Scottish & Southern Electricity Networks

Keith 132kV Substation Works

Engineering Justification Paper

1. Executive Summary

Our paper A Risk Based Approach to Asset Management[1] sets out our approach to network risk and how we subsequently identify assets that require intervention to limit the rise of risk over the RIIO-T2 period.

This paper identifies the need for intervention on the 132kV single busbar at Keith substation. The primary driver for the scheme is the asset condition with a secondary driver of network resilience.

Following a process of optioneering and detailed analysis, as set out in this paper, the proposed scope of works is:

- Offline replacement of the single 132kV AIS busbar with a double 132kV GIS busbar

This scheme costs £39.1m and will deliver the following outputs and benefits during the RIIO T2 period:

- A long-term monetised risk benefit of R£22.4m;
- A reduction of network risk calculated as R£7.3m;
- Improved operational flexibility and resilience in line with our goal to aim for 100% transmission network reliability for homes and business;
- A reduction in the volume of SF_6 on the network from the use of innovative non SF_6 equipment contributing to our goal of a one third reduction in greenhouse gas emissions.

The Keith scheme is not flagged as eligible for early or late competition due it being under Ofgem's £50m and £100m thresholds respectively.

[1]A Risk Based Approach to Asset Management

Name of Scheme/Programme	Keith 132kV Substation Works
Primary Investment Driver	Asset Health (Non-Load)
Scheme reference/ mechanism or category	SHNLT2022
Output references/type	NLRT2SH2022
Cost	£39.05m
Delivery Year	Within the RIIO-T2 period
Reporting Table	C0.7 Non-Load Master Data
Outputs included in RIIO-T1 Business Plan	No

2. Introduction

This Engineering Justification Paper sets out our plans to undertake condition-related work during the RIIO-T2 period (April 2021 to March 2026). The planned work is at Keith substation, the location of which is shown in Figure 1 on the next page.

The Engineering Justification Paper is structured as follows:

Section 3: Need

This section provides an explanation of the need for the planned works. It provides evidence of the primary and, where applicable, secondary drivers for undertaking the planned works. Where appropriate it provides background information and/or process outputs that generate or support the need.

Section 4: Optioneering

This section presents all the options considered to address the need that is described in Section 3. Each option considered here is either discounted at this Optioneering stage with supporting reasoning provided or is taken forward for detailed analysis in Section 5.

Section 5: Detailed Analysis

This section considers in more detail each of the options taken forward from the Optioneering section. Where appropriate the results of Cost Benefit Analysis are discussed and together with supporting objective and engineering judgement contribute toward the identification of a selected option. The section continues by setting out the costs for the selected option.

Section 6: Conclusion

This section provides summary detail of the selected option. It sets out the scope and outputs, costs and timing of investment and where applicable other key supporting information.

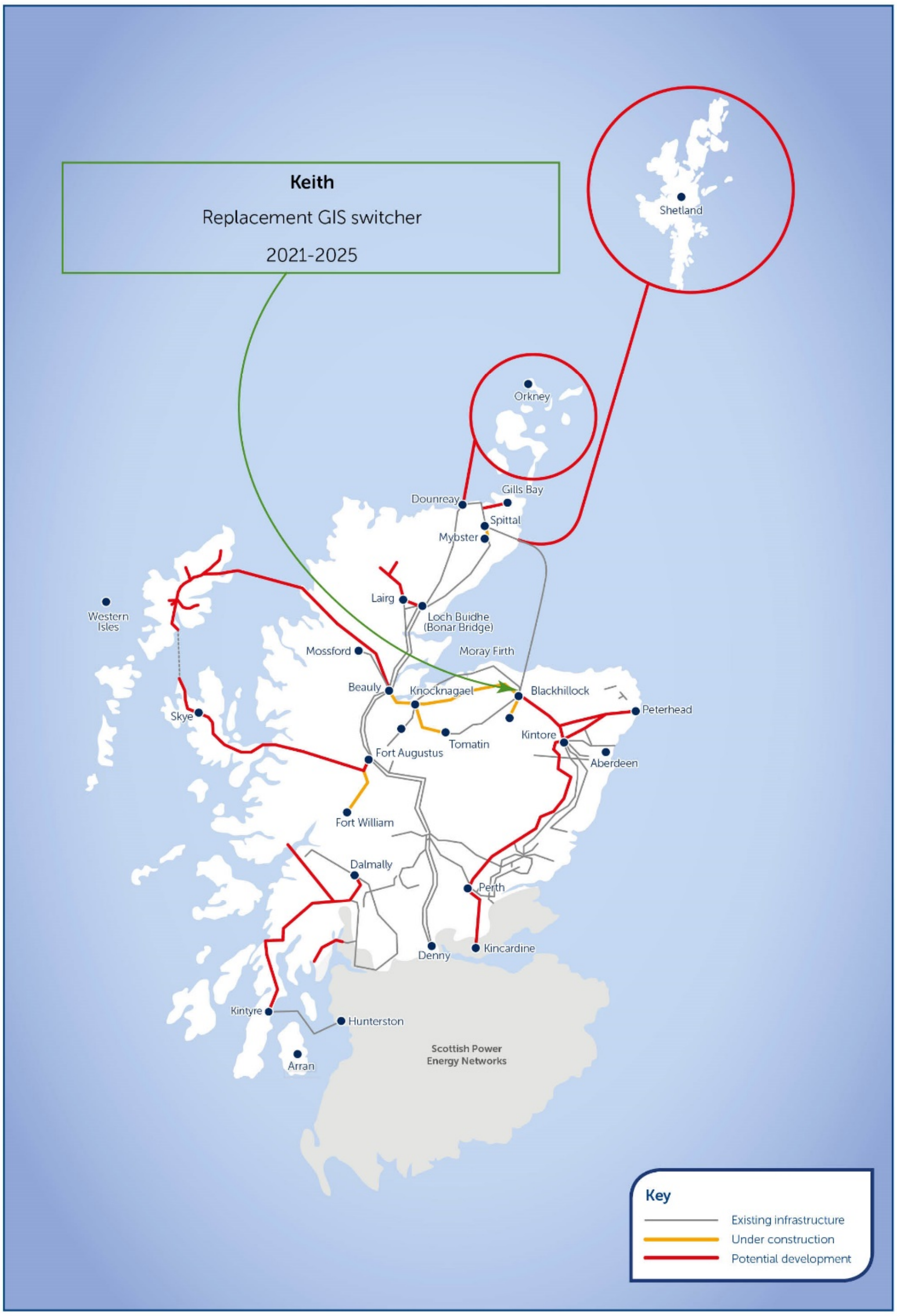
Section 7: Price Control Deliverables and Ring Fencing

This section provides a view of whether the proposed scheme should be ring-fenced or subject to other funding mechanisms.

Section 8: Outputs included in RIIO-T1 Business Plan

This section identifies if some or all the outputs were included in the RIIO-T1 Business Plan and provides explanation and justification as to why such outputs are planned to be undertaken in the RIIO-T2 period.

Figure 1: Geographical Representation



3. Need

This section provides an explanation of the need for the planned works. It provides evidence of the primary and, where applicable, secondary drivers for undertaking the planned works. Where appropriate it provides background information and/or process outputs that generate or support the need.

3.1. Background

Keith Substation, which is situated approximately 65km north west of Aberdeen, [redacted]

This substation also supplies the local network through four 132/33kV Grid Transformers (GTs) all rated at 90MVA:

- GT1 & GT3 supplying the 33kV board 1;
- GT2 & GT4 supplying the 33kV board 2.

[redacted] An illustration of the network this substation sits within, as well as a diagram of the network configuration of Keith substation itself are shown in Appendix A & B respectively.

3.2. Asset Need

Ongoing site inspections provide detailed condition assessment of the plant along with the data gathered from testing and analysis. The resulting Asset Condition Report[2] provides, in detail, the condition of existing assets and recommendations for intervention in the RIIO-T2 period. A summary of the highlighted condition issues, all relating to the 132kV single busbar, are:

- 10 of the 20 disconnectors on the 132kV single busbar, originally installed in the 1960s exhibit corrosion**;**
- 4 of the 5 earth switches on the 132kV single busbar, originally installed in the 1960s exhibit corrosion;
- 2 of the existing circuit breakers (CBs) are of a make that exhibit frequent and excessive gas leaks (a third has already been replaced under emergency works);
- The busbar insulators exhibit a history of deterioration and various busbar joints are known to have a high resistance creating the risk of hotspots developing.

In addition to the condition-related issues outlined with various 132kV switchgear, there are multiple operational limitations on the existing single busbar setup that are worth noting:

- There is only one busbar that all the overhead line, GT, and SGT circuits can connect onto, thus there is no selector configuration available to allow the connection of circuits to another busbar: this is a requirement for new build marshalling substation design according to the Security and Quality of Supply Standard (SQSS);

[redacted]

[2] Keith Substation Works Asset Condition Report T2BP-ACR-0006

- The 10 older disconnectors lack telecontrol capability which restricts the resilience and speed of network response to faults and increases the safety risk to staff who need to operate the plant manually and within proximity.

[redacted]

- Spares for the older disconnectors and earth switches, and busbar components are difficult to source;

3.3. Growth Need

A summary of the latest demand and generation capacity connected via the GTs to the wider network is summarised in the tables below:

Table 1: Keith GSP Board 1 Demand & Generation Summary

Demand		Generation		
Winter Peak (MW)	Summer Min (MW)	Connected (MW)	Contracted (MW)	Total (MW)
19.92	5.78	84.76	15.65	100.41

Table 2: Keith GSP Board 2 Demand & Generation Summary

Demand		Generation		
Winter Peak (MW)	Summer Min (MW)	Connected (MW)	Contracted (MW)	Total (MW)
30.64	7.47	67.07	54.60	121.67

On review of the demand and generation profiles of this site:

- Demand is not projected to significantly rise in the medium term to require intervention on the GTs or 33kV boards;

- While generation is projected to rise to a level that will exceed the individual rating of one of the GTs (should the other be disconnected through planned or unplanned outage), the use of intertrips to curtail generation as appropriate as well as the diversion of 26.74MW of generation to the new Rothienorman substation will mitigate the need for intervention on the GTs or 33kV boards.

In summary, there is no growth need to be considered for the site.

4. Optioneering

This section presents all the options considered to address the "need" that is described in Section 3. Each option considered here is either discounted at the Optioneering stage with supporting reasoning provided or is taken forward for Detailed Analysis in Section 5.

The recommendation from the need, outlined in section 3, details that intervention is required in the RIIO-T2 price control period so "do nothing" is not an option.

The need section identified only the 132kV single busbar as requiring intervention.

A summary of the options is presented in the table below:

Table 3: Options Summary

Option	Option Detail	Cost (£m)	Taken forward to Detailed Analysis?
1	Bare minimum works: In-situ Single Busbar Replacement	N/A	No
2	Offline Gas Insulated Switchgear (GIS) Build	39.05	Yes
3	Offline Air Insulated Switchgear (AIS) Build	64.73	Yes

With regards to interfacing projects that need to be considered when reviewing these options, any outages taken at Keith for proposed works must be coordinated with the outages under the Beauly scheme in order to secure the connection of customers on the 132kV MITS.

Option 1: Single Busbar in-situ replacement

This option considers the in-situ replacement of both the 132kV busbar and the relevant circuit bays identified as being in poor condition. This option also includes moving the two circuits to Elgin onto adjacent bays vacated by the removal of MacDuff circuits**.** However, this option fails to address the following concerns with the existing busbar configuration:

- The lack of a double busbar and associated selector configuration to allow the switching of circuits between the reserve and main busbars (a requirement for new build marshalling substation design according to the SQSS);
- The significant outages required and associated higher risk to customer supplies associated with retaining the existing single busbar arrangement.

On this basis, the option has not been progressed to detailed analysis.

NOT PROGRESSED TO DETAILED ANALYSIS

Option 2: Offline GIS Build

This option considers the offline replacement of the 132kV single busbar with a GIS solution. This approach would enable the offline build of the new substation at a nearby location, potentially within the existing site boundaries. The outage implications of this option are relatively minimal, with only some outages required for cable construction works to transfer substation circuits over to the new GIS board. It is also one of the options that would address both the condition and operational needs identified by delivering a modern double busbar solution. Based on these factors this option has been progressed to detailed analysis.

PROGRESSED TO DETAILED ANALYSIS

Option 3: Offline AIS Build

This option considers the possibility for Keith 132kV substation to be replaced with a new AIS solution. The outage implications of this option are minimal, with few outages required for cable construction works to transfer substation circuits over to the new AIS board. It is an option that would address both the condition and operational needs identified, by delivering a modern double busbar solution. Based on these factors this option is progressed to detailed analysis.

PROGRESSED TO DETAILED ANALYSIS

5. Detailed Analysis

This section considers in more detail each of the options taken forward from the Optioneering section. Where appropriate the results of Cost Benefit Analysis are discussed and together with supporting objective and engineering judgement contribute toward the identification of a selected option. The section continues by setting out the costs for the selected option.

5.1. Cost Benefit Analysis

We have carried out a Cost Benefit Analysis (CBA) using counterfactual Net Present Value (NPV) analysis to demonstrate the potential benefits of each of the shortlisted options, with Option 2 presented as the baseline option for comparison purposes. Our CBA Methodology[3] sets the process and mechanics of our approach to CBA.

The results for this CBA, including relevant calculated Net Present Values (NPVs), are summarised below:

Table 4: CBA Options Summary

CBA reference	Description of Option	Total Forecast Expenditure (£m)	Total NPV	Delta (Option to Baseline)	Total NPV (inc monetised risk)
Baseline (Option 2)	Offline 132kV GIS	-£ 39.29	-£ 36.91		-£14.55
Option 3	Offline 132kV AIS	-£ 66.81	-£ 62.39	-£25.48	-£40.03

The results of the CBA demonstrate that Option 2 is the best option from an NPV assessment as it delivers £25.48m of additional value compared to Option 3. This option has been taken forward as the proposed solution to the needs for intervention that were identified.

5.2. Project Sensitivity

As outlined in our core RIIO-T2 business plan document, A Network for Net Zero[5], we believe we have a critical role to play in delivering Net Zero ambitions in both the UK and Scotland. Therefore, our plan has been carefully designed with the flexibility to deliver pathways to Net Zero. Our policy paper A Risk-Based Approach to Asset Management[1] outlines our approach to monitoring and assessing the condition of our assets to maintain the reliable and resilient network that is expected

[3] Cost Benefit Analysis Methodology

by our stakeholders. Where asset condition deteriorates, we undertake a programme of cost-effective, risk-based interventions to maintain the longevity and performance of the transmission network. Each of our non-load related projects for T2 is underpinned by Asset Condition Reports which clearly outline that the works are necessary and driven by reliability.

Table 5: Project Sensitivities

Sensitivity	Test and impact observed – switching inputs
Asset Performance / deterioration rates	Switching deterioration assumption: The asset performance / deterioration rates can only improve or deteriorate. As the need for this project is driven by an asset condition report (as outlined in Section 3), the asset condition will not improve in the intervening period. The second option is for the asset performance to deteriorate and therefore the need remains, and the project would be considered for advancement within available outages.
Ongoing efficiency assumptions	Switching efficiency assumption: Increased or decreased. Test would have no impact on (feasible) option selection, both options move in parallel and have no impact on ordering within CBA.
Demand variations	No demand at this site and none forecast
Energy scenarios	Sensitivity considered in need already. As this is a non-load project and the need is driven by the asset condition, the work would be required regardless of any changes to the energy scenarios.
Asset utilisation	Our policy paper “A Risk-Based Approach to Asset Management” outlines our approach to monitoring and assessing the condition of our assets to maintain the reliable and resilient network that is expected by our stakeholders. Where asset condition deteriorates, we undertake a programme of cost-effective, risk-based interventions to maintain the longevity and performance of the transmission network. Each of our non-load related projects for T2 is underpinned by Asset Condition Reports which clearly outline that the works are necessary and driven for reliability.

Timing / delivery	We have considered timing of investments as part of our CBAs.
Consenting / stakeholders	Any works at this site will require a whole station outage and planning consent. This is the case for either option considered
Public policy/Government legislation	We have considered the impact of public policy, government legislation and regulations as part of the need (section 3), optioneering (section 4) and detailed analysis (section 5) and the impacts this has on the selection of the preferred solution. For example the projects have considered the impact of the UK Governments' Net Zero emission by 2050 target, SQSS and ESQCR.

5.3. Proposed Solution

The scope of the selected solution is to build an offline 132kV GIS building to house the new 132kV switchboard. A copy of the Single Line Diagram (SLD) is shown in Appendix C. The project will be energised within the RIIO-T2 period. The table below details the outputs.

Table 5: Outputs from preferred option

Plant	Size of new plant	Replacement for
132kV fully selectable double busbar	12 x 132kV breaker bays (GIS)	11 x 132kV breaker bays (AIS)

5.4. Competition

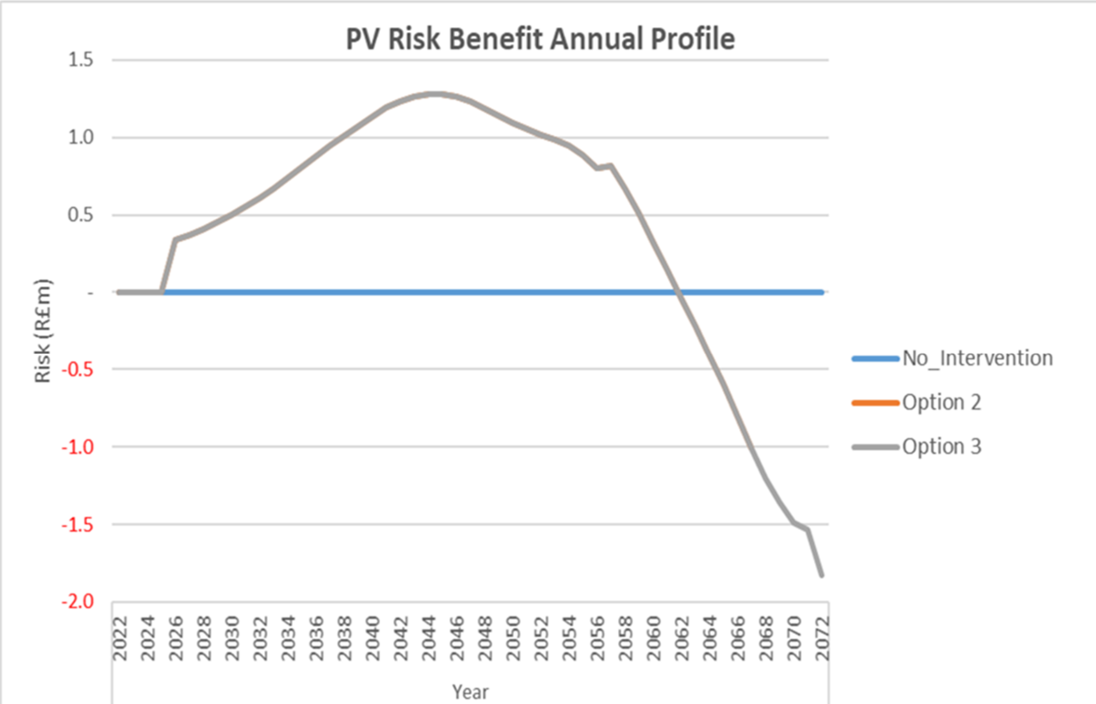
The Keith scheme is not flagged as eligible for early or late competition due the project cost being under Ofgem's £50m and £100m thresholds respectively.

5.5. Risk Benefit

A Risk Benefit Analysis has been carried out in order to compare "no intervention" against the selected "with intervention" option. Please note that while monetised risk is denoted as a financial figure, it is important to note that it is not "real" money and does not correspond to the cost that SHE Transmission would incur if an asset was to fail and these values are thus identified with R£ prefix (for more details please refer to A Risk Based Approach to Asset Management1).

The long-term monetised risk benefit which would be realised through the completion of this project is R£22.4m. The long-term benefit is derived by consideration of the risk of the asset experiencing a catastrophic failure weighted by the probability that the asset will survive for the Options and "no intervention" scenarios. The long-term benefit is an aggregation of the risk of all assets being considered within the option. The risk of each Option is then compared with the "no intervention" scenario. The "no intervention" scenario assumes that when the asset experiences a catastrophic failure the asset is replaced. The reason for the relatively low long-term benefit for this scheme is a product of the net increase in the lead assets being delivered by the solution. Although this provides better system operability the LTRB template does not take this into account, and projects the risk of all assets at the site in 50 years' time.

Figure 2: Long Term Benefit of Proposed Interventions – Offline Build of the GIS Build (Option 2) and the AIS Build (Option 3)



The long-term risk benefit for both options shown in Figure 2 follow identical profiles throughout their lifetime and as such, the graph displays only one line. In addition to assessing the long-term risk benefit, an immediate monetised risk benefit has also been determined. The monetised risk benefit which would be realised through the completion of this project is £7.3m.

5.6. Innovation & Sustainability

As outlined in our core RIIO-T2 business plan document, "A Network for Net Zero", we believe we have a critical role to play in delivering Net Zero ambitions in both the UK and Scotland. Therefore, our plan has been carefully designed with the flexibility to deliver pathways to Net Zero. Our policy paper "A Risk-Based Approach to Asset Management" outlines our approach to monitoring and assessing the condition of our assets to maintain the reliable and resilient network that is expected by our stakeholders. Where asset condition deteriorates, we undertake a programme of cost-effective, risk-based interventions to maintain the longevity and performance of the transmission network. Each of our non-load related projects for T2 is underpinned by Asset Condition Reports which clearly outline that the works are necessary and driven by reliability.

The installation of a GIS double busbar at Keith will employ a non-SF_6 filled solution in support of our Sustainability and Environmental policies.

5.7. Carbon Modelling

We are committed to managing resources over the whole asset lifecycle – i.e. including the manufacturing of assets, construction, operations and decommissioning activities – to reduce our greenhouse gas emissions in line with climate science and become a climate resilient business. It is our aspiration that the carbon lifecycle cost of investment options plays a key role within our project development and is considered in the selection of a preferred solution. We have therefore developed an internal carbon pricing model that estimates a carbon cost for each option considered in our CBA through deriving values for:

1. Embodied carbon, which relates to the carbon emissions associated with the manufacturing and production of the materials use in production of the lead assets (transformer, reactors, underground cables and overhead lines. Overhead line is made up of tower/wood pole/composite pole, conductor and fittings) procured and installed as part of the project.

The carbon emissions associated with the main stages of the project lifecycle (construction, operations and decommissioning). It is our vision to embed carbon considerations within our strategic optioneering and project development processes, which will require us to determine a way of flagging high carbon options within our CBA outputs. We will continue to develop our thinking in this space, which will involve our model being validated by a third party, so the results included in this EJP are indicative and subject to change.

In terms of the results of analysis for this project, which are captured in the carbon footprint results table, the baseline option delivers the lowest comparative carbon footprint, which does align with our option selection in the CBA.

Table 6: Carbon Calculation Summary

	Project Information	Baseline	Option1
Project info	Project Name/number	0	0
	Construction Start Year	2026	2026
	Construction End Year	2028	2028
Cost estimate £GBP	Embodied carbon	£224,766	£480,469
	Construction	£204,434	£1,164,956
	Operations	£705,127	£240,103
	Decommissioning	£93,595	£533,347

	Total Project Carbon Cost Estimate	£1,227,922	£2,418,876
Carbon footprint tCO2e	Embodied carbon	3,001	6,416
	Construction	2,689	15,323
	Operations	3,083	1,050
	Decommissioning	269	1,532
	Total Project Carbon (tCO2e)	9,042	24,321
Project Carbon Footprint by Emission Category	Total Scope 1 (tCO2e)	2,898	495
	Total Scope 2 (tCO2e)	185	555
	Total Scope 3 (tCO2e)	5,959	23,271
SF_6 Emissions	Total SF_6 Emissions 3 (tCO2e)	2,848	445

5.8. Cost Estimate

The cost of the preferred option for works at Keith has been developed using rates from existing substation framework contracts and benchmarks from delivered RIIO-T1 projects. The total cost for delivering the scope of works for the proposed solution is £39.05m.

6. Conclusion

This paper identifies the need for intervention on the 132kV single busbar at Keith substation. The primary driver for the scheme is the asset condition with a secondary driver of network resilience.

Three intervention options were identified for this scheme. Of these, two options were taken forward and considered for detailed analysis.

The proposed scope of work selected (Option 2) is:

- Offline replacement of the single 132kV AIS busbar with a double 132kV GIS busbar

This scheme costs £39.1m and will deliver the following outputs and benefits during the RIIO T2 period:

- A long-term monetised risk benefit of R£22.4m;
- A reduction of network risk calculated as R£7.3m;
- Improved operational flexibility and resilience in line with our goal of 100% network reliability for homes and business;
- Use of innovative non-SF_6 solutions to reduce the volumes of SF_6 on the network contributing to our goal of one third reduction in greenhouse gas emissions.

The Keith scheme is not flagged as eligible for early or late competition due it being under Ofgem's £50m and £100m thresholds respectively.

7. Price Control Deliverables and Ring Fencing

As set out in our Regulatory Framework paper (section 1.12 and Appendix 3) we support a key principle from Citizens Advice – one that guarantees delivery of outcomes equivalent to the funding received - to ensure that RIIO-T2 really deliver for consumers.

For our core non-load projects this means that we commit to delivering our overarching NARMs target. If we do not deliver the NARMS target, or a materially equivalent target, then we should be subject to a penalty. Equally, if we over-deliver against our target and can justify that the over-delivery is in the consumers interests and could not have been reasonably factored into our business plan at the time of target setting then we should be made cost neutral for this work.

Core non load projects should not be ring fenced. This is to allow for substitution of projects in order to meet that NARMs target. We need flexibility to respond to up to date asset data information or external influences on our network during the price control; this information might drive us to substitute one project for another in order to ensure a reliable and resilient network. Ring fencing projects may result in sub-optimal decisions, having adverse consequences for the health of our network, which will ultimately be reflected in the NARMs target.

8. Outputs included in RIIO-T1 Plans

There were four 132kV CBs from this scheme originally included in our baseline for delivery in the RIIO-T1 period. One of these CBs has been replaced during the RIIO-T1 period due to significant SF_6 leaks making deferral of replacement unfeasible. One of these four is also scheduled to be removed under Keith to Blackhillock diversion works. We were able to defer two of the 132kV CBs following preventative maintenance which has arrested the immediate problem and has allowed us to substitute with other works to ensure we met our required absolute output target in line with our licence obligation. An assessment will be undertaken at the end of the RIIO-T1 period to validate our performance against our licence target and associated Rewards and Penalties guidelines.

As explained in this paper, the CB replaced in RIIO-T1 will be replaced again during the RIIO-T2 period for the reasons outlined in the needs section (Section 3). This 132kV CB will be retained as a strategic spare for future use on our network where required.

Appendix A: Overall MITS Network Diagram

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Appendix B: Keith Substation Network Configuration

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Appendix C: SLD for Keith Works

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