Scottish & Southern Electricity Networks

SSEN Transmission

RIIO-T2 Business Plan: T2BP-EJP-0041 Rev1

St Fillans 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 sets out the need for intervention at St Fillans 132/11kV substation, the primary driver for the works is asset condition and performance. In addition to this, there are several significant issues present which are secondary drivers; these include plant being located in third party buildings and shared unmetered supplies with customers.

Following a process of optioneering and detailed analysis, the proposed scope of works is:

- Insitu re-build of the 132kV substation compound, with the replacement of all other plant at a proximal location.
- Decommissioning and removal of existing St Fillans assets and infrastructure;

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

Polaris Diagnostics & Engineering Ltd were appointed to undertake a Level 1 review of our asset information. Although the DP levels in the transformer oil are acceptable, oil maintenance is warned against by Polaris as it may damage the aged winding insultation and cause the existing condition to be further compromised. Any oil maintenance would also lead to a masking of the true condition of the paper insulation, which at this point in its life cycle is undesirable. Combining their assessment as well as the NARM end of life scores the option of delaying the transformer replacement until RIIO T3 has been added to our detailed analysis. The end of life scores indicate that the unit should be replaced between 2026 and 2029. Therefore, to carry out refurbishment during RIIO T2 and then return in RIIO T3 to replace it is not an acceptable solution. It is therefore more cost effective to carry out the transformer replacement during the works to replace the LV plant. The asset condition report supports the replacement of the 11kV circuits breaker and the protection and control systems.

Since the submission of the business plan we have received the output of an environmental assessment which has assessed all our substations and their risk of contamination to their location. The St Fillans substation is in a local conservation area next to a vulnerable water body (Loch Earn) and as such has been given a high risk of contamination score; further supporting the scope of works proposed for RIIO T2 in this paper.

This paper demonstrates that the option to replace the substation, as per the submission in 2019 is supported by the CBA and well and the engineering and environmental assessment.

[1] A Risk Based Approach to Asset Management

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

- A long-term monetised risk benefit of R[redacted];
- An immediate reduction of network risk calculated as R[redacted]
- Improved customer security of supply and resilience in line with our goal to aim for 100% transmission network reliability for homes and businesses.
- Brings the infrastructure in line with current standards and practices, increasing network security and reducing operational risks.
- Improved separation of assets between SHE Transmission and the customer
- Improved operational and maintenance access as well as increased safety to staff and the public

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

Name of Scheme/Programme	St Fillans Substation Works
Primary Investment Driver	Asset Health (Non-Load)
Scheme reference/ mechanism or category	SHNLT2014 Transformer
Output references/type	NLRT2SH2014 Transformer
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 during the RIIO-T2 (April 2021 to March 2026) period at St Fillans 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

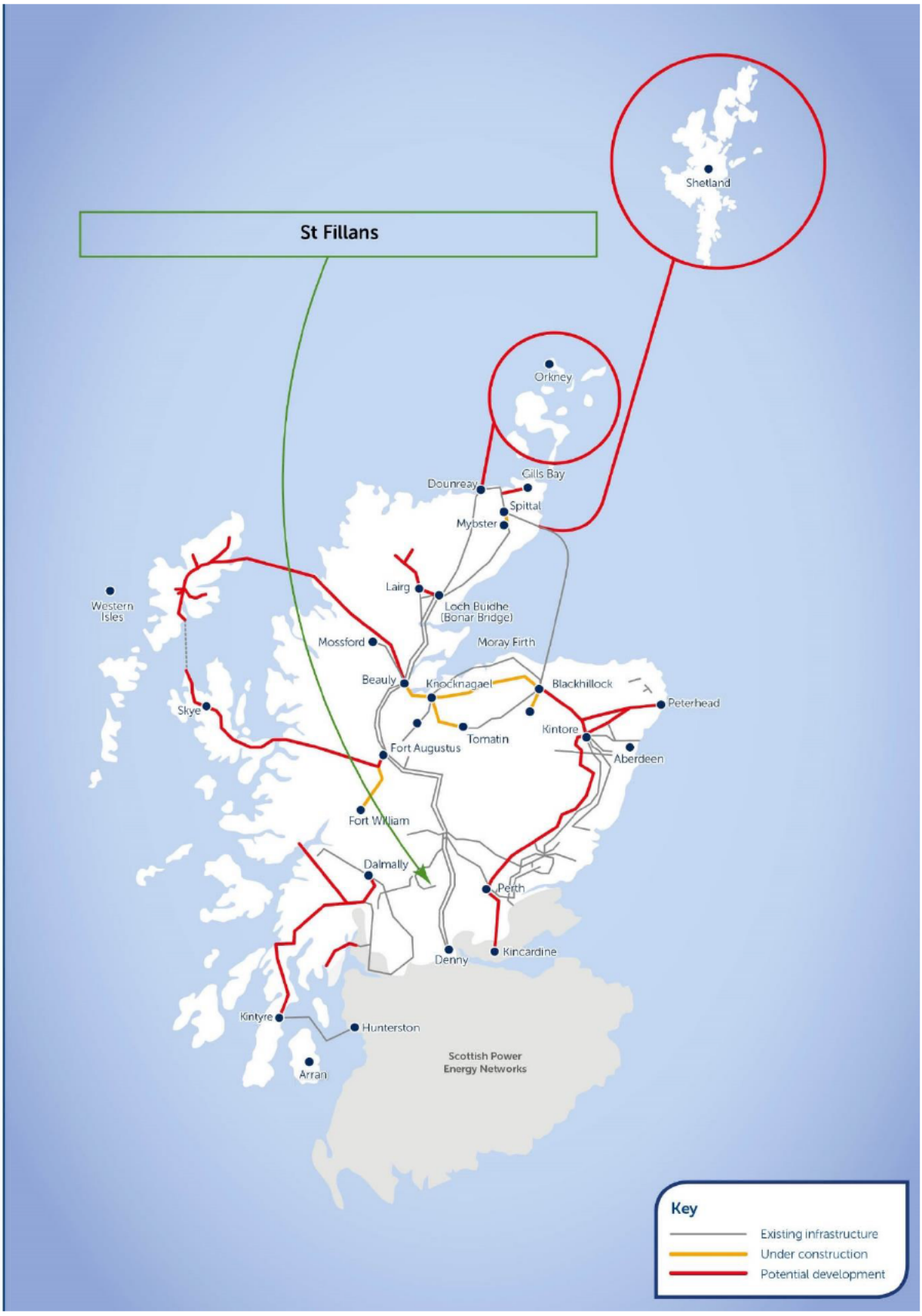
This section provides summary detail of the selected option. It sets out the scope and outputs, costs and timing of investment and where applicable other key supporting information.

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.


St Fillans
Shetland
Orkney
Cills Bay
Dounreay
Spittal
Mybster
Lairg
Loch Buidhe
(Bonar Bridge)
Western
Isles
Mossford
Moray Firth
Beauly
Knocknagael
Blackhillock
Peterhead
Skye
Tomatin
Kintore
Fort Augustus
Aberdeen
Fort William
Dalmally
Perth
Denny
Kincardine
Kintyre
Hunterston
Arran
Scottish Power
Energy Networks
Key
Existing infrastructure
Under construction
Potential development

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 St Fillans Substation. In response to Ofgem's feedback, SHE Transmission undertook the following actions:

2.1.1 Asset Condition Review

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

The conclusion of the Polaris report is that the condition of the transformer is commensurate with its age (62 years) and the condition will continue to deteriorate. The oil analysis demonstrates the presence of a thermal abnormality evidenced by the contamination of the oil. This will increase the risk of failure of the unit beyond its age itself and, as a minimum, monitoring is required to mitigate the risk of failure within the RIIO T2 period. The ACR, however, clearly shows that the external condition of the transformer tank requires intervention within the RIIO-T2 period.

The disconnectors and earth switches at St Fillans were manufactured and installed in 1958. These can only be operated manually, and spare parts are no longer available. The switch contacts are starting to exhibit high resistance and during their last maintenance round the contacts had to be re-built to pass testing. This is a common issue with disconnectors of this age and the next recourse is replacement of the plant as the contacts cannot be sourced and engineered parts are uneconomic. These switches have therefore reached the end of their useful life.

2.1.2 Development & 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 external and internal deterioration factors of the transformer and its ancillary plant. This additional option has been assessed against those submitted in the original justification paper.

The impact of this additional option for intervention is to ensure that the risk of asset failure during the RIIO T2 period is mitigated until the continued deterioration requires the transformer asset to be replaced in a future regulatory period.

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

St Fillans substation lies 12 miles to the west of Crieff. The site is the connection point to the transmission network for the St Fillans Hydro scheme and is the GSP for the 33kV Dalchonzie substation.

The site was constructed in 1957 and has not been subject to refurbishment or modification since it became operational. The substation is of an unconventional design with the HV plant constructed on a split-level platform and the LV plant and ancillaries located within the generation facility. The site is a shared location with SHE Transmission, third party generator and Scottish Hydro Electric Distribution (SHEPD) plant, and equipment and common shared services are located within a single shared compound.

The site is the connection point for 24.2MW of hydro generation and supports demand of up to 2MW.

The image below shows the geographical location of site at the tunnel entrance to the hydro facility and next to Loch Earn. The site is also next to a main arterial A road which could be affected by any failure at the site:


132kV switchgear
St Fillans transformer
Tunnel entrance
A85

3.2 Asset Need

St Fillans 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 conclusions of the Polaris report identify that the transformer is in a condition commensurate with age (62 years old), which will continue to deteriorate during the RIIO-T2 period. Analysis of the oil records clearly show that there is an underlying thermal abnormality within the transformer, manifested by contamination of the main tank oil, indicating an increased risk of failure beyond that of age-related deterioration. The report also highlights that although the DP levels are acceptable, oil maintenance is warned against as it may damage the aged winding insultation and cause the existing condition to be further compromised. Any oil maintenance would also lead to a masking of the true condition of the paper insulation, which at this point in its life cycle is undesirable.

It is also worth noting that the cause of the thermal abnormality is unknown but since the unit is on fixed tap it is likely that the issue emanates from the main tank and therefore painting, and oil regeneration will not solve the problem and prolong the useful life of the transformer.

The ACR highlights the poor external condition of the transformer. Whilst the external condition and the oil profiles can be marginally improved by cleaning, painting and oil regeneration these interventions cannot halt or reverse the aging characteristics of the unit. Any additional intervention to mitigate the risk of failure can only address the environmental consequences should the unit fail catastrophically; this would be by cleaning and lining the existing bunding arrangement to ensure oil containment. This civil work could not accommodate the replacement unit in RIIO T3.

The Asset Condition Report[2] (ACR) document supports the need for the investment and details the issues and risks for all substation plant.

The ACR highlights the following:

- The 132kV disconnectors and earth switches are obsolete. Spares are not available and re-building of the contacts was carried out during the last maintenance round to solve high resistance. In addition, these are manually operated and extend response times in the event of a fault.

[redacted]

- Grid Transformer (GT) 1 was manufactured in 1957. Oil sampling indicates that the transformer shows ageing of insulation from thermal overheating faults, moderately high Furan levels and acidity;

[redacted]

The condition of the assets is a risk to continuity of the connection of the hydro generation scheme for export if no suitable intervention work takes place.

The following two pictures show the 11kV switchgear located in the Hydro generation tunnel. [redacted]. As noted in the asset condition report this is a fault common to the other breakers on this board owned by the generator and SHEPD and a coordinated solution is required.

[2] St Fillans Substation Works Asset Condition Report T2BP-ACR-0026

The following images show the HV switching arrangement and demonstrates the space constraints of the existing layout as well as the multi levels driven by the local topography. There is a difference of approximately three metres between the ground level of the transformer compound and the 132kV switching part of the site. Should these switches fail spare parts are not available and retrofitting has not been attempted on this type of disconnector. Experience of these circa 70-year-old (by the end of RIIO-T2) disconnector units shows that they begin to demonstrate high contact resistance and need to be re-built to operate within tolerance. They are therefore at the end of their useful life.

The image below shows the HV compound area adjacent to the hydro tunnel entrance. The photo shows both SHET and SHEPD assets in this site. Therefore, the design and delivery of any works will need to be closely coordinated with SHEPD as well as the outages for carrying out the work.

The image below demonstrates the proximity if the transformer to the perimeter fence and should a disruptive failure occur there is risk to the public.

Using the Ofgem-accepted Common Network Output Measures Methodology, the transformer End of Life (EoL) scores are forecast to reach 7.5 by 2026 and 15 by 2029. Under the methodology a score of 7.5 or more indicates that unit has now reached the last stages of its useful life and replacement should be considered. A score of 15 indicates the unit has reached the end of its life and has failed. Therefore, using this scoring mechanism the St Fillans transformer should be programmed, at the latest, for replacement some time very early in RIIO T3. A refurbishment intervention will not have a

material effect on the EoL scores and timing, and it is not acceptable to replace a transformer one regulatory period after its refurbishment.

Although the primary driver for works is the condition of assets there are several secondary drivers:

- There is a legacy of shared assets with third parties with associated operational constraints. The 11kV circuit breaker as well as the protection and control systems are all housed in the generation buildings. Access to our assets is therefore controlled by a third party. There is also an issue of inadequate metering and sharing of electrical supply systems;
- [redacted]. The transformer holds 35,504 litres of oil and is within 30m of Loch Earn and the A85, a main arterial road from Crieff to Tyndrum. [redacted]

  The table extract below is from a report by our environmental consultant ERM who have assessed all our sites for land contamination risk. The St Fillans site, as shown in the maps and photographs earlier is located 30 meters from the banks of Loch Earn. The Loch Earn water body is classified as highly vulnerable and our site presents a moderate risk to it. However, the site is also within a local conservation area which, consequently, gives the site a high risk of contamination score.

Substation	Distance to nearest surface	Surface Watercourse	Surface Water Classification	Potential Flood risk on site	Vulnerability	Sensitivity	Overall Risk Assessmer	Consequence
St Fillans Grid	30m south	Loch Earn	Moderate	Medium to high (surface water)	High	Moderate	Moderate	High due to Conversation Area (on-site)

- The CVTs have been identified for replacement in line with EU regulations since they cannot be tested for PCB content and were manufactured before 1990 and are likely to be PCB containing.
- There is a Network and Security risk arising from shared assets with the third-party generator and SHEPD.
- There is no HV circuit breaker or switcher on the 132kV feeder. It is therefore not possible to clear a transformer fault locally. The arrangement at St Fillans is significantly different from current standards and practices whereby there is a single intertrip via power line carrier which is backed up by the fault thrower [redacted];
- There are potential security of supply issues due to the 132kV disconnectors and earth switches being manually operated only. This exposes customers to increased duration of fault

outage. Additionally, the 11kV switchgear is subject to an operational restriction due to unreliable operation;

- Plant and system protection [redacted] As described above the transformer protection uses a single intertrip on PLC to clear a fault with a fault thrower as backup; the LV supply system as common to SHET, SHEPD, and SSE Generation; the HV compound houses assets belonging to SHET, SHEPD and SSE Generation. This sharing of assets and access to them is contrary to current standards and means that access to and maintenance of the assets is not within SHET control.

[redacted]

3.3 Growth Need

There are no identified growth needs for the site related to load schemes, however, we should note that the unit is being operated near to its current capacity limit of 25 MVA. Analysis over the period August 2016 through December 2018 shows that the unit is regularly at 96% of its current capacity rating. As a result, the unit is experiencing overheating as identified in the oil analysis, which degrades insulation at an accelerated rate, reducing the service life of the unit.

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	[redacted]	No
1	In situ replacement	[redacted]	Yes
2	Offline replacement	[redacted]	Yes
3	Refurbishment of GT and replacement of LV plant + replacement of GT in RIIO T3	[redacted]	Yes

Option 0

The asset condition report and Polaris report do not support a "do nothing" option. The 11kV circuit breaker is subject to an operation restriction since it does not open or close reliably and should be replaced. All protection and control systems are also in need of replacement (due to obsolescence) and relocation ensuring correct commercial separation from third parties. The transformer is starting to degrade and presenting a thermal abnormality; intervention is required on this unit to ensure continued operability. Leaving the assets in their current condition presents an increasing risk of failure and presents risks to operational personnel which are unacceptable and a loss of supply to customers. Intervention is therefore required during the RIIO T2 period.

NOT PROGRESSED TO DETAILED ANALYSIS

Option 1 – In situ replacement of all assets

This option considers the in-situ replacement of existing switchgear, protection and GT at St. Fillan's.

This proposal is for full decommissioning of all Scottish Hydro Electric Transmission (SHET) Assets and complete refurbishment of the existing civil infrastructure and extension of the site compound.

In summary, the works are for:

- Complete decommissioning of all assets and provision of new civil infrastructure
- Replace 132kV and 11kV switchgear, GT1, protection, control and intertripping schemes and common services
- Provide dedicated buildings for all SSEN Transmission assets

This option resolves the primary as well as secondary drivers.

Benefits:

The following summarises the identified benefits for this option:

- This option presents a low risk against planning consent and visual impact concerns, it requires no wayleaves and consents
- There is an opportunity to provide alternate 11kV circuit breakers, which do not utilise SF_6 as an insulating and arc quenching medium
- Incorporation of GT bunds with oil interceptors and bunded hard standings for oil containment, handling and processing. This brings the facilities for the GT's up to the current standards and practices; eliminates the oil contamination risk in proximity to Loch Earn.
- Standardised protection, control intertripping and common services to current standards

Risks and Concerns:

Option 1 has a significant outage impact for the third-party generator and SHEPD. The third-party generator in particular would be subject to significant continuous outage during decommissioning and replacement works (circa 16 weeks)

The following summarises the identified risks and concerns, noted against this option:

- General space constraints of the existing site
- An HV circuit breaker which would be preferable operationally, is not possible due to space restrictions
- Ground conditions are known to be challenging, requiring extensive rock breaking
- Outage duration for the third party and the 33kV GSP for SHEPD Dalchonzie substation, will be extensive.
- GT delivery and related road upgrades will be necessary

- Construction noise, planning consent (while low is still a risk) and visual impact concerns

PROGRESSED TO DETAILED ANALYSIS

Option 2 – Offline replacement of all assets

This option considers the dismantling and decommissioning of the existing St Fillans site and replacement at a new local substation site including installation of cable connections to the St Fillans 11kV switchboard.

In summary, the works are for:

- Complete decommissioning of all SHE Transmission assets
- Offline build of a new substation with 132kV and 11kV switchgear, GT1, protection, control and intertripping schemes and common services
- Provide dedicated buildings for all SHE Transmission assets
- New cable connection from the 11kV Generation substation to the new SHE Transmission substation, connection to the 11kV SSEN Distribution switchboard
- Staged transfer to the new SHE Transmission substation site
- Road improvements and road construction to the new substation location

This option resolves the primary and all secondary drivers.

Option 2 would have the least significant impact on outages for the third-party generator and SHEPD. The third-party generator and SHEPD would have limited outage exposure for periods of circuit transfer, post completion of the offline build (circa 3 weeks)

The following summarises the identified benefits, noted against this option:

- A new location allows the construction of a full GT bay with an HV circuit breaker, which would be preferable operationally
- There is an opportunity to provide alternate 132kV and 11kV circuit breakers, which do not utilise SF_6
- Incorporation of GT bunds with oil interceptors and bunded hard standings for oil spillages, handling and processing. This brings the facilities for the GT's up to the current standards and practices; eliminates the oil contamination risk in proximity to Loch Earn.
- Standardised protection, control intertripping and common services to current standards

Risks and Concerns:

The following summarises the identified risks and concerns, noted against this option:

- Ground conditions are known to be challenging, requiring extensive rock breaking
- GT delivery and related road upgrades will be greater in scope and risk than Option 1 and 3
- Significant challenges relating to land purchase, wayleaves and consents are noted from historical works
- Construction noise, planning consent and visual impact concerns noted

PROGRESSED TO DETAILED ANALYSIS

Option 3 – Replacement of LV assets adjacent to HV compound and transformer refurbishment RIIO T2, transformer and HV asset replacement in T3

This option considers the in-situ replacement of existing 11kV switchgear, protection and ancillary plant as well as refurbishment of the GT at St. Fillan's by 2026; with a return project by 2031 to replace the GT and HV plant.

This proposal is for full decommissioning of all Scottish Hydro Electric Transmission (SHET) Assets and complete refurbishment of the existing civil infrastructure and extension of the site compound as per Option 1 but over a staged time line.

The works for RIIO T2 are:

- Complete decommissioning of all LV assets and provision of new civil infrastructure out of the hydro tunnel
- Replace 11kV switchgear, protection, control and intertripping schemes and common services
- Provide dedicated buildings for all SSEN Transmission assets
- Refurbishment of GT (clean, paint, re-gasket, oil processing, retro bunding)

The works for RIIO T3 are:

- Complete decommissioning of all HV assets and provision of new civil infrastructure in the existing HV compound
- Replace 132kV switchgear and GT1

This option resolves the primary as well as secondary drivers.

Benefits:

The following summarises the identified benefits for this option:

- This option presents a low risk against planning consent and visual impact concerns, it requires no wayleaves and consents
- There is an opportunity to provide alternate 11kV circuit breakers, which do not utilise SF_6 as an insulating and arc quenching medium
- Standardised protection, control intertripping and common services to current standards
- Refurbishment of the GT in RIIO T2 postpones capital expenditure
- By the end of RIIO T3, the GT bunds will be installed with oil interceptors and bunded hard standings for oil containment, handling and processing. This brings the facilities for the GT's up to the current standards and practices; eliminates the oil contamination risk in proximity to Loch Earn.

Risks and Concerns:

Option 3 would have the most significant impact on outages for the third-party generator and SHEPD. The third-party generator in particular would be subject to significant continuous outage during decommissioning and replacement works during two regulatory periods. This negative societal impact has been considered within the CBA.

The following summarises the identified risks and concerns, noted against this option:

- General space constraints of the existing site and land ownership boundary
- An HV circuit breaker which would be preferable operationally, is not possible due to space restrictions
- Ground conditions are known to be challenging, requiring extensive rock breaking
- Outage duration for the third party and the 33kV GSP for SHEPD Dalchonzie substation, will be extensive. (approximately 16 weeks in each of RIIO T2 and T3)
- Refurbishment of a transformer of this age and in this sensitive location carries environmental risks
- GT delivery and related road upgrades will be necessary
- Construction noise, planning consent and visual impact concerns

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[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 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	[redacted]	[redacted]		[redacted]
Option 2	Offline replacement	[redacted]	[redacted]	[redacted]	[redacted]
Option 3	Replacement of LV and ancillary plant and refurb of transformer + replacement of transformer and HV plant in RIIO T3	[redacted]	[redacted]	[redacted]	[redacted]

The CBA for Option 3 considers the cost of displaced carbon due to the loss of hydro generation for outages in two regulatory periods as well as the sunk cost of the civil works in RIIO T2 which cannot be made use of in RIIO T3 (the bunds will need to be broken out and removed for the installation on

[3] Cost Benefit Analysis Methodology

the new transformer). The results of the CBA demonstrate that Option 1 performs the best in an NPV assessment as it delivers additional value compared to Option 2 or 3.

Options 1 and 3 have the lowest risk related to construction and planning. The Option 3 postponement of the replacement of the GT attracts additional costs for both SHET and the customers which means Option 1 performs better in the CBA. [redacted].

The consequence of a failure due to extensive intervention could lead to a higher risk of oil loss. Although the DP levels are acceptable, oil maintenance is warned against by Polaris as it may damage the aged winding insultation and cause the existing condition to be further compromised. Any oil maintenance would also lead to a masking of the true condition of the paper insulation, which at this point in its life cycle is undesirable.

The main risks for Option 2 are related to ground conditions, transformer delivery, land acquisition, planning approval, wayleaves and consents.

- Land acquisition and wayleaves in the area have been difficult historically
- The construction of a dedicated site access road for transformer delivery may be impractical, costly and time consuming
- From provisional analysis, significant amounts of rock breaking, cutting and fill works would be required
- Planning consent risks include: construction noise, disruption and visual impact in a scenic location.

The Engineering, Environmental and CBA assessment support Option 1 as the preferred option.

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 4: 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, the options move in parallel and have no impact on ordering within CBA.
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.
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 the proposed option for the works.

The scope of the selected solution is to rebuild the existing substation in situ; undertaking all necessary improvements. A copy of the proposed Single Line Diagram (SLD) is shown in Appendix B. The project will be energised within the RIIO-T2 period. The table below details the outputs.

Table 3: Outputs from proposed solution

Plant	Size of new plant	Replacement for
132kV substation	1 x 132kV circuit switcher	-
	1 x 132kV disconnector	1 x 132kV disconnector
	1 x 132kV earth switch	-
	1 x 45MVA 132/11kV transformer	1 x 25MVA 132/11kV transformer
	1 x 11kV circuit breaker	1 x 11kV circuit breaker
	1 x 11kV disconnector	1 x 11kV disconnector

5.4 Competition

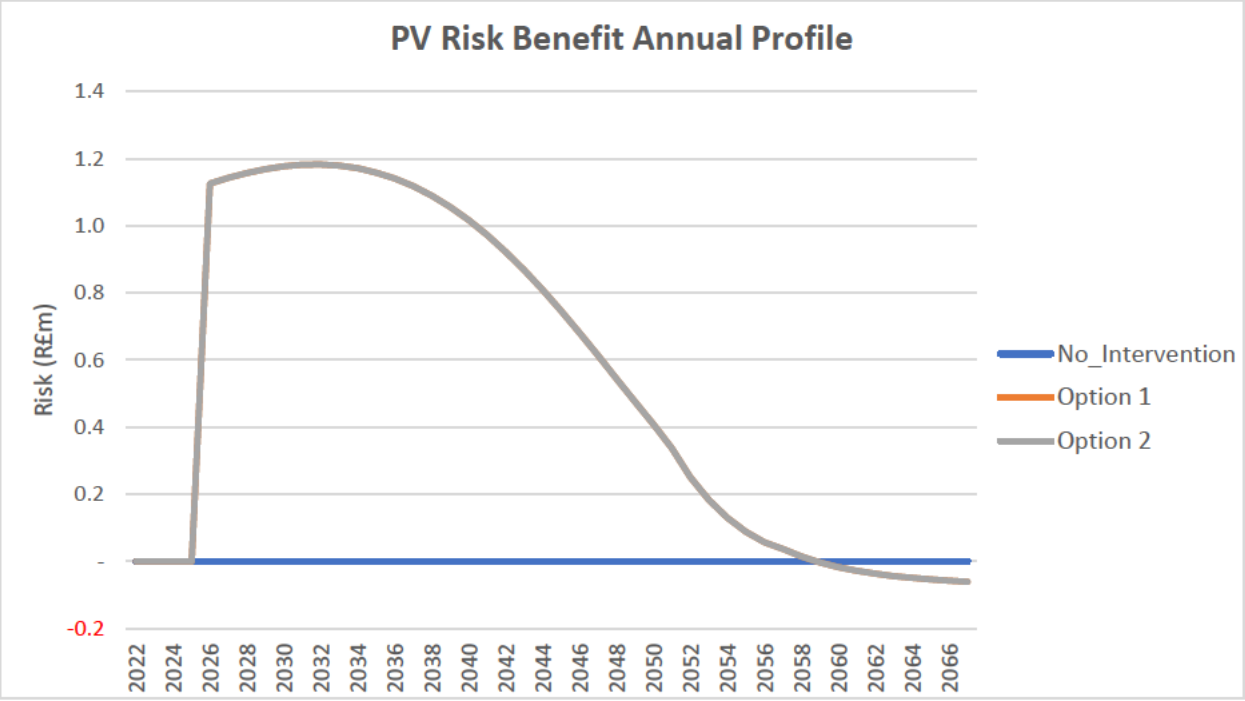
The St Fillans scheme is not flagged as eligible for early or late competition due it being under Ofgem's £50m and £100m thresholds respectively.

5.5 Risk Benefit

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 Management[1]).

The graph in figure 2 shows the long term benefits of the solutions discussed in the options presented in the paper for the 2019 submission. This showed that the location of the assets had no effect of the monetised risk and therefore the insitu replacement is preferred as supported by the CBA.

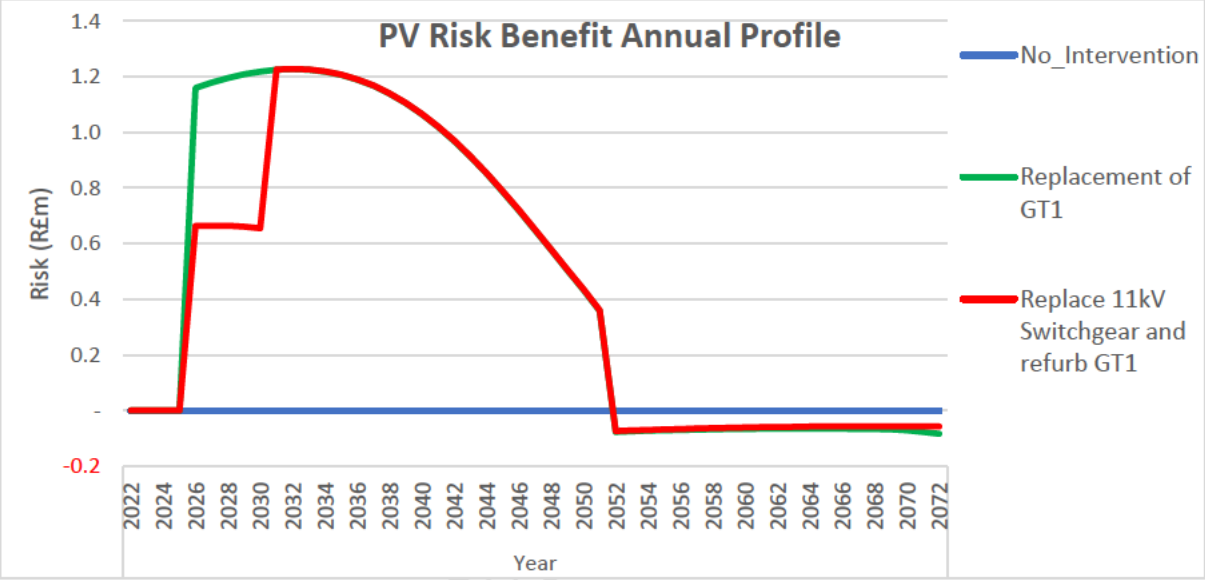
Figure 2: Long Term Benefits of off line and inline replacement of all assets



The graph in figure 3 shows the risk benefit of not intervening at all, a phased substation rebuild over the regulatory periods T2/T3, and delivering the transformer replacement works into the scope of work to be delivered in RIIO T2. The graph demonstrates that the monetized risk of the preferred option (substation replacement insitu) delivers the greatest benefit with greater immediate and longer-term benefit.

The long-term monetised risk benefit which would be realised through the completion of this project is R[redacted]. 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.

Figure 3: Long Term Benefits of intervention at different times



In addition to assessing the long-term risk benefit, an immediate monetised risk benefit has also been determined. The immediate monetised risk benefit which would be realised through the completion of this project is R[redacted]

5.6 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 (between gates 1 and 2) 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.

2 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, options 1 and 3 deliver very similar figures with option 2 significantly higher. The similarity of options 1 and 3 comes from the delivery of the same lead assets, option 2 figures are a result of the increased civil works.

Table 5: Carbon Calculation Summary

	Project Information	Baseline (Option 1)	Option 2	Option 3
Project info	Project Name/number			
	Construction Start Year	2026	2026	2026
	Construction End Year	2026	2026	2031
Cost estimate £GBP	Embodied carbon	£ 44,930	£ 91,666	£ 44,941
	Construction	£ 37,667	£ 162,930	£ 38,594
	Operations	£ -	£ -	£ -
	Decommissioning	£ 17,381	£ 75,181	£17,469
	Total Project Carbon Cost Estimate	**£ 99,978**	**£ 329,777**	**£ 101,003**
Carbon footprint tCO2e	Embodied carbon	600	1,224	600
	Construction	503	2,176	503
	Operations	-	-	-
	Decommissioning	47	227	50
	Total Project Carbon (tCO2e)	**1,153**	**3,617**	**1,153**
Project Carbon Footprint by Emission Category	Total Scope 1 (tCO2e)	-	-	-
	Total Scope 2 (tCO2e)	-	-	-
	Total Scope 3 (tCO2e)	1,153	3,617	1.153
SF_6 Emissions	Total SF_6 Emissions 3 (tCO2e)	-	-	-

5.7 Cost Estimate

The cost of the preferred option for works at St Fillans 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 St Fillans substation. The primary driver for the scheme is the asset condition and performance of existing plant and infrastructure. In addition, the economic efficiency of expanding the scope of work to encompass works that could be postponed to RIIO T3 has been considered along with engineering and environmental considerations

Between the business plan submission and the revision of the paper in response to the draft determination four options have been considered. To do nothing is unacceptable in light of the operational restrictions on the LV switchgear and the need to replace the protection control and supply systems in a location owned and controlled by SHET. To intervene on these assets only and to refurbish the existing transformer has been deemed unacceptable and uneconomic since the transformer should be planned for replacement in RIIO T3. The whole site intervention and the options of an off line or insitu rebuild were taken through CBA. The CBA supports the insitu replacement at the hydro tunnel entrance, this is also considered to carry the lesser consenting and civil risk.

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

- Decommissioning and removal of existing St Fillans assets and infrastructure from the generation buildings and the HV compound at the tunnel entrance;
- In situ construction of replacement 132kV Feeder and transformer bay;
- Construction of a new segregated compound and buildings for the LV switchgear, protection and control equipment as well as dedicated LV supplies

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

- A long-term monetised risk benefit of R[redacted];
- [redacted]An immediate reduction of network risk calculated as R£[redacted]
- Improved operational flexibility and resilience in line with our goal to aim for 100% transmission network reliability for homes and businesses;
- Brings the infrastructure in line with current standards and practices, increasing network security and reducing operational risks.
- Improved separation of assets between SHE Transmission and the customer
- Improved operational and maintenance access as well as increased safety to staff and the public

The St Fillans 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.

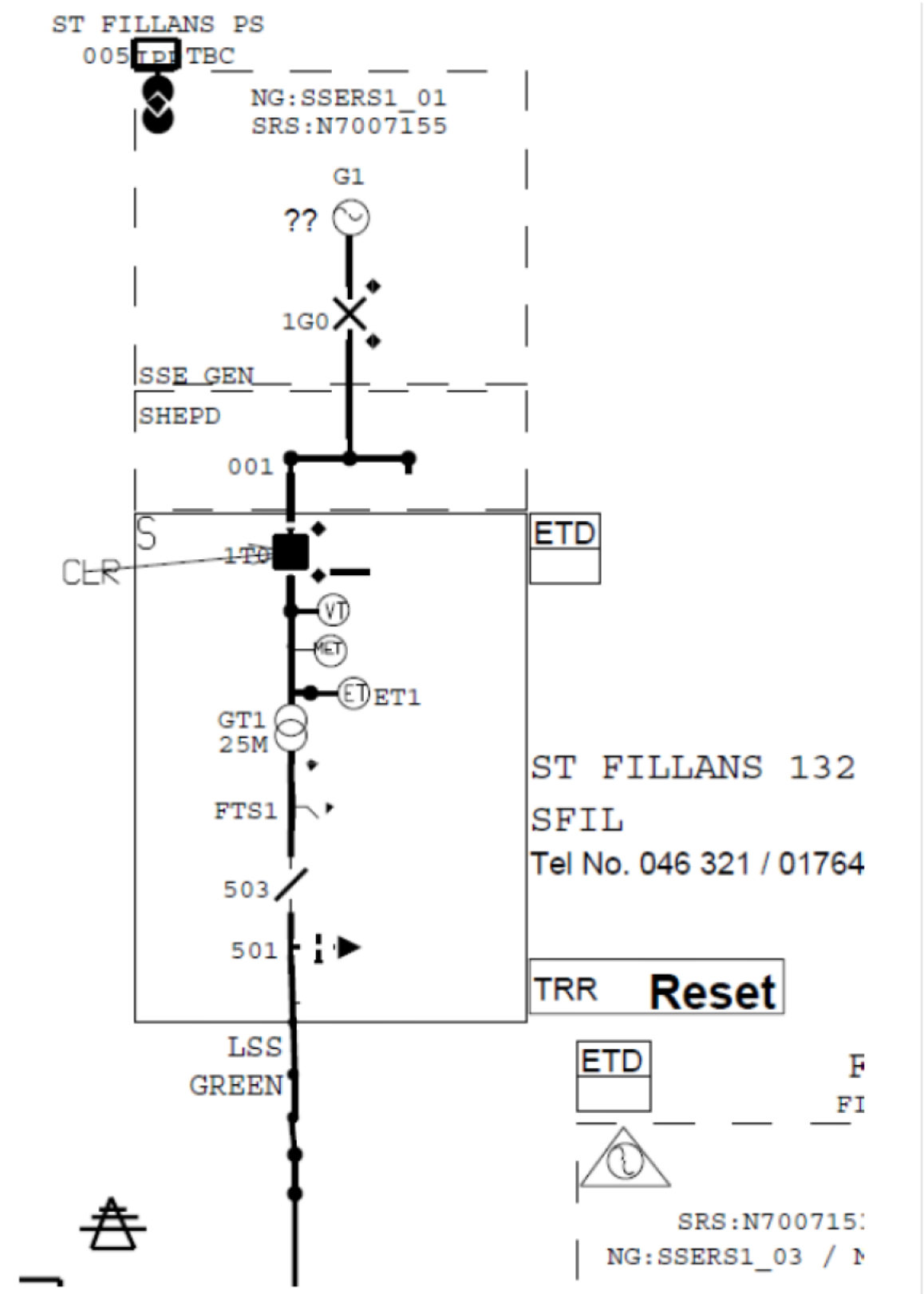
For our core non-load projects this means that we commit to delivering our overarching NARMs target. If we do not deliver the NARMS target, or a materially equivalent target, then we should be subject to a penalty. Equally, if we over-deliver against our target and are able to justify that the over-delivery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

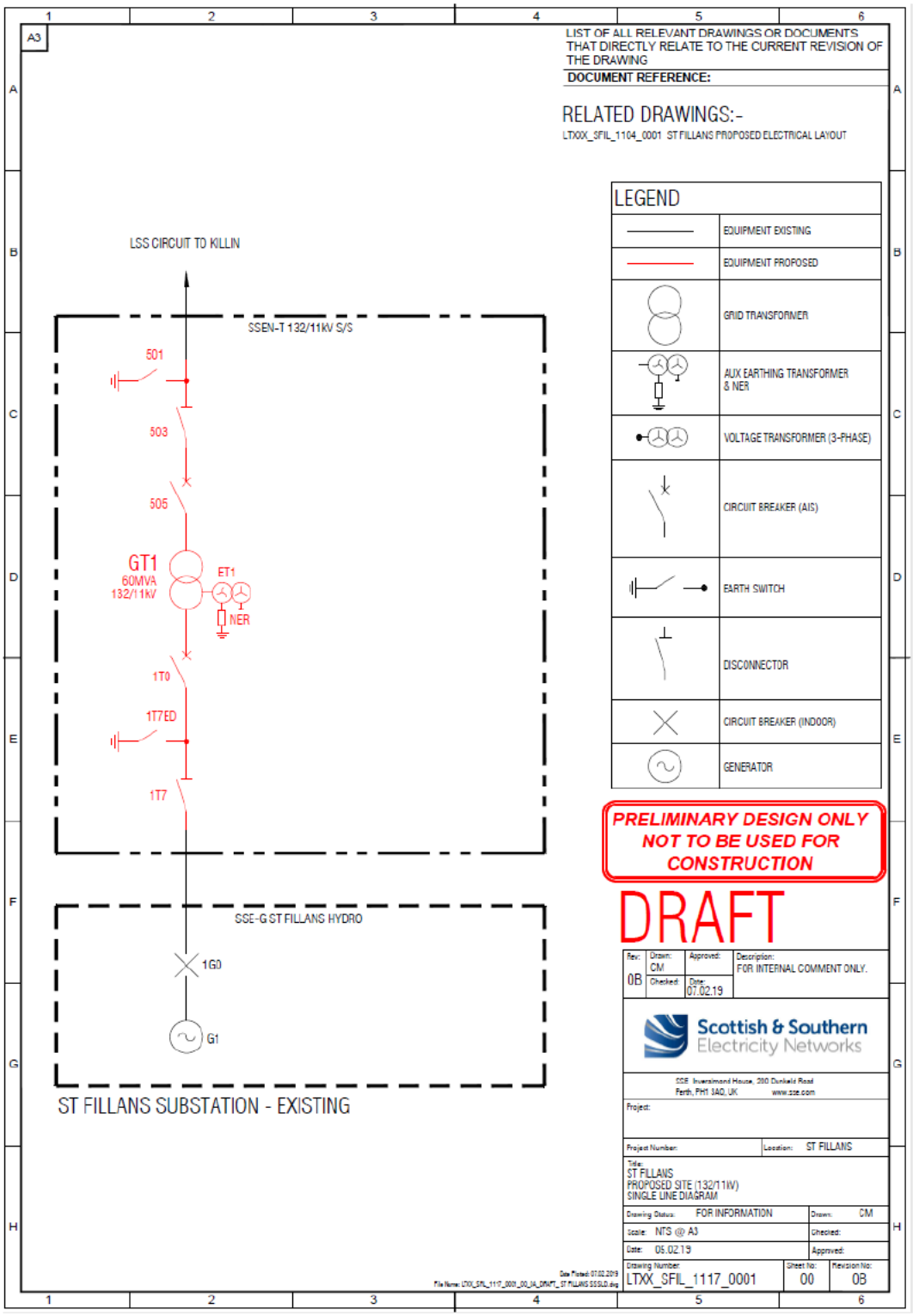
8 Outputs included in RIIO T1 Business Plan

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 site single line diagram (SLD)



Appendix C – Polaris Report – summary

Polaris Diagnostics & Engineering Ltd has been commissioned by Scottish Hydro Electric Transmission (SHE Transmission), to carry out a Level 1 condition assessment of St Fillans 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 T2-EJP-0041 both supplied by SHE Transmission.

Based on the assessment of the historical & current asset condition data, GT1 is in a condition commensurate with age and the transformer condition will deteriorate by ageing during the RIIO T2 period. There is an increased risk of failure due to an underlying thermal abnormality which will require monitoring in the form of increased DGA surveillance and may require enhanced maintenance within this period.

There is evidence that the transformer has external ageing which requires further inspection and evaluation. Given that the transformer is located in close proximity to a water course, the transformer should be considered as an environmental hazard until such times as the oil leaks have been assessed. There is a reported issue with "availability of spares" which needs to be investigated.

There is an underlying thermal abnormality as evidenced by the presence of dissolved ethylene levels in the main tank. To identify of the source of the dissolved ethylene electrical testing would be required. Whilst these magnitudes of dissolved gases are still at low level, the dissolved ethylene should be kept under surveillance, in order to check for further manifestation on what could become degenerative thermal abnormality.

Oil processing or long term topping up of the main tank oil has had a dilution effect on the measured 2FAL concentrations and as this is used to predict the condition of the paper insulation and "estimated residual life remaining" of that insulation, the estimate of 40% life remaining is considered optimistic. The oil is oxidised which would require to be regenerated to restore the oxidation levels to a quality defined as "Good" by IEC 60422, but this process would further dilute the concentrations of 2FAL. This would render the estimated DP redundant as an ageing indicator.

The conclusion of the proposed detailed evaluation, taking into account all risk factors associated with GT1, should indicate if the transformer is to be recommended for replacement or subjected to a programme of refurbishment.

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