CIRCUIT BREAKER PORTFOLIO OVERVIEW	
Name of Scheme/Programme	Circuit Breaker Portfolio Overview
Primary Investment Driver	Asset Health
Scheme reference/ mechanism or category	N/A
Output references/type	N/A
Cost	N/A
Delivery Year	N/A
Reporting Table	N/A
Outputs included in RIIO T1 Business Plan	N/A

Issue Date	Issue No	Amendment Details
October 2019	Issue 1	First issue of document
December 2019	Issue 2	Updated to reflect final business plan

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1. Introduction

This paper provides an overview of the circuit-breaker (CB) assets and their condition issues while defining the strategy on how they are prioritised for intervention.

SPT owns 529 CBs at voltages of 132kV and above of different technologies as were available at the time.

CBs are maintained, refurbished or have critical components replaced to maintain reliability, operational risk and safety performance at a level which meets defined criteria.

A method has been defined for detailed condition assessment, based upon present condition, known failure mechanisms, technical asset lives for the various CB types and their key deterioration patterns, criticality of location in terms of failure consequences, strategic importance, environmental aspects and innovation.

The CB refurbishment and replacement strategy is also based upon the NOMS asset risk methodology as implemented with the CBRM tool.

2. Executive Summary

An important aspect of asset management is to understand and quantify the condition of CBs on the network and assess their remaining lives. This has a significant bearing on the planning of a refurbishment and replacement programme which aims to make maximum use of the remaining life but which avoids failures.

The asset strategy is targeted at the replacement of Air Blast (AB) CBs and Bulk Oil (BO) CBs. These types of CB were installed between the 1950s and the 1970s and as such, are approaching or have reached end of life through an inability deliver the required performance and obsolescence leading to an inability to support the equipment.

The proposal is through the RIIO-T2 and RIIO-T3 periods, these assets will be replaced with new, high performance, fully supported equipment to deliver the required security and reliability that the transmission network requires.

3. Overview of Assets and Health Issues

The condition of the population of circuit-breakers is best understood by their categorisation by technology type: air-blast, bulk oil, hydraulic/pneumatic SF_6 and spring mechanism SF_6.

3.1 Air Blast Circuit Breakers

Air-Blast circuit-breakers of types OBR 30/60, OIBR80, Frame-R and GA6 have all been assessed and all types have reliability and obsolescence issues which place a limit on their remaining useful life. The lack of manufacturer support, the availability of critical spares and the OPEX costs associated with ongoing maintenance require that these types are included in a replacement programme as further refurbishment has been determined not to be practicable or economical.

3.2 Bulk Oil Circuit Breakers

Bulk Oil CBs such as the JW420 and OW410 are 1950s and 1960s designs that are now experiencing failure modes that class them as end of life. The failures are the results of degradation of fundamental components. These include, but are not limited to, failures of oil seals leading to carbon contamination, inability to align mechanisms, bushing issues, unable to meet transmission network fault levels and unsupported and irreplaceable components. Any one of these issues could lead to a catastrophic failure of the plant as has happened in other TOs.

3.3 SF_6 Hydraulic and Pneumatic Circuit Breakers

These CBs are constructed using SF_6 as the insulation and interruption medium and use either a pneumatic or hydraulic energy source to open and close the mechanism. While the actual CB interrupters are in good condition, the deterioration is within the hydraulic and pneumatic mechanisms. Issues with the failure of these pneumatic and hydraulic systems have begun to occur. These are caused by corrosion of the auxiliary pipes and equipment and have led to mal-operation of plant to either open or close. In addition, many of these types are now unsupported by the manufacturers or the cost of replacement mechanisms is uneconomic when compared to replacement with a new spring mechanism CB. The main current carrying components of the CBs are all similar technology and are in good condition.

A programme of mid-life intervention to replace the hydraulic and pneumatic mechanisms to prevent this failure mode driving the end of life of the SF_6 CB population or replace the circuit-breakers, whichever is the most economical is proposed for the RIIO-T2 period. The increase in market competition and the development of non-SF_6 CBs at 132kV and 275kV has reduced the price of new CBs dramatically. The price of refurbishing equipment is now comparable to replacing with a new asset. In line with the SPT approach of adopting non-SF_6 technology were it is technically viable, each of these sites will be individually evaluated to determine the best solution possible based on cost, technical and sustainability compliance.

3.4 SF_6 Spring Mechanism Circuit Breakers

The population of spring-mechanism SF_6 circuit-breakers are relatively young and have, to date, exhibited few issues that would justify intervention. The main area of concern to date has been gas tightness and given the relative simplicity of the operating mechanism, this is expected to be the case for the foreseeable future. While there are no planned interventions in the T2 period, as a responsible operator SPT will identify sites where SF_6 repairs are not effectively resolving the issues and actively seek to replace with non-SF_6 alternatives where viable.

The following table summarises the strategy.

CB Type	Interrupter condition	Mechanism	Intervention strategy
Air Blast	Poor (unsupported)	Poor (unsupported)	Replacement
Oil Filled	Poor (unsupported)	Poor (unsupported)	Replacement
SF_6 CBs hydraulic/pneumatic	Good	Deteriorating	Refurbishment of mechanism or replacement depending on component availability and supported by CBA.
SF_6 CBs (spring)	Good	Good	Minimal. Repair or replace (when SF_6 leaks beyond repair)

The investment strategy will result in the replacement of the Air Blast and Bulk Oil CBs over RIIO-T2 and RIIO-T3.

The installation dates at each voltage is reflected in the figures below (1 to 3) which mirrors the large historical investment periods of the transmission network construction. It highlights how by replacing the deteriorated air blast and bulk oil circuit breakers will result in a fleet of circuit-breakers which are fully supported and reliable.

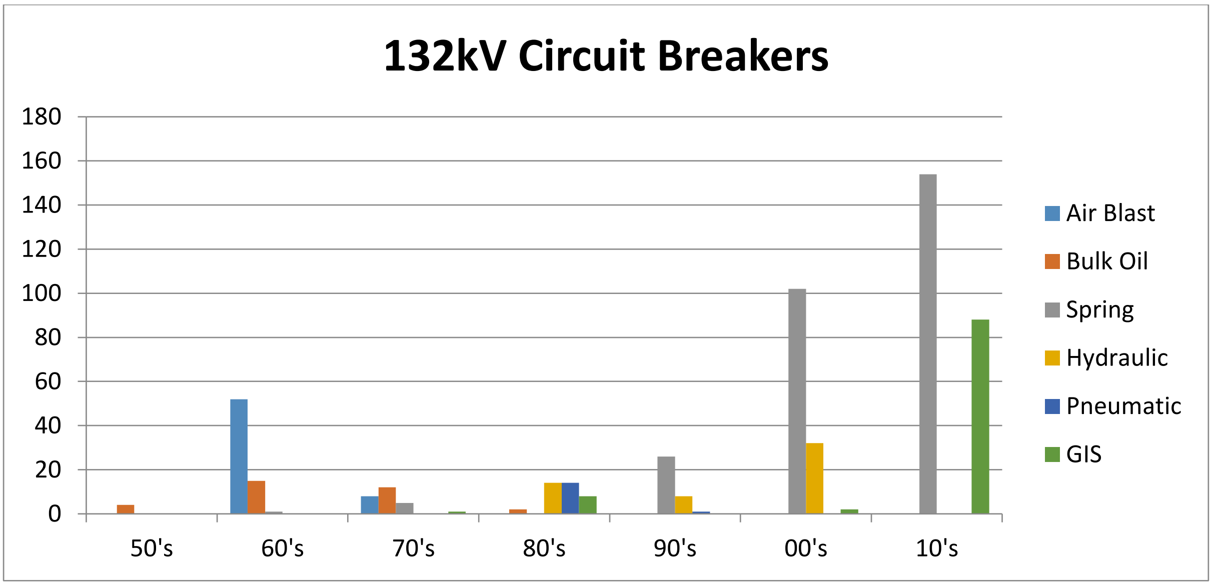

Figure 1: 132kV CB by Type Overview Installations in SPT Transmission Network.

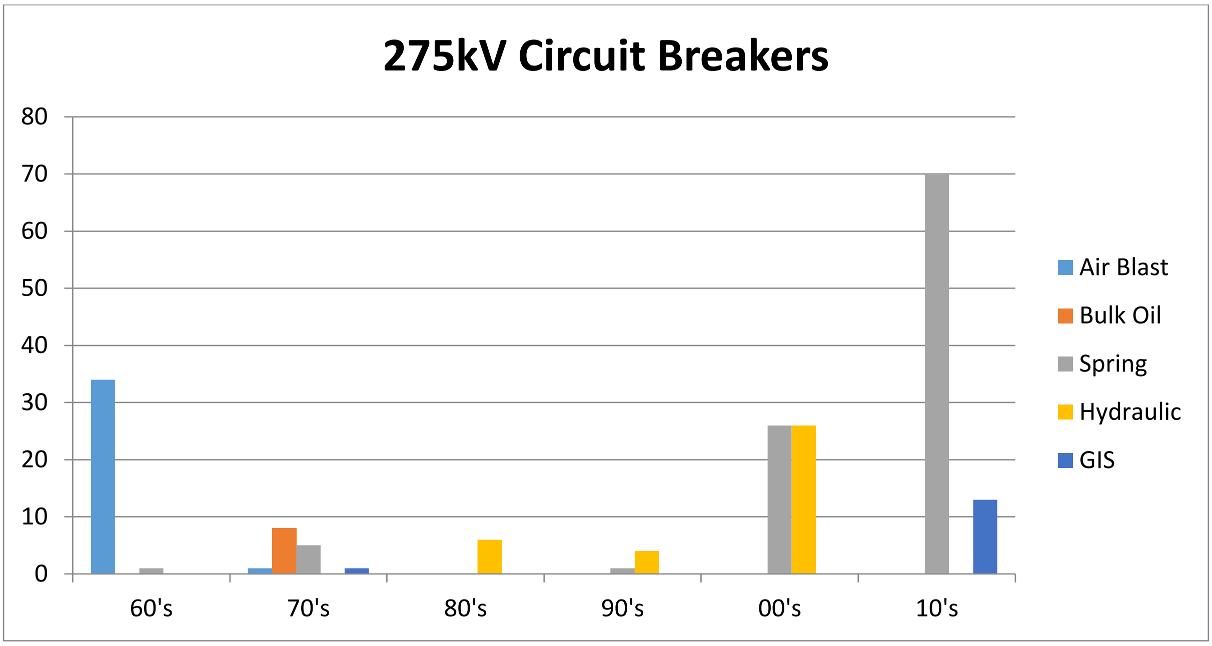

Figure 2: 275kV CB by Type Overview Installations in SPT Transmission Network.

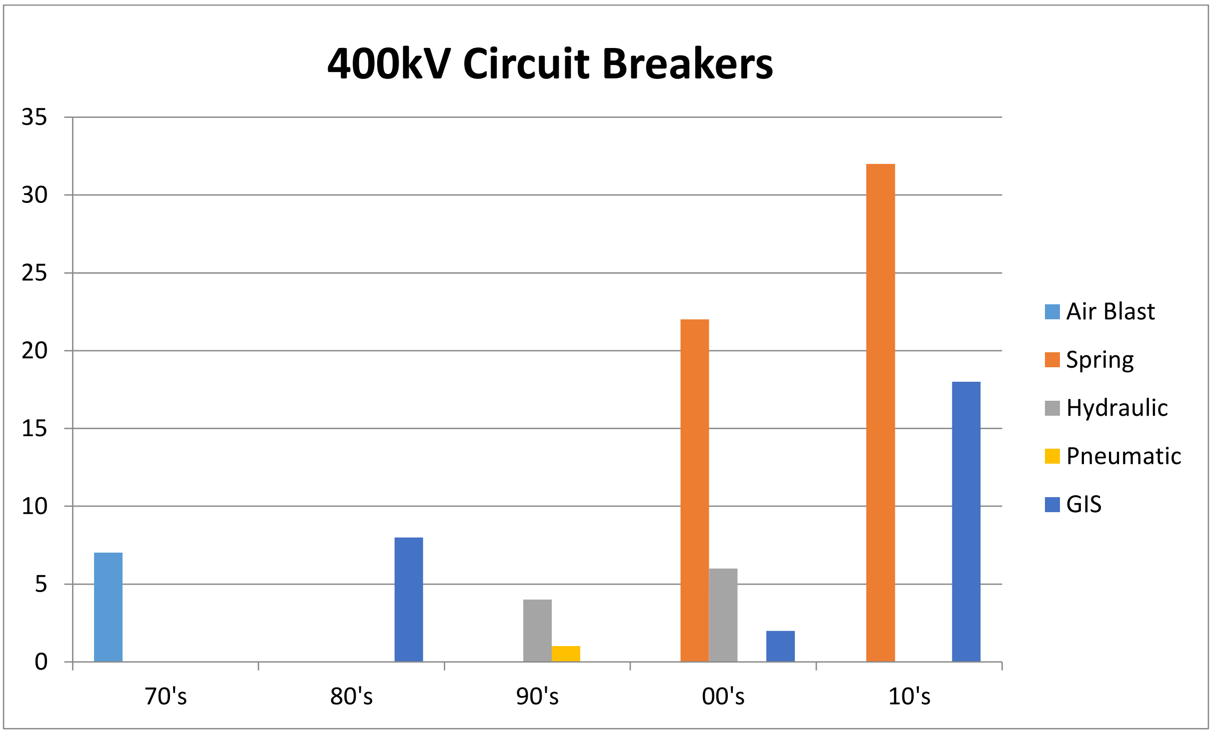

Figure 3: 400kV CB by Type Overview Installations in SPT Transmission Network.

3.5 Overall RIIO-T2 / T3 Programme

The proposed schemes for RIIO-T2 and the outlook at this time to RIIO-T3 are below.

OFGEM Scheme Reference (OSR)	Scheme Name	RIIO	Health Band	Risk Band
SPNLT2033	Windyhill 275kV switchgear replacement	T2	10	2-10
SPNLT2034	Westfield 275kV switchgear replacement (includes future 400kV upgrade)*	T2	10	5-6
SPNLT2036	Hunterston 400kV	T2	10	2-10
SPNLT2037	Hunterston 132kV switchgear replacement	T2	10	2-10
SPNLT2038	Devol Moor 132kV switchgear replacement	T2	10	7-8
SPNLT2041	Glenrothes 275kV switchgear replacement	T2	10	10
SPNLT2067	Mosmorran 132kV switchgear replacement	T2	10	3-5
SPNLT2085	Kilwinning 132kV CB works	T2	10	4-10
SPNLT2086	Meadowhead 132kV CB Works	T2	10	5-10
SPNLT2087	Strathaven 275kV FE2 CB Works	T2	10	3-9
SPNLT2088	Strathaven 400kV (Mech replacement)	T2	10	7-10
SPNLT2089	Newarthill 275kV FE2 CB Works	T2	9	7
SPNLT2090	Torness 132kV CB Works	T2	10	2-10
SPNLT2091	Torness 400kV (Mech replacement)	T2	9-10	2-9
SPNLT2099	Longannet 275kV Switchgear Replacement (includes future 400kV upgrade)*	T2	10	3-8
SPNLT2035	Westfield 132kV switchgear replacement	T3	10	3-8
SPNLT2039	Galashiels 132kV switchgear replacement	T3	10	3

*Note that these schemes are proposed as ring-fenced PCDs.

The change over the RIIO-T2 and RIIO-T3 Price control periods are shown in figure 4.

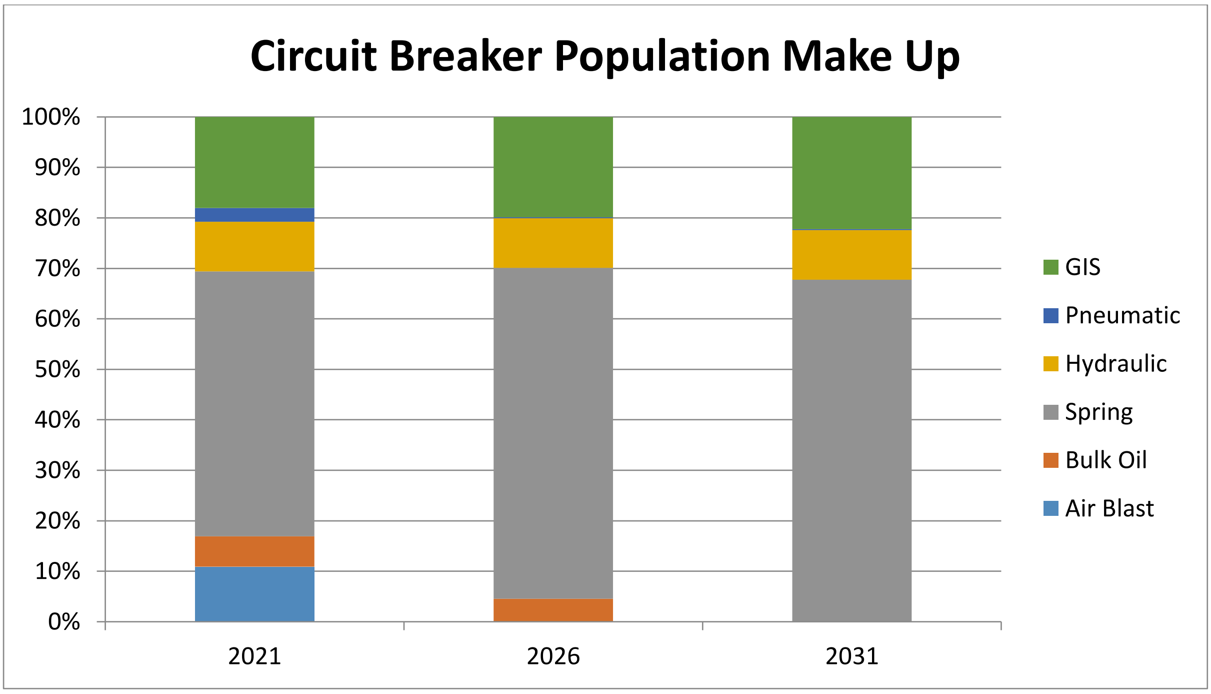

Figure 4: CB Type Overview 2021-2031 in SPT Transmission Network.

4. Programme Development

No single aspect of the rationale above could be used to drive the proposed schemes. This section expands on the rationale of what approach was taken for each and how this developed the long term programme.

4.1 Strategy

The high level policy is to maximise the economic lives of circuit-breakers but to replace before failure due to the consequences on the operation of the transmission system. To achieve this SPT has targeted the Air Blast and Bulk Oil circuit breakers as the main areas requiring investment due to performance issues, availability of spares, obsolescence and no support from any manufacturers. As well as the Air blast and Bulk oil circuit breakers, SPT have the same issues developing with early SF_6 Circuit breakers and as such are proposing intervention on a small number of these. Details of these are within their respective Justification Papers and supporting documents.

4.2 Asset Risk

The health and risk elements of the NARM models are an essential aspect of the planning of investments. The assets' current and forecast EOL values are a valuable tool in the identification of intervention need and the risk values are used in the prioritisation of interventions.

4.3 Network Access

Interventions on existing assets are the not the only type of activity that is required to be delivered on the SPT Transmission Network. There are many other activities that have to be co-ordinated to ensure that efficient access to the network is possible, while maintaining its security. SPT have worked with the ESO to develop a plan to allow the delivery of all the RIIO-T2 programme of works by co-ordinating works wherever possible regardless of the driver for investment (overhead works with switchgear works, maintenance scheduled with major outages) to ensure maximum productivity within minimum system impact. In addition the works have been staged to ensure that system security and boundary transfer capability are maximised (Longannet and Windyhill projects consecutive to ensure network security, for example).

4.4 Deliverability

SPT are on track to deliver all its outputs in RIIO-T1. This is through reviewing the works required and ensuring that any proposed works are deliverable within the agreed price control. To this end, the RIIO-T2 planning process has considered not only works required in RIIO-T2 but has forecast works that, at this time, are likely to form proposals for RIIO-T3 to ensure that a long-term view of deliverability is formed. By applying this approach, asset risk modelling outputs and SPT's expertise in managing its assets, the proposal is a deliverable and realistic plan that delivers the required network investment in circuit breakers.

4.5 RIIO-T2 / T3 Investment Graphs

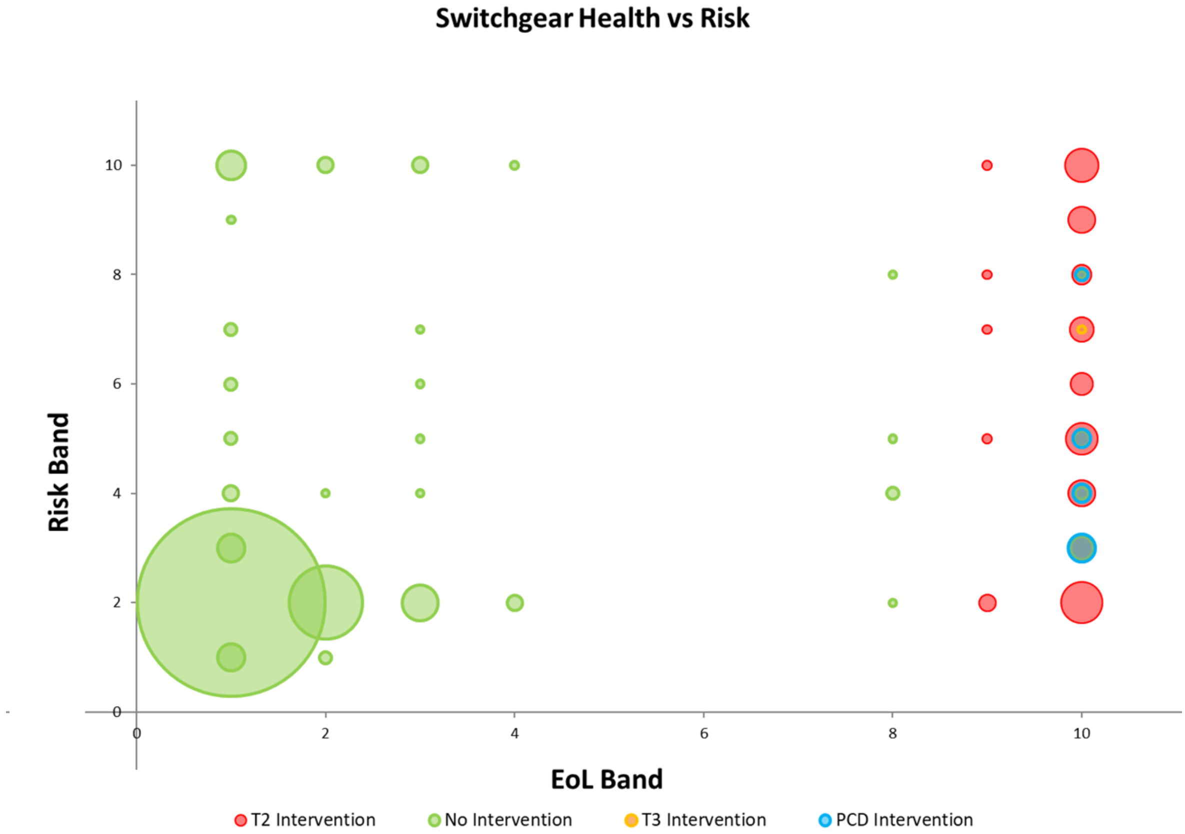

Figure 5: Overview of Circuit-breaker Investment Strategy to 2031

The figure above, where the size of the circle represents the asset count at each point, demonstrates how the proposed investments address the assets that will be at end of life by the end of RIIO-T2 without intervention and an indicative view of the likely RIIO-T3 interventions. It is clear from this chart that the interventions are justified by the condition of the assets. The interventions have been prioritised by risk but the non-lead assets, a significant component of the overall network risk but which cannot yet be identified in this way, have also been considered.

4.6 Risk Prioritisation

The intervention in the circuit-breakers in the following schemes would be justified based on their condition; however there are wider considerations and these are proposed, at this time and subject to ongoing review, for inclusion in the RIIO-T3 business plan.

4.6.1 Westfield 132kV Circuit Breakers

The 132kV bulk oil circuit-breakers at Westfield have been assessed as end of life at the end of RIIO-T2 and require to be replaced. However, during the prioritisation and deliverability review process, the condition of the civil and non-lead electrical assets was also assessed. Relative to the condition of these assets at Devol Moor 132kV, it has been proposed to defer these works. It is notable that 5 of the 13 circuit-breakers are SF_6. The site-specific risks of deferral of these works has determined that there are sufficient spares of 132kV circuit-breakers and given the expected failure modes prior to intervention, the failure of a circuit breaker, while problematic, can be managed. Therefore this project has been deferred to RIIO-T3.

4.6.2 Galashiels 132kV Circuit Breakers

Similar to Westfield, the prioritisation and deliverability review process considered that Devol Moor 132kV should be prioritised due to the more significant non-lead asset condition issues. The site-specific risks of deferral of these works has determined that there are sufficient spares of 132kV circuit-breakers and given the expected failure modes prior to intervention, the failure of a circuit breaker, while problematic, can be managed. Therefore this project has been deferred to RIIO-T3.

4.7 Conclusion

The proposed circuit breaker programme for RIIO-T2 has been carefully developed to balance the effective management of network risk, system access and deliverability, and costs to current and future consumers.