Annex A14.20
Electrical Engineering Justification Paper
December 2019

As a part of the NGGT Business Plan Submission

nationalgrid

Executive Summary

Introduction

To maintain the ongoing safe, secure and reliable operation of the UK Gas National Transmission System (NTS) it is imperative that the health of the assets that constitute the NTS is carefully managed.

Our Asset Health programme is an ongoing plan of works that assures this and consists of 7 core asset themes of work. This document outlines our approach to the management of our Electrical assets to meet desired regulatory, stakeholder and financial outcomes. A 10-year view has been taken, covering the RIIO-2 and RIIO-3 regulatory periods to ensure a balanced, lifecycle approach to asset management.

The Electrical asset health programme is split across 2 sub-themes. In total, we propose £28.5m of investment (4.6% of the 7 themes that comprise the overall asset health plan) ensuring risk levels are maintained on our Electrical assets during RIIO-2.

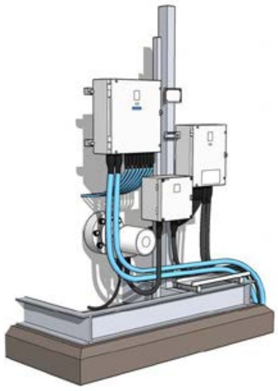
Sub-theme	Intervention Volumes	Cost
Site Electrical Systems	212	£23,238,811
Standby Power Supplies	118	£5,237,397
Total	**330**	**£28,476,208**

The profile of Electrical asset health investment for the 10-year period, derived from the volumes of work and the unit costs, is shown in the table below:

Investment (£ 000s)	RIIO-2					RIIO-3				
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Total	1,139	6,007	6,801	5,945	8,584	6,629	9,149	6,269	11,895	6,844
	28,476					**40,787**				

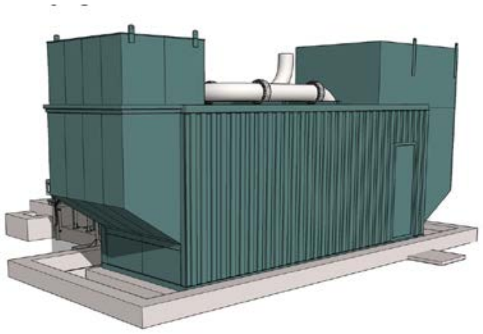
The Assets

The Electrical Infrastructure provides power to enable the safe operation of sites across the NTS. Most assets within the gas transmission system rely on an electrical supply to fulfil their function or are protected by equipment that requires an electrical supply. Key components of this asset include **Standby Power Supplies** that ensure critical services are powered should an electrical outage happen, **HV Switchgear** and **Transformers** which supply high voltage machines such as Compressor Electric Drives, **LV Switchboards and Distribution** that provide power to equipment across the sites, **Standby Generators** that provide the only means of site power should a longer-term electrical outage occur, **Site Lighting** to illuminate the site and support safe work activities and **Site Electrical Systems** that provide general power across the site.



Electrical Installations

Small Power Supplies



Standby Generators

Transformers

Site Lighting

Switchgear & distribution

The Electrical Infrastructure is essential for the safe operation of the NTS and is, thus, abundant. Most assets within the gas transmission system rely on an electrical supply to fulfil their function or are protected by equipment that requires an electrical supply. Electrical supply is taken from the local electrical distribution network but is supported as necessary by Standby Power Supplies and Generators. HV machines are the exception where the backup function of that machine would be covered by other gas generators.

Many elements of the electrical infrastructure are beyond their design life and the aging infrastructure is deteriorating with the number of defects associated with it rising. The impacts of the increasing defects on the electrical infrastructure are:

- The failures of standby power supplies and standby generators have prevented compressor units starting, reducing the resilience of the NTS. This could have potential impacts on the availability of gas or increase potential for buy backs
- Several of the aging standby generators have safety issues associated with their age, type and the location within the site

- Site lighting is becoming a safety risk across all sites with many cable failures, corroding floodlight columns and specific task lighting that is inappropriate for the work being undertaken
- There are increased outage times when failures do occur due to obsolete assets and unavailability of spares.

Impacts of No Investment

Without investment in the electrical infrastructure an increasing number of elements may need to be isolated to maintain compliance with the Electricity at Work Regulations (EAWR) and Dangerous Substances and Explosive Atmospheres Regulations (DSEAR). These isolations will lead to increasing impact on the ability to operate the NTS, the Network Capability and ultimately the availability of gas for our customers.

Age and obsolescence are significant factors that raise the risk of these assets failing. Many of the Electrical assets are at or beyond their intended design life. Failure to continue to invest in these assets can ultimately lead to significant impacts in operating and controlling key NTS sites.

Proposal Development

A proactive intervention programme is proposed to avoid unmanageable levels of defects, together with the associated adverse impacts on the safety, operation and availability of the NTS and any potential legislative non-compliance. It should also be noted that robust electrical infrastructure facilitates the intervention programmes during RIIO-2. Such proactivity is cost beneficial even without considering risks of obsolescence over the period considered, as well as meeting the desired outcomes.

In defining our proposed intervention approach, we have focused our effort on developing a least whole-life cost option that enables an optimised, ongoing, rolling programme of work. Significant expert challenge and review has underpinned the levels of intervention and the proposed phasing ensures we meet the desired engineering and stakeholder outcomes whilst smoothing out the workload across RIIO-2 and RIIO-3.

In choosing the option to be carried forward into our plan we have considered the results of our CBA analysis amongst a range of other factors, examples set out below:

- The need to achieve legislative compliance may not necessarily be reflected through the quantified benefits delivered through a cost beneficial investment option, for example, the [redacted] will not tolerate a planned increase in safety risk, regardless of the economics.
- Where there is a backlog of known asset failures to be resolved, this will not always be reflected by the CBA as the risk valuation is calculated using an expected rate of future defects across the whole population of an asset type
- Our understanding of individual asset condition has improved during RIIO-1 but there are still gaps in our knowledge. Our plan reflects the need for a likely practical mix of intervention categories once specific assets are surveyed and their true condition and risk are understood. For example, a plan based upon 100% refurbishment may require a high number of replacements should a proportion of the assets be determined as non-serviceable
- The need for a deliverable programme of work, both in terms of planning outages, resource availability and contract efficiency. For example, through “bundling” work it may be more cost-effective to undertake alternative interventions to achieve reductions in contract costs, minimise outage risks or avoid an early repeat intervention in future RIIO periods

The table below summarises the key considerations when developing this theme of work.

To deliver these outcomes….
• Meet legal requirements and agreed safety standards • Maintain the safe operational availability of compressor stations and Above Ground Installations that have electrical equipment installed • Manage obsolescence effectively ensuring all electrical assets are supportable with spare parts • Maintain reliable energy supplies across the NTS • Meeting the expectations of our customers and stakeholders and keeping risk stable
…by intervening like this…
• Maintaining a safe and reliable electrical system compliant with EAWR and DSEAR upgrading to meet current standards as necessary. • Applying repair, refurbishment and replacement interventions as appropriate • Ensuring that standby power is available and reliable on demand • Providing effective lighting on sites to allow safe working in low-light conditions • Ensuring effective earthing to protect equipment and people from surges and failings in the electrical system
…based on this knowledge:
• An asset-specific risk-based review of the results of routine inspections, maintenance and investigations already undertaken • A forecast in line with our NOMs methodology of the defects and associated risks following routine interventions • A survey of the complete DSEAR assessments to identify and assess non-conformances to the standard • Knowledge of the volumes of assets that are currently obsolete or forecast to be obsolete during the investment period. • Understanding the whole life costs of lighting solutions to optimise replacement options

RIIO-2 Electrical Asset Health Investment Proposal Summary

Electrical Asset Health investment proposal headlines:

- The total RIIO-2 proposed expenditure for this theme is £28.5m
- 42% of our Electrical programme is based on interventions to address known defects (8%) and high confidence work volumes based on historical trends (34%). The remaining work volumes are reasonably well known but has required some assumptions and extrapolation.
- All the Electrical Asset Health intervention sub-themes have been subject to cost-benefit analysis and all sub-themes are cost beneficial, paying back within the period defined by Ofgem
- None of the Electrical asset health investments are included in our NARMs model. Price Control Deliverables will be agreed on the significant areas of this proposal to assure the outputs are delivered
- A significant proportion of the proposed electrical interventions are replacement interventions due to the nature of these assets and the interventions required to remove obsolescence and failure risk

Where appropriate a range of options has been considered for each sub-theme of work:

Sub-theme	RIIO-2 Plan (£)	Percentage of Theme	Options considered	Option summary / considerations
Site Electrical Systems	£23,238,811	81.6%	Various	A balanced blend of refurbishment and replacement intervention category options has been proposed to mitigate risk on an ongoing basis to maintain stable risk
Standby Power Supplies	£5,237,397	18.4%	4	Range of options identified to balance cost/risk detailed within this justification report. Chosen option takes a risk based re-life approach to maintain stable risk

We have estimated unit costs across all our proposed Electrical interventions either from historical outturn data points, from supplier quotations or from other estimation methods (such as extrapolation to similar types of work or from reviewing industry benchmarking data). Our approach has been primarily based top down from final actual costs combined with bottom up from estimating procedures and supplier rates or quotations. We have challenged our costs through internal benchmarking review with current supply chain partners combined with use of benchmarking data where this exists.

All the unit costs include the efficiencies resulting from bundling delivery programmes across asset classes and within available outages and efficiencies resulting from our innovation projects where these are proven to deliver benefits and can be utilised in the planned investments.

Over three-quarters of the Electrical plan is supported by historical outturn costs, and the majority of is supported by multiple data points. There are many lower-value Interventions that are only supported by one point. A large proportion of quotation data is also derived from multiple data points, leading to a reasonable degree of confidence in the resulting unit costs for this theme.

Within both the Electrical sub-themes there is a diverse range of assets. The Site Electrical systems includes assets from site lighting to transformers to switchboards. Each asset type and intervention has been considered for unit cost data, which should help in the overall accuracy in showing the wide range of costs that could apply to such a different group of assets.

The table below summarises the evidence used to produce the Electrical unit costs.

Investment sub-theme	Secondary Asset Class	RIIO-2 Business Plan	Evidence		
			Outturn	Estimated - Quotation	Estimated - Other
Standby Power Supplies	Standby Power Supplies	[redacted]	100%	0%	0%
Site Electrical Assets	LV Switchboards and Distribution	[redacted]	69%	12%	18%
	Standby Generators	[redacted]	0%	100%	0%
	Lighting	[redacted]	100%	0%	0%
	HV Switchgear and Transformers	[redacted]	0%	46%	54%
	Site Electrical Systems	[redacted]	6%	0%	94%
Total		[redacted]	77%	14%	9%

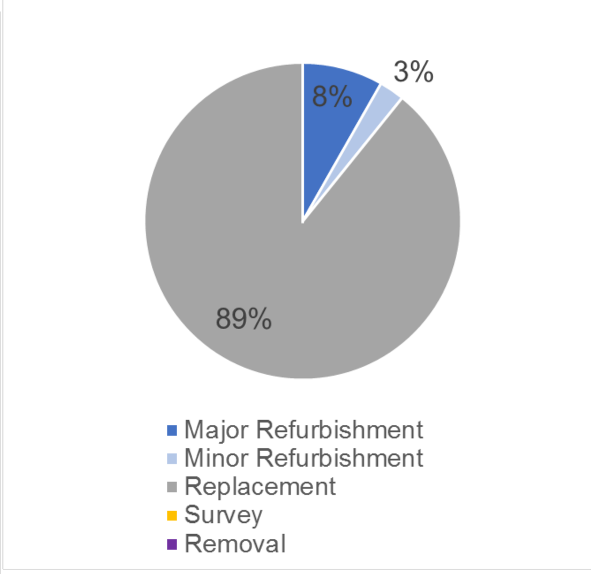
We have set out full details of our process for estimating unit costs across our asset health proposals in our Asset Health Unit Cost Annex.

The RIIO-2 Asset Health Electrical theme and intervention costs and volumes by output are provided below. All costs are in thousands (£000)

Sub-theme & Intervention	RIIO-2 Volumes	Legislation/ Safety Case & Risk Tradable	Risk Tradable	Legislation & Safety Case	Non-lead Assets
Site Electrical Systems					
AGIs - Distribution Systems - Major Refurb	[redacted]	£0	£0	£0	£0
HV Switchgear Minor Refurb	[redacted]	£0	£0	£0	£41
HV Switchgear Replacement	[redacted]	£0	£0	£0	£258
LV Distribution Boards Major Refurb	[redacted]	£0	£0	£0	£177
LV Distribution Boards Minor Refurb	[redacted]	£0	£0	£0	£94
LV Distribution Boards Replacement	[redacted]	£0	£0	£0	£532
LV Switchboards Major Refurb	[redacted]	£0	£0	£0	£412
LV Switchboards Minor Refurb	[redacted]	£0	£0	£0	£142
LV Switchboards Replacement	[redacted]	£0	£0	£0	£3,092
Other Equipment Major Refurb	[redacted]	£0	£0	£0	£134
Other Equipment Minor Refurb	[redacted]	£0	£0	£0	£64
AGI - Distribution Systems Electrical Survey/Minor refurb	[redacted]	£0	£0	£0	£0
Other Equipment Replacement	[redacted]	£0	£0	£0	£557
Site Lighting - Emergency - Major Refurb	[redacted]	£0	£0	£0	£186
Site Lighting - Emergency - Minor Refurb	[redacted]	£0	£0	£0	£82
Site Lighting - Emergency - Replacement	[redacted]	£0	£0	£0	£103
Site Lighting - External Columns Major Refurb	[redacted]	£0	£0	£0	£0
Site Lighting - External Columns Replacement	[redacted]	£0	£0	£0	£11,401
Site Lighting - Internal - Major Refurb	[redacted]	£0	£0	£0	£155
Site Lighting - Internal - Minor Refurb	[redacted]	£0	£0	£0	£52
Site Lighting - Internal - Replacement	[redacted]	£0	£0	£0	£155
Site Lighting External Task Major Refurb	[redacted]	£0	£0	£0	£268
AGIs - Distribution Systems - Replacement	[redacted]	£0	£0	£0	£0
Site Lighting External Task Minor Refurb	[redacted]	£0	£0	£0	£0
Site Lighting External Task Replacement	[redacted]	£0	£0	£0	£1,082
Standby Generator - Major Refurb	[redacted]	£0	£0	£0	£639
Standby Generator - Minor Refurb	[redacted]	£0	£0	£0	£251
Standby Generator Replacement	[redacted]	£0	£0	£0	£2,319
Transformers Major Refurb	[redacted]	£0	£0	£0	£0
Transformers Minor Refurb	[redacted]	£0	£0	£0	£46
Transformers Replacement	[redacted]	£0	£0	£0	£206
Electrical Survey/Minor refurb	[redacted]	£0	£0	£0	£0
Auxillary Equipment Major Refurb	[redacted]	£0	£0	£0	£57
Auxillary Equipment Replacement	[redacted]	£0	£0	£0	£649
Earthing & Lightning Protection Systems Major Refurb	[redacted]	£0	£0	£0	£87
Earthing & Lightning Protection Systems Minor Refurb	[redacted]	£0	£0	£0	£0
HV Switchgear - Major Refurb	[redacted]	£0	£0	£0	£0
Transformers Minor Refurb (St Fergus)	[redacted]	£0	£0	£0	£0
Transformers Major Refurb (St Fergus)	[redacted]	£0	£0	£0	£0
Transformers Replacement (St Fergus)	[redacted]	£0	£0	£0	£0
HV Switchgear Minor Refurb (St Fergus)	[redacted]	£0	£0	£0	£0
HV Switchgear Major Refurb (St Fergus)	[redacted]	£0	£0	£0	£0
LV Distribution Boards Minor Refurb (St Fergus)	[redacted]	£0	£0	£0	£0
LV Distribution Boards Major Refurb (St Fergus)	[redacted]	£0	£0	£0	£0
LV Distribution Boards Replacement (St Fergus)	[redacted]	£0	£0	£0	£0
LV Switchboards Minor Refurb (St Fergus)	[redacted]	£0	£0	£0	£0
LV Switchboards Major Refurb (St Fergus)	[redacted]	£0	£0	£0	£0
Auxillary Equipment Major Refurb (St Fergus)	[redacted]	£0	£0	£0	£0
LV Switchboards Replacement (St Fergus)	[redacted]	£0	£0	£0	£0
Standby Generator - Major Refurb (St Fergus)	[redacted]	£0	£0	£0	£0

Standby Generator Replacement (St Fergus)	[redacted]	£0	£0	£0	£0
Auxillary Equipment Replacement (St Fergus)	[redacted]	£0	£0	£0	£0
Site Lighting External Task Minor Refurb (St Fergus)	[redacted]	£0	£0	£0	£0
Site Lighting External Task Major Refurbishment (St Fergus)	[redacted]	£0	£0	£0	£0
Site Lighting External Task Replacement (St Fergus)	[redacted]	£0	£0	£0	£0
Site Lighting - External Columns Minor Refurb (St Fergus)	[redacted]	£0	£0	£0	£0
Site Lighting - External Columns Major Refurbishment (St Fergus)	[redacted]	£0	£0	£0	£0
Site Lighting - External Columns Replacement (St Fergus)	[redacted]	£0	£0	£0	£0
Site Lighting - Internal - Minor Refurb (St Fergus)	[redacted]	£0	£0	£0	£0
Site Lighting - Internal - Major Refurbishment (St Fergus)	[redacted]	£0	£0	£0	£0
Site Lighting - Internal - Replacement (St Fergus)	[redacted]	£0	£0	£0	£0
AGIs - Distribution Systems - Minor Refurb (St Fergus)	[redacted]	£0	£0	£0	£0
Site Lighting - Emergency - Minor Refurb (St Fergus)	[redacted]	£0	£0	£0	£0
Site Lighting - Emergency - Major Refurbishment (St Fergus)	[redacted]	£0	£0	£0	£0
Site Lighting - Emergency - Replacement (St Fergus)	[redacted]	£0	£0	£0	£0
AGIs - Distribution Systems - Major Refurb (St Fergus)	[redacted]	£0	£0	£0	£0
Earthing & Lightning Protection Systems Minor Refurb (St Fergus)	[redacted]	£0	£0	£0	£0
Other Equipment Minor Refurb (St Fergus)	[redacted]	£0	£0	£0	£0
Other Equipment Major Refurb (St Fergus)	[redacted]	£0	£0	£0	£0
Other Equipment Replacement (St Fergus)	[redacted]	£0	£0	£0	£0
Standby Power Supplies					
Batteries NiCad - Replacement	[redacted]	£0	£0	£0	£962
Piller Rotary UPS - Major Refurb	[redacted]	£0	£0	£0	£186
Piller Rotary UPS - Minor Refurb	[redacted]	£0	£0	£0	£0
Piller Rotary UPS - Replacement	[redacted]	£0	£0	£0	£258
UPS - Large - Major Refurb	[redacted]	£0	£0	£0	£0
UPS - Large - Minor Refurb	[redacted]	£0	£0	£0	£5
UPS - Large - Replacement	[redacted]	£0	£0	£0	£1,592
UPS - Small - Major Refurb	[redacted]	£0	£0	£0	£0
UPS - Small - Minor Refurb	[redacted]	£0	£0	£0	£0
UPS - Small - Replacement	[redacted]	£0	£0	£0	£8
Batteries VRLA - Large System - Replacement	[redacted]	£0	£0	£0	£827
Batteries VRLA - Small System - Replacement	[redacted]	£0	£0	£0	£46
DC Charger - Large - Major Refurb	[redacted]	£0	£0	£0	£0
DC Charger - Large - Minor Refurb	[redacted]	£0	£0	£0	£0
DC Charger - Large - Replacement	[redacted]	£0	£0	£0	£1,270
DC Charger - Small - Major Refurb	[redacted]	£0	£0	£0	£0
DC Charger - Small - Minor Refurb	[redacted]	£0	£0	£0	£0
DC Charger - Small - Replacement	[redacted]	£0	£0	£0	£84
UPS - Large - Minor Refurb (St Fergus)	[redacted]	£0	£0	£0	£0
UPS - Large - Major Refurb (St Fergus)	[redacted]	£0	£0	£0	£0
UPS - Large – Replacement (St Fergus)	[redacted]	£0	£0	£0	£0
DC Charger - Large - Minor Refurb (St Fergus)	[redacted]	£0	£0	£0	£0
DC Charger - Large - Major Refurb (St Fergus)	[redacted]	£0	£0	£0	£0
DC Charger - Large – Replacement (St Fergus)	[redacted]	£0	£0	£0	£0
Batteries VRLA - Large System – Replacement (St Fergus)	[redacted]	£0	£0	£0	£0
Batteries NiCad – Replacement (St Fergus)	[redacted]	£0	£0	£0	£0
Total	[redacted]	**£0**	**£0**	**£0**	**£28,476**

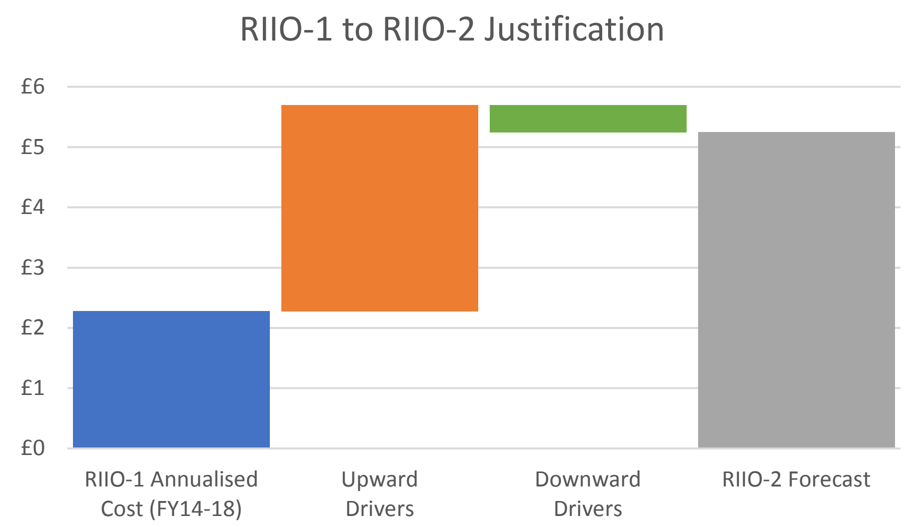
Electrical Asset Health theme outputs and intervention category:



Comparing our RIIO-2 proposal to our RIIO-1 programme

The annualised RIIO-2 spend has increased when compared to RIIO-1 from £2.3m to £5.2m for the Electrical Asset Health theme.

Note that this cost information is annualised to provide a comparative cost per year and the total RIIO-2 forecast below also includes the application of our agreed efficiency target within the downward drivers.



Upward Drivers

Significant end of life issues are driving up volumes of electrical interventions in RIIO-2. We have faced significant obsolescence issues on electrical systems for some time and this has been managed in part through grey spares in RIIO-1. Without additional investment in new systems, this approach is unsustainable into RIIO-2 and beyond. The driver for increased costs is therefore increased volumes rather than unit costs which are all in-line with our RIIO-1 outturn costs or other benchmarks.

Downward Drivers

Our delivery strategy ensures lower delivery costs by bundling site electrical system upgrades with control system work. This alignment of outages and contractor resource reduces the overall cost to deliver, and minimises the impact of electrical outages on our sites.

Additional efficiencies in this area are driven through our business change programme “Richmond”. Better asset data, enhanced planning tools and a sharp focus on unit costs all enable lower overall cost of delivery through enhanced, longer term delivery contracting.

Table of Contents

1. Summary Table

Name of Scheme/Programme	*Electrical Assets*
Primary Investment Driver	*Asset Health*
Scheme reference/ mechanism or category	*A22.20*
Output references/type	-
Cost	*£28.5m*
Delivery Year	*2022-2026*
Reporting Table	*3.03b*
Outputs included in RIIO-1 Business Plan	-

2. Introduction

2.1. The Electrical Infrastructure provides power to enable the safe operation of sites across the NTS. Most assets within the gas transmission system rely on an electrical supply to fulfil their function or are protected by equipment that requires an electrical supply. Key components of this asset include Standby Power Supplies that ensure critical services are powered should an electrical outage happen, HV Switchgear and Transformers which supply high voltage machines such as Compressor Electric Drives, LV Switchboards and Distribution that provide power to equipment across the sites, Standby Generators that provide the only means of site power should a longer-term electrical outage occur, Site Lighting to illuminate the site and support safe work activities and Site Electrical Systems that provide general power across the site.

Structure of the Case

2.2. This document summarises the justification for the required investment in the electrical infrastructure assets installed on the High-Pressure Gas NTS. All the assets have been assessed using a consistent, overall, risk-based analytical framework.

2.3. The investment case for Electrical Infrastructure investment is organised into two groups of assets: 1, Standby Power Supplies and 2, Site Electrical Assets comprising:

- HV Switchgear and Transformers
- LV Switchboards and Distribution
    - Standby Generators
    - Site Lighting
    - Site Electrical Systems

2.4. The groups enable the assets with similar drivers, purpose and impacts to be discussed and assessed collectively.

2.5. For each group of assets, the following structure has been followed:

- **Equipment summary** – a summary and profile of the asset base
- **Problem statement** – the issues facing the assets, drivers for investment and impact of no investment
- **Probability of failure and Consequence of Failure** – the way the assets fail and the subsequent stakeholder impacts
- **Options considered** – the potential mix of interventions to be considered for each of the assets within a range of programmes with differing objectives
- **Business case outline and discussion** – the preferred programme option and reasons, given the cost benefit analyses and assessment of other drivers, stakeholder requirements and business objectives
- **Preferred option scope and plan** – the final selected option restated, along with the spend profile

Overview of the Electrical Infrastructure Asset

2.6. The electrical infrastructure provides power to enable the safe operation of all sites across the NTS. Most assets within the gas transmission system rely on an electrical supply to fulfil their function or are protected by equipment that requires an electrical supply.

2.7. Many of these functions are of a critical nature for safety and for compliance with legislation. In these instances backup power supplies may also be required. Many systems are also deemed critical for the continuing supply of gas.

2.8. The main installations of Electrical Infrastructure assets in use across the NTS consists of the following:

- **Standby Power Supplies** – utilise batteries to maintain the supply of electricity to essential safety and control systems in the event of a failure of the Public Electricity Supply (PES). This is done for either the time that the standby generator takes to start or to maintain essential systems for a specified period and facilitate a safe shutdown of compressors
- **HV and LV Switchboards, Transformers and Distribution** – provide the ability to control, switch and isolate electrical power and distribute it across the site at the correct voltage
- **Standby Generators** – provide power to the site in the event of failure of the PES for the duration of the outage
- **Site and Cab Lighting** – provide a safe working environment and enhance security of the site
- **Site Electrical Systems** – comprise the remaining electrical and auxiliary systems on sites as well as earthing and lightning protection

2.9. All the infrastructure must be designed, maintained and operated in a safe manner in accordance with the Electricity at Work Regulations (EAWR). They must also be complaint with BS7671 - IET wiring regulations at the time of installation and throughout their life. In addition to these standard requirements the electrical equipment on a gas site is captured by Dangerous Substances and Explosive Atmosphere Regulations (DSEAR) which zones sites into hazardous areas with specific compliance requirements for each zone. Some, but not all, of the electrical systems on a site fall within zones covered by DSEAR many are within safe areas. Regular testing must take place of electrical assets against both the IET wiring regulations and DSEAR (for equipment within these designated zones) and if on testing a failure is found, interventions need to take place based on response standards.

2.10. Depending upon the type of asset, its location, function and method of failure the remediation action can range from immediate isolation and inability to use, through urgent repair, programmed repair/refurbishment/replacement to increased inspection. The IET outlines three response codes to which National Grid will align:

- C1 – Danger present. Risk of injury. Immediate remedial action required.
- C2 – Potentially dangerous – urgent remedial action required

- C3 – Improvement recommended.

2.11. The electrical infrastructure is essential to the safety of the of the site in that it powers all the control and safety systems and facilitates the safe shutdown of sites and compressors in the event of an emergency. It is therefore essential to comply with PM84 HSE / ISO21789 Control of Risk around Gas Turbine Enclosures.

2.12. Most of the electrical assets were installed at the time that the sites were built and as such are reaching the end of their lives, as evidenced by increasing defects and failures. Typical issues affecting these assets are individual component failures, corrosion of enclosure, insulation failures due to age, obsolescence, unsafe means of isolation, asbestos in switchgear, non-compliance with current safety standards, multiple failures and unreliability and maintenance difficulties due to poor design and being difficult to work on. The switchgear and distribution assets are in some cases non-compliant with the EAWR (Electricity at Work Regulations) and the IET (Institute of Electrical Engineers) wiring regulations. Some of the assets that are in hazardous area zones subject to DSEAR are also becoming non-compliant.

2.13. Single failures can affect specific elements of a site such as tripping a compressor. They do not often affect the whole site due to the level of redundancy, however, the more failures that occur the more it increases the probability of this occurring.

2.14. The standby generators in some cases do not meet current emission standards, have elements that are obsolete and are suffering deterioration due to corrosion.

2.15. The UPSs (Uninterruptable Power Supply) and DC Chargers within the Standby Power Supplies are shorter life assets and are becoming unreliable due to electronic component failures. They are also often unrepairable due to obsolescence or original design, significantly increasing repair and restoration times, this is particularly affecting the UPSs. In addition, the current batteries within these systems have a finite life of approximately 8 years for a VRLA (Valve Regulated Lead Acid) battery and 20 years for a NiCad (Nickel Cadmium) battery. National Grid has both types installed in large numbers. Some VRLAs will require replacement twice during the RIIO-2/3 period of 10 years.

2.16. The investment proposed in the period is to undertake a pro-active, risk-based and managed programme of refurbishment and replacement of the electrical infrastructure assets. This is combined with single targeted Investments to resolve issues on specific assets.

Standby Power Supplies (UPSs/Chargers/Batteries) (£5.2m)

3. Standby Power Supplies - Equipment Summary

3.1. Standby Power Supplies maintain operational status or provide a controlled shutdown in the event of a loss of electrical supply. UPSs and Battery chargers, with batteries, maintain a continuous electrical supply to essential systems typically Fire and Gas, Control and Instrumentation, Telemetry, communications, security systems, and auxiliary power loads. They provide support to essential systems and equipment in the following failure events:

- Complete Public Electricity Supply (PES) or standby generator failure.
- The period it takes from PES failure to the generator re-supplying the LV (Low Voltage), this is critical to prevent a gas compressor from tripping out and venting gas.
- Maintain essential systems for a specified period and facilitate safe shutdown.

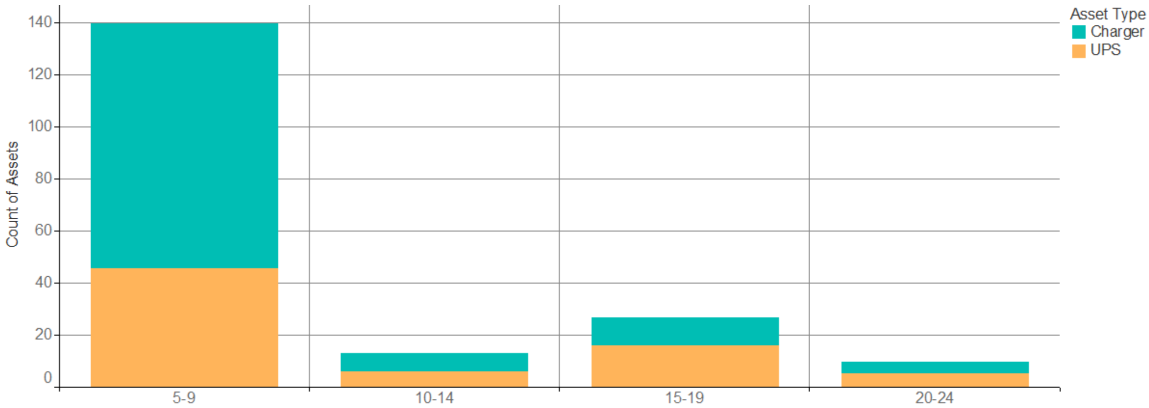
Location and Volume

3.2. Standby power supplies are installed on approximately 183 gas transmission sites with 439 standby power systems installed of various sizes ranging from 1 kVA to 60 kVA.

Age Profile

3.3. The graph below shows the current age profile of the UPS and Chargers at 2019.

Current Age Profile of the UPS and Chargers



Redundancy

3.4. The design of the Standby Power Supply systems is based on the function of the systems that they are supplying such as the site control system, unit control system or the fire and gas system etc. There are 2 types of system installed on the NTS, the design and type of the system is based on the function and the load being supplied:

3.5. For UPS systems with an output of up to 25kVA industrial modular rack-type systems shall be used with n+1 redundancy. These consist of individual rectifier, inverter and static switch modules within a rack type base and can be hot swapped in case of failure.

3.6. For UPS systems with an output above 25kVA conventional dual systems shall be used. These are non-modular in construction and cannot be hot swapped in the event of failure.

4. Standby Power Supplies - Problem Statement

4.1. The Standby Power Supply assets have been historically unreliable due to the nature of the components installed and the environment in which they are installed. Electronic components are sensitive to moisture, dirt and temperature. National Grid sites, particularly AGIs, are not air conditioned data centres but small kiosks or buildings with natural ventilation. The assets also have key elements that are now obsolete, significantly increasing repair and restoration times; this is particularly affecting the UPS and battery charger. In addition, the current batteries within these systems have a finite life of approximately 8 years for a VRLA (Valve Regulated Lead Acid) batteries and 20 years for a NiCad (Nickel Cadmium) batteries.

Drivers for Investment

4.2. The key drivers for investment in the Standby Power Supply assets are:

- Asset Age
- Asset Deterioration
- Obsolescence
- Legislation

4.3. The assets deteriorate over time and with use, which leads to their inability to perform their required function. This can also result in them no longer complying with direct legislative requirements such as EAWR.

Age – the batteries installed in the UPSs have a finite life before they fail to hold enough charge to be able to perform their function. Depending upon the type of battery this is 8 years for a VRLA batteries and 20 years for a NiCad batteries.

Deterioration – The assets deteriorate with age and become increasingly unreliable and unable to perform their duty. Increasing defects and failures are being recorded on these assets. The more modern installations with electronics suffer from random module failures from an early age. These are further increased due to moisture and dirt ingress because of the environment in which they are installed. They are reaching high levels of failure before 15 years of age. This is consistent with our experience on other electronic assets such as control systems. The older non-modular, thyristor switched assets are in some cases more reliable and can last for longer, up to approximately 25 years.

Obsolescence / Unrepairable – some of the older none modular units are becoming obsolete and typically cannot be repaired when they fail. The more modern module based systems can be repaired but are less reliable.

Legislation – The UPS and charger assets are subject to EAWR and require to be inspected and tested on a regular basis with appropriate remediation actions undertaken. Depending upon the type of asset, its location, function and method of failure the remediation action can range from immediate isolation and inability to use, through urgent repair, programmed repair/refurbishment/replacement to increased inspection.

Impact of No Investment

4.4. Lack of investment in the Standby Power Supply assets will decrease their reliability and increase the number of failures found on inspection. This will lead to their inability to perform their required function and to an increased number of short term repairs to fix failures that are found. Lack of investment in batteries would result in them becoming unusable at their finite life beyond which they hold zero charge and cannot carry out their function.

4.5. No back up supply for essential systems meaning that any loss of supply will cause instant shutdown of all or parts of the station including loss of gas safety/quality and metering systems and back up motors. This may lead to such consequences as gas out of specification and breach of statutory requirements or gas not being metered and breach of statutory requirements. UPS/charger failures have resulted in damage to downstream equipment from spikes and surges that occur when the modular rectifiers or inverters fail.

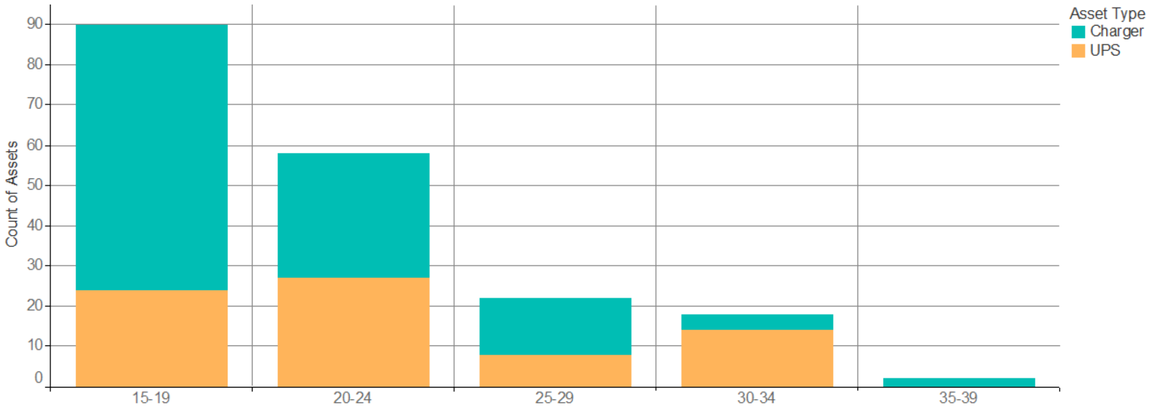
4.6. The risk of damage to compressor units and the associated safety implications mean that Compressor units cannot be started without the presence of an operating Standby Power Supply system. Also, should the safe shutdown system fail whilst the compressor is running then it will immediately trip.

4.7. Operating a compressor without the Standby Power Supply system would in the event of a failure of the main power supply cause instantaneous stop of all the support systems. This would lead to significant consequences such as, significant damage to gas turbines due to loss of back up oil pumps, potential flammable gas mixtures present due to loss of ventilation fans and gas detection systems.

Asset Age

4.8. The charts below show the age profile of the UPS and charger assets by the end of RIIO-3 given no investment. Many assets will be more than 20 years old. By the end of RIIO-3, over 60% will be greater than the design lives of 15 to 20 years old.

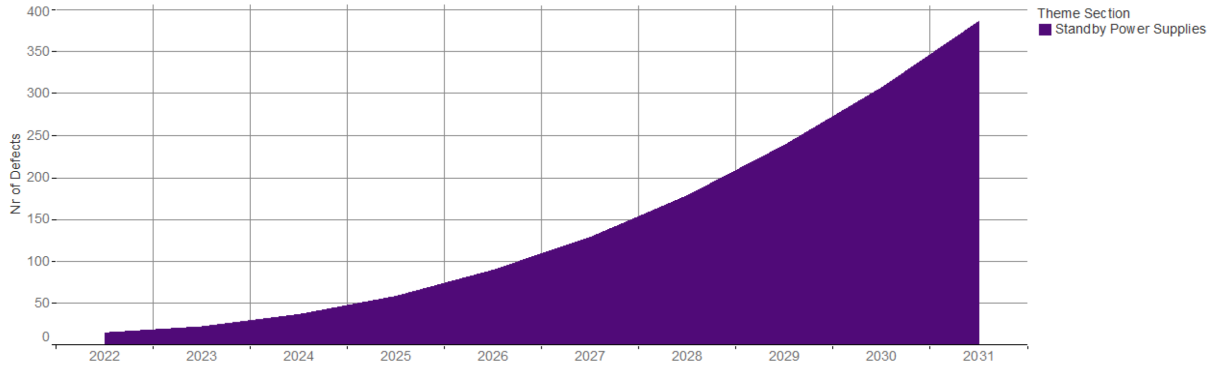
Age Profile of UPS and Chargers by End of RIIO-3 – No Investment



Defects

4.9. The chart below shows the predicted defects for Batteries/UPS/Chargers for safe shut down with no investment. This is based on the current levels of defects recorded in Ellipse projected forward using our NOMs methodology deterioration models.

Predicted Defects – No Investment



Desired Outcomes

4.10. The desired outcomes for the investment during the period are to:

- Ensure Standby Power Supply systems are not a cause affecting the availability, safety and performance of the compressors and AGIs.
- Ensure that all batteries meet the required autonomy for the systems that they support
- Ensure that the UPSs and DC Chargers meet acceptable reliability rates. Defect rates on National Grid sites should be no higher than the manufacturers overall Mean Time Between Failure (MTBF) figures.
- Undertake the inspection, testing and risk based remediation to ensure continued legal compliance against all relevant legislation.

Example of the Problem

4.11. At the Teesside AGI the UPS failed internally and couldn't be repaired despite two visits from the manufacturer. The failure of the UPS damaged several expensive downstream gas quality devices. It is not clear why this happened but may have been caused by a voltage spike resulting from the UPS internal failure. National Grid has several of this type of UPSs around the network and others have now also failed. This type of unexpected failure results in an extended period without backup protection (due to the manufacturing lead time for a replacement standby power system) which may result in out of specification gas, lack of metering, loss of control of valves or odourising plant.

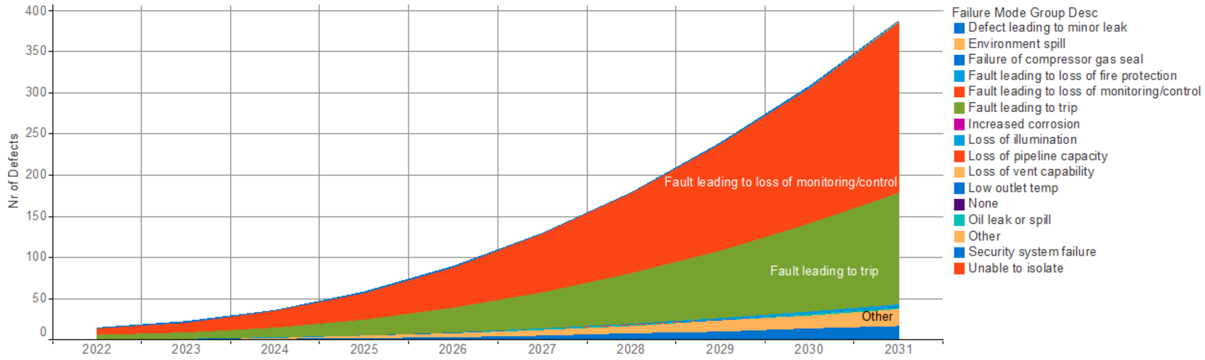
Spend Boundaries

4.12. The proposed investment includes all Standby Power Supply systems on the NTS, including any 'no-regrets' site investments at both St Fergus and Bacton to keep them safe and operational whilst the separate funding mechanism for the proposed projects are progressed via Uncertainty Mechanisms.

5. Standby Power Supplies - Probability of Failure

5.1. The chart below shows the equipment failure mode frequency of failure for batteries/UPS/Chargers assets representing the probability of failure predicted for a no investment scenario using our NOMS methodology.

Predicted Defects by Failure Mode – No Investment



5.2. The chart shows that the failure modes that contribute most to the failure of these assets are:

- Fault leading to loss of monitoring/control
- Fault leading to trip

Interventions

5.3. All Electrical interventions are defined as consequential Interventions. This is because the prime function of an Electrical asset is to allow a whole site to operate and perform its prime function of safely and reliably transporting gas, and to protect employees and the public. All risk benefits associated with Electrical assets are therefore considered to align with the following definition of a Consequential risk intervention:

"Any intervention on a network asset, or other infrastructure asset, that modifies the probability of failure, or consequence of failure of another network asset. A consequential asset can include, for example:

installation or removal of physical infrastructure designed to prevent damage to adjacent assets in the event of an asset failure (e.g. installation of a blast wall),

addition or disposal that increases or decreases the resilience of a local or regional network and hence modifies the consequence of failure of other asset(s) in the locality or region."

Consequential Interventions

5.4. The table below shows the drivers for Electrical asset investment that are defined as Consequential Interventions.

NARMS Intervention

NARMs Asset Intervention Category	Secondary Asset Classes
Consequential Interventions (Non-risk tradeable)	Electrical - safe shutdown

5.5. Our NOMs Methodology attempts to model the indirect benefits delivered by these assets in terms of the reduction in Probability of Failure (PoF) or Consequence of Failure (CoF) upon a related and/or adjacent asset (e.g. the relationship between the present reliable electrical system and a potential asset/site outage). These quantified, but indirect, impacts are used within the CBAs accompanying this justification report, but are not considered to be reliable enough for use as a NARMs monetised risk metric.

Electrical Interventions

5.6. The interventions in standby power supplies are shown in the table below:

Electrical Interventions by category

Intervention	SAC	Intervention Category
A22.20.2.1 / Batteries NiCad - Replacement	Electrical - safe shutdown	Replacement
A22.20.2.10 / Piller Rotary UPS - Major Refurb	Electrical - safe shutdown	Major Refurbishment
A22.20.2.11 / Piller Rotary UPS - Minor Refurb	Electrical - safe shutdown	Minor Refurbishment
A22.20.2.12 / Piller Rotary UPS - Replacement	Electrical - safe shutdown	Replacement
A22.20.2.13 / UPS - Large - Major Refurb	Electrical - safe shutdown	Major Refurbishment
A22.20.2.14 / UPS - Large - Minor Refurb	Electrical - safe shutdown	Minor Refurbishment
A22.20.2.15 / UPS - Large - Replacement	Electrical - safe shutdown	Replacement
A22.20.2.16 / UPS - Small - Major Refurb	Electrical - safe shutdown	Major Refurbishment
A22.20.2.17 / UPS - Small - Minor Refurb	Electrical - safe shutdown	Minor Refurbishment
A22.20.2.18 / UPS - Small - Replacement	Electrical - safe shutdown	Replacement
A22.20.2.2 / Batteries VRLA - Large System - Replacement	Electrical - safe shutdown	Replacement
A22.20.2.3 / Batteries VRLA - Small System - Replacement	Electrical - safe shutdown	Replacement
A22.20.2.4 / DC Charger - Large - Major Refurb	Electrical - safe shutdown	Major Refurbishment
A22.20.2.5 / DC Charger - Large - Minor Refurb	Electrical - safe shutdown	Minor Refurbishment
A22.20.2.6 / DC Charger - Large - Replacement	Electrical - safe shutdown	Replacement
A22.20.2.7 / DC Charger - Small - Major Refurb	Electrical - safe shutdown	Major Refurbishment
A22.20.2.8 / DC Charger - Small - Minor Refurb	Electrical - safe shutdown	Minor Refurbishment
A22.20.2.9 / DC Charger - Small - Replacement	Electrical - safe shutdown	Replacement
A22.22.4.23 / UPS - Large - Minor Refurb (St. Fergus)	Electrical - safe shutdown	Minor Refurbishment
A22.22.4.24 / UPS - Large - Major Refurb (St. Fergus)	Electrical - safe shutdown	Major Refurbishment
A22.22.4.25 / UPS - Large - Replacement (St. Fergus)	Electrical - safe shutdown	Replacement
A22.22.4.26 / DC Charger - Large - Minor Refurb (St. Fergus)	Electrical - safe shutdown	Minor Refurbishment

A22.22.4.27 / DC Charger - Large - Major Refurb (St. Fergus)	Electrical - safe shutdown	Major Refurbishment
A22.22.4.28 / DC Charger - Large - Replacement (St. Fergus)	Electrical - safe shutdown	Replacement
A22.22.4.29 / Batteries VRLA - Large System - Replacement (St. Fergus)	Electrical - safe shutdown	Replacement
A22.22.4.30 / Batteries NiCad - Replacement (St. Fergus)	Electrical - safe shutdown	Replacement

Data Assurance

5.7. All PoF and CoF values are taken from the National Grid Gas Transmission 'Methodology for Network Output Measures' (the Methodology). The Methodology was originally submitted for public consultation in April 2018, with three generally favourable responses received in May 2018. On this basis, Ofgem were happy to provisionally not reject the Methodology pending further work to:

- Produce a detailed Validation Report, confirming the validity of data sources used in the Methodology
- Test a range of supply and demand scenarios and incorporate an appropriate scenario to best represent Availability and Reliability risk

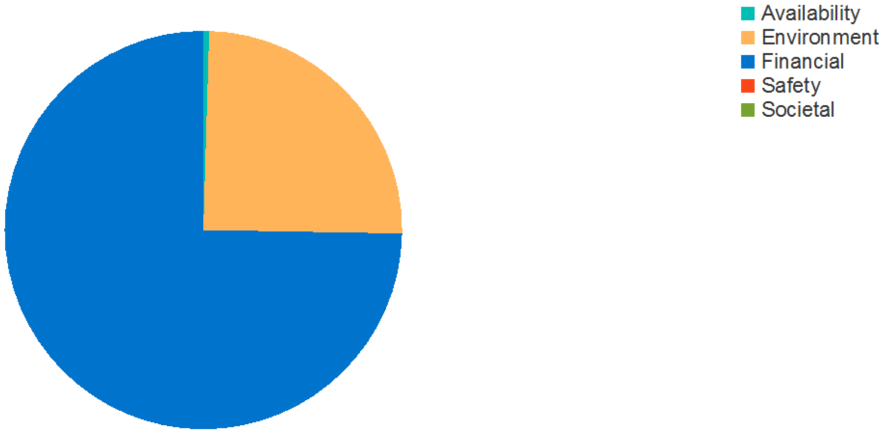
5.8. A review of the Methodology by independent gas transmission experts has been carried out and several improvements identified and incorporated.

5.9. At the time of writing, the final Validation Report has been submitted to Ofgem. We understand that once this work is complete Ofgem will formally "not reject" the Methodology and a License change progressed to restate our RIIO-1 targets in terms of monetised risk commenced.

6. Standby Power Supplies - Consequence of Failure

6.1. The chart below shows the expected stakeholder impacts because of failure occurring on the standby power supplies. The chart shows the relative numbers of consequence events, not relative monetised risk.

Stakeholder Impacts – failure of standby power supplies



6.2. There are a vast range of different types of Electrical asset used in the operation of the NTS. Electrical systems are an essential enabler, ensuring that dependent assets can perform their primary function of safely and reliably transporting gas and ensuring NTS resilience. Failure of a single electrical component will not generally have an immediate impact on service, and that a combination of failures may need to occur for a service impact to occur. Despite the variety of electrical assets, there are only two significant failure modes, which apply to standby power supplies:

- **Financial risk** is mostly associated with the costs of operating and maintaining the network at the current level of risk and compliance. The financial risk of non-compliance with legislation, such as DSEAR, are not included but could be significant
- **Environmental risk** is associated with the failure of a range the assets depend upon an electrical system to operate reliably and upon demand, which may cause a subsequent loss of gas through trips, vents and leaks. The carbon emissions associated with the maintenance of assets will contribute to Environmental risk. As there are many electrical assets within our asset maintenance systems, the proportional share of maintenance emissions attributed to electrical assets will be significant

7. Standby Power Supplies - Options Considered

Potential Intervention Options

7.1. The following individual inspection and intervention options apply to the Standby Power Supply assets:

Unplanned Reactive Repair or Planned Proactive Refurbishment – result in similar interventions being applied to the individual components within the assets, these may be like for like replacements or minor upgrades of individual components:

DC power supplies - replace fuses; replace rectifiers; update firmware; replace capacitors; replace cooling fans, upgrade of individual components

Uninterruptible power supplies (AC) - replace rectifiers; replace inverters; replace static switch; replace fuses; upgrade firmware; replace capacitors; replace cooling fans

Battery – replace battery with equivalent

Replacement – applies to larger elements of the Standby Power Supply systems and can include:

- New UPS/Charger
- Battery upgrade to NiCad
- New bypass transformer
- New bypass switch
- In some cases, the installed capacity can be reduced in the light of actual load requirements.

Intervention Unit Costs

7.2. The total RIIO-2 investment for Standby Power Supplies represents 18% of the Electrical investment theme. The unit costs that support this investment are entirely developed using historical outturn costs, however these have yet to be verified.

7.3. The table below provides the unit costs for all the potential standby power supply interventions.

Intervention Unit Costs - Standby Power Supplies

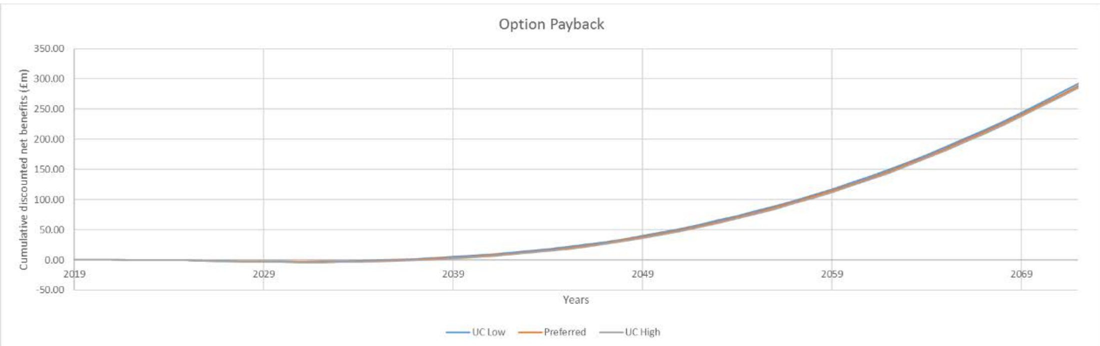
Intervention	Cost (£)	Unit	Evidence	Data Points	Overall value in BP
Standby Power Supplies					
A22.20.2.17 / UPS - Small - Minor Refurb	[redacted]	Per asset	Outturn	1	£0
A22.20.2.16 / UPS - Small - Major Refurb	[redacted]	Per asset	Estimated - Other	0	£0
A22.20.2.18 / UPS - Small - Replacement	[redacted]	Per asset	Outturn	1	£8,353
A22.20.2.14 / UPS - Large - Minor Refurb	[redacted]	Per asset	Estimated - Other	0	£4,652
A22.20.2.13 / UPS - Large - Major Refurb	[redacted]	Per asset	Outturn	1	£0

A22.20.2.15 / UPS - Large - Replacement	[redacted]	Per asset	Outturn	1	£1,592,209
A22.20.2.11 / Piller Rotary UPS - Minor Refurb	[redacted]	Per asset	Outturn	1	£0
A22.20.2.10 / Piller Rotary UPS - Major Refurb	[redacted]	Per asset	Outturn	1	£185,500
A22.20.2.12 / Piller Rotary UPS - Replacement	[redacted]	Per asset	Outturn	1	£257,639
A22.20.2.8 / DC Charger - Small - Minor Refurb	[redacted]	Per asset	Outturn	1	£0
A22.20.2.7 / DC Charger - Small - Major Refurb	[redacted]	Per asset	Estimated - Other	0	£0
A22.20.2.9 / DC Charger - Small - Replacement	[redacted]	Per asset	Outturn	1	£84,057
A22.20.2.5 / DC Charger - Large - Minor Refurb	[redacted]	Per asset	Outturn	1	£0
A22.20.2.4 / DC Charger - Large - Major Refurb	[redacted]	Per asset	Estimated - Other	0	£0
A22.20.2.6 / DC Charger - Large - Replacement	[redacted]	Per asset	Outturn	1	£1,269,645
A22.20.2.1 / Batteries NiCad – Replacement - System	[redacted]	Per asset	Outturn	1	£962,418
A22.20.2.3 / Batteries VRLA - Small System - Replacement	[redacted]	Per asset	Outturn	1	£45,500
A22.20.2.2 / Batteries VRLA - Large System - Replacement	[redacted]	Per asset	Outturn	1	£827,424

Unit Cost Sensitivity

7.4. We have used the potential range of unit cost variance to assess the sensitivity of the Cost Benefit Analysis to the upper and lower limits. The graph below shows the results of this compared to the preferred option.

Net Benefits of Upper and Lower Unit Cost Sensitivity



7.5. Whilst the level of cost benefit and the payback period changes as the unit costs vary, the investment remains cost beneficial across the range of unit costs.

8. Standby Power Supplies - Programme Options

Programme Option Overview

8.1. Our aim in developing the investment plan is to deliver value to our consumers and stakeholders. Hence, we have considered a range of options from the do nothing position through to reductions in risk across all measures. These have been used to explore the credible options for varying the investment and appraising the impact on our legal compliance, risk position and stakeholders.

8.2. In developing our plan, the following options have been considered for investment in the standby power supply assets. Please note that all programme options include any fixed 'no-regrets' investments associated with the Bacton and St Fergus sites.

Baseline – Do Nothing

8.3. The impact of no investment in our Standby Power Supplies assets increases service risk over a 10-year period, the most significant impact being a ten-fold increase in the number of fatalities every year, with an eight-fold increase in the potential number of outages, the volume of gas emissions and number of disruptions to major transportation infrastructure, occurring every year. This option includes the reactive only investment across all Standby Power Supply assets and is the option against which all the other options are compared.

Programme Option 1 – Fix on Fail

8.4. This option undertakes minimal reactive minor refurbishment to the assets as and when they fail. No proactive replacement is undertaken with only the minimal amount of either minor or major refurbishment work to restore operation and compliance.

The age driven replacement of the batteries across all the standby power supply assets is included within this and all other options. There is no option other than to undertake this work as the useful life of the batteries is age related.

Programme Option 2 – Minimal Proactive Re-lifing

8.5. This option considers minimal proactive re-lifing with only the oldest assets fully assessed and considered for replacement investment. All other assets are fixed on failure / non-compliance with the minimal amount of either minor or major refurbishment work undertaken to restore operation and compliance.

As with the other options, the age driven battery replacement is included for all relevant batteries within this option.

Programme Option 3 – Risk Based Re-lifing

8.6. This option considers risk based re-lifing of the assets based on their performance, criticality, condition and age compared to design life. A whole life cost decision on replacement or minor / major refurbishment is then made. There is some allowance for reactive fix on fail which will consist of the most appropriate minor / major refurbishment or replacement.

As with the other options, the age driven battery replacement is included for all relevant batteries within this option.

Programme Option 4 – Increased Proactive Re-lifing

8.7. This option considers increased proactive re-lifing based on asset age with all assets considered for replacement before the end of their design life. A reduced allowance for fix on fail is included for some assets which fail earlier in their lifecycle.

As with the other options, the age driven battery replacement is included for all relevant batteries is included within this option.

Programme Options Summary

8.8. In considering the CBA for each of the programme options, a summary of all the potential programme options is provided in the table below.

Potential Programme Options

Option	RIIO-2 Invest' £ m	RIIO-3 Invest' £ m	PV Costs £ m	PV benefits £ m	Net NPV £ m	CB Ratio	Payback Period (years)
1 - Fix on Fail	£3.34	£10.46	£19.00	£510.28	£491.28	26.86	8
2 - Minimal Proactive Re-lifing	£4.14	£12.45	£22.42	£397.31	£374.89	17.72	11
3 - Risk Based Re-lifing	£5.23	£15.35	£26.77	£224.56	£197.79	8.39	15
4 - Increased Proactive Re-lifing	£5.87	£17.54	£30.37	£221.55	£191.17	7.29	16

8.9. The graph shows the cumulative discounted NPV of the net benefit for each of the investment options.

Option Payback – Net NPV

Programme Options Selection

8.10. All the potential options are cost beneficial over the 45-year analysis period. The selection of the preferred option has therefore been based on an assessment of the level of risk, maintaining our compliance with legislation and delivering value for consumers and stakeholders. The outcomes associated with each option are provided below:

Programme Option 1 – Fix on Fail

8.11. This option results in increased reactive minor and major refurbishments (i.e. fix on fail) across most of standby power supply asset types. Assets are not worked on until they fail or are deemed non-compliant, so where there is no redundancy there will be an impact on the availability of the compressors and other primary assets. Whilst the safety risk of non-complaint electrical assets is managed through the inspection regime, this option results in more assets that will be found to be non-compliant and require isolation before resolution to return to operation. The overall safety risk from electrical assets is increased.

8.12. Reactive minor and major refurbishment is not a long-term solution for the assets so this option will defer significant replacement expenditure to after RIIO-2 and RIIO-3 and increase the overall whole life costs of the standby power supply assets.

Programme Option 2 – Minimal Proactive Re-lifing

8.13. Whilst re-lifing some of the oldest assets, this option still results in an unacceptable level of impact on the primary assets, disconnection of electrical assets and increases in safety risk. Significant expenditure is still deferred outside RIIO-2 and RIIO-3.

Programme Option 3 – Risk Based Re-lifing

8.14. A risk based re-lifing of the assets through a considered and appropriate mix of proactive major / minor refurbishment and replacement combined with some reactive fix on fail, maintains the levels of safety risk, asset isolations and impact on performance to current levels. There is minimal deferment of expenditure outside the RIIO-2 and RIIO-3 period. This option enables an acceptable level of investment to be maintained across the short and medium terms to manage the level of performance and risk.

Programme Option 4 – Increased Proactive Re-lifing

8.15. Increased proactive replacement and refurbishment reduces the risk of impacting the availability of operational assets and the associated service performance of the NTS. The number of failed assets and isolations to maintain compliance is minimised however this is at the expense of significantly increased investment in RIIO-2 and RIIO-3. This level of investment is unacceptable to stakeholders and results in an unachievable and unacceptable number of outages on the NTS to enable the work to be undertaken.

Preferred Option

8.16. Our preferred option is Option 3 to undertake a risk based approach to re-lifing the standby power supply assets. This will maintain the current level of risk whilst containing future investment to acceptable levels and even though some of the other options require less investment and are modelled to be more cost beneficial, this is only because the CBA does not account for the full range of relevant factors which are relevant to the consumer in the service they receive and to National Grid in terms of the obligations it has with regards to reliability and legislative requirements. In particular the other options do not meet the required outcomes of ensuring:

- Standby power supply systems do not adversely affect the availability, safety and performance of the compressors and AGIs
- All batteries meet the required autonomy for the systems that they support
- The UPSs and DC Chargers meet acceptable reliability rates
- Continued legal compliance against all relevant legislation through undertaking the inspection, testing and risk based remediation.

8.17. Our preferred option is also consistent with feedback from our stakeholder engagement who wanted at least the current level of risk maintained. Our chosen option is the most cost beneficial options that meets the desired outcomes at least whole life cost.

8.18. A complete explanation of the selected option is provided in the next section.

9. Standby Power Supplies - Business Case Outline and Discussion

9.1. In this section, we set out our overall investment plan for Standby Power Supplies. This section demonstrates why the proposed investment levels are the right levels to ensure the health and reliability of these assets for the investment period and beyond.

Key Business Case Drivers Description

9.2. The key drivers for investment in the Standby Power Supply assets are:

- Asset Age
- Asset Deterioration
- Obsolescence
- Legislation

9.3. Considering these drivers ensures that we develop plans that meet our legal obligations to intervene, allows us to manage external risks and obsolescence effectively, and ensures we select the right assets for investment.

Business Case Summary

Outcomes Delivered

9.4. In appraising asset health investment, we have considered how assets can impact on several outcomes:

- Reliability risk
- Environmental risk
- Safety risk
- Impact on the wider society

9.5. Failures of Standby Power Supplies can impact on these outcomes particularly environmental impact. This is through the loss of gas through trips, vents and leaks caused by electrical failure. Emissions associated with the maintenance of assets will also contribute to Environmental impact.

9.6. There is also a financial impact which is mostly associated with the costs of operating and maintaining the network at the current level of risk and compliance.

9.7. Maintaining the health of these assets is important in ensuring they continue to deliver the required network capability. Specific outcomes associated with this investment are:

- Ensure Standby Power Supply systems are not a cause of affecting the availability, safety and performance of the compressors and AGIs.
- Ensure that all batteries meet the required autonomy for the systems that they support
- Ensure that the UPSs and DC Chargers meet acceptable reliability rates. Defect rates on National Grid sites should be no higher than the manufacturers overall MTBF figures.

- Undertake the inspection, testing and risk based remediation to ensure continued legal compliance against all relevant legislation.

9.8. Our proposed investment will ensure that we maintain our low levels of risk across all these outcomes.

Stakeholder Support

9.9. Consumer and stakeholder research and engagement has been integral to the development of our asset health investment plans. Early discussions realised that to engage in meaningful dialogue, our plan outputs should be presented at a programme rather than asset level of detail. This is due to the integrated nature of our Asset Health plan which makes it challenging to disaggregate and engage on individual elements. For details of our stakeholder engagement approach please refer to 'I want to take gas on and off the system where and when I want' [Chapter 14 of the GT submission].

Investment Decision Approach

9.10. To deliver the outcomes for the investment period the Standby Power Supply assets require a mixture of the intervention categories.

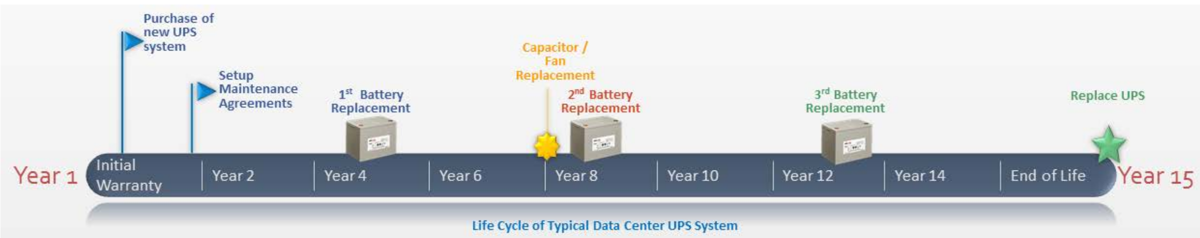
9.11. A comprehensive survey of all the assets has already been carried out and units will be replaced on a priority basis. The decision on the volume of each of the interventions required during the period has been determined using the following methodologies.

9.12. UPS and Chargers

- The overall decision that needed to be taken with respect to UPS' and Chargers is whether to run them to failure or replace / refurbish them as part of a risk based managed programme. The decision to replace / refurbish them in a controlled way has been taken to avoid unexpected outages and failures that cause damage or shutdowns to process equipment.

- The predicted volumes of assets to invest in and type of intervention are based on the age of the assets. Experience shows that UPS and Chargers, due to the limited life of the electronic components, cannot be expected to last much beyond 15 years with many failing before that age. Although terminal failures often occur sooner this lifespan has been decided upon as a reasonable estimate for investment volume purposes. Not all UPS/Charger systems will fail at exactly 15 years but this is a reasonable average of what National Grid has seen over the last 20 years. The manufacturers back this up with their own figures.

Lifecycle of Typical UPS System



- Rotary UPS systems require refurbishment and upgrade. The units are still supported and can be upgraded with new control systems and other modifications to improve performance. An allowance for replacement in due course has been allowed, given that there is 12 years to the end of RIIO-3.

- It is planned that all UPS and Chargers that will be 15 years or older by 2031 will be replaced or refurbished during that period.
- The actual intervention undertaken and their timing will be based on an inspection and risk assessment of each Standby Power Supply system. This assessment will include age, criticality together with any currently known issues such as unreliability, corrosion or obsolescence likely to result in failure, unsafe conditions or non- compliance with legislation.

9.13. The proposed mix of interventions and programme of work will be continually reassessed and reprioritised using the results of the ongoing inspections and any defects identified during the period.

9.14. Batteries - Batteries will not continue to perform their function beyond their lifespan. There is no flexibility on this, once they reach end of life they must be replaced. Batteries will be replaced on a time-based programme that is integrated as far as possible with other work on the UPS. All batteries will be replaced on a like for like basis.

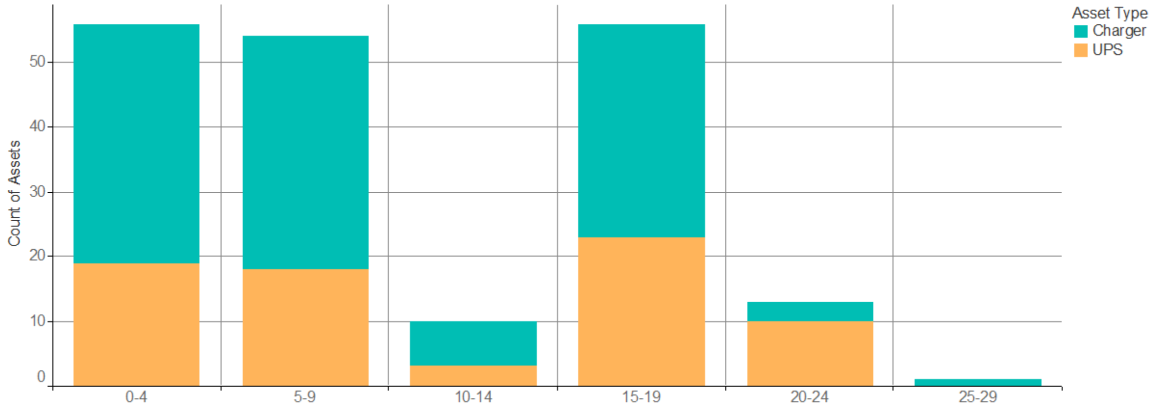
Benefits of the Investment

9.15. The investment will achieve the following improvements in the Standby Power Supply assets.

Asset Age

9.16. The chart below shows the age profile of the UPS and chargers assets after investment.

Age Profile by end of RIIO-3 – UPS and Chargers

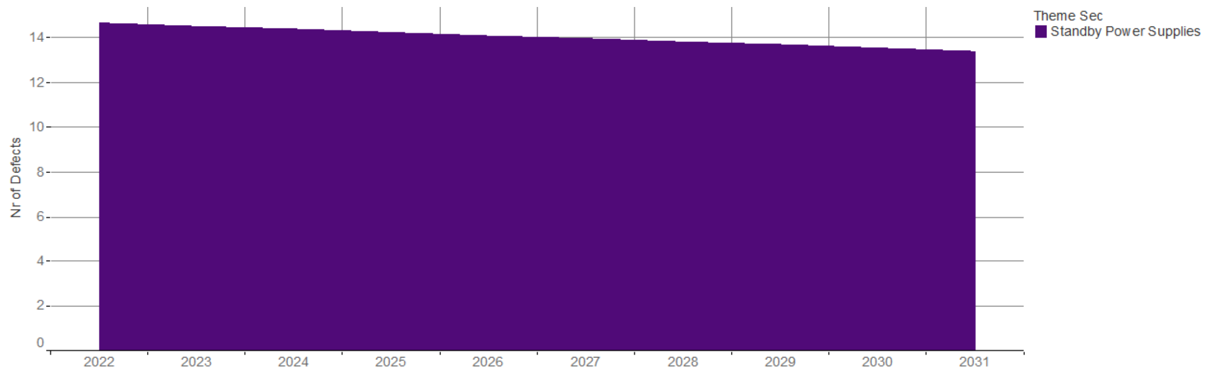


9.17. The average age of UPS assets is reduced from 33 years to 11 years at the end of RIIO-3 and from 31 years to 8 years at the end of RIIO-3 for chargers. This brings the average age inside the design life of 15 years.

Defects

9.18. The chart below shows the predicted defects for batteries/UPS/chargers for electrical safe shutdown with investment.

Predicted Defects with Preferred Investment Option



Preferred Option

9.19. To deliver the required outcomes for all our stakeholders we have developed the most effective combination of efficient interventions. These form the programme of work for the Standby Power Supply assets in the investment period. [redacted]

Volumes for each Intervention

[redacted]

Asset Health Spend Profile

9.20. The profile of investment in the Standby Power Supply assets, driven from the derived volumes of work and the efficient unit costs, for the period is shown is the table below:

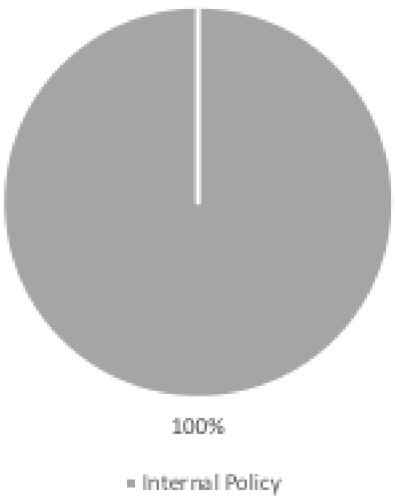
Profile of Investment in Standby Power Supply Assets

Investment (£ 000s)	RIIO-2					RIIO-3				
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Electrical - safe shutdown	239	1,076	589	923	2,410	2,852	4,037	1,957	2,435	4,069
Total	239	1,076	589	923	2,410	2,852	4,037	1,957	2,435	4,069
	5,237					**15,350**				

Intervention Drivers

9.21. The following chart shows the breakdown of investment across each of the intervention drivers. This shows that all of the investment consists of interventions that are based on internal policy.

RIIO-2 Standby Power Supplies Intervention Drivers[1]



Preferred Programme CBA

9.22. We are targeting an appropriate level of asset health investment in standby power supplies to mitigate the reliability, safety and environmental risks from the ageing standby power supply asset base.

9.23. In line with HM Treasury Green Book advice and Ofgem guidance we have appraised whether investment in standby power supplies is value for money. We have considered costs over a 45-year period in a full cost benefit analysis (CBA).

9.24. The CBA for the standby power supply assets is cost beneficial over the 45-year period. The investment pays back in 14 years, and over 45 years is significantly cost beneficial. This is shown below.

Cost Benefit Summary – Standby Power Supplies Investment[2]

[1] See Appendix A for intervention driver category definitions
[2] A14.21.2 Standby Power Supplies CBA

	10 years	20 years	30 years	45 years
Present Value costs (£m)	£6.41	£11.67	£18.62	£26.77
Present Value H&S benefits (£m)	£-	£-	£-	£-
Present Value non H&S benefits (£m)	£2.69	£19.52	£68.56	£224.56
Net Present Value (£m)	£(3.71)	£7.85	£49.93	£197.79

9.25. We have assessed the sensitivity of the Cost Benefit Analysis to the full range of unit costs. The results of this analysis are presented in the Unit Cost section above.

9.26. Whilst the investment is cost beneficial we have challenged whether this is the right programme of work. Standby power supplies are essential to the operation and availability of our compressor units, stations and above ground installations. The proposed investment reduces the risk of impact on availability of the NTS through ensuring the standby power supplies remain operational, without any significant obsolescence impacting on the consequence of any failures. Our programme of investment in replacement and refurbishment is the minimum whole life cost option to maintain the acceptable level of risk.

9.27. The level of investment will ensure we successfully manage asset deterioration and obsolescence, whilst meeting the level of availability from our compressor assets. It will ensure we deliver the outcomes that consumers and stakeholder tell us they want us to meet.

9.28. Across our stakeholders there is little support for keeping the costs the same as in RIIO-1, given the unacceptable consequential increase in risk.

10. Standby Power Supplies - Preferred Option Scope

10.1. The section summarises our preferred investment plan required to deliver acceptable and affordable outcomes for our stakeholders.

Preferred option

10.2. To deliver the required outcomes for all our stakeholders we have developed the most effective combination of efficient interventions. These form the programme of work for the Standby Power Supply assets in the investment period. [redacted]

Volumes for Each Intervention Option

[redacted]

Asset Health Spend Profile

10.3. The profile of investment in the Standby Power Supply assets, driven from the derived volumes of work and the efficient unit costs, for the period is shown is the table below:

Profile of Investment in Standby Power Supply Assets

Investment (£ 000s)	*RIIO-2*					*RIIO-3*				
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Electrical - safe shutdown	239	1,076	589	923	2,410	2,852	4,037	1,957	2,435	4,069
Total	239	1,076	589	923	2,410	2,852	4,037	1,957	2,435	4,069
	5,237					**15,350**				

Delivery Planning

10.4. At this point in time the delivery of our RIIO-2 and RIIO-3 plans are in principle deliverable based on initial assessments of work. We will regularly review the plan to consider any known or changing constraints, customer impacts and bundling opportunities. In the event of churn our plan must be reoptimised to reflect the impact of the change, and provide an opportunity to reconsider the efficient timing of delivery.

10.5. The availability of outages is extremely limited across most of the NTS due to the radial nature of the network. It is therefore most efficient from both financial and network risk points of view to bundle investment across asset classes within the same outage period. This maximises the work undertaken in any outage whilst ensuring efficient delivery through minimised project overheads.

10.6. These assets are likely to require outages as the associated plant will not be available during interventions, however this may not be the full isolation and venting that is required with other primary plant types. Where asset interventions do not require outages then the campaign approach will still be applied to maximise the opportunity for delivery of the same type of work across many locations. This enables efficient procurement through significant volumes of common works.

10.7. This approach is particularly effective when applied at a feeder level or for a whole site. In which case the preparatory inspection, investigation, risk assessment, planning and procurement activities can be completed as far as possible before the outage. This allows the maximum amount of intervention and risk reduction to be bundled into a single ‘campaign’ across the length of the feeder. During RIIO-1 this has proved to be an extremely efficient and effective approach to delivery of our programmes of work.

10.8. We recognise that whilst this is in many cases the most efficient method of delivery there are still individual or groups of assets that present a risk to our performance that do not ‘fit’ into the planned ‘campaign’ approach. We will ensure that these risks are remediated as efficiently as possible through individual or small groups of targeted interventions.

10.9. Where asset interventions do not require outages then the campaign approach will still be applied to maximise the opportunity for delivery of the same type of work across many locations. This enables efficient procurement through significant volumes of common works.

Site Electrical Assets (£23.2m)

Overview

11. Site Electrical Assets - Equipment Summary

11.1. There are a wide range of assets that are covered by the electrical asset category. To explain their purpose, it is necessary to break them down into areas.

Main Power Supplies - includes the following assets:

- High Voltage (HV) Switchboards, Isolators and Ring Main Units (RMU),
- Power Transformers,
- Standby Generators, Main Low Voltage Switchboards.

11.2. These assets take the mains power from the Distribution Network Operator (DNO) and supply it to the various parts of a gas transmission site, transforming the voltage from high voltage to low voltage and providing isolation, control and protection functions. If the mains power supply is lost, then a standby generator is provided on terminals and compressor stations and on a few of the larger Above Ground Installations (AGI). Some sites are supplied at a high voltage (11kV and above) and some at low voltage (400 or 230V).

Electrical Distribution - takes the mains power and supplies it to individual items of equipment. The assets covered are

- Motor Control Centres (MCC),
- Switchboards and Distribution Boards.
- This also includes Direct Current (DC) MCCs and Switchboards.
- Process Equipment and Building Services - includes
    - Lighting
    - Heating
    - HVAC
    - Small Power
    - Control Panels.
- Safety and Auxiliary Equipment – includes:
    - Earthing,
    - Lightning Protection Systems
    - Static and Surge Protection

11.3. All the above areas also include cabling and wiring but this is generally considered to form part of the associated asset and is usually tested and replaced with that asset.

11.4. Cabling and wiring is usually tested and replaced with the main asset; however, in some instances it may be necessary to separately upgrade a site cabling system where it has failed its regular tests or failed in service.

Location and Volume

11.5. There is a large suite of electrical systems that have the added complication that many are located on small unmanned sites making maintenance and project work difficult with large extra logistical costs. There are 23 sites which operate compressors with high volumes of equipment on each; 215 other installations with smaller asset levels but geographically spread throughout the UK.

Overall Asset Volumes

System Type	Volume
HV Switchgear	18 Systems
Transformers	20
LV switchboards/MCCs	120
Distribution Boards	450
Standby Generators	35
Lighting	215 Systems
Floodlight Installations	50
Lighting Columns	1,500 to 2,000
Internal lighting/emergency lighting	70 Systems
AGI Electrical Systems	215 Systems
Earthing and Lightning Protection	24 Systems
Auxiliary and Other Systems	70 Systems

11.6. The overall asset is a complex process installation which involves many different types of equipment and hence many types of electrical supply from High Voltage high power to extra low voltage High voltage from 1000V to 132KV AC; Low voltage from 50V to 1000VAC and extra low voltage below 50VAC and DC voltages from 24 up to 110). In addition, some assets are located within hazardous areas and need to be designed, installed, tested and maintained in accordance with the DSEAR requirements to manage the risk of fires and explosions.

Impact of No Investment

11.7. The overall effect of not investing will be a gradual deterioration of the electrical asset base. Some equipment is already at the point of failure so would have to be isolated to make it safe or removed if necessary.

11.8. Almost all the equipment connected to the gas transmission network is dependent on an electrical supply, even the pipelines require an electrical supply for the corrosion protection system to operate; therefore, it is a requirement of the NTS that the electrical system is kept operational, safe and compliant. The impacts of unavailability of the electrical supply are many and varied:

- Safety Risks
- Non-compliance against DSEAR and EAWR
- Electrical including standby generator
    - Loss of Unit;
    - Loss of illumination (including emergency);

    - Loss of Control and monitoring;
    - Loss of mains electrical supply to site;
    - Loss of standby power;
    - Failure to control or monitor;
- Loss of earthing & /or Lightning protection systems;
    - Lightning strike causing injury; loss of life; or serious damage to equipment.
    - Dangerous voltages present on equipment and failure of protection devices to operate due to loss of earth connection.

Short Term:

- Shutdown of safety and control systems
- Potential isolation of non-compliant system in DSEAR/ATEX zones to prevent potential gas explosion due to sparks or overheating of electrical equipment.
- Tripping of compressor units
- Valve control/movements unavailable
- Loss of gas quality and gas metering equipment.

Long Term:

- Cathodic protection system unavailable leading to increased pipe corrosion and potential gas escape.

11.9. The effect of isolating equipment due to faults or non-compliance varies depending on the asset in question but is likely to result in the unavailability of process equipment which would in turn mean that the gas supply on the NTS may be disrupted.

Overall Intervention Options

11.10. The general categories of intervention that have been considered for the Electrical Assets and Standby generators include:

Repair - The principle of repair is to replace or restore parts that fail as they fail or after routine tests identify deficiencies. This is only possible up to a point - if equipment has failed seriously or is obsolete then repair is not possible.

Refurbishment - The principle of refurbishment is to replace key parts that will allow the equipment to continue operating safely and reliably. This means extending the life of the equipment to a certain extent. i.e. giving an extra 5-10 years of operation.

Replacement - The principle of replacement is when the asset is considered unsafe or can no longer be operated or where spare parts are no longer available. Replacement would be of whole sub-asset types and effectively renew that asset to the design life.

Overall Delivery Planning

11.11. At this point in time the delivery of our RIIO-2 and RIIO-3 plans are in principle deliverable based on initial assessments of work. We will regularly review the plan to consider any known or changing constraints, customer impacts and bundling opportunities. In the event of churn our plan must be reoptimised to reflect the impact of the change, and provide an opportunity to reconsider the efficient timing of delivery.

11.12. We recognise that many of our asset classes are co-located across the NTS pipe network and sites. Much of our investment delivery also requires outages of the associated pipelines or plant and equipment. The availability of outages is extremely limited across most of the NTS due to the radial nature of the network. It is therefore most efficient from both financial and network risk points of view to bundle investment across asset classes within the same outage period. This maximises the work undertaken in any outage whilst ensuring efficient delivery through minimised project overheads.

11.13. These assets are likely to require outages as the associated plant will not be available during interventions, however this may not be the full isolation and venting that is required with other primary plant types. Where asset interventions do not require outages then the campaign approach will still be applied to maximise the opportunity for delivery of the same type of work across many locations. This enables efficient procurement through significant volumes of common works.

11.14. This approach is particularly effective when applied at a feeder level or for a whole site. In which case the preparatory inspection, investigation, risk assessment, planning and procurement activities can be completed as far as possible before the outage. This allows the maximum amount of intervention and risk reduction to be bundled into a single 'campaign' across the length of the feeder. During RIIO-1 this has proved to be an extremely efficient and effective approach to delivery of our programmes of work.

11.15. We recognise that whilst this is in many cases the most efficient method of delivery there are still individual or groups of assets that present a risk to our performance that do not 'fit' into the planned 'campaign' approach. We will ensure that these risks are remediated as efficiently as possible through individual or small groups of targeted interventions.

Structure of the Individual Investment Cases

11.16. The investment case for each of the individual electrical asset type is presented individually in the following sections. For each asset type, there are individual sections:

- **Equipment summary** – which provides a summary and profile of the asset base
- **Problem statement** – the issues facing the assets, drivers for investment and impact of no investment
- **Probability of failure and Consequence of Failure** – sections which set out the way the assets fail and the subsequent stakeholder impacts
- **Intervention options considered** – the potential mix of interventions to be considered for each of the assets

There are then a set of common sections:

- **Business case outline and discussion** – the preferred programme option containing individual asset investment decision methodologies and benefits of investment. Also contained are the reasons for the preferred programme given the cost benefit analyses and assessment of other drivers, stakeholder requirements and business objectives
- **Preferred option and plan** – the final selected option restated, along with the spend profile

LV Switchboards and Distribution

12. LV Switchboards and Distribution - Equipment Summary

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

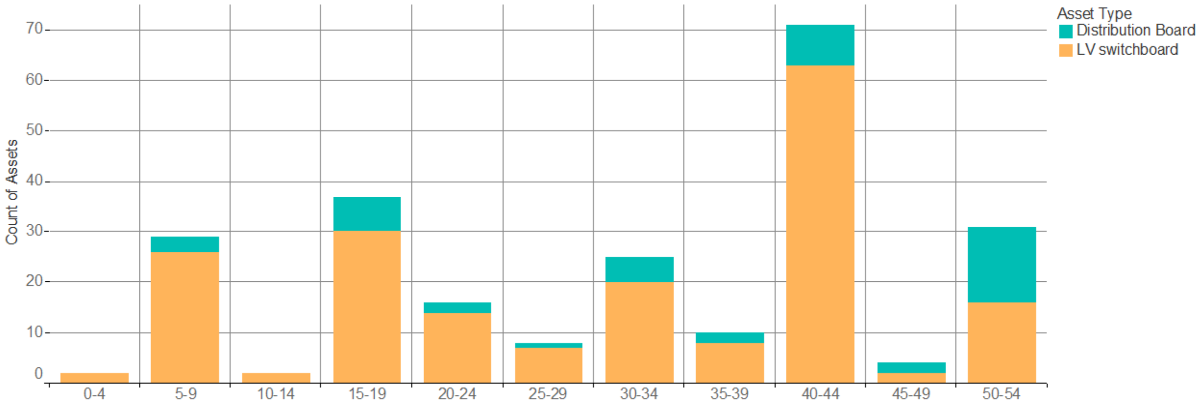
12.2. They are of metal clad construction with a fault rated busbar system and individual incoming and outgoing circuit breakers and/or fuse-switches plus control and instrumentation equipment as required. The boards can be either AC or DC – where the DC are fed from battery chargers for standby power/emergency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

Location and Volume

12.3. There are typically 3 or 4 LV Switchboards on each site leading to 157 permanently installed on sites across the NTS.

12.4. The chart below shows the age profiles for LV switchboards and distribution boards at 2019.

Current Age Profile



Redundancy

12.5. There is typically no redundancy for the main LV switchboards although some sites have a split busbar system for dual supply. The other LV switchboards, compressor boards and other systems boards, have no specific redundancy. There are some instances of interconnection on the LV distribution at some sites which means some rerouting of LV power is possible. Redundancy is generally achieved using multiple compressor units.

13. LV Switchboards and Distribution - Problem Statement

13.1. The LV Switchboards and Distribution assets are old, with most installed at the time the site was constructed. They are of many varied designs and from a multitude of manufacturers and therefore have widely differing standards of design and construction. Inspections and testing are finding an increasing number of defects being raised against a range of issues. Such as:

- Components are either not functioning or operating correctly
- Inability to be safely operated or worked on
- There is a lack of compliance with EAWR and DSEAR

13.2. Some of the assets are also obsolete and therefore spares are difficult to obtain leading to increased remediation timescales.

Drivers for Investment

13.3. The key drivers for investment in the LV Switchboards and Distribution assets are:

- **Asset Deterioration** – Elements of the assets are deteriorating due to age, corrosion and wear. Increasing defects are being recorded and the assets are becoming unreliable, unsafe to operate or difficult to work on.
- **Industry Safety Bulletins** – As part of the National Electricity Defect Reporting Scheme (NEDERS) operated by the energy networks association Dangerous Incident Notifications (DINs) are issued. These DINs detail safety issues, defects or operational restrictions associated with HV assets and their recommendations mist be complied with to maintain safe systems of work.
- **Legislation** – Some of the assets do not meet current safety standards. The inspections on the assets are showing increased defects that need to be rectified to maintain compliance with the EAWR and in some cases DSEAR.

Impact of No Investment

13.4. The use of the LV Switchboard and Distribution assets without investment in inspection, assessment and remediation will breach legal obligations under EAWR. With no investment in proper remediation the assets would continue to deteriorate which will result in an increasing number of defects. Depending upon the severity of the defect then the affected assets may require immediate isolation rather than planned repair which further increases the impact.

13.5. The impact of loss of supply to all of a site is dependent upon the nature of the site and the asset being supplied:

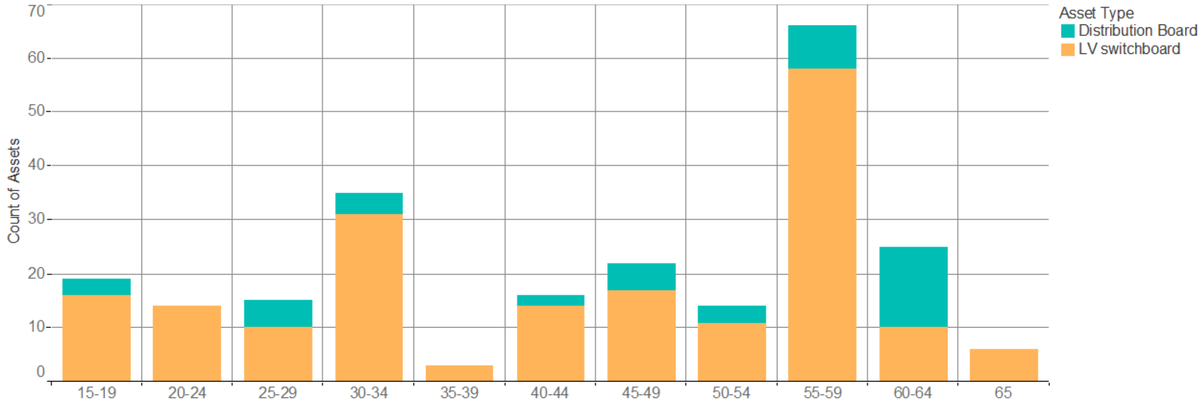
- compressor unit trips
- unavailability of safety, quality and/or metering systems
- inability to utilise standby generation

13.6. Due to the critical nature of the electrical supplies, without a manged programme of investment the LV Switchboards and Distribution could rapidly become a major risk to the continued safe and efficient operation of the NTS.

Asset Age

13.7. The charts below show the age profiles by the end of RIIO-3 of the LV switchboards and distribution boards assets given no investment. Over 60% of the assets will be at or over their design life of 40 years.

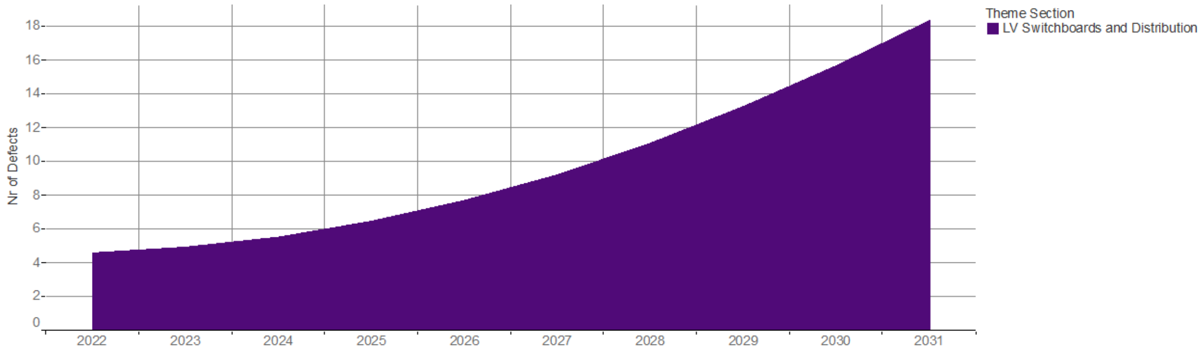
Age Profile by End of RIIO-3 – No Investment



Defects

13.8. The chart below shows the predicted defects for LV switchboards and distribution boards given no investment. This is based on the current levels of defects and applying our NOMS deterioration models. The predicted number of defects rises to 30 per year by the end of RIIO-3.

Predicted Defects – No Investment



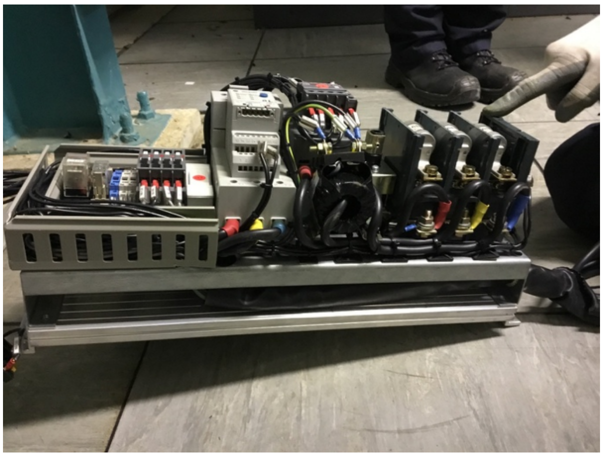
Desired Outcomes

13.9. The outcome of the investment in LV Switchboard and Distribution assets is to:

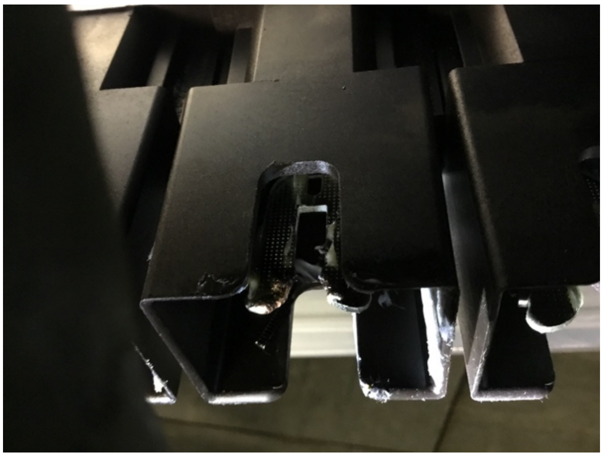
- Maintain the safe operational availability of compressor stations and AGIs that have electrical equipment installed
- Ensure continued compliance with all legal obligations and required standards

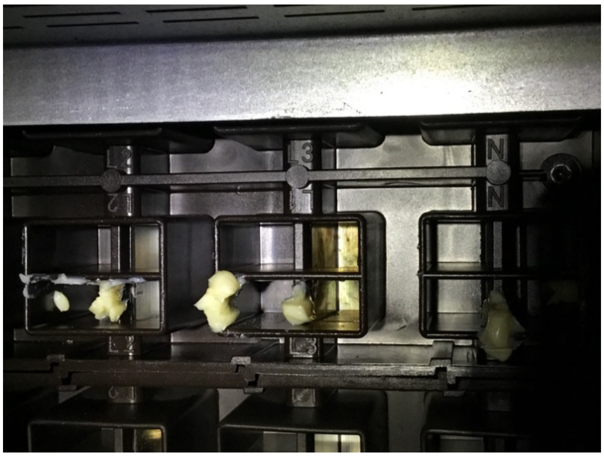
Example of Problem

13.10. The Unit C MCC/LV Switchboard at Kings Lynn suffered a failure of the connector between the motor starter section and the main busbars. The starter section is connected to the busbars by a push-on spring loaded connector (see photographs). The middle phase connector did not make proper contact with the busbars which resulted in excessive heat, arcing and damage to the connector and eventually failure of the connection causing the protective device to trip out the starter. The section in question supplied one of the Unit C vent fans. With the vent fan not running the Unit C compressor could not be run and had to be made unavailable at a time that it was needed by GNCC for gas flows from Bacton. Kings Lynn Unit C is a preferred unit for running under the network conditions at the time.



Unit C MCC   Vent Fan Starter Section (removed)





The damaged connector

The busbar side of the connector

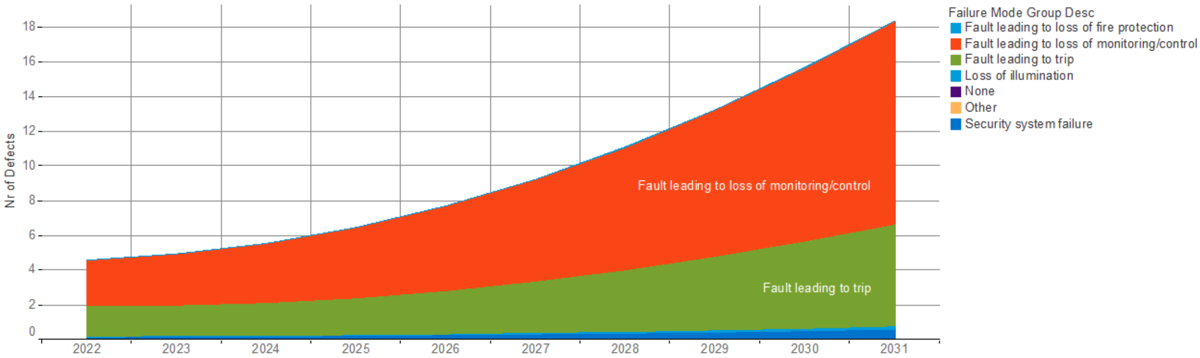
Spend Boundaries

13.11. The proposed investment includes all LV Switchboards and Distribution on the NTS, including any 'no-regrets' site investments at both St Fergus and Bacton to keep them safe and operational whilst the separate funding mechanism for the proposed projects are progressed via Uncertainty Mechanisms.

14. LV Switchboards and Distribution - Probability of Failure

14.1. The chart below shows the equipment failure mode frequency for LV switchboard and distribution board assets representing the probability of failure predicted for a no investment scenario using our NOMS methodology.

Predicted Defects by Failure Mode – No Investment



14.2. The failure modes that contribute most to failures of this type of asset are

- Fault leading to loss of monitoring/control
- Fault leading to trip

Interventions

14.3. All Electrical interventions are defined as consequential interventions. This is because the prime function of an Electrical asset is to allow a whole site to operate and perform its prime function of safely and reliably transporting gas, and to protect employees and the public. All risk benefits associated with Electrical assets are therefore considered to align with the following definition of a consequential risk intervention:

"Any intervention on a network asset, or other infrastructure asset, that modifies the probability of failure, or consequence of failure of ***another network asset****. A consequential asset can include, for example:*

- *installation or removal of physical infrastructure designed to prevent damage to adjacent assets in the event of an asset failure (e.g. installation of a blast wall),*
- *addition or disposal that increases or decreases the resilience of a local or regional network and hence modifies the consequence of failure of other asset(s) in the locality or region."*

Consequential Interventions

14.4. The table below shows the drivers for Electrical asset investment that are defined as consequential Interventions.

Types of Electrical Intervention

NARMs Asset Intervention Category	Secondary Asset Classes
Consequential Interventions (Non-risk tradeable)	Electrical - including standby generators

14.5. Our NOMs Methodology attempts to model the indirect benefits delivered by these assets in terms of the reduction in Probability of Failure (PoF) or Consequence of

Failure (CoF) upon a related and/or adjacent asset (e.g. the relationship between the presence reliable electrical system and a potential asset/site outage). These quantified, but indirect, impacts are used within the CBAs accompanying this justification report, but are not considered to be reliable enough for use as a NARMs monetised risk metric.

Electrical Interventions

14.6. The interventions in LV Switchboards and Distribution boards are shown in the table below:

Interventions by Category

intervention	SAC	Intervention Category
A22.20.1.12 / LV Distribution Boards Major Refurb	Electrical - including standby generators	Major Refurbishment
A22.20.1.13 / LV Distribution Boards Minor Refurb	Electrical - including standby generators	Minor Refurbishment
A22.20.1.14 / LV Distribution Boards Replacement	Electrical - including standby generators	Replacement
A22.20.1.15 / LV Switchboards Major Refurb	Electrical - including standby generators	Major Refurbishment
A22.20.1.16 / LV Switchboards Minor Refurb	Electrical - including standby generators	Minor Refurbishment
A22.20.1.17 / LV Switchboards Replacement	Electrical - including standby generators	Replacement
A22.22.4.15 / LV Distribution Boards Minor Refurb (St. Fergus)	Electrical - including standby generators	Minor Refurbishment
A22.22.4.16 / LV Distribution Boards Major Refurb (St. Fergus)	Electrical - including standby generators	Major Refurbishment
A22.22.4.17 / LV Distribution Boards Replacement (St. Fergus)	Electrical - including standby generators	Replacement
A22.22.4.18 / LV Switchboards Minor Refurb (St. Fergus)	Electrical - including standby generators	Minor Refurbishment
A22.22.4.19 / LV Switchboards Major Refurb (St. Fergus)	Electrical - including standby generators	Major Refurbishment
A22.22.4.20 / LV Switchboards Replacement (St. Fergus)	Electrical - including standby generators	Replacement

Data Assurance

14.7. All PoF and CoF values are taken from the National Grid Gas Transmission 'Methodology for Network Output Measures' (the Methodology). The Methodology was originally submitted for public consultation in April 2018, with three generally favourable responses received in May 2018. On this basis, Ofgem were happy to provisionally not reject the Methodology pending further work to:

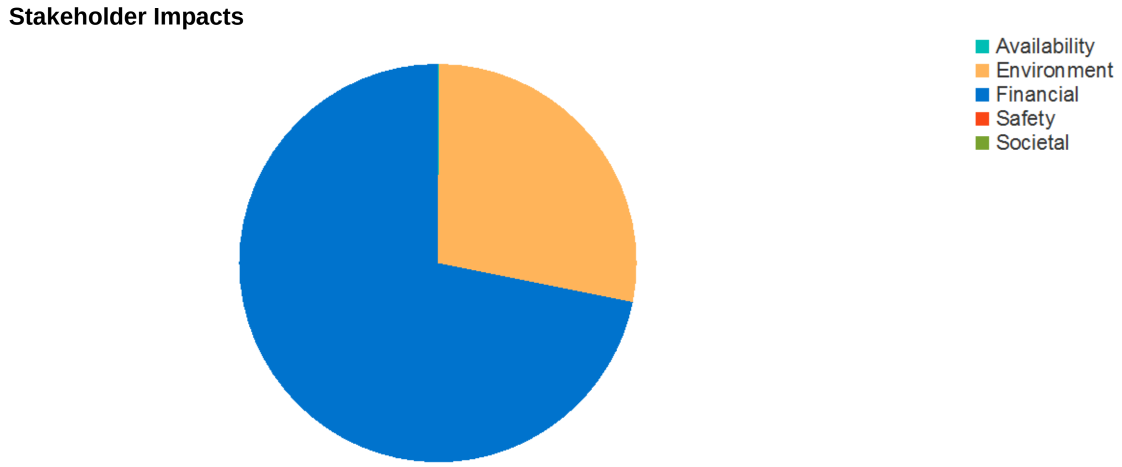
- Produce a detailed Validation Report, confirming the validity of data sources used in the Methodology
- Test a range of supply and demand scenarios and incorporate an appropriate scenario to best represent Availability and Reliability risk

14.8. A review of the Methodology by independent gas transmission experts has been carried out and several improvements identified and incorporated.

14.9. At the time of writing, the final Validation Report has been submitted to Ofgem. We understand that once this work is complete Ofgem will formally “not reject” the Methodology and a License change progressed to restate our RIIO-1 targets in terms of monetised risk commenced.

15. LV Switchboards and Distribution - Consequence of Failure

15.1. The chart below shows the expected stakeholder impacts because of failure occurring on the LV switchboards and distribution board assets. The charts show the relative numbers of consequence events, not relative monetised risk. The charts show the relative numbers of consequence events, not relative monetised risk.



15.2. There are a vast range of different types of Electrical asset used in the operation of the NTS. Electrical systems are an essential enabler, ensuring that dependent assets can perform their primary function of safely and reliably transporting gas and ensuring NTS resilience. Failure of a single electrical component will not generally have an immediate impact on service, and that a combination of failures may need to occur for a service impact to occur. Despite the variety of electrical assets, there are only two significant failure modes, which apply to all asset categories above:

- **Financial risk** is mostly associated with the costs of operating and maintaining the network at the current level of risk and compliance. The financial risk of non-compliance with legislation, such as DSEAR, are not included but could be significant
- **Environmental risk** is associated with the failure of a range the assets depend upon an electrical system to operate reliably and upon demand, which may cause a subsequent loss of gas through trips, vents and leaks. The carbon emissions associated with the maintenance of assets will contribute to Environmental risk. As there are many electrical assets within our asset maintenance systems, the proportional share of maintenance emissions attributed to electrical assets will be significant

16. LV Switchboards and Distribution - Options Considered

Potential Intervention Options

16.1. The following intervention categories apply to the LV Switchboard and Distribution assets:

- **Repair** – replacement of individual components such as circuit breakers, fuses, relays. Repair of cable and terminations.
- **Refurbishment** – upgrade starters or circuit breakers to more modern equivalents; replace oil filled equipment; install intelligent starters; and add monitoring
- **Replacement** – Installation of new switchboards, new cables, new distribution boards and new containment.

Intervention Unit Costs

16.2. The total RIIO-2 investment for LV Switchboard and Distribution Assets represents 16% of the Electrical investment theme. A majority (69%) of the unit costs that support this subtheme have been developed using historical outturn cost data points, which need to be verified. The remainder of the costs have been developed using other estimating methods.

16.3. The table below provides the unit costs for all the potential LV Switchboard and Distribution assets interventions.

Intervention Unit Costs – LV switchboard and Distribution assets

Intervention	Cost (£)	Unit	Evidence	Data Points	Overall value in BP
LV switchboard and Distribution assets					
A22.20.1.13 / LV Distribution Boards Minor Refurb	[redacted]	Per asset	Estimated - Other	0	£93,781
A22.20.1.12 / LV Distribution Boards Major Refurb	[redacted]	Per asset	Estimated - Other	0	£177,256
A22.20.1.14 / LV Distribution Boards Replacement	[redacted]	Per asset	Estimated - Other	0	£531,767
A22.20.1.16 / LV Switchboards Minor Refurb	[redacted]	Per asset	Estimated - Quotation	5	£142,217
A22.20.1.15 / LV Switchboards Major Refurb	[redacted]	Per asset	Estimated - Quotation	5	£412,222
A22.20.1.17 / LV Switchboards Replacement	[redacted]	Per asset	Outturn	5	£3,091,667
A22.22.4.15 / LV Distribution Boards Minor Refurb (St. Fergus)	[redacted]	Per asset	Estimated - Other	0	£0
A22.22.4.16 / LV Distribution Boards Major Refurb (St. Fergus)	[redacted]	Per asset	Estimated - Other	0	£0
A22.22.4.17 / LV Distribution Boards Replacement (St. Fergus)	[redacted]	Per asset	Estimated - Other	0	£0
A22.22.4.18 / LV Switchboards Minor Refurb (St. Fergus)	[redacted]	Per asset	Estimated - Quotation	1	£0
A22.22.4.19 / LV Switchboards Major Refurb (St. Fergus)	[redacted]	Per asset	Estimated - Quotation	1	£0
A22.22.4.20 / LV Switchboards Replacement (St. Fergus)	[redacted]	Per asset	Estimated - Quotation	5	£0

Standby Generators

17. Standby Generators - Equipment Summary

17.1. Standby generators are located at terminals, compressor stations and a few of the larger above ground installations to provide essential electrical power if the mains power supply fails or is not available for any reason.

17.2. In the event of a mains power failure the Standby Generators are the ONLY means of power to a site. Therefore, if the standby generator fails whilst there is no mains power all electrically powered assets including safety, control, metering and quality system cannot be operated. This would lead to a loss of compression at compression sites leading to a potential inability to receive gas, supply gas to customers or operate the NTS.

17.3. The availability of standby generation impacts local and national energy resilience. Without standby generation, there is the potential for loss of gas supply when it is needed most i.e. when there is no electricity supply; with the consequential effect of loss of gas supply to gas powered electricity generations sites

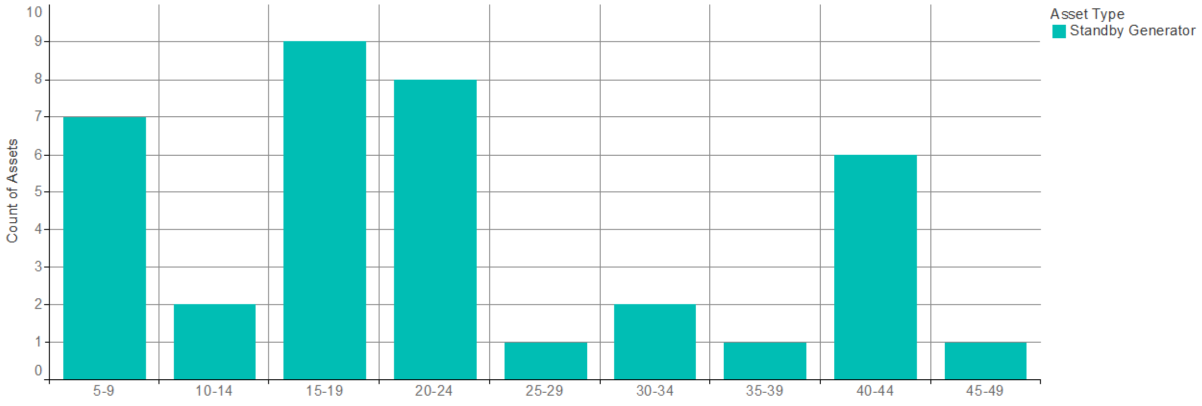
17.4. Most of the standby generators are powered by diesel although some are still gas turbine engine powered. The generators are contained within either a permanent building or purpose built container. They are started via a battery supply and may be fitted with an automated load bank. The unit operates in island mode and cannot be connected to the electricity grid.

17.5. They consist of a diesel engine or gas turbine driving an alternator producing alternating 400VAC electrical power, controlled by electronic control system, and switched via an air circuit breaker. Connection to the site electrical system is via the main LV switchboard or similar arrangement. Some have a changeover switch to allow a temporary generator to be connected if required in emergencies. Typically rated at 500-1500kVA continuous.

Location and Volume

17.6. The chart below shows the age profiles in years for standby generator assets at 2019.

Current Age Profile



Redundancy

17.7. On all sites there is no redundancy in the standby generation, except for St Fergus but this is only whilst Plant 2 remains operational (refer to Uncertainty Mechanism).

18. Standby Generators - Problem Statement

18.1. There are a low number of Standby Generators on the NTS; some of these have known issues which need to be resolved. The engines and generators themselves have a long life. However, the associated assets are becoming unreliable and corrosion issues/failures are becoming evident on some of the generator containers and diesel fuel tanks. There are several control systems that are becoming obsolete.

18.2. The old Centrax gas turbine driven units are obsolete and require replacement. These include the emergency generators at Diss (currently out of service) and Chelmsford. There are specific safety issues with these emergency generators due to the proximity of the gas turbines and associated high pressure gas supplies to the site offices. There are 5 other generators with specific issues requiring investment in the RIIO-2 period.

Drivers for Investment

18.3. The key drivers for investment in the Standby Generator assets are:

- Legislation
- Asset Deterioration
- Obsolescence

18.4. The Standby Generation assets deteriorate over time and with use which leads to their inability to perform their required function. This can also result in them no longer complying with direct legislative requirements such as EAWR.

- **Legislation** - The inspections on the assets are showing increased defects that need to be rectified to maintain compliance with the EAWR.
- **Asset Deterioration** – Elements of the assets are deteriorating due to age, corrosion and wear. Increasing defects are being recorded and the assets are becoming unreliable.
- **Obsolescence – Specific Elements** of the assets, such as control systems, within the standby generators have exceeded their original design life and are now obsolete. National Grid operates a comprehensive spares management strategy by which assets that are removed from service are stored and reused as far as possible. This mitigates the issue of obsolescence to some extent and extends the useful life of assets for as long as practicable. However, spares and not limitless or fully comprehensive. Therefore, where an asset is obsolete and no spare is available the repair time for any failure is increased.

Impact of No Investment

18.5. There are current known issues resulting in a small number of generators being unavailable; these need investment to remediate the issues and return them to service. A continued lack of investment in the Standby Generator assets would allow them to continue to deteriorate in an uncontrolled manner. This will lead to increased failures and the assets becoming unreliable and being unavailable to perform when required to do so. Obsolescence of elements of the assets increases the impact of any asset failure by increasing the repair and restoration time of the asset.

18.6. The safety risks with the two Centrax gas turbine driven generators due to the proximity of their gas supplies, other associated hazardous areas and the site offices would increase as the probability of failure of these assets increase.

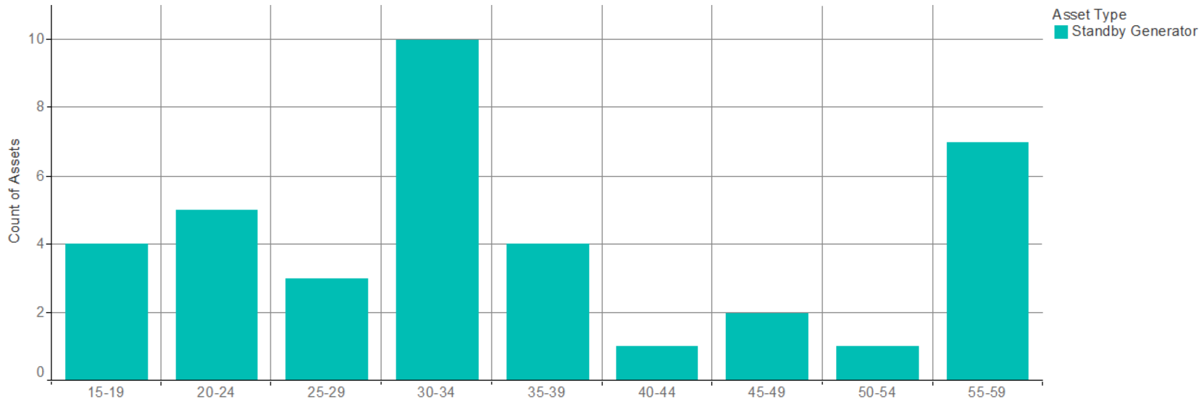
18.7. In the event of a mains power failure the Standby Generators are the only means of power to a site. Therefore, if the standby generator fails whilst there is no mains power all electrically powered assets including safety, control, metering and quality system cannot be operated. This would lead to a loss of compression on compressor stations and potential inability to receive gas, supply gas to customers or operate the NTS.

18.8. The availability of standby generation impacts local and national energy resilience. Without standby generation, there is the potential for loss of gas supply when it is needed most i.e. when there is no electricity supply. In the event of a major natural disaster such as flooding or snow/ice storms resulting in a large or prolonged power outage keeping our gas compressors running and the gas supply on will be critical and a standby power supply on site is necessary for this.

Asset Age

18.9. The chart below shows the age profiles by end of RIIO-3 of the standby generator assets given no investment.

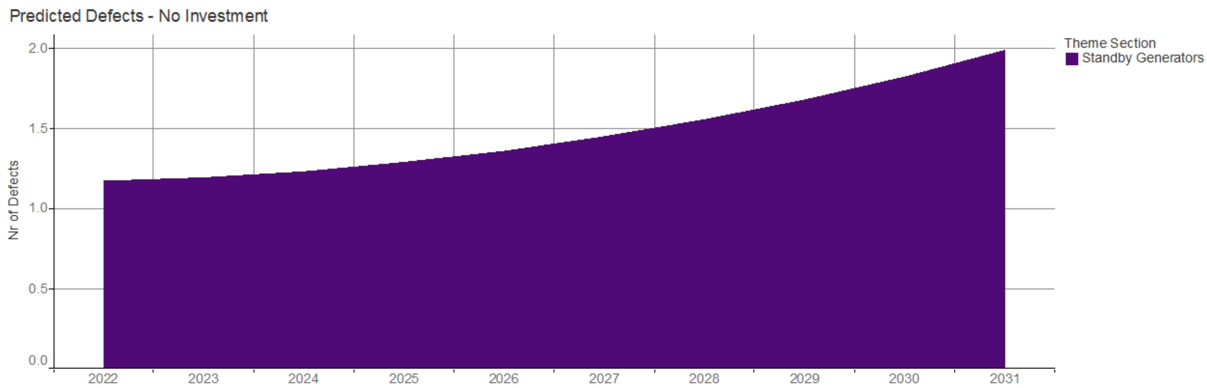
Age Profile by End of RIIO-3 – No Investment



Defects

18.10. The chart below shows the predicted defects for standby generators given no investment. This is based on the current levels of defects and applying our NOMS deterioration models.

Predicted Defects – No Investment



Desired Outcomes

18.11. The outcome of this investment in standby generators is to:

- Ensure that the standby generation assets are available when required and perform their duty to provide power to the site in the case of loss of the Public Electricity Supply
- Ensure all standby generators are fit for purpose, legally compliant and meet the required standards.

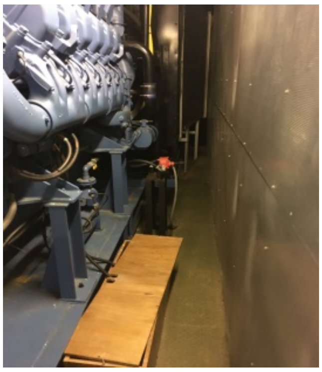
Example of the Problem

18.12. The picture below shows the gas powered Centrax unit at Diss which are due for replacement.

18.13. The pictures below show typical standby generator issues

Corroded floor plate

Heat detectors close to exhaust



Damaged cab internals

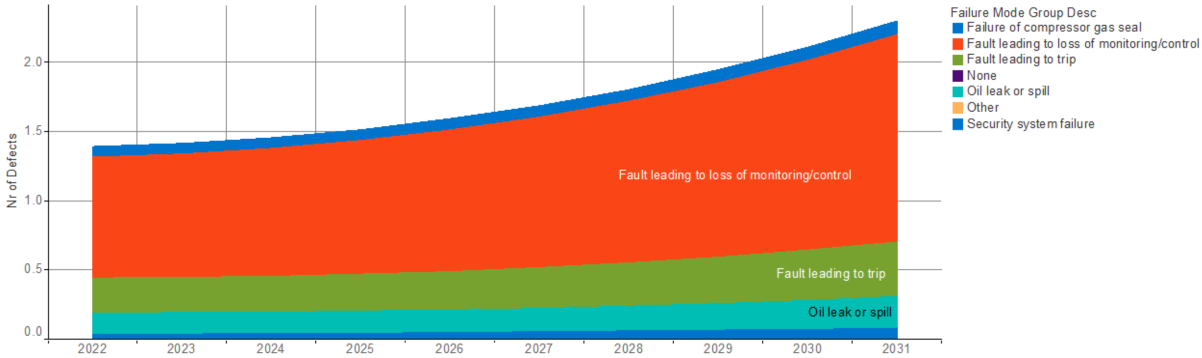
Spend Boundaries

18.14. The proposed investment includes all Standby Generators on the NTS, including any 'no-regrets' site investments at both St Fergus and Bacton to keep them safe and operational whilst the separate funding mechanism for the proposed projects are progressed via Uncertainty Mechanisms.

19. Standby Generators - Probability of Failure

19.1. The chart below shows the equipment failure mode frequency for standby generator assets representing the probability of failure predicted for a no investment scenario using our NOMS methodology.

Predicted Defects by Failure Mode – No Investment



19.2. The failure modes that contribute most to failures of this type of asset are

- Fault leading to loss of monitoring/control
- Fault leading to trip

Interventions

19.3. All Electrical interventions are defined as consequential interventions. This is because the prime function of an Electrical asset is to allow a whole site to operate and perform its prime function of safely and reliably transporting gas, and to protect employees and the public. All risk benefits associated with Electrical assets are therefore considered to align with the following definition of a consequential risk intervention:

*"Any intervention on a network asset, or other infrastructure asset, that modifies the probability of failure, or consequence of failure of **another network asset**. A consequential asset can include, for example:*

- *installation or removal of physical infrastructure designed to prevent damage to adjacent assets in the event of an asset failure (e.g. installation of a blast wall),*
- *addition or disposal that increases or decreases the resilience of a local or regional network and hence modifies the consequence of failure of other asset(s) in the locality or region."*

Consequential Interventions

19.4. The table below shows the drivers for Electrical asset investment that are defined as Consequential Interventions.

Types of Electrical Intervention

NARMs Asset Intervention Category	Secondary Asset Classes
Consequential Interventions **(Non-risk tradeable)**	Electrical - including standby generators

19.5. Our NOMs Methodology attempts to model the indirect benefits delivered by these assets in terms of the reduction in Probability of Failure (PoF) or Consequence of

Failure (CoF) upon a related and/or adjacent asset (e.g. the relationship between the presence reliable electrical system and a potential asset/site outage). These quantified, but indirect, impacts are used within the CBAs accompanying this justification report, but are not considered to be reliable enough for use as a NARMs monetised risk metric.

Electrical Interventions

19.6. The interventions in standby generators are shown in the table below:

Interventions by Category

Intervention	SAC	Intervention category
A22.20.1.32 / Standby Generator - Major Refurb	Electrical - including standby generators	Major Refurbishment
A22.20.1.33 / Standby Generator - Minor Refurb	Electrical - including standby generators	Minor Refurbishment
A22.20.1.34 / Standby Generator Replacement	Electrical - including standby generators	Replacement
A22.22.4.21 / Standby Generator - Major Refurb (St. Fergus)	Electrical - including standby generators	Major Refurbishment
A22.22.4.22 / Standby Generator Replacement (St. Fergus)	Electrical - including standby generators	Replacement

Data Assurance

19.7. All PoF and CoF values are taken from the National Grid Gas Transmission 'Methodology for Network Output Measures' (the Methodology). The Methodology was originally submitted for public consultation in April 2018, with three generally favourable responses received in May 2018. On this basis, Ofgem were happy to provisionally not reject the Methodology pending further work to:

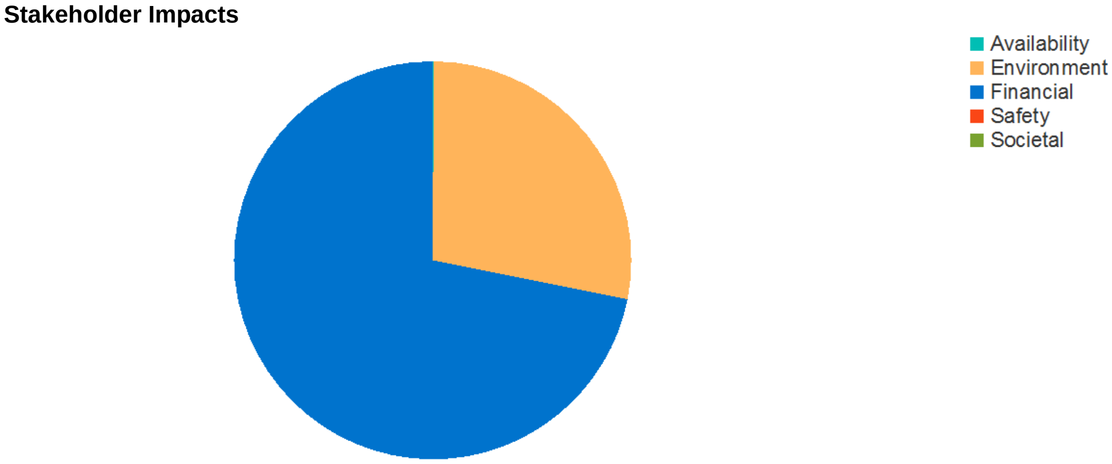
- Produce a detailed Validation Report, confirming the validity of data sources used in the Methodology
- Test a range of supply and demand scenarios and incorporate an appropriate scenario to best represent Availability and Reliability risk

19.8. A review of the Methodology by independent gas transmission experts has been carried out and several improvements identified and incorporated.

19.9. At the time of writing, the final Validation Report has been submitted to Ofgem. We understand that once this work is complete Ofgem will formally "not reject" the Methodology and a License change progressed to restate our RIIO-1 targets in terms of monetised risk commenced.

20. Standby Generators - Consequence of Failure

20.1. The chart below shows the expected stakeholder impacts because of failure occurring on the standby generator assets. The charts show the relative numbers of consequence events, not relative monetised risk.



20.2. There are a vast range of different types of Electrical asset used in the operation of the NTS. Electrical systems are an essential enabler, ensuring that dependent assets can perform their primary function of safely and reliably transporting gas and ensuring NTS resilience. Failure of a single electrical component will not generally have an immediate impact on service, and that a combination of failures may need to occur for a service impact to occur. Despite the variety of electrical assets, there are only two significant failure modes, which apply to all asset categories above:

- **Financial risk** is mostly associated with the costs of operating and maintaining the network at the current level of risk and compliance. The financial risk of non-compliance with legislation, such as DSEAR, are not included but could be significant
- **Environmental risk** is associated with the failure of a range the assets depend upon an electrical system to operate reliably and upon demand, which may cause a subsequent loss of gas through trips, vents and leaks. The carbon emissions associated with the maintenance of assets will contribute to Environmental risk. As there are many electrical assets within our asset maintenance systems, the proportional share of maintenance emissions attributed to electrical assets will be significant

21. Standby Generators - Intervention Options Considered

Potential Intervention Options

21.1. The following individual inspection and intervention categories apply to the Standby Generator assets:

- **Repair** – includes minor engine repair/service, battery replacement and fuel cleaning
- **Refurbishment –** includes upgrade of control system, replace enclosure, new alternator, major engine overhaul
- **Replacement –** includes the replacement of the generator and all the associated assets

Intervention Unit Costs

21.2. The total RIIO-2 investment for Standby Generators represents 11% of the Electrical investment theme. The entire investment for Standby Generators has been developed using quotes obtained from suppliers.

21.3. The table below provides the unit costs for all the potential Standby Generator interventions.

Intervention Unit Costs – Standby Generators

Intervention	Cost (£)	Unit	Evidence	Data Points	Overall value in BP
Standby Generators					
A22.20.1.33 / Standby Generator - Minor Refurb	[redacted]	Per asset	Estimated - Quotation	1	£251,198
A22.20.1.32 / Standby Generator - Major Refurb	[redacted]	Per asset	Estimated - Quotation	1	£638,945
A22.20.1.34 / Standby Generator Replacement	[redacted]	Per asset	Estimated - Quotation	2	£2,318,750
A22.22.4.21 / Standby Generator - Major Refurb (St. Fergus)	[redacted]	Per asset	Estimated - Quotation	1	£0
A22.22.4.22 / Standby Generator Replacement (St. Fergus)	[redacted]	Per asset	Estimated - Other	0	£0

Lighting

22. Lighting - Equipment Summary

22.1. The assets consist of external lighting columns for road lighting and area flood lighting; external task lighting; internal lighting for compressor cabs and other buildings; emergency lighting for the same indoor areas.

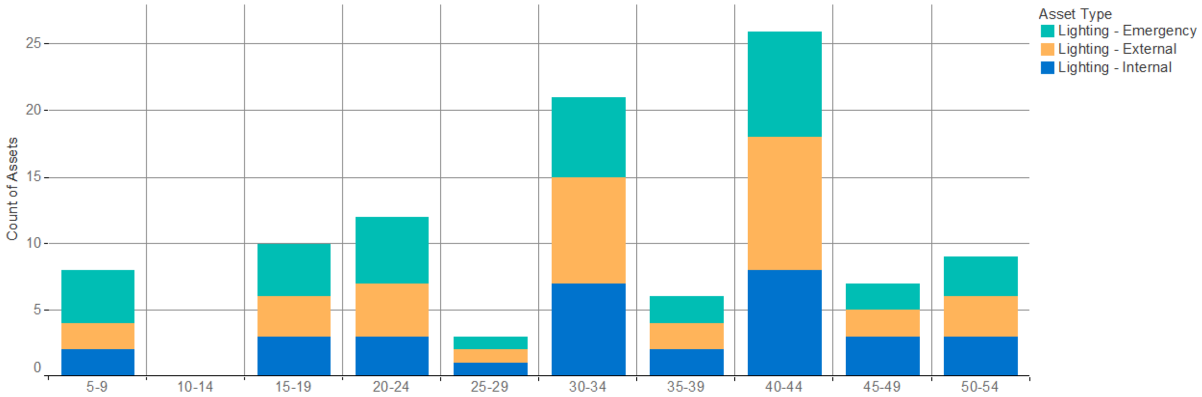
22.2. External site lighting columns are a steel lighting column that is typically 8m to 10m high typically supporting a single floodlight.

Location and Volume

22.3. There are 215 site lighting systems, 50 Flood lighting systems (consisting of a total of 1500 to 2000 columns) and 70 Internal lighting/emergency lighting installations permanently installed on sites across the NTS.

22.4. The chart below shows the age profiles for external, internal and emergency lighting assets at 2019.

Current Age Profile



Redundancy

22.5. Other than more than one lighting point being installed across sites and in buildings, there is no specific redundancy in the lighting assets except for that specifically required for the emergency lighting systems.

23. Lighting - Problem Statement

23.1. The lighting systems were installed at the time that the sites were built and many are approaching the end of their life. This large asset base requires investment to manage the deterioration and whole life costs. There are specific issues with task lighting not meeting the current requirements for the use of the assets and not meeting current lighting standards.

23.2. There is a specific deterioration problem on the site lighting on many sites. These are floodlights on the top of a steel column. There is corrosion on the column itself and the hinge mechanism that allows them to be lowered for maintenance. We have had instances of them falling. This presents a significant safety hazard, does not enable maintenance to be undertaken and luminaires changed. There is also increasing evidence of the deterioration of the cables at the foot of the column which is causing them to fail BS7671 testing.

23.3. Cables installed within compressor cabs and other areas that require fire protection are degrading. These ‘Pyro’ cables are an older type metal sheathed fire resistant cable which tends to become damaged with age and the metal sheath breaks leading them to fail testing.

Drivers for Investment

23.4. The key drivers for investment in the Lighting assets are:

- Asset Deterioration
- Whole Life Cost
- Legislation

23.5. The lighting and associated assets, particularly steel column supports deteriorate over time and with use which leads to them presenting a significant safety risk and inability to perform their required function. This can also result in them no longer complying with direct legislative requirements such as EAWR, DSEAR and BS7671 The IET wiring regulations.

- **Asset Deterioration** - Elements of the assets are deteriorating due to age, corrosion and wear. Increasing defects are being recorded and the assets are becoming unreliable, unsafe to operate or difficult to work on. They are failing electrical tests required by BS7671. The fire-resistant cables within compressor cabs and other site areas are deteriorating and can become damaged leading to the breaking of the protective metal sheath and subsequent loss of screening and earthing integrity. Corrosion of columns is presenting safety risks and preventing the assets being maintained.
- **Whole Life Cost** – the lighting solutions used on some of the systems is inefficient and has a short life leading to higher whole life costs.
- **Legislation** - Some of the assets do not meet current safety standards. The inspections on the assets are showing increased defects that need to be rectified to maintain compliance with the EAWR and DSEAR

Impact of No Investment

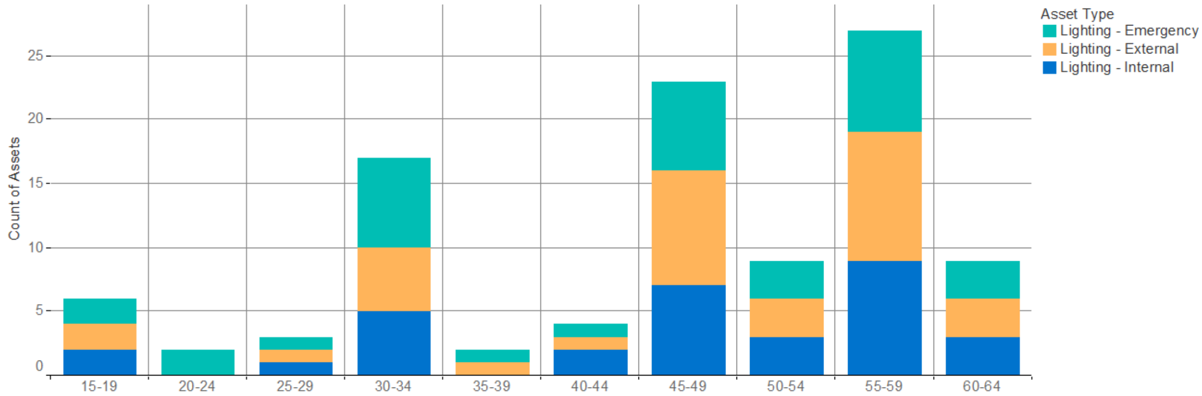
23.6. No investment within the lighting assets would allow them to continue to deteriorate. Corrosion issues on the site lighting would continue to increase to a point where accidents will occur, due to either the collapse of a column or the lack of illumination on the site.

23.7. No investment would result in the inability to work at night or in enclosed spaces. The safety of entrances and exits from sites would be reduced presenting a danger to personnel. The inability to work at night would results in inability to operate or undertake remediation and emergency work on the assets.

Asset Age

23.8. The chart below shows the age profiles by the end of RIIO-3 of the external, internal and emergency lighting assets given no investment.

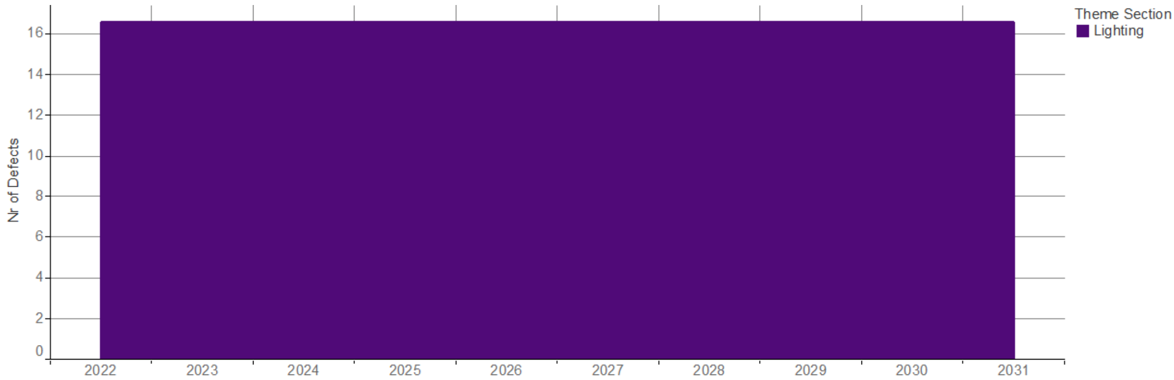
Age Profile by end of RIIO-3 – No Investment



Defects

23.9. The chart below shows the predicted defects for lighting assets given no investment. This is based on the current levels of defects and applying our NOMS deterioration models.

Predicted Defects – No Investment



Desired Outcomes

23.10. The outcome of this investment is to:

- Allow safe access and egress to/from site and enable National Grid staff and contractors to work safely in low light areas or at night.
- Allow safe egress for all staff in emergency situations.

- Ensure lack of lighting is not a cause of affecting the availability and performance of the compressor or other sites.
- Ensure continued compliance of the lighting assets with legal obligations and required standards

Example of Problem

23.11. The photographs below show some of the issues present on many of the lighting columns.

Corrosion of the column and reduction in the wall thickness particularly at the base of the column

Corrosion of the hinge mechanism used to lower the column for maintenance.

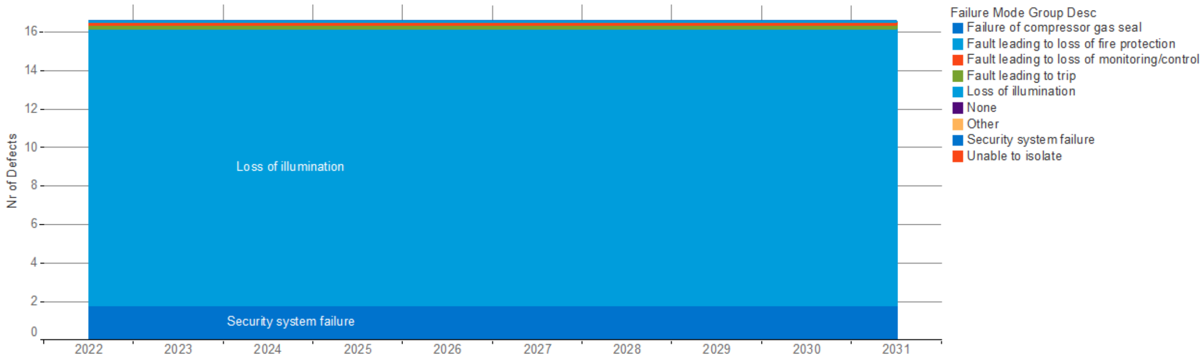
Spend Boundaries

23.12. The proposed investment includes all fixed Lighting on the NTS, including any 'no-regrets' site investments at both St Fergus and Bacton to keep them safe and operational whilst the separate funding mechanism for the proposed projects are progressed via Uncertainty Mechanisms.

24. Lighting – Probability of Failure

24.1. The chart below shows the equipment failure mode frequency for lighting assets representing the consequences resulting from failures predicted for a no investment scenario using our NOMS methodology.

Predicted Defects by Failure Mode – No Investment



Interventions

24.2. All Electrical interventions are defined as consequential interventions. This is because the prime function of an Electrical asset is to allow a whole site to operate and perform its prime function of safely and reliably transporting gas, and to protect employees and the public. All risk benefits associated with Electrical assets are therefore considered to align with the following definition of a consequential risk intervention:

"Any intervention on a network asset, or other infrastructure asset, that modifies the probability of failure, or consequence of failure of ***another network asset****. A consequential asset can include, for example:*

- *installation or removal of physical infrastructure designed to prevent damage to adjacent assets in the event of an asset failure (e.g. installation of a blast wall),*
- *addition or disposal that increases or decreases the resilience of a local or regional network and hence modifies the consequence of failure of other asset(s) in the locality or region."*

Consequential Interventions

24.3. The table below shows the drivers for Electrical asset investment that are defined as consequential interventions.

Types of Intervention

NARMs Asset Intervention Category	Secondary Asset Classes
Consequential Interventions **(Non-risk tradeable)**	Electrical - including standby generators

24.4. Our NOMs Methodology attempts to model the indirect benefits delivered by these assets in terms of the reduction in PoF or Consequence of Failure (CoF) upon a related and/or adjacent asset (e.g. the relationship between the presence reliable electrical system and a potential asset/site outage). These quantified, but indirect, impacts are used within the CBAs accompanying this justification report, but are not considered to be reliable enough for use as a NARMs monetised risk metric.

Electrical Interventions

24.5. The interventions in site lighting are shown in the table below:

Interventions by Category

Intervention	SAC	Intervention Category
A22.20.1.21 / Site Lighting - Emergency - Major Refurb	Electrical - including standby generators	Major Refurbishment
A22.20.1.22 / Site Lighting - Emergency - Minor Refurb	Electrical - including standby generators	Minor Refurbishment
A22.20.1.23 / Site Lighting - Emergency - Replacement	Electrical - including standby generators	Replacement
A22.20.1.24 / Site Lighting - External Columns Major Refurb	Electrical - including standby generators	Major Refurbishment
A22.20.1.25 / Site Lighting - External Columns Replacement	Electrical - including standby generators	Replacement
A22.20.1.26 / Site Lighting - Internal - Major Refurb	Electrical - including standby generators	Major Refurbishment
A22.20.1.27 / Site Lighting - Internal - Minor Refurb	Electrical - including standby generators	Minor Refurbishment
A22.20.1.28 / Site Lighting - Internal - Replacement	Electrical - including standby generators	Replacement
A22.20.1.29 / Site Lighting External Task Major Refurb	Electrical - including standby generators	Major Refurbishment
A22.20.1.30 / Site Lighting External Task Minor Refurb	Electrical - including standby generators	Minor Refurbishment
A22.20.1.31 / Site Lighting External Task Replacement	Electrical - including standby generators	Replacement
A22.22.4.31 / Site Lighting External Task Minor Refurb (St. Fergus)	Electrical - including standby generators	Minor Refurbishment
A22.22.4.32 / Site Lighting External Task Major Refurbishment (St. Fergus)	Electrical - including standby generators	Major Refurbishment
A22.22.4.33 / Site Lighting External Task Replacement (St. Fergus)	Electrical - including standby generators	Replacement
A22.22.4.34 / Site Lighting - External Columns Minor Refurb (St. Fergus)	Electrical - including standby generators	Minor Refurbishment
A22.22.4.35 / Site Lighting - External Columns Major Refurbishment (St. Fergus)	Electrical - including standby generators	Major Refurbishment
A22.22.4.36 / Site Lighting - External Columns Replacement (St. Fergus)	Electrical - including standby generators	Replacement
A22.22.4.37 / Site Lighting - Internal - Minor Refurb (St. Fergus)	Electrical - including standby generators	Minor Refurbishment
A22.22.4.38 / Site Lighting - Internal - Major Refurbishment (St. Fergus)	Electrical - including standby generators	Major Refurbishment
A22.22.4.39 / Site Lighting - Internal - Replacement (St. Fergus)	Electrical - including standby generators	Replacement
A22.22.4.40 / Site Lighting - Emergency - Minor Refurb (St. Fergus)	Electrical - including standby generators	Minor Refurbishment
A22.22.4.41 / Site Lighting - Emergency - Major Refurbishment (St. Fergus)	Electrical - including standby generators	Major Refurbishment
A22.22.4.42 / Site Lighting - Emergency - Replacement (St. Fergus)	Electrical - including standby generators	Replacement

Data Assurance

24.6. All PoF and CoF values are taken from the National Grid Gas Transmission 'Methodology for Network Output Measures' (the Methodology). The Methodology was originally submitted for public consultation in April 2018, with three generally favourable responses received in May 2018. On this basis, Ofgem were happy to provisionally not reject the Methodology pending further work to:

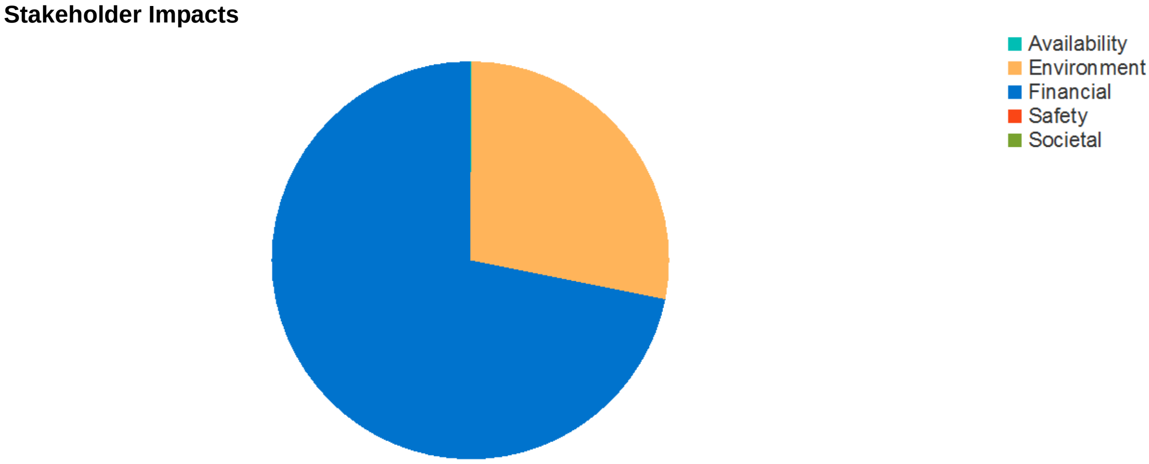
- Produce a detailed Validation Report, confirming the validity of data sources used in the Methodology
- Test a range of supply and demand scenarios and incorporate an appropriate scenario to best represent Availability and Reliability risk

24.7. A review of the Methodology by independent gas transmission experts has been carried out and several improvements identified and incorporated.

24.8. At the time of writing, the final Validation Report has been submitted to Ofgem. We understand that once this work is complete Ofgem will formally "not reject" the Methodology and a License change progressed to restate our RIIO-1 targets in terms of monetised risk commenced.

25. Lighting - Consequence of Failure

25.1. The chart below shows the expected stakeholder impacts because of failure occurring on the lighting assets. The charts show the relative numbers of consequence events, not relative monetised risk.



25.2. There are a vast range of different types of Electrical asset used in the operation of the NTS. Electrical systems are an essential enabler, ensuring that dependent assets can perform their primary function of safely and reliably transporting gas and ensuring NTS resilience. Failure of a single electrical component will not generally have an immediate impact on service, and that a combination of failures may need to occur for a service impact to occur. Despite the variety of electrical assets, there are only two significant failure modes, which apply to all asset categories above:

- **Financial risk** is mostly associated with the costs of operating and maintaining the network at the current level of risk and compliance. The financial risk of non-compliance with legislation, such as DSEAR, are not included but could be significant
- **Environmental risk** is associated with the failure of a range the assets depend upon an electrical system to operate reliably and upon demand, which may cause a subsequent loss of gas through trips, vents and leaks. The carbon emissions associated with the maintenance of assets will contribute to Environmental risk. As there are many electrical assets within our asset maintenance systems, the proportional share of maintenance emissions attributed to electrical assets will be significant

26. Lighting - Intervention Options Considered

Potential Intervention Options

26.1. The following intervention categories apply to the Lighting assets:

- **Monitoring** - monitoring of column corrosion, wall thicknesses, plinth condition
- **Repair** - replace lamps with existing, repair or replace individual cables
- **Refurbishment** - change to LED fittings, replacement of fittings like for like
- **Replacement** – replace whole light fittings, cables and columns

Intervention Unit Costs

26.2. The total RIIO-2 investment for Lighting represents 47% of the Electrical investment theme. The unit costs that underpin this investment are entirely developed using historical outturn costs that are supported by one or two data points.

26.3. The table below provides the unit costs for all the potential lighting asset interventions.

Intervention Unit Costs - Lighting

Intervention	Cost (£)	Unit	Evidence	Data Points	Overall value in BP
Lighting					
A22.20.1.22 / Site Lighting - Emergency - Minor Refurb	[redacted]	Per site	Outturn	1	£82,444
A22.20.1.21 / Site Lighting - Emergency - Major Refurb	[redacted]	Per site	Outturn	1	£185,500
A22.20.1.23 / Site Lighting - Emergency - Replacement	[redacted]	Per site	Outturn	1	£103,056
A22.20.1.24 / Site Lighting - External Columns Major Refurb	[redacted]	Per site	Estimated - Quotation	2	£0
A22.20.1.25 / Site Lighting - External Columns Replacement	[redacted]	Per site	Outturn	2	£11,401,076
A22.20.1.27 / Site Lighting - Internal - Minor Refurb	[redacted]	Per site	Outturn	1	£51,528
A22.20.1.26 / Site Lighting - Internal - Major Refurb	[redacted]	Per site	Outturn	1	£154,583
A22.20.1.28 / Site Lighting - Internal - Replacement	[redacted]	Per site	Outturn	1	£154,583
A22.20.1.30 / Site Lighting External Task Minor Refurb	[redacted]	Per site	Estimated - Other	1	£0
A22.20.1.29 / Site Lighting External Task Major Refurb	[redacted]	Per site	Outturn	1	£267,944
A22.20.1.31 / Site Lighting External Task Replacement	[redacted]	Per site	Outturn	1	£1,082,083
A22.22.4.40 / Site Lighting - Emergency - Minor Refurb (St. Fergus)	[redacted]	Per site	Estimated - Other	0	£0
A22.22.4.41 / Site Lighting - Emergency - Major Refurbishment (St. Fergus)	[redacted]	Per site	Estimated - Other	0	£0
A22.22.4.42 / Site Lighting - Emergency – Replacement (St. Fergus)	[redacted]	Per site	Estimated - Other	0	£0
A22.22.4.34 / Site Lighting - External Columns Minor Refurb (St. Fergus)	[redacted]	Per site	Estimated - Quotation	1	£0

A22.22.4.35 / Site Lighting - External Columns Major Refurbishment (St. Fergus)	[redacted]	Per site	Estimated - Other	0	£0
A22.22.4.36 / Site Lighting - External Columns Replacement (St. Fergus)	[redacted]	Per site	Estimated - Other	0	£0
A22.22.4.37 / Site Lighting - Internal - Minor Refurb (St. Fergus)	[redacted]	Per site	Outturn	1	£0
A22.22.4.38 / Site Lighting - Internal - Major Refurbishment (St. Fergus)	[redacted]	Per site	Estimated - Other	0	£0
A22.22.4.39 / Site Lighting - Internal – Replacement (St. Fergus)	[redacted]	Per site	Estimated - Other	0	£0
A22.22.4.31 / Site Lighting External Task Minor Refurb (St. Fergus)	[redacted]	Per site	Estimated - Other	0	£0
A22.22.4.32 / Site Lighting External Task Major Refurbishment (St. Fergus)	[redacted]	Per site	Outturn	1	£0
A22.22.4.33 / Site Lighting External Task Replacement (St. Fergus)	[redacted]	Per site	Estimated - Other	0	£0

HV Switchgear and Transformers

27. HV Switchgear and Transformers - Equipment Summary

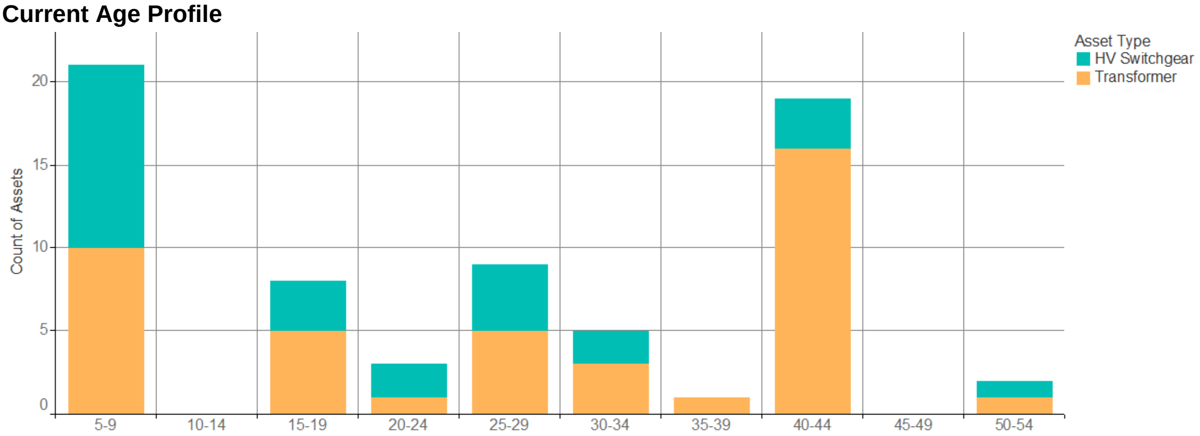
27.1. The HV Switchgear consists of 132/33/11kV Air insulated or Gas Insulated Metalclad switchgear supplying and switching the HV supply from the DNO to the site. The main site distribution transformers receive the HV supply to the site and convert it to a 400V LV supply for distribution to the process equipment and plant on the site. The HV switchgear also supplies the power to the HV VSD compressor units which are detailed within the compressor investment paper.

Location and Volume

27.2. There are 18 HV switchgear systems and 20 oil transformers permanently installed across the NTS.

27.3. The chart below shows the age profiles for HV switchgear and transformer assets at 2019.

Current Age Profile



Redundancy

27.4. There is no site with redundancy for the HV Switchgear although some sites have a split busbar system for dual supply.

28. HV Switchgear and Transformers - Problem Statement

28.1. The HV Switchgear and Transformers were installed at the time that the sites were built and some are experiencing increased defects leading to a loss of insulation oil and increased likelihood of faults, or the HV switchgear may be deemed unsafe to operate. There are specific issues with some of the transformers for which oil tests are showing reduced winding insulation levels and increased levels of DBDS inhibitors in the oil indicating a breakdown of the insulating properties of the oil.

Drivers for Investment

28.2. The key drivers for investment in the HV Switchgear and Transformer assets are:

- Asset Deterioration
- Legislation

28.3. The assets deteriorate over time and with use which leads to an inability to perform their required function. This can also result in them no longer complying with direct legislative requirements such as EAWR.

28.4. **Asset Deterioration** - Elements of the assets are deteriorating due to age, corrosion and wear. Increasing defects are being recorded and the assets are becoming unreliable, unsafe to operate or difficult to work on. On the main site transformers specifically, we are seeing increasing:

- Degradation of the insulation and windings
- Failure of cast resin insulation on dry type transformers
- Tap changer failures
- Corrosion of the enclosure
- Degradation of the insulating properties of the oil
- Failure of auxiliary components and instrumentation

Legislation - The inspections on the assets are showing increased defects that need to be rectified to maintain compliance with the EAWR.

Impact of No Investment

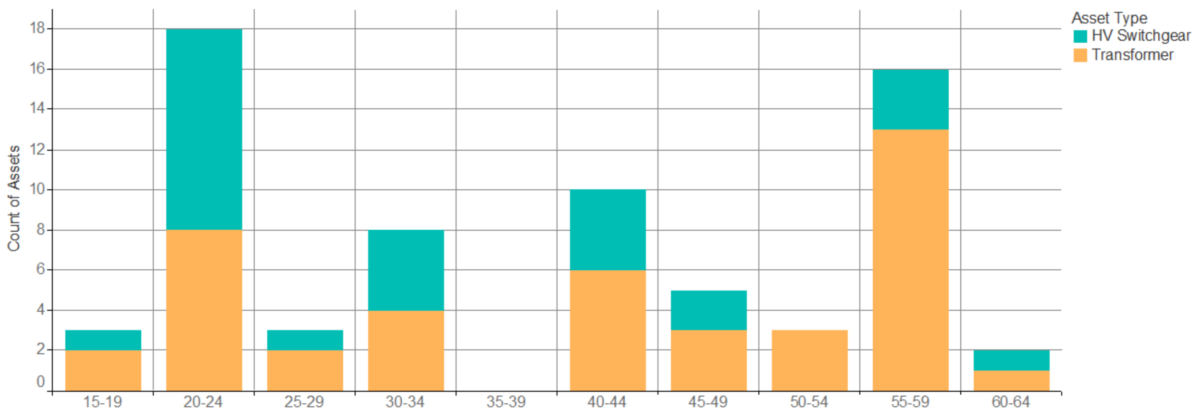
28.5. The impact of no investment in the HV Switchgear and Transformer asset will lead to further deterioration of the assets and the inability to operate them safely or asset failure. This will impact the efficient operation of the sites on which the assets are located, primarily compressor sites and therefore will impact the availability of the compressors. This could affect the flow of gas on the NTS and impact the ability to deliver service to our customers.

28.6. The use of HV Switchgear and Transformers without investment in inspection and remediation will breach legal obligations under EAWR.

Asset Age

28.7. The chart below shows the age profiles by the end of RIIO-3 for HV switchgear and transformer assets given no investment.

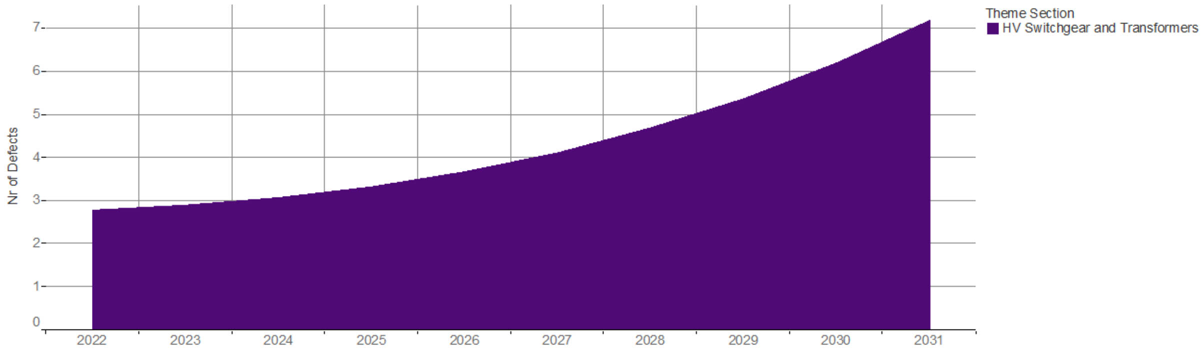
Age Profile by End of RIIO-3 – No Investment



Defects

28.8. The chart below shows the predicted defects for HV switchgear and transformer assets given no investment. This is based on the current levels of defects and applying our NOMS deterioration models.

Predicted Defects – No Investment



Desired Outcomes

28.9. The outcome of the investment in HV Transformers and Switchgear is to:

- Ensure all HV Switchgear and Transformers are fit for purpose, legally compliant and meet the required standards.

Example of Problem

28.10. The photographs below show some of the corrosion defects found on the HV transformers. These are typically in locations that are difficult to remediate because of the narrow gap between cooling fins.

Spend Boundaries

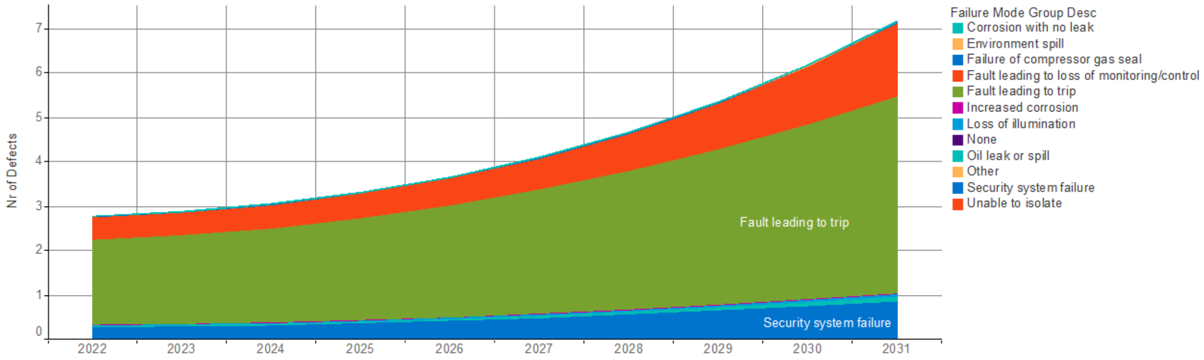
28.11. The proposed investment includes all HV Switchgear and Transformers on the NTS, including any ‘no-regrets’ site investments at both St Fergus and Bacton to keep them safe and operational whilst the separate funding mechanism for the proposed projects are progressed via Uncertainty Mechanisms.

29. HV Switchgear and Transformers – Probability of Failure

Probability of Failure

29.1. The chart below shows the equipment failure mode frequency for HV switchgear and transformer assets representing the consequences resulting from failures predicted for a no investment scenario using our NOMS methodology.

Predicted Defects by Failure Mode – No Investment



Interventions

29.2. All Electrical interventions are defined as consequential interventions. This is because the prime function of an Electrical asset is to allow a whole site to operate and perform its prime function of safely and reliably transporting gas, and to protect employees and the public. All risk benefits associated with Electrical assets are therefore considered to align with the following definition of a consequential risk intervention:

"Any intervention on a network asset, or other infrastructure asset, that modifies the probability of failure, or consequence of failure of ***another network asset****. A consequential asset can include, for example:*

- installation or removal of physical infrastructure designed to prevent damage to adjacent assets in the event of an asset failure (e.g. installation of a blast wall),
- addition or disposal that increases or decreases the resilience of a local or regional network and hence modifies the consequence of failure of other asset(s) in the locality or region."

Consequential Interventions

29.3. The table below shows the drivers for Electrical asset investment that are defined as consequential interventions.

Types of Intervention

NARMs Asset Intervention Category	Secondary Asset Classes
Consequential Interventions **(Non-risk tradeable)**	Electrical - including standby generators

29.4. Our NOMs Methodology attempts to model the indirect benefits delivered by these assets in terms of the reduction in PoF or Consequence of Failure (CoF) upon a related and/or adjacent asset (e.g. the relationship between the presence reliable electrical system and a potential asset/site outage). These quantified, but indirect, impacts are used within the CBAs accompanying this justification report, but are not considered to be reliable enough for use as a NARMs monetised risk metric.

Electrical Interventions

29.5. The interventions in HV switchgear and transformers are shown in the table below:

Interventions

Interventions	SAC	Intervention Categories
A22.20.1.10 / HV Switchgear Minor Refurb	Electrical - including standby generators	Minor Refurbishment
A22.20.1.11 / HV Switchgear Replacement	Electrical - including standby generators	Replacement
A22.20.1.9 / HV Switchgear - Major Refurb	Electrical - including standby generators	Major Refurbishment
A22.22.4.13 / HV Switchgear Minor Refurb (St. Fergus)	Electrical - including standby generators	Minor Refurbishment
A22.22.4.14 / HV Switchgear Major Refurb (St. Fergus)	Electrical - including standby generators	Major Refurbishment
A22.20.1.35 / Transformers Major Refurb	Electrical - including standby generators	Major Refurbishment
A22.20.1.36 / Transformers Minor Refurb	Electrical - including standby generators	Minor Refurbishment
A22.20.1.37 / Transformers Replacement	Electrical - including standby generators	Replacement
A22.22.4.10 / Transformers Minor Refurb (St. Fergus)	Electrical - including standby generators	Minor Refurbishment
A22.22.4.11 / Transformers Major Refurb (St. Fergus)	Electrical - including standby generators	Major Refurbishment
A22.22.4.12 / Transformers Replacement (St. Fergus)	Electrical - including standby generators	Replacement

Data Assurance

29.6. All PoF and CoF values are taken from the National Grid Gas Transmission 'Methodology for Network Output Measures' (the Methodology). The Methodology was originally submitted for public consultation in April 2018, with three generally favourable responses received in May 2018. On this basis, Ofgem were happy to provisionally not reject the Methodology pending further work to:

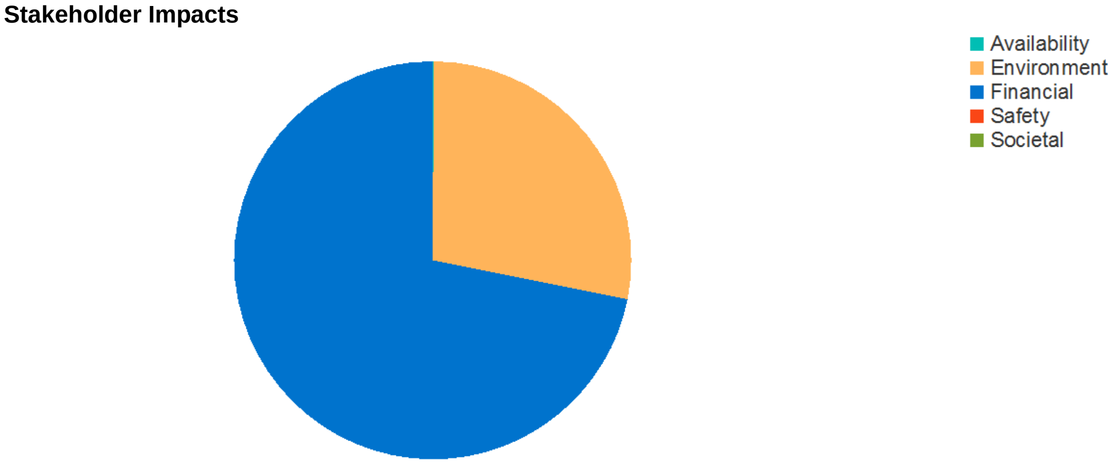
- Produce a detailed Validation Report, confirming the validity of data sources used in the Methodology
- Test a range of supply and demand scenarios and incorporate an appropriate scenario to best represent Availability and Reliability risk

29.7. A review of the Methodology by independent gas transmission experts has been carried out and several improvements identified and incorporated.

29.8. At the time of writing, the final Validation Report has been submitted to Ofgem. We understand that once this work is complete Ofgem will formally "not reject" the Methodology and a License change progressed to restate our RIIO-1 targets in terms of monetised risk commenced.

30. HV Switchgear and Transformers - Consequence of Failure

30.1. The chart below shows the expected stakeholder impacts because of failure occurring on the HV switchgear and transformer assets. The charts show the relative numbers of consequence events, not relative monetised risk.



30.2. There are a vast range of different types of Electrical asset used in the operation of the NTS. Electrical systems are an essential enabler, ensuring that dependent assets can perform their primary function of safely and reliably transporting gas and ensuring NTS resilience. Failure of a single electrical component will not generally have an immediate impact on service, and that a combination of failures may need to occur for a service impact to occur. Despite the variety of electrical assets, there are only two significant failure modes, which apply to all asset categories above:

- **Financial risk** is mostly associated with the costs of operating and maintaining the network at the current level of risk and compliance. The financial risk of non-compliance with legislation, such as DSEAR, are not included but could be significant
- **Environmental risk** is associated with the failure of a range the assets depend upon an electrical system to operate reliably and upon demand, which may cause a subsequent loss of gas through trips, vents and leaks. The carbon emissions associated with the maintenance of assets will contribute to Environmental risk. As there are many electrical assets within our asset maintenance systems, the proportional share of maintenance emissions attributed to electrical assets will be significant

31. HV Switchgear and Transformers - Options Considered

Potential Intervention Options

31.1. The following intervention categories apply to the HV Switchgear and Transformer assets:

31.2. HV Switchgear

- **Repair** – includes items such as insulating gas top ups or new individual components
- **Refurbishment** – includes replacement circuit breaker or new protection relay
- **Replacement** – includes the replacement of the whole switchboard and its associated assets

Transformer

- **Repair** – includes painting or other coating replacement, new cooling fins
- **Refurbishment** – includes oil replacement, new tap changer, new terminal box or new instruments
- **Replacement** - includes the replacement of the transformer and its associated assets

Intervention Unit Costs

31.3. The total RIIO-2 investment for HV Switchgear & Transformer represents 2% of the Electrical investment theme. Less than half (46%) of the unit costs that support this subtheme have been developed using supplier quotations. The remainder of the costs have been developed using other estimation methods (54%) due to there being limited supplier quotations available.

31.4. The table below provides the unit costs for all the potential HV Switchgear and Transformer interventions.

Intervention Unit Costs – HV Switchgear and Transformers

Intervention	Cost (£)	Unit	Evidence	Data Points	Overall value in BP
HV Switchgear & Transformer					
A22.20.1.10 / HV Switchgear Minor Refurb	[redacted]	Per asset	Estimated - Other	0	£41,222
A22.20.1.9 / HV Switchgear - Major Refurb	[redacted]	Per asset	Estimated - Other	0	£0
A22.20.1.11 / HV Switchgear Replacement	[redacted]	Per asset	Estimated - Other	0	£257,639
A22.20.1.35 / Transformers Major Refurb	[redacted]	Per asset	Estimated - Quotation	2	£0
A22.20.1.36 / Transformers Minor Refurb	[redacted]	Per asset	Estimated - Quotation	2	£46,375
A22.20.1.37 / Transformers Replacement	[redacted]	Per asset	Estimated - Quotation	2	£206,111
A22.22.4.13 / HV Switchgear Minor Refurb (St. Fergus)	[redacted]	Per asset	Estimated - Other	0	£0
A22.22.4.14 / HV Switchgear Major Refurb (St. Fergus)	[redacted]	Per asset	Estimated - Other	0	£0

A22.22.4.10 / Transformers Minor Refurb (St. Fergus)	[redacted]	Per asset	Estimated - Quotation	1	£0
A22.22.4.11 / Transformers Major Refurb (St. Fergus)	[redacted]	Per asset	Estimated - Quotation	1	£0
A22.22.4.12 / Transformers Replacement (St. Fergus)	[redacted]	Per asset	Estimated - Quotation	1	£0

Site Electrical Systems

32. Site Electrical Systems - Equipment Summary

32.1. There are a large number of other site electrical systems distributed across sites on the NTS. These consist of the following:

- **Compressor Station Electrical Systems** - These include supplies to valve actuators /motors/process heaters/trace heating/building services/Instrument power supplies etc. (including cabling and junction boxes) etc.
- **Compressor Station Auxiliary Systems** - The auxiliary equipment associated with a gas compressor and gas generator including oil systems/water systems/starter systems, motors etc. (electrical elements only)
- **Earthing and Lightning Protection** - The earthing system provides an essential fault return path for any electrical system and includes conductors, bars and rods. A lightning protection system conducts a lightning strike safely to ground and provides surge protection to sensitive equipment. Both systems provide an essential safety function for personnel and for equipment.
- **AGI Electrical Systems** - Electrical systems installed on all above ground installations except for compressors and terminals.

Location and Volume

32.2. There are 70 auxiliary systems permanently installed on sites across the NTS, including 24 earthing and lightning protection systems.

Redundancy

32.3. Auxiliary systems on the compressor sites have full redundancy. There is no redundancy on the AGI electrical systems or the earthing/lightning protection systems.

33. Site Electrical Systems - Problem Statement

33.1. The Site Electrical Systems and Distribution assets are old, with most installed at the time the site was constructed. They are of many varied designs and from a multitude of manufacturers and therefore widely differing standards of design and construction. Inspections and testing are finding an increasing number of defects being raised against a range of issues.

- Components are either not functioning or not operating correctly
- Inability to be safely operated or worked on
- There is a lack of compliance with EAWR and DSEAR

Drivers for Investment

33.2. The key drivers for investment in the Site Electrical Systems assets are:

- Asset Deterioration
- Legislation

33.3. The Site Electrical Systems deteriorate over time and with use which leads to their inability to perform their required function. This can also result in them no longer complying with direct legislative requirements such as EAWR and DSEAR.

Asset Deterioration – Elements of the assets are deteriorating due to age, corrosion of terminations, erosion of insulation and corrosion of equipment is evident across the asset base. Increasing defects are being recorded and the assets are becoming unreliable, unsafe to operate or difficult to work on. Tests of the earthing systems are showing deterioration of performance and lack of effective protection for parts of some sites.

Legislation – Some of the assets do not meet current safety standards. The inspections on the assets are showing increased defects that need to be rectified to maintain compliance with the EAWR and in some cases DSEAR.

Impact of No Investment

33.4. The use of the Site Electrical Systems without investment in inspection, assessment and remediation will breach legal obligations under EAWR and DSEAR. With no investment in proper remediation the assets would continue to deteriorate which will result in an increasing number of defects. Depending upon the severity of the defect then the affected assets may require immediate isolation rather than planned repair which further increases the impact.

33.5. The impact of loss of supply to all of a site is dependent upon the nature of the site and the asset being supplied:

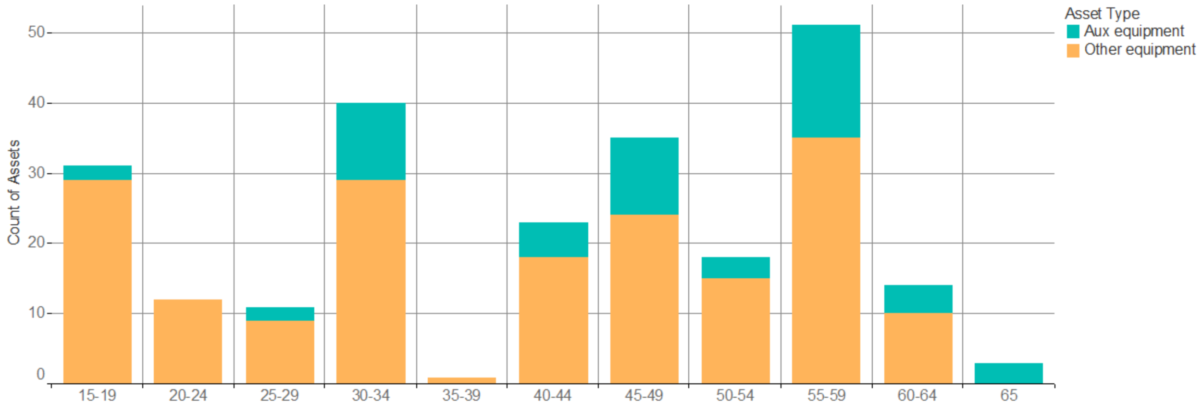
- compressor unit trips
- unavailability of safety, quality and/or metering systems
- inability to utilise standby generation

33.6. Due to the critical nature of the electrical supplies, without a manged programme of investment the Site Electrical Systems could rapidly become a major risk to the continued safe and efficient operation of the NTS.

Asset Age

33.7. The chart below shows the age profiles by the end of RIIO-3 for auxiliary and other electrical system assets given no investment.

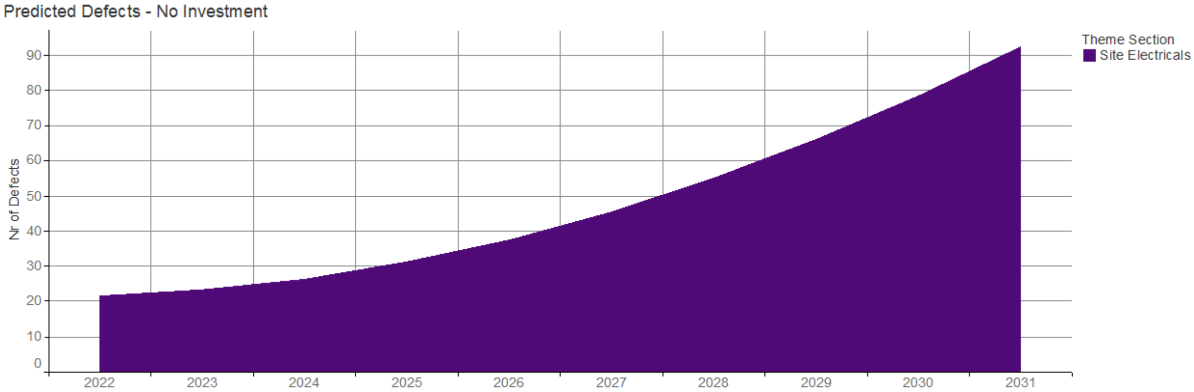
Age Profile by End of RIIO-3 – No Investment



Defects

33.8. The chart below shows the predicted defects for auxiliary and other electrical systems assets given no investment. This is based on the current levels of defects and applying our NOMS deterioration models.

Predicted Defects – No Investment



33.9. Lack of investment in Site Electrical Systems may also lead to the loss of containment of high pressure gas, safety related issues and environmental damage.

Desired Outcome

33.10. The outcome of the investment is to ensure all AGI distribution systems, auxiliary equipment, earthing and lightning protection and other equipment is fit for purpose, legally compliant and meets the required standards.

Examples of the Problem

33.11. The photographs below show some of the defects on the site earthing systems.

Degraded joints and broken earthing bonds

33.12. Typical earthing issues to correct are poor joints, corroded rods, increased earthing protection where a site fault level has increased. This is all part of a programme of refurbishment to ensure that site earthing systems meet current standards and are in a suitable state to continue to operate correctly for the next 10-15 years.

33.13. Typical lightning protection system issues are:

- addition of surge protection equipment to meet current standards and protect equipment and personnel against the secondary effects of a lightning strike travelling along a cable and damaging vital equipment within the control building;
- improved building protection to meet current standards which will protect personnel working within site buildings in the event of a direct lightning strike on the building;
- refurbishment of existing systems.

33.14. This work has an important health and safety impact and has been identified by the HSE as a requirement.

AGI Distribution Issues

33.15. Typical AGI distribution issues are age expired and/or unsafe switchgear and cabling.

Spend Boundaries

33.16. The proposed investment includes all Site Electrical Systems on the NTS, including any 'no-regrets' site investments at both St Fergus and Bacton to keep them safe and operational whilst the separate funding mechanism for the proposed projects are progressed via Uncertainty Mechanisms.

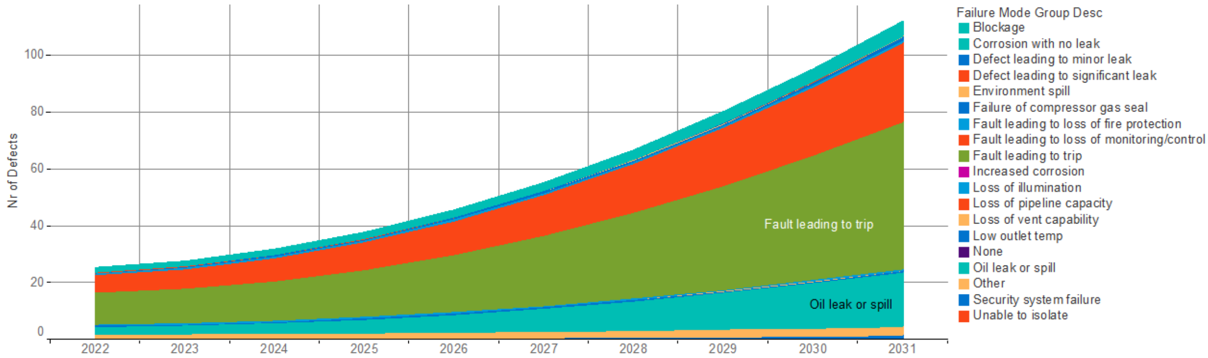
33.17. In the case where the electrical system supplies an end component only, the electrical supply element is included in this investment case, whereas the end process element is included elsewhere; valve actuators are an example of this.

34. Site Electrical Systems - Probability of Failure

Probability of Failure

34.1. The chart below shows the equipment failure mode frequency for auxiliary and other electrical systems assets representing the consequences resulting from failures predicted for a no investment scenario using our NOMS methodology.

Predicted Defects by Failure Mode – No Investment



Interventions

34.2. All Electrical interventions are defined as consequential interventions. This is because the prime function of an Electrical asset is to allow a whole site to operate and perform its prime function of safely and reliably transporting gas, and to protect employees and the public. All risk benefits associated with Electrical assets are therefore considered to align with the following definition of a consequential risk intervention:

"Any intervention on a network asset, or other infrastructure asset, that modifies the probability of failure, or consequence of failure of ***another network asset****. A consequential asset can include, for example:*

- *installation or removal of physical infrastructure designed to prevent damage to adjacent assets in the event of an asset failure (e.g. installation of a blast wall),*
- *addition or disposal that increases or decreases the resilience of a local or regional network and hence modifies the consequence of failure of other asset(s) in the locality or region."*

Consequential Interventions

34.3. The table below shows the drivers for Electrical asset investment that are defined as consequential interventions.

Types of Intervention

NARMs Asset Intervention Category	Secondary Asset Classes
Consequential Interventions (Non-risk tradeable)	Electrical - including standby generators

34.4. Our NOMs Methodology attempts to model the indirect benefits delivered by these assets in terms of the reduction in PoF or Consequence of Failure (CoF) upon a related and/or adjacent asset (e.g. the relationship between the presence reliable electrical system and a potential asset/site outage). These quantified, but indirect, impacts are used within the CBAs accompanying this justification report, but are not considered to be reliable enough for use as a NARMs monetised risk metric.

Electrical Interventions

34.5. The interventions in AGIs, auxiliary and other systems are shown in the table below:

Interventions

Intervention	SAC	Intervention Category
A22.20.1.1 / AGIs - Distribution Systems - Major Refurb	Electrical - including standby generators	Major Refurbishment
A22.20.1.2 / AGI - Distribution Systems Electrical Survey/Minor refurb	Electrical - including standby generators	Minor Refurbishment
A22.20.1.3 / AGIs - Distribution Systems - Replacement	Electrical - including standby generators	Replacement
A22.22.4.4 / AGIs - Distribution Systems - Minor Refurb (St. Fergus)	Electrical - including standby generators	Minor Refurbishment
A22.22.4.5 / AGIs - Distribution Systems - Major Refurb (St. Fergus)	Electrical - including standby generators	Major Refurbishment
A22.20.1.4 / Auxillary Equipment Major Refurb	Electrical - including standby generators	Major Refurbishment
A22.20.1.6 / Auxillary Equipment Replacement	Electrical - including standby generators	Replacement
A22.22.4.2 / Auxillary Equipment Major Refurb (St. Fergus)	Electrical - including standby generators	Major Refurbishment
A22.22.4.3 / Auxillary Equipment Replacement (St. Fergus)	Electrical - including standby generators	Replacement
A22.20.1.7 / Earthing & Lightning Protection Systems Major Refurb	Electrical - including standby generators	Major Refurbishment
A22.20.1.8 / Earthing & Lightning Protection Systems Minor Refurb	Electrical - including standby generators	Minor Refurbishment
A22.22.4.6 / Earthing & Lightning Protection Systems Minor Refurb (St. Fergus)	Electrical - including standby generators	Minor Refurbishment

Data Assurance

34.6. All PoF and CoF values are taken from the National Grid Gas Transmission ‘Methodology for Network Output Measures’ (the Methodology). The Methodology was originally submitted for public consultation in April 2018, with three generally favourable responses received in May 2018. On this basis, Ofgem were happy to provisionally not reject the Methodology pending further work to:

- Produce a detailed Validation Report, confirming the validity of data sources used in the Methodology
- Test a range of supply and demand scenarios and incorporate an appropriate scenario to best represent Availability and Reliability risk

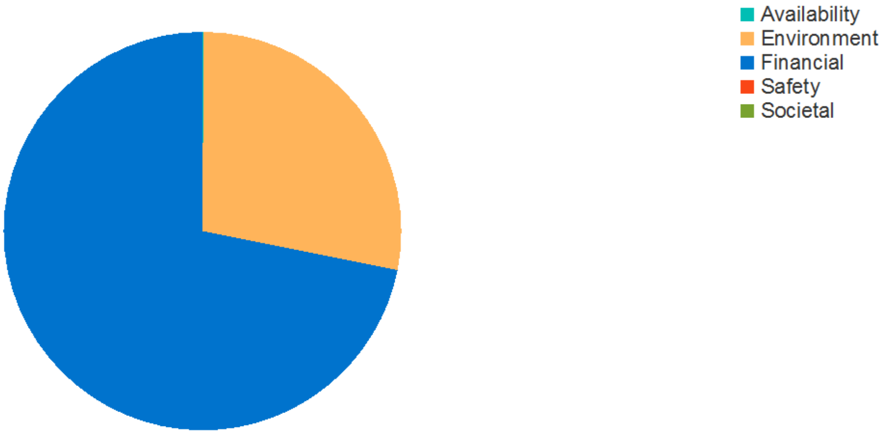
34.7. A review of the Methodology by independent gas transmission experts has been carried out and several improvements identified and incorporated.

34.8. At the time of writing, the final Validation Report has been submitted to Ofgem. We understand that once this work is complete Ofgem will formally “not reject” the Methodology and a License change progressed to restate our RIIO-1 targets in terms of monetised risk commenced.

35. Site Electrical Systems - Consequence of Failure

35.1. The chart below shows the expected stakeholder impacts because of failure occurring on the auxiliary and other electrical systems assets. The charts show the relative numbers of consequence events, not relative monetised risk.

Stakeholder Impacts



35.2. There are a vast range of different types of Electrical asset used in the operation of the NTS. Electrical systems are an essential enabler, ensuring that dependent assets can perform their primary function of safely and reliably transporting gas and ensuring NTS resilience. Failure of a single electrical component will not generally have an immediate impact on service, and that a combination of failures may need to occur for a service impact to occur. Despite the variety of electrical assets, there are only two significant failure modes, which apply to all asset categories above:

- **Financial risk** is mostly associated with the costs of operating and maintaining the network at the current level of risk and compliance. The financial risk of non-compliance with legislation, such as DSEAR, are not included but could be significant
- **Environmental risk** is associated with the failure of a range of assets that depend upon an electrical system to operate reliably and upon demand, which may cause a subsequent loss of gas through trips, vents and leaks. The carbon emissions associated with the maintenance of assets will contribute to Environmental risk. As there are many electrical assets within our asset maintenance systems, the proportional share of maintenance emissions attributed to electrical assets will be significant.

36. Site Electrical Systems - Intervention Options Considered

Potential Intervention Options

36.1. The following intervention categories apply to the Site Electrical Systems:

36.2. Other Electrical Systems

- **Repair** – replacement of individual components, repair of cable and terminations.
- **Refurbishment** –new heater, new motor, new cable
- **Replacement** – new system including all parts

Earthing/Lightning Protection Systems

- **Repair** – clean and remake joints.
- **Refurbishment** – replace earth rods or conductors, install surge protection devices
- **Replacement** – Not considered

AGI Electrical Systems

- **Repair** – replacement of individual components, repair of cable and terminations.
- **Refurbishment** –new heater, new motor, new cable
- **Replacement** – new system including all parts

Intervention Unit Costs

36.3. The total RIIO-2 investment for Electrical Systems represents 5% of the Electrical investment theme. A minor proportion of the unit costs (6%) that support this subtheme have been developed using historical outturn cost data points, which need to be verified. The remainder of the costs have been developed using other estimation methods (94%) because there are limited supplier quotations available.

36.4. The table below provides the unit costs for all the potential site electrical systems interventions.

Intervention Unit Costs – Electrical Systems

Intervention	Cost (£)	Unit	Evidence	Data Points	Overall value in BP
Electrical Systems					
A22.20.1.2 / AGI - Distribution Systems Electrical Survey/Minor refurb	[redacted]	Per asset	Estimated - Other	0	£0
A22.20.1.1 / AGIs - Distribution Systems - Major Refurb	[redacted]	Per asset	Estimated - Other	0	£0
A22.20.1.3 / AGIs - Distribution Systems - Replacement	[redacted]	Per asset	Estimated - Other	0	£0
A22.20.1.4 / Auxillary Equipment Major Refurb	[redacted]	Per site	Estimated - Other	0	£56,681
A22.20.1.6 / Auxillary Equipment Replacement	[redacted]	Per site	Estimated - Other	0	£649,250
A22.20.1.7 / Earthing & Lightning Protection Systems Major Refurb	[redacted]	Per asset	Outturn	1	£86,567
A22.20.1.8 / Earthing & Lightning Protection Systems Minor Refurb	[redacted]	Per asset	Outturn	1	£0
A22.20.1.19 / Other Equipment Minor Refurb	[redacted]	Per site	Estimated - Other	0	£63,894
A22.20.1.18 / Other Equipment Major Refurb	[redacted]	Per site	Estimated - Other	0	£133,972
A22.20.1.20 / Other Equipment Replacement	[redacted]	Per site	Estimated - Other	0	£556,500
A22.22.4.4 / AGIs - Distribution Systems - Minor Refurb (St. Fergus)	[redacted]	Per asset	Estimated - Other	0	£0
A22.22.4.5 / AGIs - Distribution Systems - Major Refurb (St. Fergus)	[redacted]	Per asset	Estimated - Other	0	£0
A22.22.4.2 / Auxillary Equipment Major Refurb (St. Fergus)	[redacted]	Per site	Estimated - Other	0	£0
A22.22.4.3 / Auxillary Equipment Replacement (St. Fergus)	[redacted]	Per site	Estimated - Other	0	£0
A22.22.4.6 / Earthing & Lightning Protection Systems Minor Refurb (St. Fergus)	[redacted]	Per asset	Outturn	1	£0
A22.22.4.7 / Other Equipment Minor Refurb (St. Fergus)	[redacted]	Per site	Estimated - Other	0	£0
A22.22.4.8 / Other Equipment Major Refurb (St. Fergus)	[redacted]	Per site	Estimated - Other	0	£0
A22.22.4.9 / Other Equipment Replacement (St. Fergus)	[redacted]	Per site	Estimated - Other	0	£0

Business Case

In this section, we set out our overall investment plan for Electrical Assets. This section includes the overall case for investment in the electrical assets and provide the decision rationale and benefits for all the individual asset classes. This section demonstrates why the proposed investment levels are the right levels to ensure the health and reliability of these assets for the investment period and beyond.

37. Business Case Outline and Discussion – Site Electrical Assets

Key Business Case Drivers Description

37.1. The site electrical assets deteriorate over time and with use, which leads to their inability to perform their required function. This can also result in them no longer complying with direct legislative requirements such as EAWR, DSEAR and the IET wiring regulations.

37.2. Therefore, in developing our risk forecasts and proposed plans we have considered the impact of the following drivers for investment in the Site Electrical Systems are:

- Legislation
- Asset Deterioration
- Whole Life Cost
- Obsolescence

37.3. Considering these drivers ensures that we develop plans that meet our legal obligations to intervene and prioritise the right assets for investment.

Business Case Summary – Site Electrical Assets

Outcomes delivered

37.4. In appraising asset health investment, we have considered how assets can impact on several outcomes:

- Reliability risk
- Environmental risk
- Safety risk
- Impact on wider society

37.5. Maintaining the health of these assets is important in ensuring they continue to deliver the required capability in a safe manner. Specific outcomes associated with this investment are:

- To maintain compliance and safe operation of the all the site electrical systems assets on compressor sites and AGIs through effective lowest whole life cost replacement or refurbishment
- To ensure that the site electrical assets are not a contributory factor to the failure of supply of gas to our customers through their impact on the AGI and compressor assets.

- To ensure that the site electrical systems do not result in a loss of containment of high pressure gas, present a safety risk and are not a limiting factor on availability or performance of the NTS.

Stakeholder Support

37.6. Consumer and stakeholder research and engagement has been integral to the development of our asset health investment plans. Early discussions realised that to engage in meaningful dialogue, our plan outputs should be presented at a programme rather than asset level of detail. This is due to the integrated nature of our Asset Health plan which makes it challenging to disaggregate and engage on individual elements. For details of our stakeholder engagement approach please refer to 'I want to take gas on and off the system where and when I want' [Chapter 14 of the GT submission].

Programme Options – Site Electrical Assets

37.7. Our aim in developing the investment plan is to deliver value to our consumers and stakeholders. Hence, we have considered a range of options from the do nothing position through to reductions in risk across all measures. These have been used to explore the credible options for varying the investment and appraising the impact on our legal compliance, risk position and stakeholders.

37.8. In developing our plan, the following options have been considered for investment in the site electrical systems assets. Please note that all programme options include any fixed 'no-regrets' investments associated with the Bacton and St Fergus sites.

Baseline – Do Nothing

37.9. The impact of no investment in our Site Electrical Systems increases service risk over a 10-year period, the most significant being an eight-fold increase in the volume of gas released to atmosphere every year, through the associated failure of a range of assets that depend upon an electrical system to operate reliably and on demand, which may cause a subsequent loss of gas through trips, vents and leaks. This option includes the reactive only investment across all the Site Electrical Systems types and is the option against which all the other options are compared.

Programme Option 1 – Fix on Fail

37.10. This option undertakes minimal reactive minor refurbishment to the assets as and when they fail. No proactive replacement is undertaken with only the minimal amount of either minor or major refurbishment work to restore operation and compliance.

Programme Option 2 – Minimal Proactive Re-lifing

37.11. This option considers minimal proactive re-lifing with only the oldest assets fully assessed and considered for replacement investment. All other assets are fixed on failure / non-compliance with the minimal amount of either minor or major refurbishment work undertaken to restore operation and compliance.

Programme Option 3 – Risk Based Re-lifing

37.12. This option considers risk based re-lifing of the assets based on their performance, criticality, condition and age compared to design life. A decision on replacement or minor / major refurbishment is then made. There is some allowance for reactive fix on fail which will consist of the most appropriate minor / major refurbishment or replacement.

Programme Option 4 – Increased Proactive Re-lifing

37.13. This option considers increased proactive re-lifing based on asset age with all assets considered for replacement before the end of their design life. A reduced allowance for fix on fail is included for some assets which fail earlier in their lifecycle.

Programme Options Summary

37.14. In considering the CBA for each of the programme options, a summary of all the potential programme options is provided in the table below.

Potential Programme Options

Option	RIIO-2 Invest' £ m	RIIO-3 Invest' £ m	PV Costs £ m	PV benefits £ m	Net NPV £ m	CB Ratio	Payback Period (years)
1 - Fix on Fail	£10.14	£16.35	£32.52	£10,283.58	£10,251.06	316.27	5
2 - Minimal Proactive Re-lifing	£14.93	£19.11	£38.10	£8,967.72	£8,929.62	235.38	5
3 - Risk Based Re-lifing	£23.24	£25.44	£49.68	£6,427.64	£6,377.96	129.38	6
4 - Increased Proactive Re-lifing	£51.31	£36.20	£86.44	£6,542.73	£6,456.29	75.69	8

37.15. The graph shows the cumulative discounted NPV of the net benefit for each of the investment options.

Option Payback – Net NPV

Programme Options Selection

37.16. All the potential options are cost beneficial over the 45-year analysis period. The selection of the preferred option has therefore been based on an assessment of the level of risk, maintaining our compliance with legislation and delivering value for consumers and stakeholders. The outcomes associated with each option are provided below:

Programme Option 1 – Fix on Fail

37.17. This option results in increased reactive minor and major refurbishments (i.e. fix on fail) across most of site electrical asset types. Assets are not worked on until they fail or are deemed non-compliant, so where there is no redundancy there will be an impact on the availability of the compressors and other primary assets. Whilst the safety risk of non-complaint electrical assets is managed through the inspection regime, this option results in more assets that will be found to be non-compliant and require isolation before resolution to return to operation. The overall safety risk from electrical assets is increased. Reactive minor and major refurbishment is not a long-term solution for the assets so this option will defer significant replacement expenditure to after RIIO-2 and RIIO-3 and increase the overall whole life costs of the standby power supply assets.

Programme Option 2 – Minimal Proactive Re-lifing

37.18. Whilst re-lifing some of the oldest assets, this option still results in an unacceptable level of impact on the primary assets, disconnection of electrical assets and increases in safety risk. Significant expenditure is still deferred outside RIIO-2 and RIIO-3.

Programme Option 3 – Risk Based Re-lifing

37.19. A risk based re-lifing of the assets through a considered and appropriate mix of proactive major / minor refurbishment and replacement combined with some reactive fix on fail, maintains the levels of safety risk, asset isolations and impact on performance to current levels. There is minimal deferment of expenditure outside the RIIO-2 and RIIO-3 period. This option enables an acceptable level of investment to be maintained across the short and medium terms to manage the level of performance and risk.

Programme Option 4 – Increased Proactive Re-lifing

37.20. Increased proactive replacement and refurbishment reduces the risk of impacting the availability of operational assets and the associated service performance of the NTS. The number of failed assets and isolations to maintain compliance is minimised however this is at the expense of significantly increased investment in RIIO-2 and RIIO-3. This level of investment is unacceptable to stakeholders and results in an unachievable and unacceptable number of outages on the NTS to enable the work to be undertaken.

Preferred Option

37.21. Our preferred option is Option 3 to undertake a risk based approach to re-lifing the site electrical assets. This will maintain the current level of risk whist containing future investment to acceptable levels and even though some of the other options require less investment or are more cost beneficial, this is only because the CBA does not account for the full range of relevant factors which are relevant to the consumer in the service they receive and to National Grid in terms of the obligations it has with regards to reliability and legislative requirements. In particular, the other options do not meet the required outcomes to:

- Allow safe access and egress to/from site and enable National Grid staff and contractors to work safely in low light areas or at night.
- Ensure lack of availability or performance of any of the electrical systems does not affect the availability and performance of the compressor or other sites.
- Ensure continued compliance of all electrical assets with legal obligations and required standards
- Maintain the safe operational availability of compressor stations and AGIs that have electrical equipment installed

37.22. Our preferred option is also consistent with feedback from our stakeholder engagement who wanted at least the current level of risk maintained. Our chosen option meets the desired outcomes in at least whole life cost.

37.23. A complete explanation of the selected option is provided in the next sections.

38. Decision Approach and Benefits – LV Switchboards and Distribution

38.1. In this section, we set out our investment decision approach for LV Switchboards and Distribution together with the benefits of the investment.

Key Drivers

38.2. The key drivers for investment in the LV Switchboards and Distribution assets are:

- Legislation
- Asset Deterioration

Investment Decision Approach

38.3. To deliver the outcomes for the investment period the LV Switchboards and Distribution assets require a mixture of intervention categories.

- To prevent the assets entering a state of unmanaged decline and the associated performance impacts on the NTS an inspection and risk based proactive programme of work will be undertaken. This will be supplement by repair activity for unexpected failures. All assets past the end of their design life of 40 years by the end of RIIO-2, plus any others with known reliability or operational issues will be considered for refurbishment or replacement as part of this programme.
- The predicted volumes of assets to invest in and type of intervention are based on a risk based assessment utilising the current known defects, the age of the assets, the defects that may occur and the criticality of the assets and sites supplied by the assets.
- Work on these assets has a relatively high unit costs therefore the actual interventions undertaken on each asset and their timing will be based on an inspection and technical risk assessment of each LV Switchboard and Distribution asset. This assessment will include age, criticality of the assets and sites supplied together with any currently known issues such as unreliability, corrosion or obsolescence likely to result in failure, unsafe conditions or non-compliance with legislation.

38.4. The proposed mix of interventions and programme of work will be continually reassessed and reprioritised using the results of the ongoing inspections and any individual defects that arise during the period.

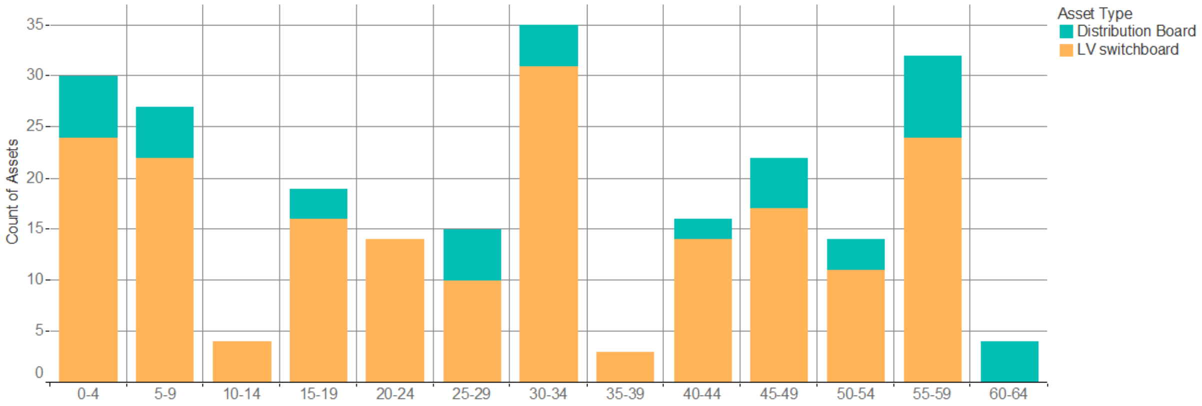
Investment Benefits

38.5. The investment will achieve the following improvements in the LV Switchboards and Distribution assets.

Asset Age

38.6. The chart below shows the expected age profiles for the LV switchboards and distribution boards after investment. The average age at the end of RIIO-3 is reduced from 43 years to 28 years.

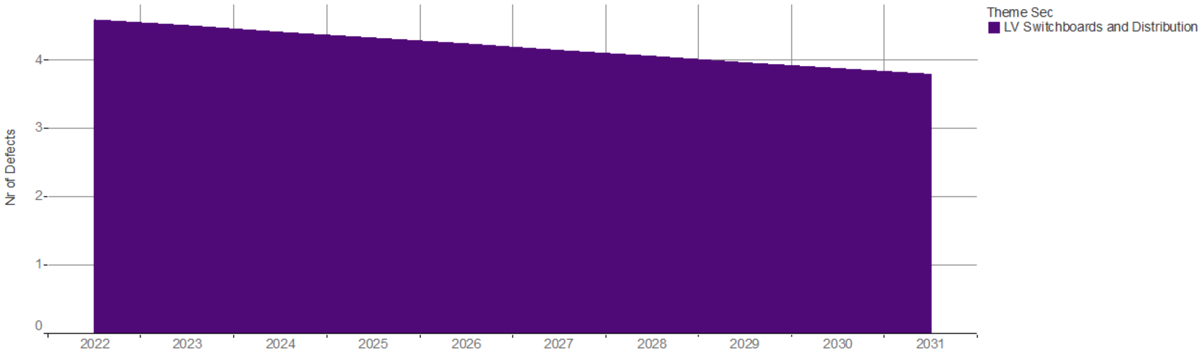
Age Profile by End of RIIO-3 – With Investment



Defects

38.7. The chart below shows the predicted numbers of defects of LV switchboards and distribution boards after investment based on our current levels of defects and our NOMS methodology.

Predicted Defects with Preferred Investment Option



39. Decision Approach and Benefits – Standby Generators

39.1. In this section, we set out our investment decision approach for Standby Generators together with the benefits of the investment.

Key Drivers

39.2. The key drivers for investment in the Standby Generators assets are:

- Legislation
- Asset Deterioration
- Obsolescence

Investment Decision Approach

39.3. To deliver the outcomes for the investment period the Standby Generator assets require a mixture of intervention categories.

- To prevent the assets entering a state of unmanaged decline and the associated performance impacts on the NTS an inspection and risk based proactive programme of work will be undertaken. This will be supplement by repair activity for unexpected failures.
- The predicted volumes of assets to invest in and type of intervention are based on a risk based assessment utilising the current known defects, the age of the assets, the defects that may occur and the criticality of the assets and sites supplied by the assets.
- Work on these assets has a relatively high unit cost therefore the actual interventions undertaken on each asset and their timing will be based on an inspection and technical risk assessment of each Standby Generator asset. This assessment will include age, criticality of the assets and sites supplied together with any currently known issues such as unreliability, corrosion or obsolescence likely to result in failure, unsafe conditions or non-compliance with legislation.
- The ageing gas turbine generators at Diss and Chelmsford may be replaced during the period with package diesel generators. The diesel generators at Aylesbury and Felindre may be repaired or refurbished. The diesel generators at Wisbech and Peterborough will be further assessed during the remainder of RIIO-1 and a decision on their future taken. Other units on the network require upgrade of the control systems and replacement enclosures due to corrosion.

39.4. The proposed mix of interventions and programme of work will be continually reassessed and reprioritised using the results of the ongoing inspections and any individual defects that arise during the period.

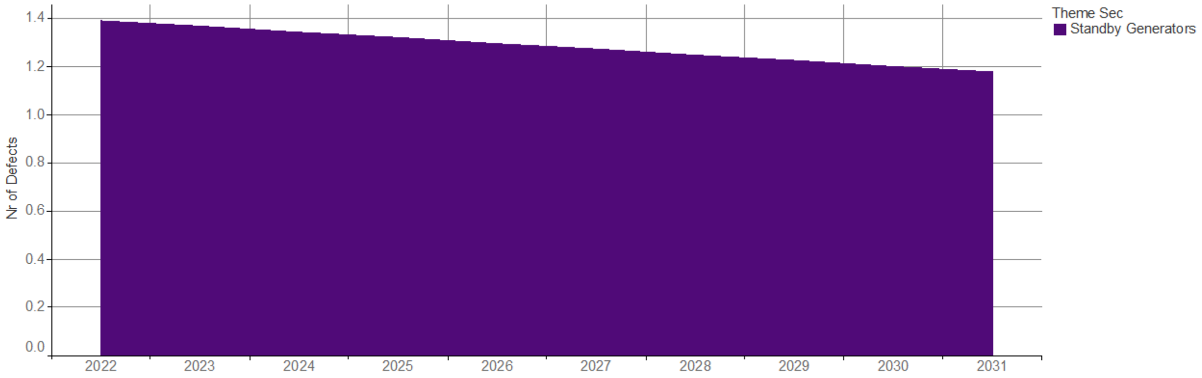
Asset Age

39.5. The average age at the end of the standby generators at the end of RIIO-3 is reduced from 33 years to 18 years.

Defects

39.6. The chart below shows the predicted numbers of defects of standby generators after investment based on our current levels of defects and our NOMS methodology.

Predicted Defects with Preferred Investment Option



40. Decision Approach and Benefits – Lighting

40.1. In this section, we set out our investment decision approach for Lighting together with the benefits of the investment.

Key Drivers

40.2. The key drivers for investment in the lighting assets are:

- Asset Deterioration
- Whole Life Cost
- Legislation

Investment Decision Approach

40.3. To deliver the outcomes for the investment period the Lighting assets require a mixture of intervention categories. The decision on the volume of each of the interventions required has been determined using the following methodologies.

40.4. Site Road and Floodlighting

- Continuation of the network wide system of monitoring of column wall thicknesses is required. This was started in 2018 and is planned to finish in 2021.
- A risk based assessment of the results of the monitoring will be used to identify the site road and flood lighting that requires replacement due to corrosion of columns and failing cables. Opportunity will be taken to replace them with more energy efficient and longer lasting LED fittings where appropriate. Alternative column materials and lower maintenance fittings are being considered.

40.5. Compressor Cab Internal Lighting

- Due to age a programme of upgrade/replacement is needed to energy efficient LED lamps and to replace life expired fire resistant cables and maintain compliance with DSEAR.

40.6. External Task Lighting and Emergency Lighting

- External task lighting to be reviewed and updated where required to meet current standards of safe lighting. Phasing will be based on work already begun and processed to design phase in RIIO-1 plus priority based on risk based assessment following surveys already undertaken and to be undertaken.
- The mix of interventions proposed for the investment period are based on the results of survey and inspection information already obtained together with the analysis of historic investment.
- The proposed mix of interventions and programme of work will be continually reassessed and reprioritised using the results of the ongoing inspections and any specific defects that arise

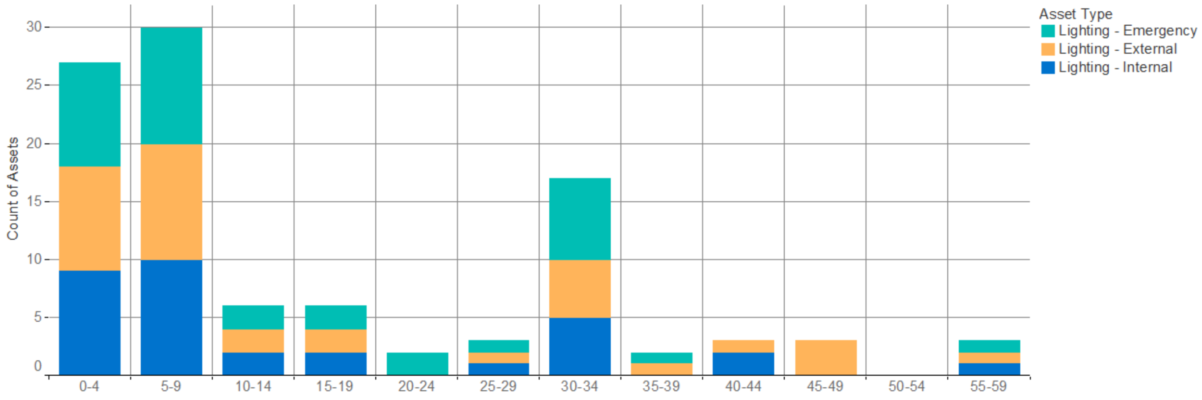
Investment Benefits

40.7. The investment will achieve the following improvements in the Lighting assets.

Asset Age

40.8. The chart below shows the expected age profiles for external, internal and emergency lighting after investment.

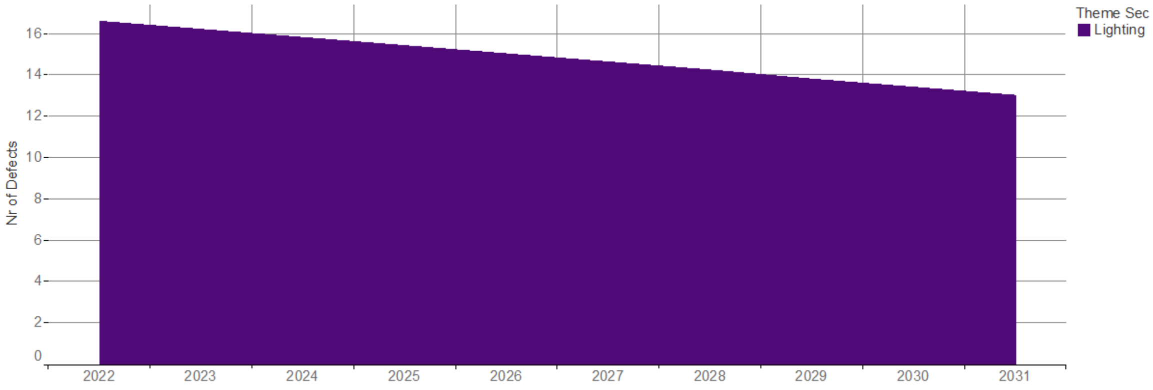
Age Profile by End of RIIO-3 – With Investment



Defects

40.9. The chart below shows the predicted numbers of defects of lighting assets after investment based on our current levels of defects and our NOMS methodology.

Predicted Defects with Preferred Investment Option



41. Decision Approach and Benefits – HV Switchgear and Transformers

41.1. In this section, we set out our investment decision approach for HV Switchgear and Transformers together with the benefits of the investment.

Key Drivers

41.2. The key drivers for investment in the HV Switchgear and Transformer assets are:

- Legislation
- Asset Deterioration

Investment Decision Approach

41.3. To deliver the outcomes for the investment period the HV Switchgear and Transformers assets require a mixture of intervention categories.

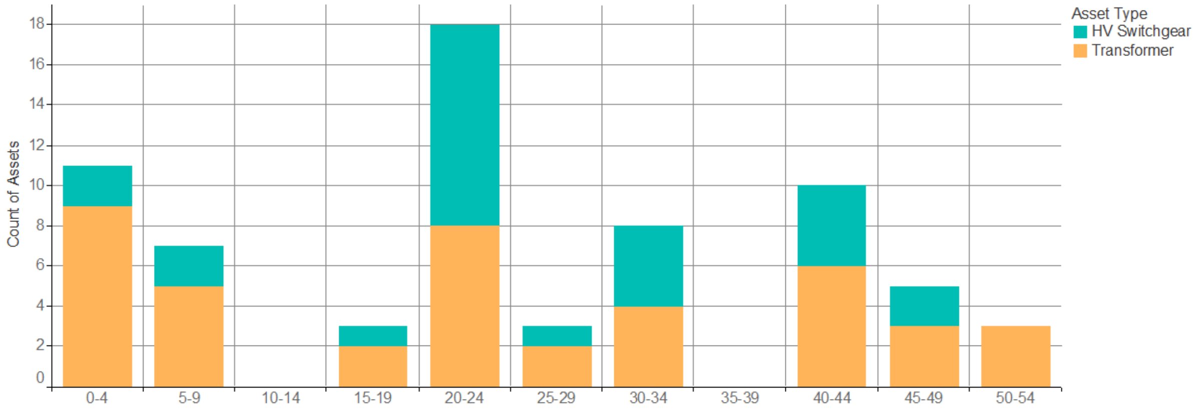
- To prevent the assets entering a state of unmanaged decline and the associated performance impacts on the NTS the inspection, testing and risk based proactive programme of work will be continued.
- The predicted volumes of assets to invest in and type of intervention are based on a risk based assessment utilising the current known defects, the age of the assets, the defects that may occur and the criticality of the assets and sites supplied by the assets. This has been combined with analysis of historical interventions.
- Work on these assets has a relatively high unit cost therefore the actual interventions undertaken on each asset and their timing will be based on an inspection, test and technical risk assessment of each asset. This assessment will include age, criticality of the assets and sites supplied together with any currently known issues such as unreliability, corrosion or obsolescence likely to result in failure, unsafe conditions or non-compliance with legislation.

41.4. The proposed mix of interventions and programme of work will be continually reassessed and reprioritised using the results of the ongoing inspections and any individual defects that arise during the period.

Asset Age

41.5. The charts below show the expected age profiles for HV switchgear and transformer assets after investment. The average age of the transformers and HV switchgear at the end of RIIO-3 falls from 37 to 27 years.

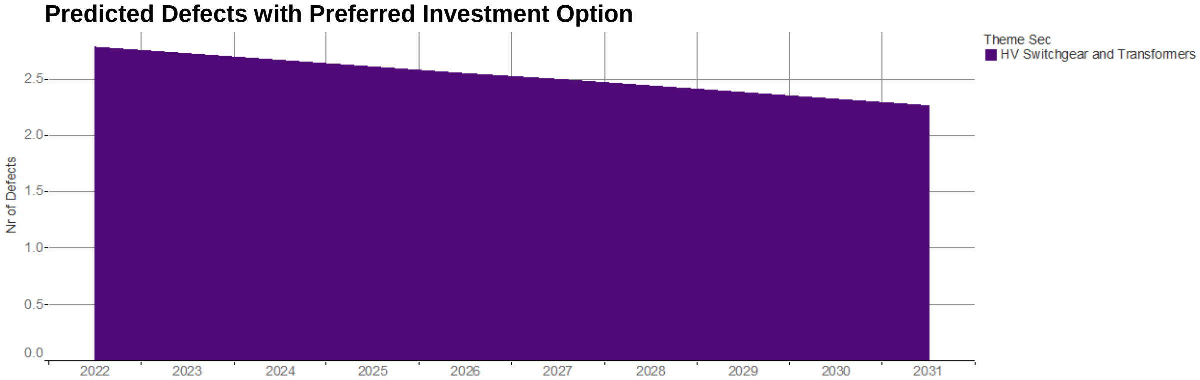
Age Profile by End of RIIO-3 – With Investment



Defects

41.6. The chart below shows the predicted numbers of defects of HV switchgear and transformer assets after investment based on our current levels of defects and our NOMS methodology.

Predicted Defects with Preferred Investment Option



42. Decision Approach and Benefits – Site Electrical Systems

42.1. In this section, we set out our investment decision approach for Site Electrical Systems together with the benefits of the investment.

Key Drivers

42.2. The site electrical systems deteriorate over time and with use, which leads to their inability to perform their required function. This can also result in them no longer complying with direct legislative requirements such as EAWR, DSEAR and the IET wiring regulations.

42.3. Therefore, in developing our risk forecasts and proposed plans we have considered the impact of the following drivers for investment in the Site Electrical Systems are:

- Legislation
- Asset Deterioration

42.4. Considering these drivers ensures that we develop plans that meet our legal obligations to intervene and prioritise the right assets for investment.

Investment Decision Approach

42.5. To deliver the outcomes for the investment period the Site Electrical Systems require a mixture of intervention categories.

42.6. To prevent the assets entering a state of unmanaged decline and the associated performance impacts on the NTS an inspection and risk based proactive programme of work will be undertaken.

42.7. The predicted volumes of assets to invest in and type of intervention are based on a risk based assessment utilising the current known defects, the age of the assets, the defects that may occur and the criticality of the assets and sites supplied by the assets. This has been combined with analysis of the historical levels of defects and category of intervention.

42.8. Work on these assets has a relatively high unit costs therefore the actual interventions undertaken on each asset and their timing will be based on an inspection and test results combined with a technical risk assessment of each Site Electrical System. This assessment will include age, criticality of the assets and sites supplied together with any currently known issues such as unreliability, corrosion or obsolescence likely to result in failure, unsafe conditions or non-compliance with legislation.

Compressor Stations Electrical and Auxiliary Systems - A planned programme of surveys will be undertaken during the period to give a detailed risk assessment report of each Compressor Electrical and Auxiliary System and a recommendation on whether it needs repairing, refurbishing or replacing and what it's expected life is.

Earthing and Lightning Protection - A complete programme of surveys and condition reports has been produced for all the compressor stations followed by remedial action where required during RIIO-1. This will be extended to the rest of the network during RIIO-2. All sites need to be checked.

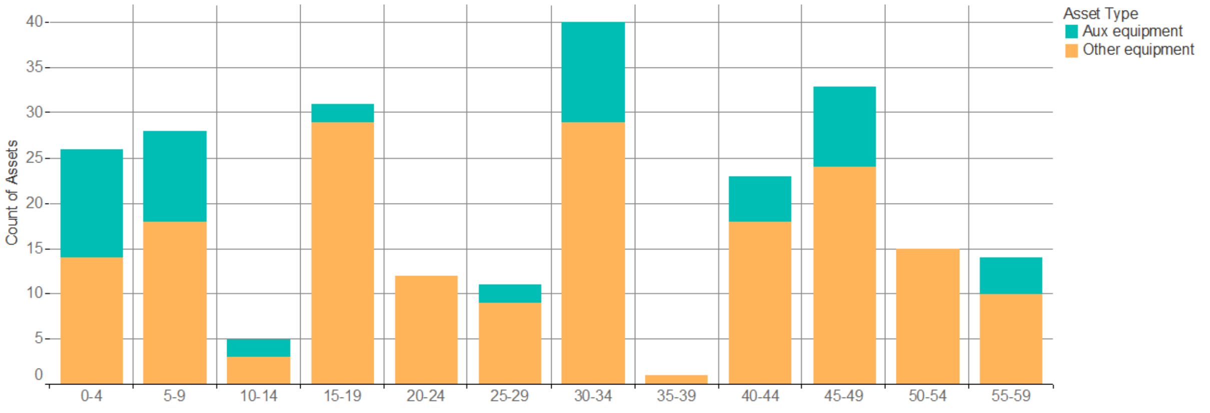
AGI Systems – A planned programme of surveys will be undertaken during the period to give a detailed assessment report of each AGI electrical system and a recommendation on whether it needs repairing, refurbishing or replacing and what it's expected life is.

42.9. The proposed mix of interventions and programme of work will be continually reassessed and reprioritised using the results of the ongoing inspections and any individual defects that arise during the period.

Asset Age

42.10. The charts below show the expected age profiles for auxiliary and other electrical systems assets after investment. The average age of these assets will reduce from 41 years to 30 years at the end of RIIO-3.

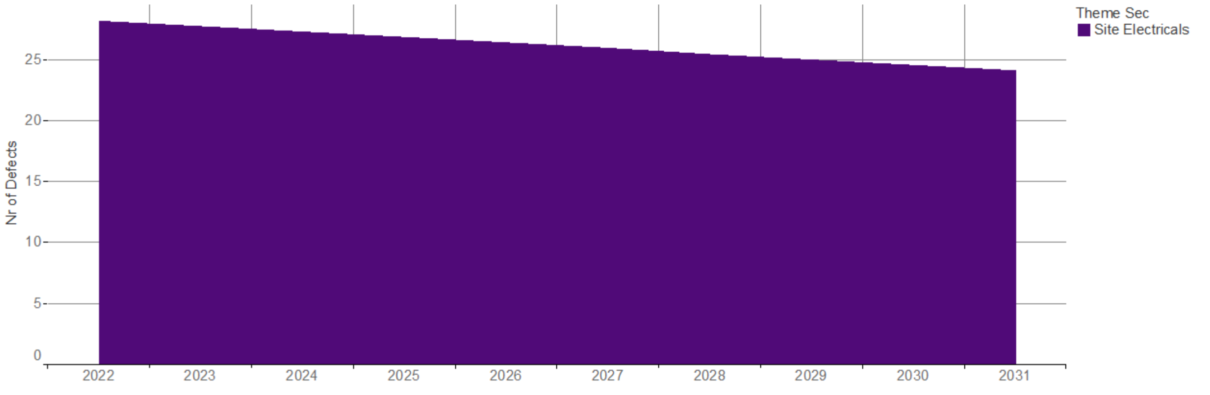
Age Profile by End of RIIO-3 – With Investment



Defects

42.11. The chart below shows the predicted numbers of defects of auxiliary and other electrical systems assets after investment based on our current levels of defects and our NOMS methodology.

Predicted Defects with Preferred Investment Option



43. Business Case Summary

Preferred Option

43.1. To deliver the required outcomes for all our stakeholders we have developed the most effective combination of efficient interventions. These form the programme of work for the site electrical systems in the investment period. [redacted]:

Intervention Volumes

[redacted]

[redacted]

Asset Health Spend Profile

43.2. The profile of investment in the site electrical systems, driven from the derived volumes of work and the efficient unit costs, for the period is shown is the table below:

Profile of Investment in Site Electrical Assets

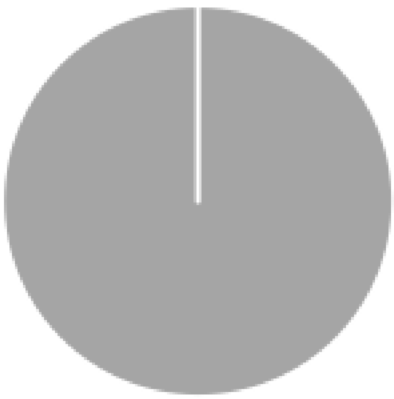
Investment (£ 000's)	RIIO-2					RIIO-3				
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Electrical – including standby generators	900	4,931	6,212	5,021	6,174	3,778	5,111	4,312	9,460	2,776
Total	900	4,931	6,212	5,021	6,174	3,778	5,111	4,312	9,460	2,776
	23,239					**25,437**				

43.3. We are targeting an appropriate level of asset health investment to mitigate the reliability, safety and environmental risks from an ageing asset base.

Intervention Drivers

43.4. The following chart shows the breakdown of investment across each of the intervention drivers. This shows that all of the investment consists of interventions that are based on internal policy.

RIIO-2 Site Electrical Assets Intervention Drivers[3]



Programme CBA

43.5. In line with HM Treasury Green Book advice and Ofgem guidance we have appraised whether investment in site electrical systems is value for money. We have considered costs over a 45-year period in a full cost benefit analysis (CBA).

43.6. The CBA shows that investment in these assets is cost beneficial over the 45-year period. The investment pays back in 6 years. This is shown below.

Cost Benefit Summary Site Electrical Assets[4]

	10 years	20 years	30 years	45 years
Present Value costs (£m)	£17.15	£27.61	£35.69	£49.68
Present Value H&S benefits (£m)	£0.00	£0.03	£0.10	£0.36
Present Value non H&S benefits (£m)	£39.94	£370.90	£1,576.57	£6,427.29
Net Present Value (£m)	£22.79	£343.32	£1,540.98	£6,377.96

43.7. Due to the varied nature of the electrical systems and their direct impact on many of the primary assets, investment in them is generally cost beneficial. The challenge is therefore developing the right level of investment to manage the risk to service. The

[3] See Appendix A for intervention driver category definitions
[4] A14.21.1 Site Electrical Systems CBA

forecast for defects by the end of RIIO-3 with no investment shows a significant rise in defects and outcome risk to levels unacceptable to ourselves and our stakeholders.

43.8. In developing the proposed programme of work, we aimed to achieve the optimal balance between the level of investment and the risk to outcomes. We believe we have achieved this through a programme of re-lifing a proportion of the assets on a site by site basis whilst managing any individual defects on other sites on a case by case basis.

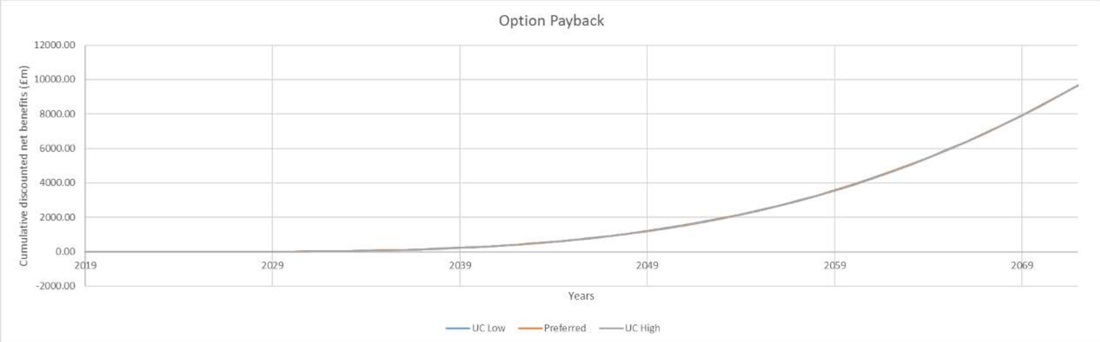
43.9. This approach achieves the balance of ensuring the assets remain fit for purpose in the medium term whilst maintaining affordable and deliverable levels of investment in the short term.

43.10. 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.

Unit Cost Sensitivity

43.11. We have used the potential range of unit cost variance to assess the sensitivity of the Cost Benefit Analysis to the upper and lower limits. The graph below shows the results of this compared to the preferred option.

Net Benefits of Upper and Lower Unit Cost Sensitivity



43.12. Whilst the level of cost benefit and the payback period changes as the unit costs vary, the investment remains cost beneficial across the range of unit costs.

43.13. This level of investment will ensure we successfully manage asset deterioration and obsolescence, whilst meeting our legal obligations. It will ensure we deliver the outcomes that consumers and stakeholder tell us they want us to meet.

43.14. Across our stakeholders there is little support for keeping the costs the same as in RIIO-1, given the unacceptable consequential increase in risk.

Preferred Option

44. Preferred Option Scope and Project Plan - – Site Electrical Assets

44.1. The section summarises our preferred investment plan required to deliver acceptable and affordable outcomes for our stakeholders.

Preferred option

44.2. To deliver the required outcomes for all our stakeholders we have developed the most effective combination of efficient interventions. These form the programme of work for the site electrical systems in the investment period.

Intervention Volumes

[redacted]

[redacted]

Asset Health Spend Profile

44.3. The profile of investment in the site electrical systems, driven from the derived volumes of work and the efficient unit costs, for the period is shown is the table below:

Profile of Investment in Site Electrical Assets

Investment (£ 000's)	RIIO-2					RIIO-3				
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Electrical – including standby generators	900	4,931	6,212	5,021	6,174	3,778	5,111	4,312	9,460	2,776
Total	900	4,931	6,212	5,021	6,174	3,778	5,111	4,312	9,460	2,776
	23,239					**25,437**				

Delivery Planning

44.4. At this point in time the delivery of our RIIO-2 and RIIO-3 plans are in principle deliverable based on initial assessments of work. We will regularly review the plan to consider any known or changing constraints, customer impacts and bundling opportunities. In the event of churn our plan must be reoptimised to reflect the impact of the change, and provide an opportunity to reconsider the efficient timing of delivery.

44.5. We recognise that many of our asset classes are co-located across the NTS pipe network and sites. Much of our investment delivery also requires outages of the associated pipelines or plant and equipment. The availability of outages is extremely limited across most of the NTS due to the radial nature of the network. It is therefore most efficient from both financial and network risk points of view to bundle investment across asset classes within the same outage period. This maximises the work undertaken in any outage whilst ensuring efficient delivery through minimised project overheads.

44.6. These assets are likely to require outages as the associated plant will not be available during interventions, however this may not be the full isolation and venting that is required with other primary plant types. Where asset interventions do not require outages then the campaign approach will still be applied to maximise the opportunity for delivery of the same type of work across many locations. This enables efficient procurement through significant volumes of common works.

44.7. This approach is particularly effective when applied at a feeder level or for a whole site. In which case the preparatory inspection, investigation, risk assessment, planning and procurement activities can be completed as far as possible before the outage. This allows the maximum amount of intervention and risk reduction to be bundled into a single 'campaign' across the length of the feeder. During RIIO-1 this has proved to be an extremely efficient and effective approach to delivery of our programmes of work.

44.8. We recognise that whilst this is in many cases the most efficient method of delivery there are still individual or groups of assets that present a risk to our performance that do not 'fit' into the planned 'campaign' approach. We will ensure that these risks are remediated as efficiently as possible through individual or small groups of targeted interventions.

44.9. Where asset interventions do not require outages then the campaign approach will still be applied to maximise the opportunity for delivery of the same type of work across many locations. This enables efficient procurement through significant volumes of common works.

Appendix A – Intervention Driver Categories

Intervention Driver Categories

	Name	Definition
A	Legislation & Industry Standards	Intervention required to ensure compliance with relevant safety legislation and/or adopted industry standards.
B	OEM Guidance	Intervention recommended by OEM to maintain intended asset performance and safe operation. Any deviation from this guidance shall be specifically risk-assessed to ensure compliance with relevant safety legislation.
C	Internal Policy	Internal policy defined intervention required to maintain asset performance, and to align with relevant safety legislative requirements