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ENGINEERING JUSTIFICATION PAPER (EJP)

OFFICIAL – FOR PUBLIC RELEASE

# Electrical Infrastructure: Switchgear and Transformers

Version: 1.0

Issue: Final

December 2024

RIIO-GT3 NGT_EJP10

# Contents

# 1 Summary table

*Table 1 Summary table for Electrical Infrastructure Asset Health: Switchgear and Transformers*

| | | | |
|---|---|---|---|
| **Name of Project** | *Electrical Infrastructure Asset Health: Switchgear and Transformers* | | |
| **Scheme Reference** | *NGT_EJP010_Electrical Infrastructure: Switchgear and Transformers_RIIO-GT3* | | |
| **Primary Investment Driver** | *Asset Health* | | |
| **Project Initiation Year** | *2026* | | |
| **Project Close Out Year** | *2032* | | |
| **Total Installed Cost Estimate (£m, 2023/24)** | *£19.86m* | | |
| **Cost Estimate Accuracy (%)** | *+/-30%* | | |
| **Project Spend to date (£m, 2023/24)** | *0* | | |
| **Current Project Stage Gate** | *ND500 4.0* | | |
| **Reporting Table Ref** | *6.2/6.4* | | |
| **Outputs included in RIIO-GT2 Business Plan** | *No* | | |
| **Spend apportionment (£m)** | **RIIO-T2** | **RIIO-GT3** | **RIIO-GT4** |
| | £2.01 | £17.84 | £0.01 |

# 2 Executive summary

2.1.1 This paper proposes £19.86m of baseline funding to address defect, obsolescence, and safety related issues on 78 (40%) of our switchgear and transformers population in RIIO-GT3. This is part of a wider request for £74.07m across our electrical infrastructure, measured through a non-lead asset PCD and summarised in the table below.

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

| Engineering Justification Asset Group | Intervention Volumes | Funding Request |
|---|---|---|
| **This EJP (Switchgear and Transformers)** | **90** | **19.86** |
| Associated 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, 90 on the assets within this Engineering Justification paper (EJP). The NARMS Long Term Risk Benefit (LTRB) of the interventions within this paper is £11.18m.

2.1.4 Across our electrical infrastructure investment programme we developed 70 intervention options, 20 for our switchgear and transformers and assessed these within five portfolio options assessing different risk outcomes. In summary, we are proposing the following intervention programme for these assets.

*Table 3: RIIO-GT3 volumes proposed in this EJP*

| | Replacement | Overhauls/ Refurbishments | Total |
|---|---|---|---|
| Transformers | [redacted] | [redacted] | **31** |
| LV Switchgear | [redacted] | [redacted] | **59** |
| **Total** | [redacted] | [redacted] | **90** |

2.1.5 In RIIO-T2 we are forecasting to deliver 273 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 bespoke 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 4,062 (80%) of our proposed 5,058 volumes. This has driven the significant increase in investment volumes without the equivalent increase in investment cost.

*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% | 32% |

2.1.7 The deliverability of this investment programme has been assessed and we have high confidence that this can be delivered during RIIO-GT3. The switchgear and transformer investment profile for RIIO-GT3 is shown in Table 5.

*Table 5: RIIO-GT3 funding request for switchgear and transformers (£m, 2023/24)*

| Assets | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | Total | Funding Mechanism |
|---|---|---|---|---|---|---|---|---|---|
| HV Switchgear | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | 0 | Baseline – Non lead asset PCD |
| HV Transformers | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | 5.04 | Baseline – Non lead asset PCD |
| LV Switchgear | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | 14.95 | Baseline – Non lead asset PCD |
| **Total in this EJP** | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | [redacted] | **19.86** | |
| **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 National Transmission System (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 Drives (VSD) or gas compression units.

3.1.2 Compressor stations have complex electrical systems involving High Voltage (HV) Electrical connections, Transformers, Standby Generators and Low Voltage (LV) Switchgear with LV 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 an LV 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 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 St Fergus Electrical EJP around the consistency of our investment proposals.

### Business plan commitments

3.1.5 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

3.1.6 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 the figure below.

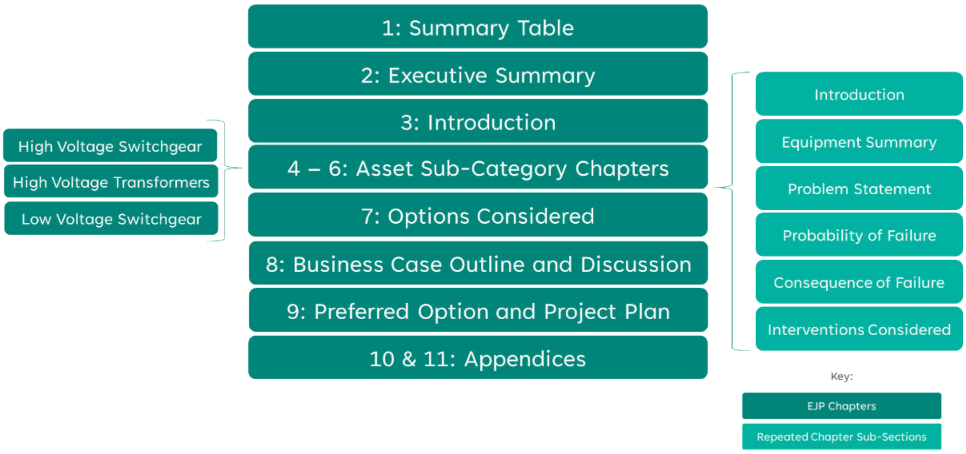


*Figure 1 EJP Document Structure*

3.1.7 Three Engineering Justification Papers are included within the investment decision pack, both covering a range of electrical assets.

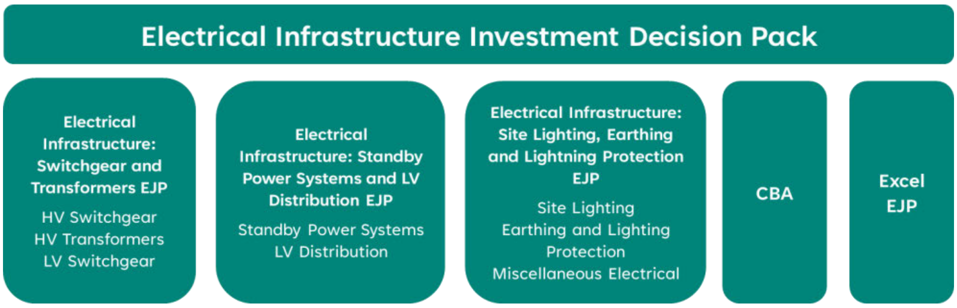


*Figure 2: IDP document structure*

# 4 High Voltage Switchgear (£0m)

## 4.1 Equipment summary

4.1.1 HV Switchgear is used for the control, isolation and protection of downstream electrical equipment, having several switching circuits installed within it. The primary function of HV Switchgear is to supply electrical feeds to 132Kv/33Kv/11Kv to 415v Distribution or Auxiliary Transformers for onward Low Voltage distribution within a site or to 132Kv/33Kv/11Kv Step Down Transformers for onward distribution to our electric Variable Speed Drive (VSD) compressors.

4.1.2 A total of 18 HV Switchgear systems are installed across the NTS of various types such as SF6, Vacuum and Oil. These are owned by NGT or jointly owned between the Distribution Network Operator (DNO) and NGT. The majority of our HV switchgear assemblies are less than 20 years old and therefore mid-way through the anticipated asset lifecycle.

4.1.3 Within HV Switchgear assemblies, protection relays are installed, designed to detect a problem within a downstream circuit and, working with a circuit breaker, remove the affected circuit from service.

4.1.4 Protection relays installed within NGT HV Switchgear are microprocessor based, as this has been the most common technology utilised across the last 20 years Several protection relays are obsolete but are still required to protect downstream circuits and ensure plant operations.

4.1.5 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 Excel EJP[1].

## 4.2 Problem/opportunity statement

### Micro-Processor Protection Relays

4.2.1 Electronic Micro Processor Protection relays are control systems which have a limited assets life of around 25 years and experience obsolescence challenges from limited availability of OEM support.

4.2.2 For the 31 Electronic protection relays installed within our HV Switchgear, 19 will reach 24 years old by the end of RIIO-GT3 and four 28 years old, at or in excess of the expected asset lives of these intelligent digital control systems . Of these installations, 13 electronic protection relays are also unsupported by the OEM, presenting challenges in obtaining spares and seeking support to continue their operation.

- [redacted] - Schneider ended the sale of this equipment at the end of 2023, and it is expected that the end of full spare parts availability will be reached in 2028[2]. A recommended upgrade path has been proposed by the OEM.
- [redacted] – Siemens ended the sale of this equipment in September 2023 and it is currently unsupported, with recommended upgrade paths provided by the OEM.

4.2.3 Figure 3 shows two different protection relays within our HV switchgear installations.


*Figure 3:* [redacted]

[1] NGT_IDP02_Portfolio EJP Electrical Infrastructure_RIIO-GT3

[2] [redacted]

**4.2.4** HSE RR823 Plant Ageing study document highlights this as a problem for operators of this equipment, *"Operators should recognise that their Electrical, Control & Instrumentation (EC&I) systems will very likely need refurbishment or replacement during the overall life of the plant"*……. And *"that EC&I equipment is normally designed for replacement during the overall plant lifetime, and that EC&I equipment life is frequently determined by spares availability."* Whilst this is a recommendation, NGT as prudent operator of essential services needs to ensure that our critical assets, such as HV switchgear, have appropriate interventions within overall asset lives to maintain the availability of this equipment.

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

**4.2.5** Investment in our HV Switchgear seeks to ensure that we maintain high levels of HV switchgear availability and address specific known obsolescence challenges within installations.

**4.2.6** Without a managed programme of investment, age and obsolescence related failure mechanisms might affect the availability or performance of the NTS, through unavailability of compressor stations. 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.

### What is the outcome that we want to achieve?

- Maintain Compressor Station availability through ensuring the availability of HV Switchgear is sufficient to avoid interruptions to Compressor station electricity distribution;
- Manage obsolescence affecting assets in a planned manner, preventing multiple asset management risks that require swift mitigation with limited supportability;
- Ensure continued compliance with Electricity At Work Regulations (EAWR).

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

**4.2.7** The outcome of the investment shall ensure we maintain the safe operational availability of compressor stations and ensure continued compliance with all legal obligations and required standards affecting our HV Switchgear.

### Narrative Real Life Example of Problem

**4.2.8** Figure 4 shows [redacted] installed within the [redacted] HV Switchgear installation. Six relays can be seen to be installed on this equipment, each used to protect a circuit connected to this HV Switchgear Installation. Four of these circuits are owned by NGT with two owned by the DNO, Scottish Power.


*Figure 4:* [redacted]

**4.2.9** These [redacted] are obsolete and unsupported [redacted], and a failure of one of the panels has already been seen at this site, impacting on the effectiveness of the level of control of circuit breaker operations to effectively protect the downstream circuits.

**4.2.10** Proactive management of the obsolescence issues can ensure that we can support these assets through soft parts ensuring their functionality is quickly restored, should further asset failures occur resulting in unavailability of switching circuits.

### Project Boundaries

4.2.11 Our investment considers all components within the HV switchgear installation, including circuit breakers, protection relays and vacuum bottles. The cabling to and from the HV Switchgear is out of scope of this investment.

4.2.12 Investment has not been considered for the HV switchgear at [redacted], which have been subject to investment during the RIIO-T2 period or Bacton and St Fergus, subject to separate funding requests.

## 4.3 Probability of failure

4.3.1 In general, HV Switchgear has a proven record of reliability and performance. Accidents experienced within industry have shown that failure usually occurs at, or shortly after, operation of the equipment. Thus, the way HV switchgear is operated, its condition and the circumstances existing in the system at the time of operation, to a large extent, determines whether the equipment will safely perform its duty.

4.3.2 On NGT owned HV switchgear, as of April 2024, 38 defects have been raised since 2016. Three failures of our 31 electronic protection relays have been seen since 2019, two at Avonbridge compressor station and one at Cambridge, representing a failure rate of ~10% across a 5 year period.

### Probability of Failure Data Assurance

4.3.3 Across all probability of failure data presented in this paper historic failure has been determined based on NGTs Defect management system. An extract from the system was undertaken on the 30 April 2024, with data analysis undertaken based on the columns of data exported from the system.

## 4.4 Consequence of failure

4.4.1 The consequence of failure for Protection relays within our HV Switchgear assets is presented below mapped against our Network Asset Risk Metric (NARMS) Consequence of Failure service risk measures.

Table 6: Consequence of failure of HV switchgear

| Sub-Asset Type | Impact / Consequence | | | |
|---|---|---|---|---|
| | Availability | Environment | Financial | Safety |
| **High Voltage Switchgear – Protection relay** | A failure of the protection relay will result in the inability to supply electrical power to outgoing circuits. This will require the utilisation of Standby Generators to support the Compressor Station operation, but would not be able to support any VSD units.<br><br>The lack of supply to our Variable Speed Driver units could require the utilisation of alternative Gas Generators within the station or alternative compression located on other sites to maintain network pressures and security of supply.<br><br>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. | Failure of the HV Switchgear can result in loss of supply to VSD compressors requiring the utilisation of gas turbines.<br><br>The unavailability of VSD(s) would add hours onto less efficient compressors, resulting in additional emissions.<br><br>It may also push certain units to their derogated hour limits under emissions legislation which would have an additional impact on availability. More information on this is available in the Compressor Fleet EJPs. | Failure of the HV Switchgear would require the Standby Generator to maintain supplies to keep UPS systems running to maintain operational assets' functionality, such as gas turbines, but would not enable the operation of VSDs. This would result in increases in running costs, such as cost of fuel and cost of GT Operations resources.<br><br>There is also a financial risk associated with legislative non-compliance, such as DSEAR, EAWR regulation 4. | Electrical faults due to switchgear failures can expose operational personnel to electrical burns or electrocution in worst case.<br><br>Fires, explosion and risk of electric shock can occur through failure of the HV Switchgear protection relays.<br><br>Failure of the HV Switchgear would result in the operation of the Standby generator running to maintain supplies whilst the failure was rectified. 24/7 operation of the standby generator would require GT Operations resource to operate, which has an increasing human factor impact the longer the issue takes to mitigate. |

## 4.5 Interventions considered

### Interventions

4.5.1 The following interventions on our HV Switchgear have been identified to address the problems stated previously. No refurbishment intervention is proposed due to the lack of drivers for investment identified through investigations into the needs case for investment. We have also split interventions into further granularity, moving away from major and minor refurbishment options.

*Table 7: HV switchgear interventions*

| Intervention | Intervention measure | Intervention Type | Cost (2023/24 prices) |
|---|---|---|---|
| Counterfactual (Do Nothing) | | - | - |
| Replacement of HV electronic protection relays | Per asset | Refurbishment | £39,580.87 |
| Replacement of HV Switchgear Installation | Per asset | Replacement | £385,041.30 |

#### Counterfactual (Do Nothing)

4.5.2 Our Counterfactual intervention considers no specific action to be undertaken on our HV Switchgear, with the exception of HV Switchgear maintenance. Investment is deferred into future price control periods.

#### Replacement of HV Electronic Protection Relays

4.5.3 This intervention proposes the replacement of 13 obsolete, aged electronic protection relays which are present within four of our HV Switchgear installations.

4.5.4 HV Switchgear assets are mid lifecycle with a low number of defects, therefore no additional investment has been identified to progress during RIIO-GT3.

4.5.5 Two sub options have been considered for this intervention:

- **Proactive replacement:** Replacement of these units with modern equivalents in a planned programme of investment.
- **Fix on Fail:** Replacement of these units with modern equivalents using a fix on fail strategy, waiting for the protection relays to fail before replacing.

#### Replacement of HV Switchgear Installation

4.5.6 This intervention proposes the holistic replacement of a whole HV Switchgear installation. In this option NGT would replace the existing installation with a new intelligent digital HV Switchgear in a pre-assembled unit and dispose of the old installation.

### Intervention Summary

4.5.7 Table 8 shows a summary of the interventions considered.

*Table 8: HV Switchgear Intervention technical summary table*

| Intervention | Equipment Design Life | Positives | Negatives | Taken Forward |
|---|---|---|---|---|
| Counterfactual (Do Nothing) | N/A | Lower Capex Cost solution | Does not manage obsolete component risk. This could be managed through increased inspection and ad hoc repairs resulting in higher opex costs, which are not factored into our RIIO-GT3 submission.<br>In the long term activities to address the increasing number of defects and the complexities of the issues will result in a larger programme of investment. | No |
| Replacement of HV Electronic Protection Relays - **Proactive** | 15 Years | Addresses component age and obsolescence issues within installations.<br>The replacement option ensures we fully comply with all relevant industry standards and legislative requirements. | None | Yes |

| Intervention | Equipment Design Life | Positives | Negatives | Taken Forward |
|---|---|---|---|---|
| | | Releasing of spares that can be utilised to support the estate of protection relays on our HV Switchgear. | | |
| Replacement of HV Electronic Protection Relays - **Fix on Fail** | 15 years | Reduces the cost to consumers. | Waiting for the protection relay to fail could result in unavailability of the downstream circuit, impacting on the availability of the station, and compressors on the site. | No |
| Replacement of HV Switchgear Installation | 40 Years | The replacement option ensures we fully comply with all relevant industry standards and legislative requirements | Highest cost option<br>Larger scope than needed as other components within the HV Switchgear installation are mid lifecycle, with no needs case for investment. | No - No needs case for investment identified |

## Volume Derivation

**4.5.8** For each HV Switchgear the asset information was collated, including parameters of the sub-components (e.g. protective devices). OEMs were approached to understand the obsolescence position for these components and volumes derived based on this position and the expected life of these protection relays (15-20 years).

**4.5.9** [redacted] protection relays were identified with ages reaching 19-23 years at the start of RIIO-GT3 with Schneider Electric and Siemens indicating assets as obsolete. This informed our recommended investment proposal on these assets, prior to the completion of our deliverability assessment.

## Unit Cost Derivation

**4.5.10** The table below provides a summary of the cost derivation approach for the HV Switchgear interventions. Both interventions have been estimated through engaging with market participants. A generic scope was identified from [redacted] HV Switchgear installation, a five circuit breaker installation, which is mid-sized for NGT sites.

*Table 9: HV switchgear unit cost summary table (£, 2023/24)*

| Intervention | Unit of Measure | Unit Cost | Cost Accuracy | Number of Data Points | Source Data |
|---|---|---|---|---|---|
| Replacement of HV electronic protection relays | Per Asset | £[redacted] | +/-10% | [redacted] | [redacted] |
| Replacement of HV Switchgear Installation | Per Asset | £[redacted] | +/-10% | [redacted] | [redacted] |

**4.5.11** 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 is in line with government cost estimating guidance[3] and IPA standard.

**4.5.12** Cost accuracies +/-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. [redacted]

**4.5.13** The unit cost for the replacement of HV Electronic protection relays was estimated through first principles. A quotation was received from [redacted] for the replacement of the different makes and models of protection relays within our HV Switchgear (Sepam 1000, Siprotec models). An average of these prices were used with installation costs and project overheads applied.

**4.5.14** We have confidence in the volumes presented in this paper, utilising asset information from our Maximo asset repository and information collected from RIIO-T2 electrical surveys. Obsolescence information for electronic protection relays was sourced from OEMs. Costs have been derived through first principle estimation utilising supplier quotes. A breakdown of the unit costs are provided in Appendix 2 – Unit Cost Derivation

[3] Cost Estimating Guidance - GOV.UK

# 5 High Voltage Transformers (£5.04m)

## 5.1 Equipment summary

5.1.1 A transformer is a static electrical device that transfers electrical energy between two or more circuits. Transformers are typically used for increasing or decreasing the alternating voltages in electric power applications.

5.1.2 We utilise auxiliary power and distribution transformers at sites where a HV connection needs to be transformed to an LV supply; typically from 132 kV, 33 kV, 11 kV.

5.1.3 Across the network we have 47 transformers, 37 of which are auxiliary or distribution transformers. The remaining Ten are converter transformers. Nine of these are located at [redacted] and two are located at [redacted] both outside the scope of this investment theme. Below is an example of a 132 kV to 33 kV distribution transformer utilised at [redacted] used to step down power supplies for our Variable Speed drive at the site (Unit D).

5.1.4 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.


*Figure 5: 132 kV to 33 kV distribution transformer utilised at* [redacted]

## 5.2 Problem/opportunity statement

5.2.1 There are several drivers for investment into our HV Transformer assets:

- **Asset Deterioration** - Corrosion on the external surfaces such as cooling fins and main tank is seen. Over time, corrosion accelerates resulting in oil leaks or material perforations allowing moisture to penetrate into the transformer. If water does enter the transformer, then the oil properties will breakdown and cause moisture into the windings paper insulation causing a short circuit fault with possible catastrophic failure. Surveys completed on our converter transformers installed between 2007 and 2011 highlighted coating corrosion after only 17 years.
- **Age** - By the end of RIIO-GT3, 11 of the our Transformers will reach 30 years old, (23% of the population), an age expectancy defined by CIBSE and IEEE. Degradation of internal componentry and of the external coating with age can be experienced resulting in increased number of defects and reduction in the performance of the equipment. The impact of this degradation is not uniform or predicable and therefore presents an asset management challenge in managing proactive vs reactive investment over these assets lifecycle. Reactive investment can result in unavailability of the station due to the criticality of these assets within the sites electrical distribution. Failures can be sudden and catastrophic, necessitating the station standby generator to be used to support the station operation.

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

**5.2.2** Investment in our HV Transformers seeks to ensure that we maintain the required levels of availability of these assets, as the loss of auxiliary and distribution transformers are a single point of failure risk for electricity distribution across our compressor stations. The resulting impact is a 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.

### What is the outcome that we want to achieve?

1. Maintain Compressor Station availability, for efficient network operation, through ensuring the availability of auxiliary/distribution Transformers and Converter Transformers to support station power distribution.
2. Ensure that the installed assets are safe, fit for purpose, secure by design, reliable and maintainable by complying with the applicable standards and regulations, whilst managing the cost of interventions for consumers.

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

**5.2.3** The outcome of the investment shall ensure we maintain the safe operational availability of compressor stations and ensure continued compliance with all legal obligations and required standards affecting our HV Transformers.

### Narrative real life example of the problem

**5.2.4** At [redacted] 20kv to 415v distribution transformer is installed. The transformer was installed in 1979, so will reach 47 years old at the end of RIIO-T2. Corrosion is present on the coating of the transformer and an oil leak is present.

**5.2.5** Minor repairs on this transformer are proposed during RIIO-T2 to mitigate the oil leak, but further interventions are required to mitigate the corrosion. Due to the age of the asset further defects are likely to be seen.

*Figure 6: Bishop Auckland Transformer defects*

### Project Boundaries

**5.2.6** Our investment considers all components within the HV Transformers installation, including radiator banks, instrumentation and external coating.

**5.2.7** Investment has not been considered for the transformers at [redacted], which have been subject to significant investment during the RIIO-T2 period or [redacted], subject to separate funding requests.

## 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** Not all modelled failures will result in real-world asset failure and this forecast is not a prediction of how many defects will be identified.

**5.3.3** Within our NARMS model, HV Transformer specific failure modes are associated with the loss of the asset and the consequential impact this has on operation of our compressor units. Each failure mode is presented in the table below, for all applicable failure modes, with the average proportion of failures. In general failure rates are low as assets have long asset lives and a low number of failure types.

*Table 10: HV transformer failure modes*

| Failure Mode | Average Proportion of Failures |
|---|---|
| **Loss of Compressor Unit - Trip** | 0.22 |
| **Loss of Electric Drive unit - Trip** | 0.20 |
| **Loss of Compressor Unit** | 0.19 |
| **Loss of Control / Monitoring** | 0.09 |

**5.3.4** 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 8. The average failure rate represents the proportion of that asset type with an unresolved failure. The forecast failures per year shows the quantity of new failures modelled to occur each year.

*Table 11: HV transformer defect rates*

| Asset Type | No. of Assets | Cumulative Average Failure Rates | | | | | Forecast Failures per Year | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2027 | 2028 | 2029 | 2030 | 2031 | 2027 | 2028 | 2029 | 2030 | 2031 |
| **HV Transformers** | 273 | 0.45 | 0.46 | 0.48 | 0.50 | 0.52 | 2 | 5 | 5 | 5 | 6 |

**5.3.5** The forecast defect rate for HV Transformers increases by 16% over the RIIO-GT3. Not all defects will result in failures that result in a loss of the entire system however will impact on the efficiency of operation and the potentially result in further failures that impact on asset availability.

### Asset Condition

**5.3.6** Surveys of six transformers were completed in May 2024 by a third party, [redacted]. Oil sampling, thermographic and radio frequency surveys were completed on converter transformers at [redacted], [redacted] and two auxiliary transformers at [redacted]

**5.3.7** Across each of the transformers, oil sampling identified no thermal or dielectric anomalies, however minor corrosion was evidenced (on five of the six transformers surveyed). These transformers were installed between 2007 and 2011 and therefore are mid lifecycle. This is consistent with expected failure modes and rates.

### Defect Analysis

**5.3.8** As of April 2024, 50 defects had been raised against our 47 HV Transformers since 2014; shown in Figure 7, by calendar year.

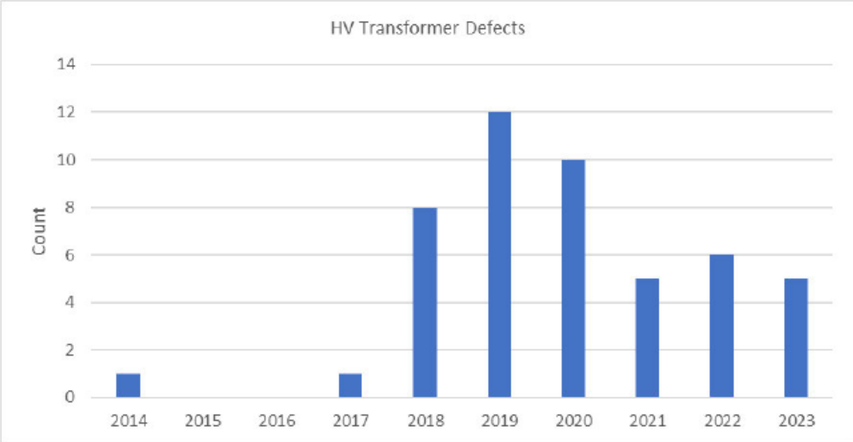


*Figure 7: HV Transformer defects volume by year raised*

**5.3.9** The raised defects can broadly be split into the following categories:

- Corrosion on the external surfaces (13)
- Component Replacements (including Tap Chargers) (13)
- Maintenance Corrective Actions; such as replacing gaskets (21)

### Probability of Failure Data Assurance

**5.3.10** Across all probability of failure data presented in this paper historic failure 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 columns of data exported from the system.

**5.3.11** Forecast probability of data information has been collated using the Copperleaf system and connected Power BI dashboards, with data taken on 14 June 2024.

**5.3.12** Information captured from surveys completed as advanced RIIO-GT3 activities has been utilised to inform the condition of our installations, and defects were logged within our defect management system where faults were identified in our surveys. An example of this is included in Appendix 3 – Example Electrical Survey Report.

## 5.4 Consequence of Failure

**5.4.1** The consequence of failure for our HV Distribution/Auxiliary and Converter Transformer assets, is presented below in tabular form mapped against our NARMS Consequence of Failure service risk measures.

*Table 12: HV transformers consequence of failure*

| Sub-Asset Type | Impact / Consequence | | | |
|---|---|---|---|---|
| | Availability | Environment | Financial | Safety |
| **HV Transformers (Distribution/ Auxiliary and Converter)** | (1) Distribution/Auxiliary Transformer failure would require the utilisation of a Standby Generator to support the station operation and gas turbine compressors<br><br>(2) Converter transformer failure would prevent supply to any VSDs. The Standby Generator would be used to support the Compressor Station operation, but would not be able to support the VSD units.<br><br>(3) The lead time for transformer replacement can be up to two years, due to the complexities of the manufacturing process. A catastrophic failure of a transformer could lead to station unavailability for this period. | (4) Oil leaks, potential to go into water courses and the ground with environmental harm.<br><br>(5) Catastrophic failure is likely to throw oil further than the extent of the bunds.<br>In addition, there is the potential for oil to combust, which will result in acrid black smoke and fumes being released from fires.<br><br>(6) Failure of the Converter Transformers can result in loss of supply to VSD compressors requiring the utilisation of gas turbines, generating greater emissions. | (7) Failure of the HV Transformer would require the Standby Generator to maintain supplies to keep UPS systems running to maintain operational assets functionality. This would result in increases in running costs, such as cost of fuel and cost of GT Operations resources. | (8) Catastrophic failure (Failure of windings, breakdown of insulation) of the transformers could result in fire and/or explosion that could have serious implications to personnel on site.<br><br>(10) Failure of the HV Transformer would result in the operation of the Standby generator running to maintain supplies whilst the failure was rectified.<br>24/7 operation of the standby generator would require GT Operations resource to operate, which has an increasing human factor impact the longer the issue takes to mitigate. |

## 5.5 Interventions Considered

### Interventions

**5.5.1** A range of interventions have been considered across our Auxiliary, Distribution (step down) and converter transformers to address the drivers for investment.

Counterfactual (Do Nothing)

**5.5.2** Our Counterfactual intervention considers no specific intervention to be undertaken in RIIO-GT3 on our HV Transformers over and above our usual maintenance activities (defined within policy T/SP/EL/50, T/PM/MAINT/6, and work procedures T/PR/MAINT/11019).

**5.5.3** Oil sampling will continue to be undertaken manually, with samples taken once per year, in accordance with work procedure T/PR/MAINT/11019.

Step Down Transformer / Converter Transformer Coating Replacement

**5.5.4** We propose to undertake proactive over-coating of the transformers, similar to our approach for managing the coating on our Above Ground Pipework assets within our AGIs.

**5.5.5** The breakdown of transformer coating is the primary source of oil leaks and moisture ingress within the transformer affecting the dielectric strength of the transformer, ultimately affecting its operation.

Installation of [redacted]

**5.5.6** Installation of [redacted] oil monitoring units on all [redacted] 132KV and 33KV Distribution transformers and VSD converter transformers, due to the criticality of providing power to the connected VSD compressor units, for efficient network operation.

**5.5.7** [redacted] units are online moisture drying units, utilised to remove moisture from the internal transformer oil. These use moisture and temperature sensors to monitor the relative saturation, the parts per million concentration data, and the temperature of the oil flowing through transformer and can remove the moisture ensuring transformer oil quality, prolonging the life of these transformers and avoiding early failures of these assets.

**5.5.8** Moisture or water ingress is a key concern for the operation of oil filled transformers due to the potential corrosion to the winding insulation within the transformers impacting the dielectric strength and ultimately transformer performance.

Installation of Dissolved Gas (DG) Analysers

**5.5.9** Installation of Dissolved Gas Analysers (DG Analysers) onto our 132KV and 33KV Distribution transformers and VSD Converter transformers to condition monitor the oil. It is proposed that they are installed onto these [redacted] installations due to the criticality of providing power to the connected VSD compressor units, for efficient network operation.

**5.5.10** These devices provide continuous sampling of oil within these transformers, identifying issues in the composition of the oil, enabling proactive management of issues before further deterioration of these issues occur. Monitoring of known faults with early detection using continuous trending of critical gases defect's incipient fault conditions at an early stage.

Transformer Replacement

**5.5.11** Auxiliary/Distribution or Step Down Transformer installation is replaced in its entirety, including the transformers and associated monitoring systems. Any modification to the transformer pens will be funded through civil investment included in the NGT_EJP19_Civils_RIIO-GT3

**5.5.12** Transformers have a range of input ratings from 132KV to 11KV, and the new transformers will be designed in accordance with the output power rating from the HV Switchgear.

## Intervention Summary

**5.5.13** Table 12 shows a summary of the interventions considered.

*Figure 8: Summary of HV Transformer Interventions considered*

| Intervention | Equipment Design Life | Positives | Negatives | Taken Forward |
|---|---|---|---|---|
| Counterfactual (Do Nothing) | N/A | Lower Capex Cost solution | Corrosion has been identified on our HV Transformers which will not be addressed, and a number of our transformers are deeply aged, requiring mid lifecycle and end of lifecycle interventions, to avoid unavailability of the stations. | No |
| Step Down Transformer / Converter Transformer Coating Replacement | 10 years | Addresses surface corrosion on our transformers, preventing, active corrosion that could lead to through wall metal loss and oil leaks.<br>Slows down the rates of corrosion and ensuring we do not experience failure of the transformers through reduced dielectric strength.<br>Reduce the risk of large oil leakage from severe corrosion occurring, resulting in loss of operation of the transformer and the associated consequences of this until the loss of containment is fixed. | Severe corrosion cannot be addressed through overcoating. A number of our transformers are deeply aged, requiring additional mid lifecycle and end of lifecycle interventions, to avoid unavailability of the stations. | Yes |
| Installation of [redacted] | 40 years | Automatic oil monitoring and moisture removal system should extend the lifecycle of our most critical transformers and enable greater clarity of transformer asset health condition.<br>Minimises internal degradation and the need for unplanned outages, leading to increased availability of the transformers.<br>Converter transformer availability is key to ensuring a high level of Variable Speed Drive (VSD) compressor availability. | Higher cost than counterfactual<br>Short term outage will be required to facilitate installation of this equipment | Yes |
| Installation of Dissolved Gas (DG) Analysers | 40 years | Automatic oil sampling will result in more frequency condition monitoring data sets, reduce human and external influence in sampling enabling greater clarity of transformer asset health condition.<br>Automatic readings removes both human error and external influences that impact manual sampling.<br>Studies by CIGRE indicate that 45% of transformer failures are due to faults in the active part (Main tank oil insulating the transformer windings). Continuous monitoring of the active part by using an online DGA monitoring device to measure gas accumulations can make an important contribution to the monitoring and maintenance of transformers. | Higher cost that manual sampling in short term<br>Short term outage will be required to facilitate installation of this equipment | Yes |
| Transformer Replacement | 40 years | Addresses deterioration and corrosion on our deeply aged transformers, ensuring ongoing operation.<br>Replacement of aging assets ensures a low probability of failure, mitigating the external coating defects and impact of internal corrosion on the transformer performance.<br>Replacement of aging assets ensures compliance with up-to-date legislation and regulations and reduces the risk of transformer failure therefore ensuring reliability of electrical supplies for operation of site assets.<br>Mitigates the risk of environmental pollution issues caused by oil leaks from corroded radiator fins. | Highest cost intervention<br>Civil investment may also be required to modify existing transformer pens, enclosures (Funded through the civil IDP) | Yes |

## Volume Derivation

**5.5.14** Intervention volumes have been derived through an engineering assessment of the open defects and survey outputs. Using industry standard information from the Institute of Electrical and Electronics Engineers (IEEE), the Chartered Institute of Building Services Engineers (CIBSE) and British Standard BS EN 50216-6 2002[4] a transformer investment lifecycle was developed, with coating replacements proposed with a 10 year frequency and transformer replacement proposed at the 30 year period. Table 13below provides a summary of the volume derivation approach.

*Table 13: HV transformers bottom-up volume derivation summary*

| Intervention | RIIO-GT3 Volumes | Unit of Measure | How this volume has been developed |
|---|---|---|---|
| Step Down Transformer Coating Replacement | [redacted] | [redacted] | [redacted] |
| Converter Transformer Coating Replacement | [redacted] | [redacted] | [redacted] |
| Installation of Transec Units | [redacted] | [redacted] | [redacted] |
| Installation of Dissolved Gas (DG) Analysers | [redacted] | [redacted] | [redacted] |
| Step Down Transformer Replacement 11 and 33KV | [redacted] | [redacted] | [redacted] |
| Step Down Transformer Replacement 132KV | [redacted] | [redacted] | |

## Unit Cost Derivation

**5.5.15** In developing our RIIO-GT3 investments we have assessed our interventions 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.

**5.5.16** Where historical outturn or tendered costs have not been available, we have undertaken estimating using first principles, including sourcing quotations from our supply chain. 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) and the similarity of the scope of these historical data points against our RIIO-GT3 investment programme.

**5.5.17** For HV Transformers, four interventions have been estimated from first principle estimation and two determined from historical unit costs. Table 14 summarises the cost sources and datapoints used to inform the unit costs in this EJP. A breakdown of our costs is also provided in Appendix 2 – Unit Cost Derivation

*Table 14: HV Transformers unit cost summary table (£, 2023/24)*

| Intervention | Unit of Measure | Unit Cost | Cost Accuracy | Number of Data Points | Source Data |
|---|---|---|---|---|---|
| Step Down Transformer Replacement 11/33KV | Per Asset | £[redacted] | +/-10% | [redacted] | [redacted] |
| Step Down Transformer Replacement 132KV | Per Asset | £[redacted] | +/-10% | [redacted] | [redacted] |
| Install DG Analyser | Per Asset | £[redacted] | +/-10% | [redacted] | [redacted] |
| Step Down Transformer Coating Replacement | Per Asset | £[redacted] | +/-30% | [redacted] | [redacted] |
| Converter Transformer Coating Replacement | Per Asset | £[redacted] | +/-30% | [redacted] | [redacted] |
| New – Install Transec Unit | Per Asset | £[redacted] | +/-10% | [redacted] | [redacted] |

[4] Power transformer and reactor fittings - Part 6: Cooling equipment - Removable radiators for oil-immersed transformers

**5.5.18** 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 our in line with government cost estimating guidance and IPI standard. Cost accuracies of +/-10% are allocated due to the estimates produced being derived from 4.0 level scopes with costs derived from supplier quotations and installation and project overhead rates, which are well defined.

**5.5.19** An example of the cost derivation for Electrical Infrastructure works is a recent construction estimate for "Step Down Transformer Replacement 11kv/33kv down to 415v". The Unit Cost utilised informed budgetary quotations from the supply chain and intelligence from subject matter experts to generate appropriate allowances for the scope.

**5.5.20** The estimate used [redacted] as the site example and assumes all isolation/de-isolation works would be carried out by NGT personnel. The bulk of the works in this example would be completed by the supply chain, with a main works contractor equating to over [redacted] of the unit cost. This includes initial surveying, design and final testing on top of the actual replacement of the transformer itself. It also relies on available access for a 120-tonne crane.

**5.5.21** A [redacted] risk and contingency provision has been applied for both NGT and the MWC due to a large number of unknowns. The length of cable runs, budgetary nature of the supplier quotation (supply only) and the varying location of where the transformers could be on site could all have significant impact on the cost for this intervention.

# 6 Low Voltage Switchgear (£14.95m)

## 6.1 Equipment Summary

**6.1.1** A low-voltage switchgear and control gear assembly is a combination of low-voltage switching devices together with associated equipment for controlling, measuring, protecting, signalling and regulating downstream equipment. It includes several mechanical and electrical interconnections and structural parts.

**6.1.2** It is used for the control of Low Voltage (LV) electrical energy from our site transformers at 400V AC to our downstream connected electrical assets.

**6.1.3** Our LV switchgear installations are in the form of:

- Main LV switchgear
- General Services Boards
- Compressor Unit AC Motor Control Centres (AC MCCs)
- Compressor Unit DC Motor Control Centre (DC MCCs)

**6.1.4** A Motor Control Centre (MCC) is a type of LV Switchgear dedicated to the switching and control of equipment used to support a compressor unit (e.g., motors, heaters, lighting, air conditioning). A compressor unit typically has two MCCs, one supplied from the mains supply and another supplied from either an AC or DC Uninterruptible Power System (UPS).

**6.1.5** At the start of RIIO-T2, we had 201 LV Switchgear assemblies in operation on the NTS. [redacted] of these installations are located at [redacted], which are outside the scope of this paper. In addition, [redacted] LV switchgear have investment in progress during the RIIO-T2 period, leaving a resultant position of [redacted] assemblies.

**6.1.6** 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

## 6.2 Problem/ Opportunity Statement

**6.2.1** There are several drivers for investment into our LV Switchgear assets:

- **Health and Safety Risks** – The calculated fault level at LV Switchgear installations is high. With these high fault levels there typically comes a risk of Arc flash which may impact the health and safety of operatives. Older assemblies do not meet with the requirements of current standards (e.g., BS EN 61339) resulting in health and safety concerns, such as access to energised components even when the asset is isolated.

- **Asset deterioration** – Mechanical and EC&I components within LV switchgear assets deteriorate through operation and age related degradation of materials. This has resulted in assets that are unsafe and non-compliant with standards.
- **Asbestos** – Older LV switchgear commonly contains parts that were manufactured from asbestos or asbestos-containing materials (ACMs). For our LV Switchgear we need to ensure that we manage this risk and our activities do not disturb this asbestos and we mitigate the risk to As Low as Reasonably Practicable (ALARP).
- **Age and Obsolescence** –Our LV Switchgear has been manufactured by a range of Original Equipment Manufacturers (OEM), several of which are no longer operating. Volumes of LV Switchgear assemblies against each manufacturer are shown in Table 15, with the OEMs' status.

*Table 15: OEM Summary for LV Switchgear*

| OEM | Volume | OEM Status |
|---|---|---|
| [redacted] | [redacted] | [redacted] |
| [redacted] | [redacted] | [redacted] |
| [redacted] | [redacted] | [redacted] |
| [redacted] | [redacted] | [redacted] |
| [redacted] | [redacted] | [redacted] |
| [redacted] | [redacted] | [redacted] |
| [redacted] | [redacted] | [redacted] |
| [redacted] | [redacted] | [redacted] |
| **Total** | **110** | |

**6.2.2** Several LV Switchgear assemblies incorporate electronic controls such as protection relays and motor managers which have a life expectancy of 15 to 20 years. We have identified that 264 motor managers and 14 Electronic protection relays installed on our network are now obsolete with the OEM confirming these are unsupported, resulting in a lack of spare availability, software updates and support should issues be experienced.

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

**6.2.3** Investment in our LV Switchgear seeks to ensure that we maintain high levels of LV switchgear availability and address specific known obsolescence challenges within installations. A large volume of assets are obsolete and unsupported, resulting in challenges to maintain.

**6.2.4** Not undertaking investment will breach legal obligations under EAWR, and result in assets that continue to deteriorate with limited to no support. These may require immediate isolation and result in disruption to NTS compressor operations.

### What is the outcome that we want to achieve?

**6.2.5** All LV Switchboards and MCCs are fully functional with all known issues resolved and compliant to key legislation such as EAWR and the Dangerous Substances and Explosive Atmospheres Regulations, British and International standards and all relevant NGT standards.

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

**6.2.6** The outcome of the investment shall ensure we maintain the safe operational availability of compressor stations and ensure continued compliance with all legal obligations and required standards affecting our LV Switchgear.

### Narrative Real Life Example of Problem

[redacted]

**6.2.7** [redacted].

**6.2.8** There are a range of issues with the current assembly including obsolescence. For example, [redacted] have limited support and spares availability. They also have no barriers to the busbars, exposing technicians to live electrical component and a lack of compartmentalisation making maintenance challenging.

*Figure 9:* [redacted]

6.2.9 We considered refurbishment of this equipment. However, upon survey and subsequent tendering discussions, it quickly became apparent that major refurbishment was not a feasible intervention for switchboards that are particularly aged (40-50 years old). The build standards and associated refurbishment work would entail mobilisation of workforce and equipment at an operational site similar to the panel build capabilities of factories.

6.2.10 The estimated cost benefit would likely be marginal or negative whilst the project delivery risk (additional issues uncovered, time overruns, etc) would be greater.

6.2.11 Given the age of the equipment it was likely that further upgrades of additional parts would be identified and need replacing to comply with the British Standards and EAWR regulations.

6.2.12 Feedback from supply chain also highlighted that the assembly could retain features not compliant with current standards and therefore the installation would not be certified, placing all of the risk from future failures onto NGT. Investment has progressed in RIIO-GT2 to replace this installation.

[redacted]

6.2.13 The main incoming board [redacted] There are a variety of issues with the current installation, including electromagnetic protection relays that are no longer supported, obsolete and aged. The isolators within the installation are obsolete and do not meet the requirements of our policy EL_50, designed against British standards and legislation (BS EN 61339).

6.2.14 The boards also include red spot fuses holders which have known safety issues. Given the age of the equipment it is likely that further upgrades of additional parts would be identified and need replacing to comply with the British Standards and EAWR regulations. We have included investment in our RIIO-3 plan to replace this installation. Survey report is included in Appendix 3 – Example Electrical Survey Report.

[redacted]

### Project Boundaries

**6.2.15** The proposed investments include all components within the LV Switchgear assembly, but does not include the upstream cabling from the Transformer to the LV Switchgear, as this is included in our Transformer interventions.

**6.2.16** We have considered our electrical investment drivers against our overall Compressor investment plan, defined within our Compressor Fleet EJPs. This shall ensure we reduce the risk of stranded assets.

**6.2.17** Investment has not been considered for LV Switchgear subject to investment during RIIO-GT2 or Bacton and St Fergus, subject to separate funding requests.

**6.2.18** Inspection and maintenance activities, including minor component replacement, are included within our opex plan and not within the scope of this investment case.

## 6.3 Probability of Failure

**6.3.1** Switchgear assemblies deteriorate, typically resulting in excess heat, which leads to further deterioration and eventually failure. The age and frequency of usage such as the number of switching operations undertaken also have implications. For LV Switchgear, switching operations may occur frequently as compressors are turned on and off to meet the network pressure requirements.

**6.3.2** 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.

**6.3.3** Within our NARMS model LV Switchgear 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 average proportion of failures.

*Table 16: LV switchgear failure modes*

| Failure Mode | Average Proportion of Failures |
|---|---|
| Loss of Gas Quality information | 0.87 |
| Loss of compressor unit | 0.38 |
| Loss of unit - trip | 0.22 |
| Loss of Monitoring / control | 0.16 |

**6.3.4** 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 17. The average failure rate represents the proportion of that asset type with an unresolved failure. The forecast failures per year shows the quantity of new failures modelled to occur each year. The forecast failure rate for LV Switchgear increases by 4% over RIIO-GT3.

*Table 17: Forecast LV switchgear 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 switchgear | 619 | 0.91 | 0.92 | 0.93 | 0.94 | 0.95 | 7 | 6 | 6 | 6 | 5 |

### Defects

**6.3.5** Since 2008, 72 defects have been raised against our LV Switchgear assets[5], 68 of which since 2016 within Maximo, our asset data repository.

**6.3.6** A significant increase was seen in 2017 due to a system transfer, with an increase in defects raised in RIIO-T2 through the completion of surveys from our electrical capital delivery programme.

**6.3.7** Of the 68 defects on the system, 24 have been assessed to be opex in nature and 54 assessed to require capex investment. The graph below, Figure 11, shows the quantity of defects raised per year split by capex and opex categorisation.

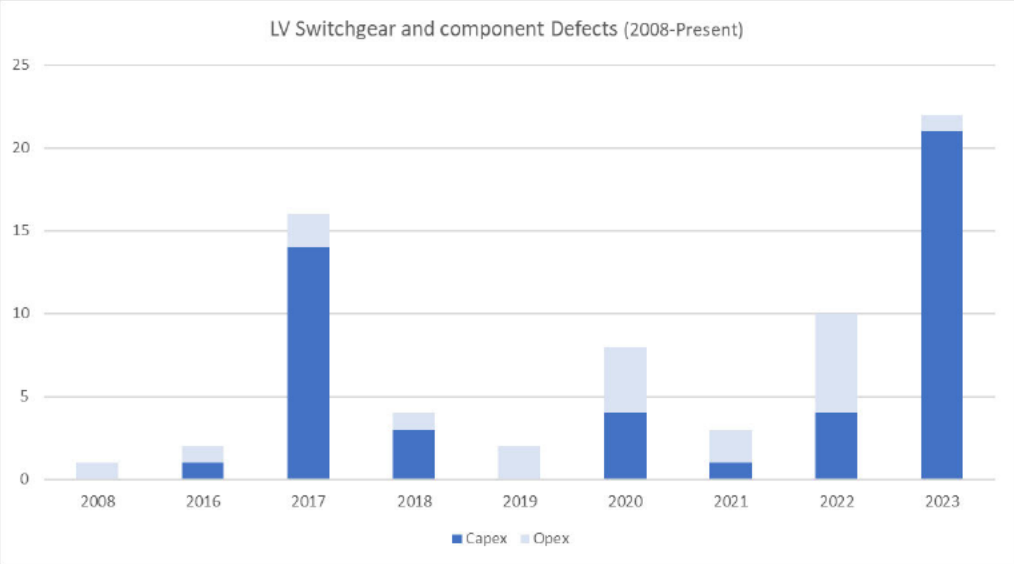


*Figure 11: LV Switchgear defect rate*

**6.3.8** The table below summarises the volume of defects by fault categorisation, split by capex and opex. A significant number of defects are categorised against equipment that is aged, obsolete, unsupported by OEMs, with compartments that provide access to live supplies even when the board has been isolated.

*Table 18: Defect Assessment Summary*

| Capex | Number of Defects |
|---|---|
| Motor Manager Issues | 1 |
| Motor Manager Obsolescence | 3 |
| Aged, Obsolete and unsupported installations, with Health & Safety concerns (access to live components) | 40 |
| Protection Relay Obsolescence | 1 |
| Asbestos Removal | 1 |
| Worm gear damaged – needing replacement | 3 |
| **Total** | **48** |
| **Opex** | **Number of Defects** |
| Component Failure | 9 |
| Fault Rectification | 8 |
| Labelling and Testing | 3 |
| **Total** | **20** |

**6.3.9** Of these 72 total defects: 52 are awaiting corrective actions, 18 are associated with investments in progress in RIIO-T2 to replace obsolete and defects switchgear with 17 originally planned for RIIO-T2, now awaiting investment in RIIO-GT3. These have been deferred due to funding constraints, a delay to our investment due to supply chain challenges, for which we have taken steps to address. An example survey report is shown in Appendix 3.

[5] As of April 2024

### Probability of Failure Data Assurance

6.3.10 The system data used is consistent with the approach documented for HV Transformers.

6.3.11 Information captured from surveys completed through our RIIO-T2 project delivery was utilised to inform the condition of our installations, as defects were logged within our defect management system where faults, and issues were identified in our surveys. Due to funding shortfalls within our electrical interventions, we have not been able to deliver investment against all of the identified defects and issues in RIIO-T2.

## 6.4 Consequence of Failure

6.4.1 In the event of a failure of our LV Switchgear assets there are a range of potential impacts to our site operations.

6.4.2 This section of the EJP shall provide an overview of the consequence of failure for our LV Switchgear Assets, which is presented below in tabular form mapped against NGTs NARMS Consequence of Failure service risk measures.

*Table 19: LV switchgear consequence of failure*

<table>
<tr><th rowspan="2">Sub-Asset Type</th><th colspan="4">Impact / Consequence</th></tr>
<tr><th>Availability</th><th>Environment</th><th>Financial</th><th>Safety</th></tr>
<tr><td>Main Switchgear</td><td>(1) Failure of the switching circuit supplying downstream gas compressor units is a single point of failure to compressor station operation.<br>Any loss of compression has the potential to cause significant impact to customers.<br><br>(2) Inability to supply electrical power to outgoing circuits. Loss of power to certain parts of the compressor station such as telemetry, gas quality systems, necessitating the use of backup power supplies</td><td rowspan="3">(3) The unavailability of primary compressor units can add hours onto less efficient compressors which result in additional emissions. Some of these may have restricted running hours under emissions legislation derogations.</td><td rowspan="3">(4) Failure resulting in lack of compression causing a network constraint, potential buy backs. This is a multi-million pound risk.<br><br>(5) Use of the Standby Generator to maintain supplies to maintain operational assets functionality. This would result in increases in running costs, such as cost of fuel and cost of GT Operations resources.<br><br>(6) There is financial risk associated with legislative non-compliance, such as DSEAR, and EAWR regulation 4(2).</td><td>(7) Exposure of operational personnel to electrical burns or electrocution in worst case. It is risk that needs active management.<br><br>(8) Fires, explosion and risk of electric shock can occur through failure of the LV Switchgear components.<br><br>(9) Asbestos can be installed in arc chutes and distribution boards within the panels. We need to limit exposure of our personnel to our asbestos.</td></tr>
<tr><td>Protection Relays</td><td>As (2) above</td><td>Failure of the Protection relays can result in (7) and (8) above.</td></tr>
<tr><td>Motor Control Centre</td><td>As (1) above<br><br>(10) Loss of power to outgoing circuits supplying compressors, potential damage to process plant resulting in unavailability of the unit for a significant period.</td><td>Failure of the Moto Manager can result in (6) and (7) above.<br><br>(11) Failure of the oil/ventilation systems resulting in damage to a compressor unit, that could impact the health and safety of GT Operations teams.<br><br>(13) Loss of the safety related systems within the Compressor Cab</td></tr>
</table>

6.4.3 The graph below presents the modelled baseline risk over RIIO-GT3 for our LV Switchgear Assets, assuming no investment in the period.

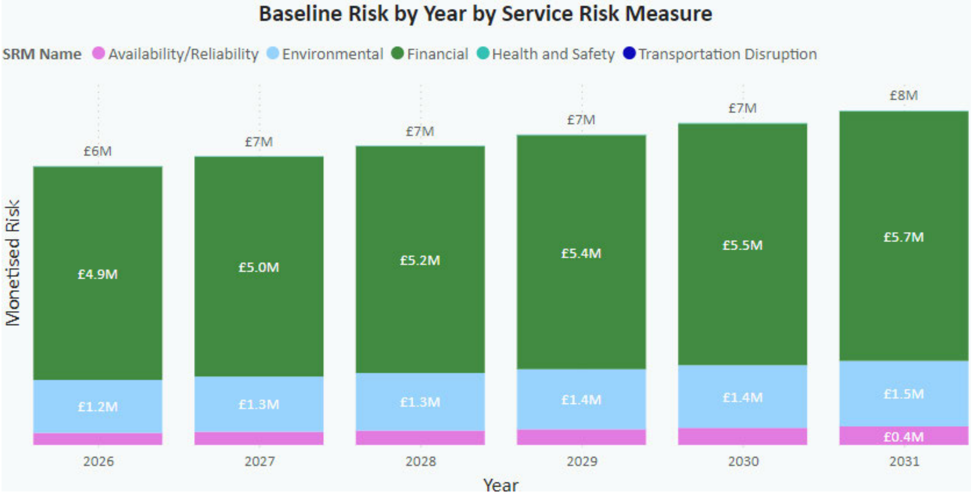


*Figure 12: Modelled baseline risk for LV switchgear over RIIO-GT3*

6.4.4 The graph shows that risk starts RIIO-GT3 at £7.1m and reaches £8.4m at the end of the period, an increase of 18%.

## 6.5 Interventions Considered

### Interventions

6.5.1 A range of interventions on our LV Switchgear have been considered (including Main Switchgear, General Services Board and Motor Control Centres) to address the drivers for investment.

Counterfactual

6.5.2 Our Counterfactual intervention considers no specific intervention to be undertaken on our LV Switchgear, with the exception of LV Switchgear maintenance. Investment is deferred into future price control periods.

Replacement of LV Protection Relays and Motor Managers

6.5.3 This intervention proposes the replacement of obsolete aged electronic protection relays and motor managers within our LV Switchgear installations.

6.5.4 A range of assets are obsolete, unsupported by the OEM and reach their 15 year expected asset life within RIIO-GT3, [redacted] having already reached this age. Replacement of these units with modern equivalents will help to prevent failures resulting in a loss of supply to the downstream systems impacting the operation of connected assets.

6.5.5 Within this intervention we have considered:

- Fix on fail replacement
- Proactive replacement

**Fix on Fail Replacement**

6.5.6 LV protection relays and motor managers are replaced on a fix on fail basis, through the procurement and distribution of replacement components across the NTS. Significant spares management practises would need to be adopted and managed across a NTS wide campaign.

6.5.7 The failure of a protection relay or motor manager would require the quick replacement of these components to restore power to a certain circuit, without unavailability of the connected assets.

**Proactive Replacement**

6.5.8 Assets are replaced through a proactive campaign utilising OEM upgrade pathways, assuming a 15 year control system life for these assets and with information on OEMs on obsolescence.

6.5.9 Proactive replacement of these devices would also release spares that can be utilised to support the remaining legacy devices across our LV Switchgear estate of assets, providing resilience should failure occur.

Refurbishment of LV Switchgear Installation

6.5.10 In this intervention, a mains work contractor would mobilise at our operational site, complete the isolation of the relevant switchgear installation and complete the refurbishment of components such as circuit breakers, switch fuses, motor starters, within the existing switchgear frame, based on asset specific surveys.

Replacement of LV Switchgear Installation

6.5.11 This intervention proposes the holistic replacement of a whole LV Switchgear installation (comprising either a General Services Board, Main LV switchgear Installation or Motor Control Centre).

6.5.12 We would replace the existing installation with a new intelligent digital LV Switchgear in a pre-assembled unit and dispose of the old installation.

### Intervention Summary

6.5.13 Table 20 presents a summary of the interventions considered.

*Table 20: LV Switchgear Intervention summary*

| Intervention | Equipment Design Life | Positives | Negatives | Taken Forward |
|---|---|---|---|---|
| Counterfactual (Do nothing) | N/A | Lower Capex cost solution | Does not manage increasing defect rate, obsolete components and unsafe installations.<br>Potential for higher opex costs due to ad hoc repairs and component replacement. | No |
| Replacement of LV Protection Relays - **Proactive** | 15 Years | Addresses known age and obsolescence issues that have the potential to impact the availability of downstream circuits and equipment operation in a planned manner .<br>Releases spares that can be utilised to support the maintenance of the remaining I electronic protection relays.<br>Can be delivered through local isolation.<br>Low-cost intervention. | None | Yes |
| Replacement of LV Protection Relays – **Fix on Fail** | 15 Years | Addresses known age and obsolescence issues that have the potential to impact the availability of downstream circuits and equipment operation.<br>Can be delivered through local isolation.<br>Low-cost intervention. | The failure of a protection relay would require the quick replacement of these components to restore power to a certain circuit, without unavailability of the connected assets. | No |
| Replacement of Motor Managers | 15 Years | Addresses known age and obsolescence issues that have the potential to impact the availability of connected compressor units.<br>Can be delivered through local isolation.<br>Low-cost intervention. | None | Yes |
| Refurbishment of LV Switchgear Installation | 20 years | Lower cost intervention than replacement | Potential for challenges with getting supply chain to complete activity.<br>Several LV Switchgear contain Asbestos containing materials. Refurbishment of these installations' risks disturbance of asbestos fibres that pose a risk to site personnel, contractors and project staff undertaking these projects.<br>Additional scope could be identified through the delivery programme which could result in project time overruns, affect other works programmes and increase the cost of the intervention.<br>Assemblies could retain features of their construction that not in line with current standards and this could result in assets that remain unsupported or non-compliant with safety standards. Therefore, contractors are unlikely to certify the installation, and this places all of the risk onto National Gas. | No |
| Replacement of LV Switchgear Installation | 30-40 years | Addresses defects and asbestos issues.<br>Fully comply with all relevant industry standards and legislative requirements.<br>The replacement intervention can be delivered through a shorter outage window than the refurbishment intervention given the assembly would be manufactured and tested offsite, then transported to site installed and commissioned onsite. | Highest cost intervention | Yes |

### Volume Derivation

**6.5.14** The investment programme has been developed through the collation of a range of data sets around the asset parameters. This included asset condition information, collated through surveys and defect information, obsolescence information from OEMs and information on the presence of asbestos. Information from the programme of investment on these assets which commenced in RIIO-T2 was also fed into our engineering judgement.

**6.5.15** Industry information from the IEEE and CIBSE for mean time between failures and age expectations were assessed to inform our investment position.

**6.5.16** Consideration was also made in relation to the Compressor Fleet investment programme and the future life of compressor stations and units to avoid stranded asset risks.

*Table 21: Development of bottom-up LV switchgear intervention volumes for RIIO-GT3*

| Intervention | RIIO-GT3 Volumes | Unit of Measure | How this volume has been developed |
|---|---|---|---|
| Replacement of LV Switchgear Assembly | [redacted] | [redacted] | [redacted] |
| Replacement of LV Protection Relays | [redacted] | [redacted] | [redacted] |
| Replacement of motor managers on Motor Control Centre (MCC) switchgear | [redacted] | [redacted] | [redacted] |
| **Total** | **312** | | |

### Unit Cost Derivation

**6.5.17** In developing our RIIO-GT3 investments we have assessed our interventions against historically completed investments. In this assessment we have mapped RIIO-GT3 interventions to RIIO-T2 Unique identifiers (UIDs) and assessed the available costs (Outturn and estimate at cost of completion).

**6.5.18** Where historical outturn or tendered costs have not been available we have undertaken estimating using first principles, including sourcing quotations from our supply chain..

**6.5.19** For LV Switchgear two options have been estimated from first principles with one determined from the estimated cost of completion and one from historical RIIO-T1 unit costs. Table 22 summarises the cost sources and datapoints used to inform the unit costs in this EJP. A breakdown of the unit costs is also provided in Appendix 2 – Unit Cost Derivation.

**6.5.20** A specific example of how we have developed costs for Switchgear works is the "Replacement of motor managers on Motor Control Centre (MCC) switchgear". This project detailed the need to replace an existing motor manager across multiple sites including disposal. The reason for this requirement is that the original E3 product is no longer produced and has been replaced with the E300/E200 Electronic Overload Relay. The Unit Cost for this was built up through estimation using an allowance for an electrical engineer to complete the replacement of the necessary motor manager in a single 8hr day. There are no allowances for design or testing included in the estimate as it is a routine activity. This is also reflected in a [redacted]

**6.5.21** For the Replacement of LV Switchgear Assembly intervention our unit cost is based on the estimated cost of completion for [redacted] LV switchgear installations with inflight projects in RIIO-T2. These projects are all at the F4 (Project Execution) stage of delivery.

*Table 22: LV Switchgear unit cost summary table (£, 2023/2024)*

| Intervention | Unit of Measure | Unit Cost | Cost Accuracy | Number of Data Points | Source Data |
|---|---|---|---|---|---|
| [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] |

**6.5.22** We have confidence in the volumes presented in this paper, utilising condition information from RIIO-T2 electrical surveys and industry standards, and through assessing the installations against several metrics.

# 7 Options Considered

## 7.1 Portfolio Approach

7.1.1 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.

7.1.2 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 (NGT_IDP02_V5 CBA Electrical Infrastructure_RIIO-GT3).

7.1.3 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.

7.1.4 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.

7.1.5 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 23 and Appendix 1.

*Table 23: 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, but applies further constraints from our deliverability |
| 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 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. 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. |

## 7.2 Options

7.2.1 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.

7.2.2 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.

7.2.3 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

7.2.1 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.

7.2.2 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.

7.2.3 The proposed intervention volumes and the associated spend for this option are shown in Table 24 below, with a full intervention breakdown in Appendix 1.

*Table 24: 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

7.2.4 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.

7.2.5 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.

7.2.6 The proposed intervention volumes and the associated spend for this option are shown in Table 25 below, with a full intervention breakdown in Appendix 1.

*Table 25 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

7.2.7 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.

7.2.8 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.

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

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

*Table 26: 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)

7.2.11 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.

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

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

*Table 27: 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

**7.2.14** 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.

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

**7.2.16** The proposed intervention volumes and the associated spend for this option are shown in Table 28 below.

*Table 28: 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** |

## 7.3 Options Summary

**7.3.1** Table 29 below presents the technical summary table comparing our Portfolio Options 1 to 4.

*Table 29: 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 | [redacted] | £75.56 |
| 1A. Total Monetised Risk Stable to RIIO-T2 start Post Deliverability | 2027 | 2031 | [redacted] | 15-40 years | [redacted] | £74.08 |
| 2. 10% Additional Risk Reduction | 2027 | 2031 | [redacted] | 15-40 years | [redacted] | £80.80 |
| 3. Lowest WLC | 2027 | 2031 | [redacted] | 15-40 years | [redacted] | £82.56 |
| 4. Availability and Reliability Risk Stable | 2027 | 2031 | [redacted] | 15-40 years | [redacted] | £81.86 |

# 8 Business Case Outline and Discussion

## 8.1 Key Business Case Drivers Description

8.1.1 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.

8.1.2 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

8.1.3 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.

## 8.2 Business Case Summary

8.2.1 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.

8.2.2 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 cost benefit analysis (CBA) utilising our Copperleaf Portfolio Optimisation tool.

8.2.3 We have appraised these portfolio options through completing a cost benefit analysis, the results of which are shown in Figure 13 and Table 30, including the post deliverability option.


*Figure 13: Graphical representation of option payback periods*

*Table 30: 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 | 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% |

**8.2.4** 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, with a summary overleaf.

**8.2.5** 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.

**8.2.6** The Option 3, Lowest Whole Life Cost (WLC), increases investment volumes by 55% compared with option 1. With this option seeking to deliver a combination of intervention options which achieves the lowest total cost of CAPEX incurred over the operational life of the assets it recommends a high volume of low value interventions. 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.

**8.2.7** 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.

**8.2.8** The table below summarises the positives and negatives of the 4 options considered within our Cost Benefit Analysis

*Table 31 Positive 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.<br>• Meets the expectations of our customers and stakeholders and keeps total monetised risk stable at the risk level at the start of RIIO-T2.<br>• 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<br>• 3rd 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.<br>• Option has the lowest payback period. | • Most expensive option (11% higher than option 1A) |
| 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.<br>• This option provides the highest risk benefit in all service risk measures.<br>• Payback period within the 20 year period. | • 2nd most expensive option |

# 9 Preferred Option and Project Plan

## 9.1 Preferred Option

**9.1.1** 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 Option 1A : Post Deliverability which includes the mix of interventions listed in Table 32 below.

*Table 32: Preferred option summary (£, 2023/24)*

| Intervention | Primary Driver | Volume | Unit of Measure | % Assets Intervened Upon | Total RIIO-GT3 Request | Funding Mechanism | PCD Measure |
|---|---|---|---|---|---|---|---|
| Converter Transformer Coating Replacement | AH Risk Management | [redacted] | Per Asset | [redacted] | [redacted] | Baseline – Non-Lead Asset PCD | Volume |
| Install DG Analyser | Maintainability | [redacted] | Per Asset | [redacted] | [redacted] | Baseline – Non-Lead Asset PCD | Volume |
| Install [redacted] Units | Maintainability | [redacted] | Per Project | [redacted] | [redacted] | Baseline – Non-Lead Asset PCD | Volume |
| Replacement of LV Protection Relays | AH Risk Management | [redacted] | Per Asset | [redacted] | [redacted] | Baseline – Non-Lead Asset PCD | Volume |
| Replacement of LV Switchgear Installation | AH Legislation | [redacted] | Per Asset | [redacted] | [redacted] | Baseline – Non-Lead Asset PCD | Volume |
| Replacement of motor managers on Motor Control Centre (MCC) switchgear | AH Risk Management | [redacted] | Per Asset | [redacted] | [redacted] | Baseline – Non-Lead Asset PCD | Volume |
| Step Down Transformer Coating Replacement | AH Risk Management | [redacted] | Per Asset | [redacted] | [redacted] | Baseline – Non-Lead Asset PCD | Volume |
| Step Down Transformer Replacement 11/33Kv | AH Risk Management | [redacted] | Per Asset | [redacted] | [redacted] | Baseline – Non-Lead Asset PCD | Volume |
| Step Down Transformer Replacement 132Kv | AH Risk Management | [redacted] | Per Asset | [redacted] | [redacted] | Baseline – Non-Lead Asset PCD | Volume |
| **Total** | | **90** | | | **£19,858,435.43** | | |

**9.1.2** 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 and completed a robust deliverability assessment of this investment proposal within our wider capex investment programme (Option 1A).

**9.1.3** 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.

**9.1.4** 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.

**9.1.5** 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.

**9.1.6** The preferred option for Switchgear & Transformers delivers £11.18m of NARMS Long Term Risk Benefit with our full programme of electrical Infrastructure investment in RIIO-GT3 delivering £43.6m.

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

## 9.2 Asset Health Spend Profile

**9.2.1** The below spend profile provides an indicative view on when the above interventions are to be carried out.

**9.2.2** Our programme of investment on our Electrical Infrastructure switchgear and transformer assets 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.

[redacted]

*Figure 14: Switchgear and transformers spend profile RIIO-GT3*

**9.2.3** The peak in FY2027 is driven from the proposed LV switchgear replacement on 6 sites across the NTS. Supply chain analysis against our current supply chain partners, [redacted], shows available capacity to deliver this increased investment programme without needing to modify our existing supply chain framework.

## 9.3 Investment Risk Discussion

**9.3.1** 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.

**9.3.2** 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. This shall partly be mitigated through the CPI-H inflation and real price effect mechanisms within our RIIO-GT3 regulatory framework.

**9.3.3** Key risks and currently identified mitigations are summarised in Table 33.

*Table 33: 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 and 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 |

## 9.4 Project Plan

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

*Table 34: 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) |

**9.4.2** The below table shows the summary plan and provisional delivery phases for Electrical Infrastructure sanctions within RIIO-GT3, for the investments within scope of this paper. An annual sanction approach for all electrical infrastructure investments is proposed to ensure efficient bundling of investment, with delivery of this investment bundled with investments from our wider capex investment plan.

*Table 35: Electrical Infrastructure Portfolio Programme for RIIO-GT3 period*

| | RIIO-T2 | | RIIO-GT3 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Sanctions | FY25 | FY26 | FY27 | FY28 | FY29 | FY30 | FY31 | FY32 | FY33 |
| T3_Sites_AH_Electrical_FY31 | | | | | | | | | |
| T3_Sites_AH_Electrical_FY28 | | | | | | | | | |
| T3_Sites_AH_Electrical_FY30 | | | | | | | | | |
| T3_Sites_AH_Electrical_FY29 | | | | | | | | | |
| T3_Sites_AH_Electrical_FY27 | | | | | | | | | |

## 9.5 Key Business Risks and Opportunities

**9.5.1** Changes to supply and demand scenarios are 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 assessment and through the development of this electrical infrastructure investment programme.

**9.5.2** Our programme of investment on our Electrical infrastructure switchgear and transformers 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.

**9.5.3** A transition to hydrogen for NTS sites would still require supporting electrical infrastructure, to enable asset operations.

## 9.6 Outputs included in RIIO-T2 Plans

**9.6.1** 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.

# 10 Appendix 1

10.1.1 The table below presents the bottom up intervention volumes proposed across our electrical infrastructure portfolio. Interventions highlighted in yellow are within the scope of this engineering justification paper.

*Table 36: 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) |
|---|---|---|---|---|---|
| [redacted] | [redacted] | [redacted] | | [redacted] | [redacted] |
| [redacted] | [redacted] | [redacted] | | [redacted] | [redacted] |
| [redacted] | [redacted] | [redacted] | | [redacted] | [redacted] |
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# 11 Appendix 2 – Unit Cost Derivation

| Intervention | 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) |
|---|---|---|---|---|---|---|---|---|---|---|
| [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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# 12 Appendix 3 – Example Electrical Survey Report

File Provided: Example Electrical Survey Report - [redacted] - Electrical Survey October 21