial	Health and safety	Environmental	Availability Reliability	Societal
Option 0 Counterfactual	-	-	6.54	130.09%	-	-	-	-	122.97%	167.91%	140.56%	227.98%	166.67%
Option 1: Total Monetised Risk Stable to RIIO-T2 start	5,329	£75.56	4.06	80.79%	£72.76	£50.00	£(22.76)	Does Not payback in the Period	77.70%	167.91%	87.87%	106.35%	166.67%
Option 1A: Post Deliverability	5,058	£74.08	4.72	93.85%	£71.33	£45.61	£(25.73)	Does Not payback in the Period	91.35%	167.91%	100.73%	108.23%	166.67%
Option 2: 10% Additional Risk Reduction	7,419	£80.80	3.75	74.49%	£77.81	£57.01	£(20.80)	Does Not payback in the Period	71.28%	167.91%	87.80%	68.96%	166.67%
Option 3: Lowest WLC	8,263	£82.56	3.69	73.47%	£79.50	£58.34	£(21.16)	Does Not payback in the Period	70.34%	167.91%	87.80%	60.61%	166.67%
Option 4: Availability and Reliability Risk Stable	8,221	£81.86	3.74	74.41%	£78.83	£57.36	£(21.47)	Does Not payback in the Period	70.46%	167.91%	87.80%	84.84%	166.67%

7.2.4 The portfolio options have a variety of payback periods and PV benefits. The selection of a preferred option has been based on an assessment of the outcome risk levels, the cost of the options, the compliance with legislation and ensuring we deliver value to our customer and stakeholders. The following narrative shall explain the rationale for the discounting of portfolio options and the selection of our preferred option.

7.2.5 In Option 2 our electrical outcome risk position is 10% lower at the end of RIIO-GT3 than at the start of RIIO-T2 period. This results in increased investment position compared to our other options with the exception of the lowest whole life cost option. The risk outcome achieves a position that is not aligned to our business plan commitments and the feedback from customers and stakeholders, achieving a lower risk outcome.

7.2.6 The Option 3, Lowest Whole Life Cost (WLC), increases investment volumes by 55% compared with Option 1. We have deliverability challenges in having outage and resources available to deliver this significant increase volume of investments in this option, evidenced through the reduction in volumes between Option 1 and 1A. In addition, it brings forward 165 volumes of UPS battery replacements which would not be due until RIIO-GT4 and therefore not an investment approach we believe is in the interest of consumers.

7.2.7 The Option 4, Availability and Reliability Risk Stable, delivers a similar outcome to the 10% Additional Risk Reduction with a similar level of investment across the RIIO-GT3 period. Not all to the service measures are constrained to risk stable, which could lead to asset deterioration leading to asset failures. Additionally, this option has the second higher investment spend across our portfolio options and the second highest number of interventions, which have deliverability challenges, evidenced through the reduction in volumes between Option 1 and 1A.

7.2.8 Table 30 summarises the positives and negatives of the 4 options considered within our Cost Benefit Analysis

Table 30: Positives and negatives of the options considered

Option	Option Name	Description	Positives	Negatives
Option 1	Total Monetised Risk Stable to RIIO-T2 start	This option is a programme of investments developed to achieve stable risk level at the end of RIIO-GT3 as of risk at the start of RIIO-T2.	• Option with the lowest investment forecast. • Meets the expectations of our customers and stakeholders and keeps total monetised risk stable at the risk level at the start of RIIO-T2. • Balances investment now vs investment in the future across an aged asset base.	
Option 1A	Total Monetised Risk Stable to RIIO-T2 start (Post Deliverability)	This option is a programme of investments developed to achieve risk level at the start of RIIO-T2, constrained by our deliverability assessment.	• Option with the lowest investment forecast, Option built against our overarching strategy to achieve stable risk across the RIIO-Gt2 and RIIO-GT3 periods.	
Option 2	10% Additional Risk Reduction	This option is a programme of investments developed to achieve 10% lower than the risk level at the start of RIIO-T2, therefore 10% additional risk reduction.	• Exceeds the expectations of our customers and stakeholders and achieves a lower total monetised risk than that at the start of RIIO-T2 • 2nd highest PV benefit of all options.	• 2nd most expensive option,
Option 3	Lowest Whole Life Cost (WLC)	This option is a programme of investments developed to achieve the lowest total cost of CAPEX incurred over the operational life of the assets based on unconstrained service risk measures.	• Option provides the highest benefit of all options. • Option has the lowest payback period.	• Most expensive option (11% higher than option 1)
Option 4	Availability and Reliability Risk Stable	In this option the Availability and Reliability service risk measure is constrained only, and other service risk measure are left unconstrained.	• Achieves the highest total monetised risk benefit. • This option provides the highest risk benefit in all service risk measures. • Payback period within the 20 year period.	

8 Preferred Option and Project Plan

8.1 Preferred Option

8.1.1 The preferred option to manage our electrical assets is **Option 1**. Our programme of electrical investments has been taken through a deliverability assessment which assesses this programme of works against outputs across our entire capital investment plan. This results in a slightly adjusted **Option1A: Post Deliverability**, our funding request, which includes the mix of interventions listed in Table 31.

Table 31: Preferred option summary (£, 2023/24)

Intervention	Primary Driver	Volume	Unit of Measure	% Assets Intervened Upon	Total RIIO-GT3 Request	Funding Mechanism	PCD Measure
Replace AC UPS (Large) - AGIs	AH Policy	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Replace AC UPS (Large) - Compressor Station	AH Policy	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Replace AC UPS (Small) - AGIs	AH Policy	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Replace Batteries (Nicad) (Large) (Compressors)	AH Policy	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Replace Batteries (VRLA) (Large) (Compressors)	AH Policy	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Replace Batteries (VRLA) (Small) (AGIs)	AH Policy	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Replace Batteries (VRLA) (Small) (ISS)	AH Policy	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Replace DC UPS (Large) - Compressor Station	AH Policy	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Replace DC UPS (Small) - AGIs	AH Policy	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Replace DC UPS (Small) - AGIs (Compressors)	AH Policy	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Replace DC UPS (Small) - AGIs (ISS)	AH Policy	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Replace Piller Rotary UPS (Compressors)	AH Policy	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Replacement of Entire AGI Distribution & Wiring Systems	AH Legislation	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Replacement of Uninterruptible Motor Drives (UMD)	AH Policy	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
UPS & Battery Room Heating/Cooling Enhancement	AH Policy	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Control System Replacement	AH Known Defects Secondary	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Integral switchgear replacement	AH Risk Management	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Link box replacement	AH Known Defects Secondary	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Load bank replacement	AH Policy	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
New load bank installation including switchgear modification	AH Policy	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Standby Generator - Battery replacement	AH Policy	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Standby Generator-Day tank replacement	AH Policy	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
AGI LV Distribution Major Refurb	AH Legislation	[redacted]	Per Site	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Compressor Distribution Individual Board replacement	AH Legislation	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
LV Distribution Individual Asset Replacement	AH Legislation	[redacted]	Per Asset	[redacted]	[redacted]	Baseline – Non-Lead Asset PCD	Volume
Total		**504**			**£35,564,462.25**		

8.1.2 To deliver the required outcomes for all our stakeholders, we have developed the most effective combination of efficient interventions to maintain stable risk across the RIIO-T2 and RIIO-GT3 periods (Option 1A).

8.1.3 We have developed these investments both from engineering assessment of the identified problems but also through undertaking risk based assessments using our Copperleaf Asset management decision support tool, underpinned by our NARMs framework. This combined plan forms our preferred programme of work on our Electrical Infrastructure.

8.1.4 Our preferred option of interventions manages known obsolescence risks, addresses safety risks posed by our current assets and rising levels of defects on these installations to ensure these systems continue to support our critical site operations whilst managing the cost to consumers.

8.1.5 It can be delivered effectively within outage constraints on our stations and ensures appropriate levels of site and asset availability to deliver effective and efficient network operations.

8.1.6 The preferred option for Standby Power Systems delivers £17.52m of NARMs Long Term Risk Benefit with our full programme of electrical Infrastructure investment in RIIO-GT3 delivering £43.6m.

8.1.7 Our programme of investment on our Electrical Infrastructure has been taken through a deliverability assessment, including a network access/outage assessment, procurement assessment and contracting strategy development. These constraints enable the assessment of the delivery of this programme of works against our other outputs across our capital investment plan.

8.1.8 The outputs from this investment will be included in the non-lead asset PCD reporting mechanism, and cost variance managed through the TIM mechanism.

8.2 Asset Health Spend Profile

8.2.1 Our programme of investment on our Electrical Infrastructure has been taken through a deliverability assessment, including a network access/outage assessment, procurement assessment and contracting strategy development. These constraints enable the assessment of the delivery of this programme of works against our other outputs across our capital investment plan.

8.2.2 Figure 13 presents the spend profile of our preferred options interventions for Standby Power Supply and LV Distribution assets.

[redacted]

8.2.3 The peak in FY2027 is driven from the proposed DC UPS and Piller Rotary UPS replacement scheme. UPS replacement activities have been scheduled to ensure intervention occurs before failure occurs. This investment can be delivered both through our delivery units and supply chain partners or via our operations teams, and we have considerable experience in delivering this investment, with these interventions having been completed through previous price control periods.

8.3 Investment Risk Discussion

8.3.1 The risk associated with our preferred options revolves around the difference in condition between the information utilised to build our investment proposals, defect information, condition surveys, and that identified through construction surveys at the time of delivery. This has the potential to increase the scope in excess of that identified through the development of the plan.

8.3.2 Our costs have been built through unit cost analysis and estimates from the market, however there is a risk that costs of materials may increase due to macro-economic conditions and the demand from other operators of electrical infrastructure.

8.3.3 Key risks and currently identified mitigations are summarised in Table 32

Table 32 Electrical Infrastructure key risks and identified mitigations

No.	Risk	Mitigation (based on current view)
1	There is a risk of additional scope requirements (including electrical, design & civil) leading to scope change / scope creep	Close engagement with contractor and site operations, development of standard scopes to capture baseline requirements early in the development process.
2	There is a risk of outage issues (prior, during or post mobilisation)	Assessed through our deliverability assessment and shall be monitored through our plan delivery.
3	There is a risk of unavailability / delayed delivery of long lead items, e.g., transformers	Frequent communication with Contractor to ensure that Long Lead Items are ordered, and FAT Test dates are reserved on Programme.
4	There is a risk of additional works after commissioning relating to unresolved defects	Known concern due to nature of the discipline. Project to produce a commissioning plan and report, and investigation methodologies to minimise impact of identification and rectification processes

8.4 Project Plan

8.4.1 Project delivery has been split into three phases which align with our Network Development Process (ND500) as shown in Table 33. Commissioning dates are not relevant to all intervention types but take place at the end of the delivery phase.

Table 33 Delivery phase alignment with ND500

Delivery Phase	ND500 Stage Gate(s)
Preparation	T0, T1, F1 (Scope establishment), T2, F2 (Option selection), T3, F3 (Conceptual Design Development and Long Lead Items Purchase), T4
Delivery	F4 (Execute Project), T5, Available for Commercial Load (ACL), T6
Close Out	F5 (Reconcile and Close)

8.4.2 Table 34 shows the summary plan and provisional delivery phases for Electrical Infrastructure sanctions within RIIO-GT3. Internal stakeholder engagement and deliverability assessment has identified when we can obtain network access and site shutdowns to complete these investments.

Table 34 Electrical Infrastructure Portfolio Programme for RIIO-GT3 period

EJP	Sanctions	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32
Electrical Infrastructure: Standby Power Systems and LV Distribution EJP	T3_Sites_AH_Electrical_FY30								
Electrical Infrastructure: Standby Power Systems and LV Distribution EJP	T3_Sites_AH_Electrical_FY31								
Electrical Infrastructure: Standby Power Systems and LV Distribution EJP	T3_Sites_AH_Electrical_FY27								
Electrical Infrastructure: Standby Power Systems and LV Distribution EJP	T3_Sites_AH_Electrical_FY28								
Electrical Infrastructure: Standby Power Systems and LV Distribution EJP	T3_Sites_AH_Electrical_FY29								
Electrical Infrastructure: Standby Power Systems and LV Distribution EJP	T3_Bacton Electrical								

8.5 Key Business Risks and Opportunities

8.5.1 Changes to supply and demand scenarios is unlikely to impact upon the proposal in this EJP. Significant changes could mean that particular assets or sites become redundant which would remove the need for some interventions, but this has been assessed through our network capability analysis as defined within our network capability annex.

8.6 Outputs included in RIIO-T2 Plans

8.6.1 In RIIO-T2 our investment in electrical infrastructure focussed on addressing defective and obsolete assets on compressor stations. A programme of surveys was undertaken during the design development stage of the project and this included surveying neighbouring AGIs to the compressor stations. No investment within this EJP has been deferred from RIIO-T2, however investment was identified and planned for delivery in RIIO-T2 on our AGI distribution assets, although not included as outputs in our RIIO-T2 determination. These investments have been included into our RIIO-GT3 investment plan and are included within the Electrical Infrastructure funding request.

9 Appendix

9.1 Appendix 1 - Bottom up plan intervention volumes

9.1.1 The table below presents the bottom up intervention volumes and investment value in 2023/24 prices proposed across our electrical infrastructure portfolio, both pre our deliverability assessment (Option 1), and post this deliverability assessment. Interventions highlighted in yellow are within the scope of this engineering justification paper.

Table 35: Bottom Up Intervention Volumes (£, 2023/24)

Intervention	Pre Deliverability Bottom Up Volumes	Pre Deliverability Bottom Up RIIO-GT3 Investment Value £ (23/24)		Post Deliverability Bottom Up Volumes	Post Deliverability Bottom Up RIIO-GT3 Investment Value £ (23/24)
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9.2 Appendix 2 – UPS Details

9.2.1 We have a range of types on UPS installed across its network. These are:

- **Direct Current (DC) UPS** – This equipment does not have an inverter and are therefore limited to supplying units which require DC current. These DC UPS are installed to support systems such Fire & Gas, & Control and Instrumentation equipment and have ratings between 2kVA and 20kVA
- **Alternating Current (AC) UPS** – AC UPS systems provide emergency power to systems with an alternating current requirement, such as site and emergency lighting, and control processes. AC UPS systems are also used to condition the electricity supply to connected assets to mitigate from disturbances such as transient current, interruptions, sag/undervoltage, swell/overvoltage and waveform distortion. These disturbances can result in the unavailability of downstream connected equipment. The systems have ratings between 500VA and 20 kVA.
- **Rotary UPS** – Rotary UPS combine a motor and a generator in a single, three-phase synchronous unit. They have a higher capacity to take the increased load associated with starting a standby generator motor or to maintain operation of compressor units. We have Rotary UPS installed within Compressor units to support unit operation in the event of a loss of PES. These assets generally have a high rating of 220KVA.
- **Uninterruptible Motor Drivers (UMDs)** – A type of AC UPS, UMD systems contain power electronic components, sophisticated control equipment and software for speed control and are utilised to support our electric drive compressor packages in the event of loss of PES.

PSUP UPS

9.2.2 Through a programme developed by the Department of Energy Security and Net Zero (Net Zero) we have installed several enhanced physical security solutions. The technology assets associated with this system have a backup UPS power supply to keep these critical assets operational in the event of a loss of PES or failure of upstream electrical assets.

9.3 Appendix 3 – Cost Breakdown

Intervention Name	External Cost	External %	NG Cost	NG %	Pre build Cost	Pre build %	Materials, Plant & Equipment cost	Materials, Plant & Equipment %	Risk & Contingency cost	Risk & Contingency (% of total cost)	Total
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]			[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]			[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]			[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
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[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]			[redacted]
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[redacted]	[redacted]	[redacted]	[redacted]	[redacted]			[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]			[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
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Intervention Name	External Cost	External %	NG Cost	NG %	Pre build Cost	Pre build %	Materials, Plant & Equipment cost	Materials, Plant & Equipment %	Risk & Contingency cost	Risk & Contingency (% of total cost)	Total
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