Scottish & Southern Electricity Networks

SSEN Transmission

RIIO-T2 Business Plan: T2BP-EJP-0042 Rev1

Tummel Bridge 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 presents a revised scope of intervention at Tummel Bridge. The primary driver for the works proposed is asset condition and performance.

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

- In-situ replacement of the 132kV disconnectors and earth switches
- In-situ replacement of the protection and control schemes
- Mid-life refurbishment of the grid transformers and bunds

This paper has been revised in response to the Draft Determination on the business plan submitted in 2019.

Polaris Diagnostics & Engineering Ltd was appointed to undertake a Level 1 review of our asset information. With the removal of the previously identified overload addressed by the installation of an Active Network Management scheme, the transformers are in good condition. The end of life scores for the transformers indicate that the units should be replaced circa 2041. The replacement of the transformers has been removed from the scope of work. The asset condition report supports the replacement of the 132kV switchgear and protection and control systems.

The paper demonstrates that with the application of the ANM scheme addressing the transformer overload pattern the scope of work proposed for RIIO T2 should be refined to address the remaining non-lead asset condition and performance and carry out a mid-life refurbishment of the grid transformers.

This scheme will cost £[redacted] and deliver the following outputs and benefits during the RIIO T2 period:

- To make a well-timed intervention to replace obsolete switchgear and protection systems, and,
- maintain a reliable connection for customers.

The Tummel Bridge 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	Tummel Bridge Substation Works
Primary Investment Driver	Asset Health (Non-Load)
Scheme reference/ mechanism or category	SHNLT2015
Output references/type	NLRT2SH2015
Cost	[redacted]
Delivery Year	Within the RIIO T2 period.
Reporting Table	C.07 Non-Load Master Data
Outputs included in RIIO T1 Business Plan	No

2 Introduction

This Engineering Justification Paper sets out our plans to undertake network condition work at Tummel Bridge during the RIIO-T2 period (April 2021 to March 2026) at Tummel Bridge substation as shown on the map on the following 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.

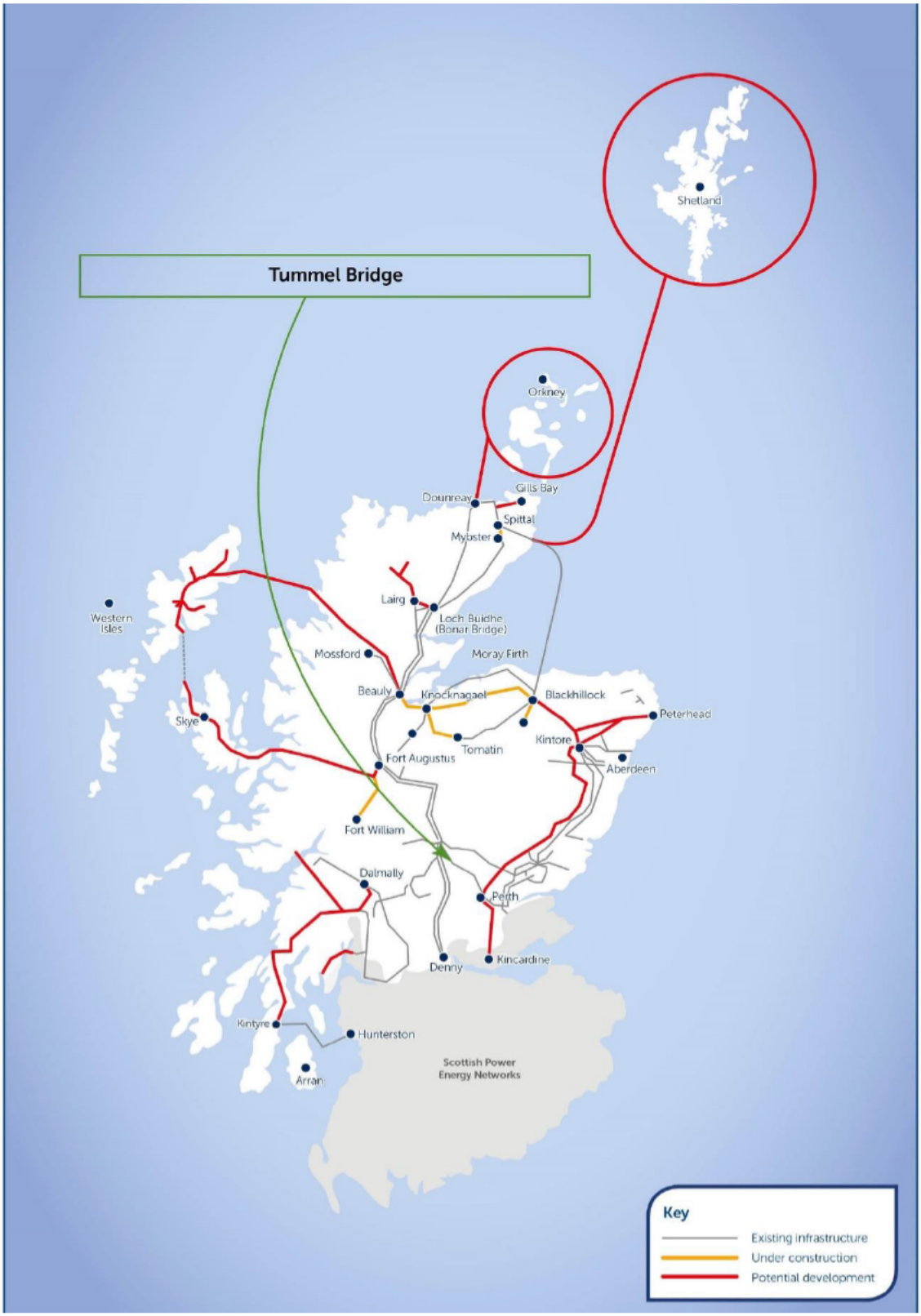
Section 7: Price Control Deliverables and Ring Fencing

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: Location of Tummel Bridge Substation



2.1 Post Draft Determination Update

The Ofgem Draft Determination did not agree with the proposal from SHE Transmission, stating that the need case had not been made for the replacement of the all plant at Tummel Bridge Substation. In response to Ofgem's feedback, SHE Transmission undertook the following actions:

2.1.1 Asset Condition Review

Polaris Diagnostics & Engineering Ltd (summaries included in Appendix C) was commissioned to review the SHE Transmission Asset Condition Report and historical oil data for the transformer at Tummel Bridge.

The conclusion of the Polaris reports is that the condition of the transformers are relatively good and that they should continue to operate satisfactorily through RIIO T2. The report highlights that oil dilution makes accurate end of life prediction inaccurate and that continued and frequent monitoring should be carried out.

The asset condition report had highlighted a pattern of overloading on the Tummel Bridge transformers which lead to the replacement recommendation since this was causing overheating and accelerated aging. Since the submission of the business plan at the end of 2019 an Active Network Management (ANM) scheme has been installed, with the agreement of SHEPD, which protects the transformers from overload by managing the generation export. By removing the overloading pattern, the transformers are no longer under stress and should achieve their anticipated end of life circa RIIO T5. (2041 for the purposes of the CBA). Therefore, the transformer condition portions of the asset condition report are superseded by the reports produced by Polaris. With the ANM scheme in place, the condition of the transformers is such that with a mid-life refurbishment carried out and ongoing monitoring these units should expect to perform satisfactorily until their predicted end of life circa 2041.

A recent oil leak from one of the transformers has demonstrated the inadequacy of the transformer bunding and oil handling arrangements at this site and as per the ACR they need to be improved.

The asset condition report highlights the defect and poor operating history of the disconnectors and earth switches, and there remains a driver to replace these. The protection and control systems, as noted in the report are obsolete with relays no longer supported and should be replaced.

2.1.2 Development and Assessment of a Refurbishment Intervention Option

Following the recommendation of the Polaris report and the content of the ACR, SHET developed an additional option to address the deterioration factors of the transformer and its ancillary plant. This additional option has been assessed against those submitted in the original justification paper.

This document presents a revised scope of work to that submitted in the business plan which seeks to address the remaining condition and performance issues at Tummel Bridge; unreliable 132kV switchgear; poor transformer bunding arrangements; obsolete protection and control systems.

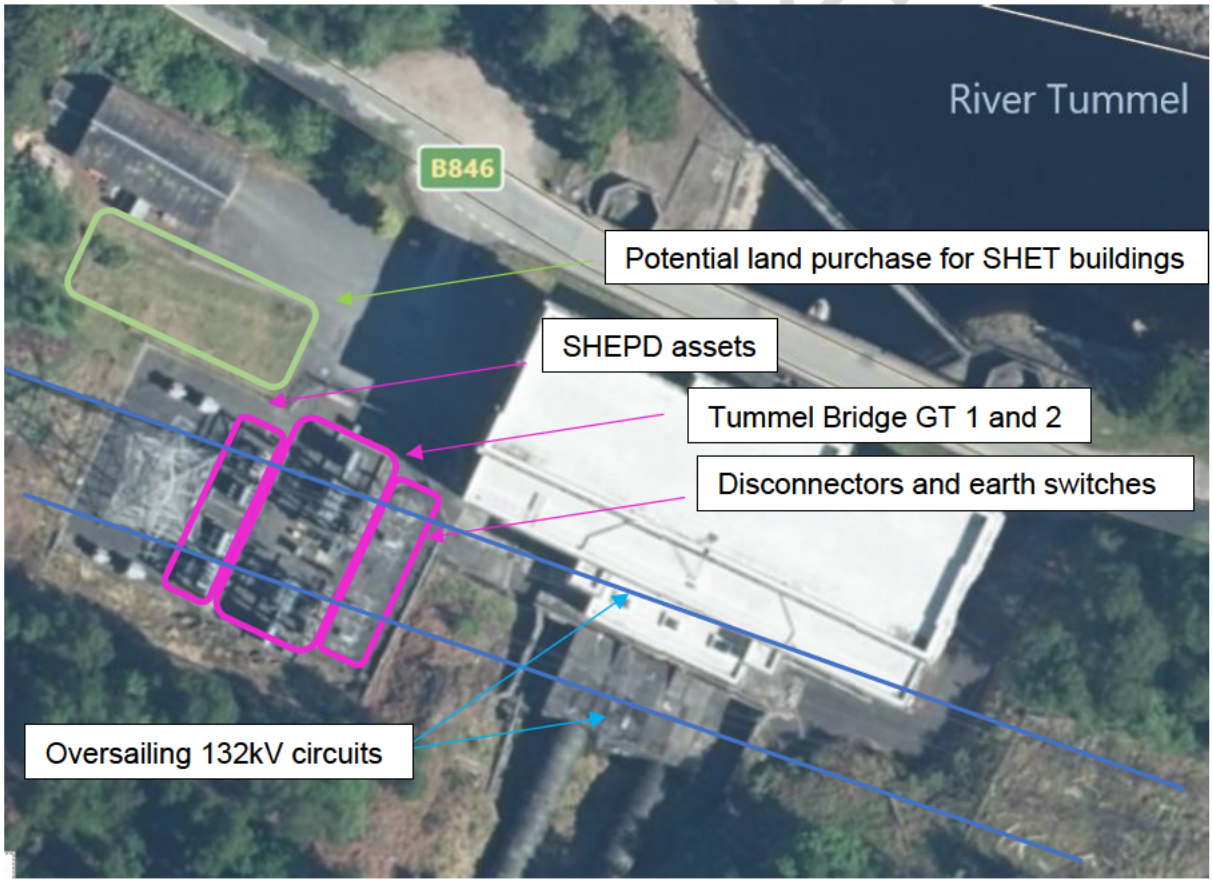
3 Need

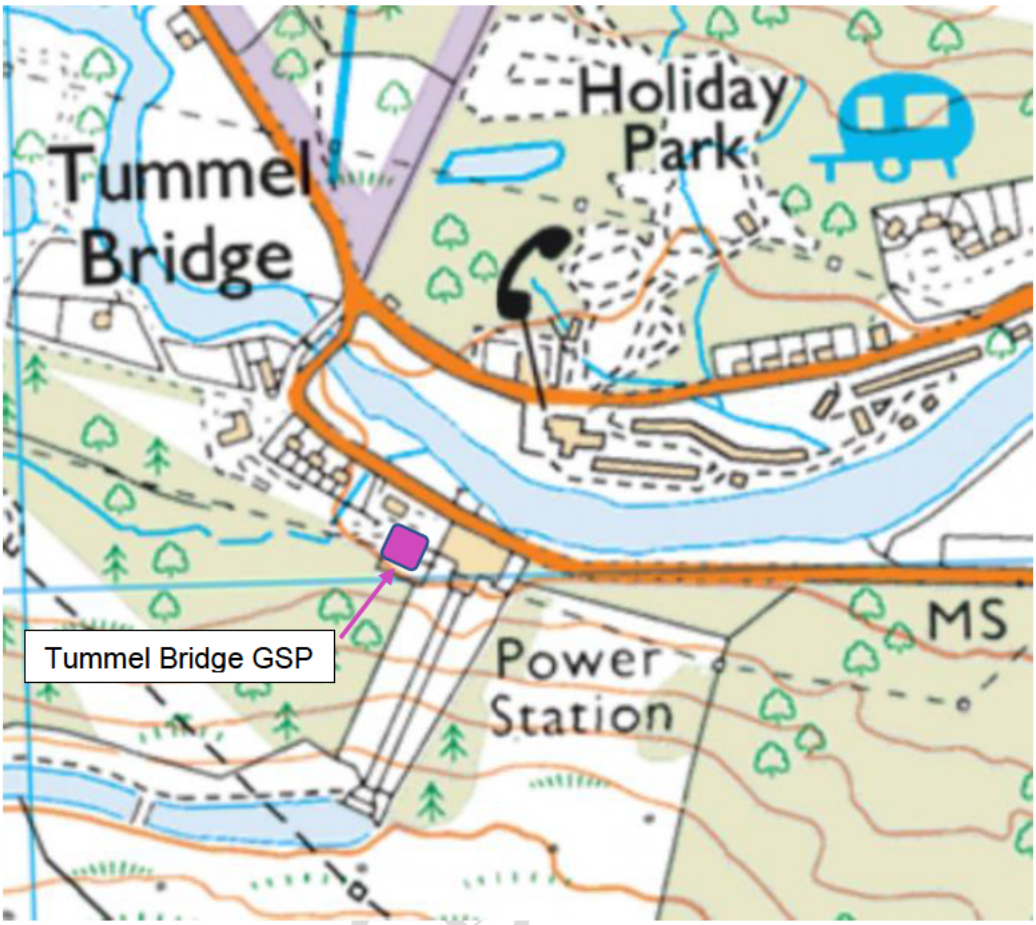
This section provides an explanation of the need for the planned works. It provides evidence of the primary and, where applicable, secondary drivers for undertaking the planned works. Where appropriate it provides background information and/or process outputs that generate or support the need.

3.1 Background

Tummel Bridge Substation is the connection point to the transmission network for the Tummel Bridge Hydro Generation scheme and is located 0.5km from Tummel 275kV substation, 0.7km from Errochty 132kV substation. The site lies 13 miles to the west of Pitlochry.

Transmission primary assets are located within a single shared compound with SHEPD assets. Our secondary assets are within the third-party generator building. There are common shared services between all parties in the generation buildings.





3.2 Asset Need

The Tummel Bridge Substation proposal is driven by the condition of the plant and equipment and the risk that they present to the security of supply and the environment.

Polaris Diagnostics & Engineering Ltd was commissioned to undertake a review of the SHE Transmission Asset Condition Report and historical oil data for the GT. The conclusion of the Polaris report is that the transformers are in good condition.

The ACR highlighted a pattern of overload of the transformers. Since the submission of the business plan SHE Transmission has continued to work with SHEPD to address this and an Active Network Management scheme has been installed which prevents the generation export exceeding the transformer rating.

With the ANM scheme in place the intervention on the transformer should be limited to a mid-life refurbishment. The Polaris report supersedes the transformer section of the asset condition report.

The Asset Condition Report highlights the following remaining issues:

- The 132kV switchgear is obsolete and there are recorded operational failures of the switchgear. The switches are manually operated. Refurbishment has been carried out to retro fit a drive mechanism from another manufacturer, however their operation remains unreliable. Manual intervention for an unplanned outage means that restoration may be delayed by several hours with the loss of generation from Tummel and Rannoch hydro power stations.
- The protection systems at Tummel require replacement since the relays are no longer supported due to their age and obsolescence.

[redacted]

The under-performance of these assets is a risk to the continuity of the connection of 48MW of hydro generation and up to 12MW of demand if no suitable intervention work takes place.

The picture above shows the protection and control panels, located in the generation building.

3.3 Growth Need

Until recently there has been no system in place to prevent generation increasing to levels well in excess of the transformer ratings. This is now managed through an Active Network Management Scheme with the agreement of SHEPD. The ANM scheme limits the generation to within the capacity of the transformer. Therefore, the outstanding issues highlighted in the ACR which remain to be addressed are ones of mid-life refurbishment. With the overloading prevented it is reasonable to expect these units to provide satisfactory service into the late 2030's.

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 to Detailed Analysis in Section 5.

The following table captures the options considered:

Table 1: Options

Option	Option Detail	Cost (£m)	Taken forward to Detailed Analysis?
0	Do nothing	-	No
1	Minimum intervention	[redacted]	Yes
2	Minimum plant intervention & re-location of ancillary plant	[redacted]	Yes
3	Offline re-build	[redacted]	Yes

Option 0 – Do Nothing

The Asset Condition Report does not support "do nothing" scenario(s). Leaving the installed assets in their current condition is not an option due to poor asset health which presents an increasing risk of failure.

It is considered that the asset replacement works must occur within the RIIO-T2 period (April 2021 to March 2026) since any interventions carried out to date on the 132kV switchgear has proven to be ineffective.

NOT PROGRESSED

Option 1 – Transformer Refurbishment and protection and control replacement

This option considers the minimal in situ replacement of the existing 132kV switchgear and protection and control systems at Tummel Bridge.

Replacement of:

- Line Disconnectors 113 (GT1), 213 (GT2) with new equivalents
- Earth Switches 101 (GT1), 201 (GT2) with new equivalents

- Protection and control systems

Additional scope of works included:

- Mid-life refurbishment of GT1 and GT2
- Cleaning and refurbishment of transformer bunds

This option does not resolve a number of drivers including the existing safety issues, operational constraints and network risks associated with the site. It does not segregate the GT's from the 132kV OHL or, the SHEPD and third-party generator assets. This option is progressed to detailed analysis.

does not address the existing safety issues, operational constraints and network risks associated with the site. It does not segregate the GT's from the 132kV OHL or, the SHEPD and third-party generator assets. This option is progressed to detailed analysis.

PROGRESSED TO DETAILED ANALYSIS

Option 2 – Option 1 plus the addition of a new Control Room

This option considers the in-situ replacement of the existing 132kV switchgear, protection and ancillary plant at Tummel Bridge.

Replacement of:

- Line Disconnectors 113 (GT1), 213 (GT2) with new equivalents
- Earth Switches 101 (GT1), 201 (GT2) with new equivalents
- Protection and control systems
- Common shared services - LVAC, DC Battery, Communications Systems with dedicated equivalents in a segregated control building

Additional scope of works included:

- Mid-life refurbishment of GT1 and GT2
- Cleaning and refurbishment of transformer bunds

This option does not resolve some of the existing safety issues, operational constraints and network risks associated with the site since it does not segregate the GT's from the 132kV OHL or, the SHEPD and third-party generator assets. However, it does address the business and customer separation issues. This option is taken forward to detailed analysis.

PROGRESS TO DETAILED ANALYSIS

Option 3 – Offline build at Errochty, connect to Tummel Bridge

This option considers the dismantling and decommissioning of the existing Tummel Bridge assets, with asset relocation and replacement at Errochty substation. The customer connection is made between the new GT bays at Errochty via 11kV cabling to the Tummel Bridge 11kV switchboard.

In summary, the works are for:

- Disconnection of the 132kV OHL Tee connection (Errochty Rannoch North and South Circuits)
- Decommissioning and removal works at Tummel Bridge for both GT bays
- Construction offline 2 off, 132/11kV GT bays at Errochty substation
- 11kV Cabling 2 off circuits from Errochty to Tummel Bridge substations

This option fully resolves all drivers.

The offline build away from the constraining infrastructure, resolves the existing safety issues, operational constraints and network risks associated with the existing site. It segregates the GT's from the 132kV OHL; SHEPD and third-party generator asset

The picture below shows the confined configuration of the existing compound and the oversailing 132kV circuits.

Benefits:

Several factors increase network security for the local substation group:

- Removal of the Tummel Bridge "T" from the Errochty to Rannoch circuits
- Introduction of an HV Circuit breaker on the GT circuits
- Dedicated 132kV GT bays, double busbar arrangement, dual busbar selection
- Standardised Protection, Control and Intertripping functionality to current standards
- Uprating to current standards the Errochty site Diesel generator, DC Battery Systems

The offline build of the new assets at Errochty; eliminate or, mitigate the previously stated concerns relating to:

- Asset failure risks, network security
- Operational and maintenance concerns, proximity restrictions, double circuit OHL outage requirements
- Environmental issues

[redacted]

[redacted]

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 1 presented as the baseline option for comparison purposes. Our CBA Methodology[2] 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 2: 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 1)	In-situ replacement of 132kV switchgear and Protection & Control systems	[redacted]	[redacted]		[redacted]
Option 2	In-situ replacement of 132kV switchgear and construction of new control building with new Protection & Control systems and all ancillary plant	[redacted]	[redacted]	[redacted]	[redacted]

[2] Cost Benefit Analysis Methodology

Option 3	Relocation of whole site	[redacted]	[redacted]	[redacted]	[redacted]

The CBA considers the whole site replacement during RIIO T2 (option 3) against the alternative of minimal intervention in RIIO T2 and site replacement in 2041.

The CBA does not support the early replacement of the site and therefore the refurbishment of the transformers in RIIO T2 as well as replacement of the 132kV switchgear and protection systems is proposed.

The minimal scope of work in option 1 addresses the immediate condition and performance issues raised in the ACR. While the scope of option 2 goes further to address some of the secondary drivers neither option deals with the historical issues of the HV compound and the additional scope of option 2 only addresses commercial issues.

Therefore, on the basis of the CBA Option 1 is selected as the preferred option.

Project Sensitivity

5.2 Project Sensitivity

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.

Table 3: Sensitivity Analysis table

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, only one option was taken forward to detailed analysis and therefore there is no impact on the preferred solution.
Demand variations	No significant demand forecast
Energy scenarios	Sensitivity considered in Section 3 (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. Although the transformers have been sized to accommodate the network demand increases.
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	Where applicable we have considered consenting and stakeholder engagement as part of section 5 (Detailed Analysis) and the impact which this has had on the selection of the preferred solution.
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

From the detailed analysis, Option 1 is the preferred and proposed solution to the needs identified in section 3.

The scope of the selected solution is replacement of the 132kV disconnectors and earth switches as well as the protection and control systems in their current location, the scope also includes the mid-life refurbishment of the grid transformers and clearing and refurbishment of the transformer bunds.

The proposed solution will replace the existing plant as follows:

Table 2 – Outputs from proposed solution

Plant	Size of new plant	Replacement for
132kV Switchgear	2 x 132kV Disconnectors 2 x 132kV Earth switches	2 x 132kV Disconnectors 2 x 132kV Earth Switches

5.4 Competition

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

5.5 Risk Benefit

The works proposed at Tummel Bridge provide no measurable NARM benefit as NARM and the Long-Term Risk Benefit analysis only consider lead assets.

Cost Estimate

The cost of the preferred option for works at Tummel Bridge 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 [redacted].

6 Conclusion

This paper identifies the need for intervention on existing assets at Tummel Bridge substation. The primary driver for the scheme is the asset condition and performance of existing plant and infrastructure.

Since the submission of the original business plan the previously identified transformer overload has been addressed with the installation of an Active Network Management scheme. With the generation export managed to within the capacity limits of the transformers the risks of accelerated aging and damage are addressed. The Polaris report also supports the continued use of the transformers as they are otherwise in good condition and should offer a further 15-20 years of serviceable life subject to ongoing maintenance and performance.

The options for intervention presented in this paper are to address the remaining issues identified in the Asset Condition Report; 132kV switchgear and, protection and control systems. These options have been compared by Cost Benefit Analysis with the previously proposed option.

The proposed scope of work selected (Option 1) is:

- In-situ replacement of the 132kV disconnectors and earth switches
- In-situ replacement of the protection and control schemes
- Mid-life refurbishment of the grid transformers and bunds

This scheme will cost [redacted] and deliver the following outputs and benefits during the RIIO T2 period:

- To make a well-timed intervention to replace obsolete switchgear and protection systems, and,
- maintain a reliable connection for customers.

The Tummel Bridge 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.

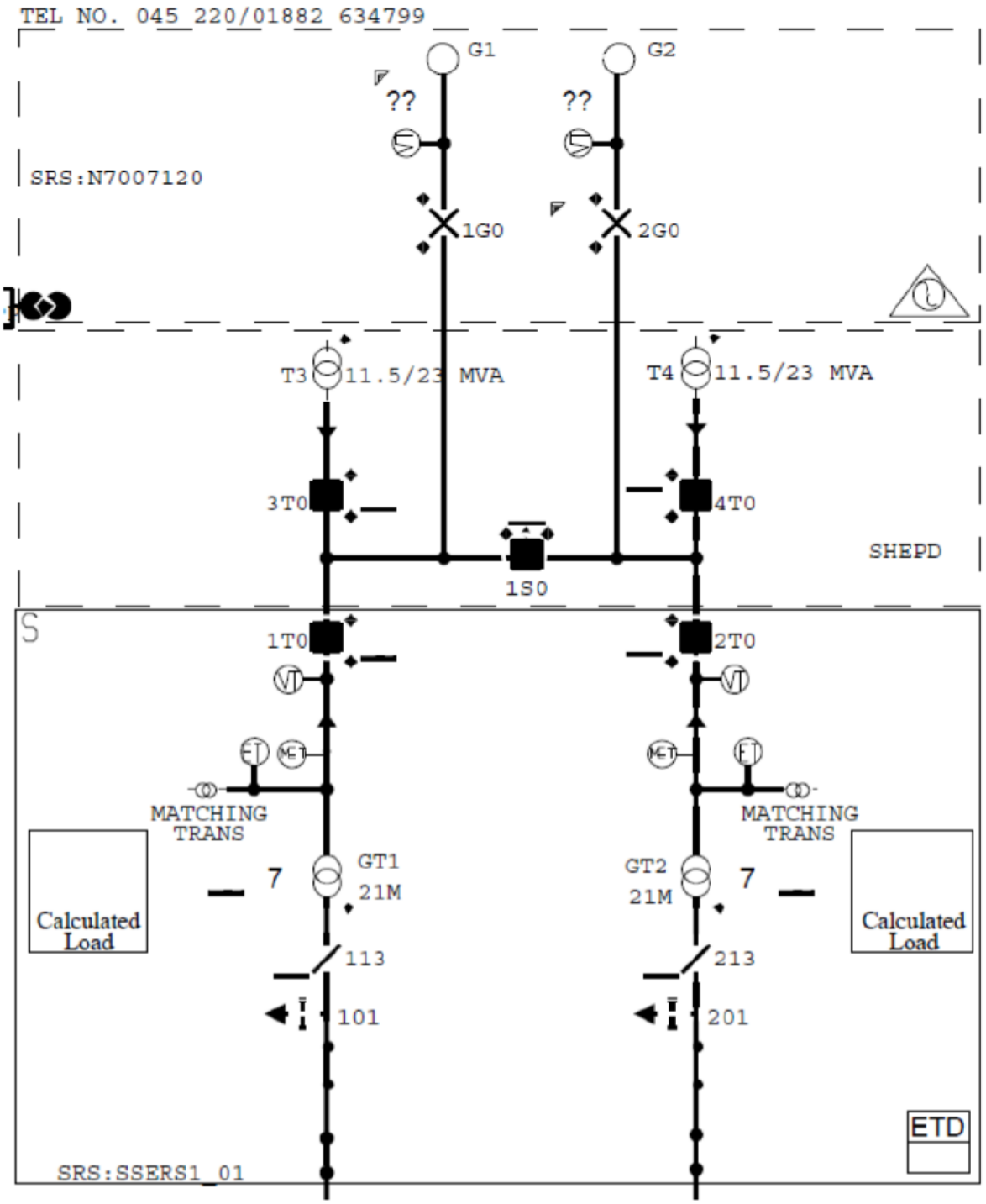
For our core non-load projects this means that we commit to delivering our overarching NARMs target. If we do not deliver the NARMS target, or a materially equivalent target, then we should be subject to a penalty. Equally, if we over-deliver against our target and are able to justify that the over-delivery 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.

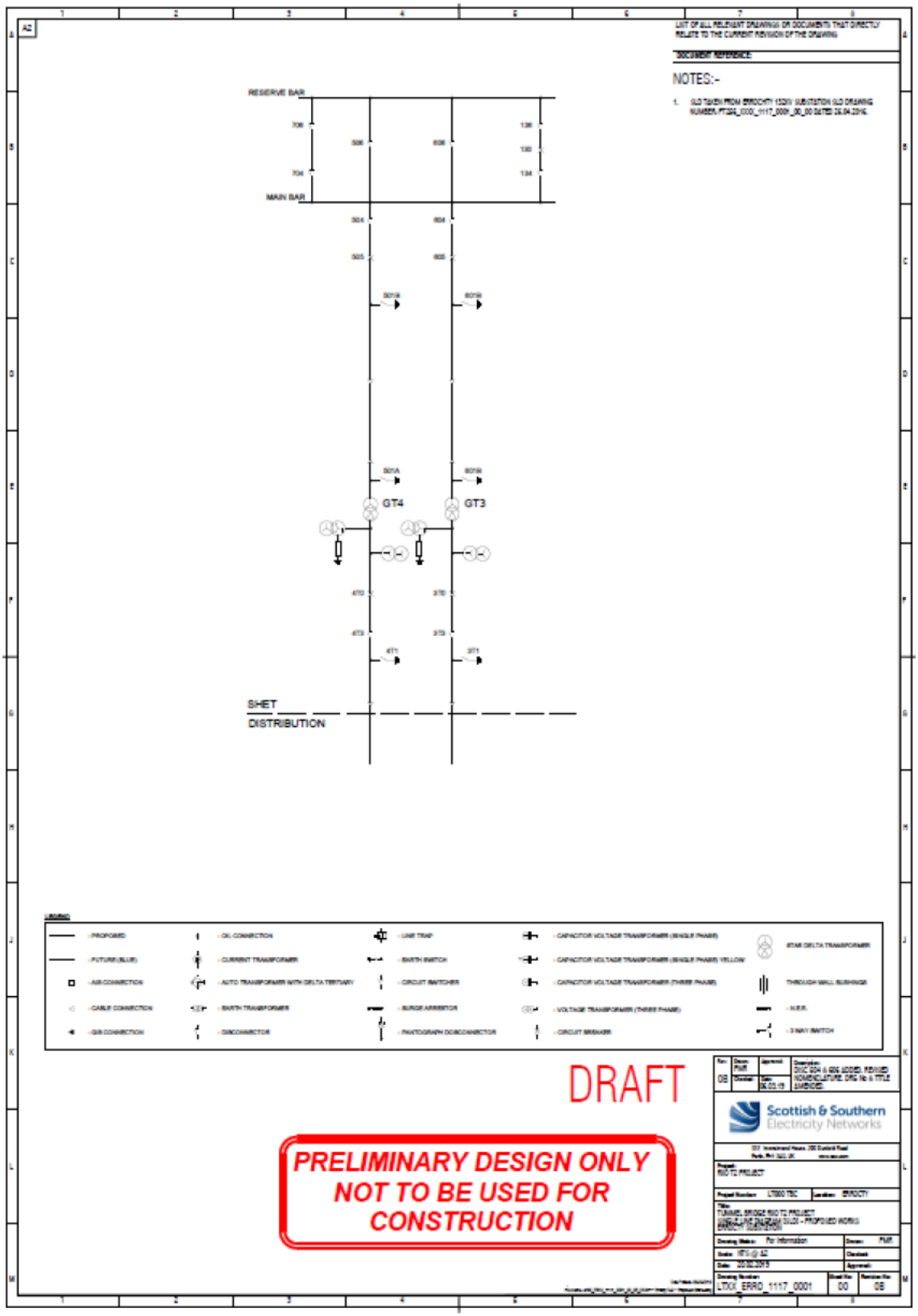
8 Outputs included in RIIO T1 Business Plan

There are no outputs associated with this scheme included in our RIIO-T1 plans.

Appendix A – Existing site single line diagram (SLD)



Appendix B – Proposed Errochty site single line diagram (SLD)



Appendix C – Polaris summary documents

Polaris
Diagnostics & Engineering Ltd

Polaris Diagnostics & Engineering Ltd has been commissioned by Scottish Hydro Electric Transmission (SHE Transmission), to carry out a Level 1 condition assessment of Tummel Bridge GT1 132/11kV Transformer.

The level 1 condition assessment has been carried out, based on a review and independent assessment of the historic oil data and SSEN Report T2BP-ACR-0016 Revision 1.0 dated November 2019,both supplied by SHE Transmission.

Based on the assessment of the historical & current asset condition data, GT1 is in reasonably good condition and there is a low likelihood that the transformer condition will deteriorate by ageing during the RIIO T2 period.

In order to further assess and manage the condition of this transformer, the following recommendations are made:

- Continue with routine oil sampling and analysis of the main tank and tap changer.
- Continue with routine maintenance.
- Continue with routine inspection.
- Detailed load flow monitoring.
- 132kV bushings should be oil sampled for DGA and moisture analysis and assessed by the criteria set out in National Grid TGN 82. In addition the bushing power factor and capacitance should be measured. This would require an outage and the removal of the 132kV and 11kV bushings to facilitate the testing.

Polaris Diagnostics & Engineering Ltd has been commissioned by Scottish Hydro Electric Transmission (SHE Transmission), to carry out a Level 1 condition assessment of Tummel Bridge GT2 132/11kV Transformer.

The level 1 condition assessment has been carried out, based on a review and independent assessment of the historic oil data and SSEN Report T2BP-ACR-0016 Revision 1.0 dated November 2019,both supplied by SHE Transmission.

Based on the assessment of the historical & current asset condition data, GT2 is in reasonably good condition and there is a low likelihood that the transformer condition will deteriorate by ageing during the RIIO T2 period.

The tap changer is recorded as category 4 (serious deterioration or damage that requires specific action in the short term) which specifically relates to the "mechanism". The inspection data is not explicit as to the nature of the issue, or if this issue has been addressed.

In order to further assess and manage the condition of this transformer, the following recommendations are made:

- Investigate the reported "Category 4" iSIM score for the tap changer. This may require an intervention depending on the findings.
- Continue with routine oil sampling and analysis of the main tank and tap changer.
- In addition to routine oil analysis, the following tests are recommended to assess the rising DDF – These are Interfacial Tension (IFT), Sediment & Sludge & Particle Count.
- Continue with routine maintenance.
- Continue with routine inspection.
- Detailed load flow monitoring.
- 132kV bushings should be oil sampled for DGA and moisture analysis and assessed by the criteria set out in National Grid TGN 82. In addition the bushing power factor and capacitance should be measured. This would require an outage and the removal of the 132kV and 11kV bushings to facilitate the testing.
- Dielectric Frequency Response (DFR) test to assess the condition of the insulation system. This should be considered following assessment of the additional oil analysis to investigate the DDF. This would require an outage and the removal of the 132kV and 11kV bushings to facilitate the testing.