Scottish & Southern Electricity Networks

Foyers Substation Works

Core Non-Load

Engineering Justification Paper

Foyers 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 the risk over the RIIO-T2 period.

This paper identifies the need for intervention on the 275/18kV transformers at Foyers substation. The primary driver for the scheme is the asset condition with a secondary driver of network resilience (black start capability).

The delivery of this project ensures continued generation connection of 300MW into the transmission network, as well as maintaining connection to a critical part of the 'black start' infrastructure on the transmission network.

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

- Offline replacement of the 275/18kV Generation Transformers (GTs)
- Replacement of the single oil filled 275kV cable circuit between the generation site and Foyers Switching Station with two new XLPE 275kV cable circuits including 275kV circuit breakers

This scheme delivers the following outputs and benefits:
- An immediate reduction of total network risk calculated as R£2.2m
- Improved operational flexibility and resilience in line with our goal of 100% network reliability
- Use of innovative non-SF_6 solutions
- Contribution to our goal of one third reduction in greenhouse gas emissions

The immediate monetised risk benefit which would be realised through the completion of this project is R£2.285m for a cost of £41.6m and the works are planned to be completed within the RIIO-T2 period.

The Foyers 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	Foyers Substation Works
Primary Investment Driver	Asset Health (Non-Load)
Scheme reference/ mechanism or category	SHNLT2017
Output references/type	NLRT2SH2017 2 x 165MVA 275/18kV Grid transformers 5 x 275kV Circuit Breakers 700m 275kV cable 150m 18kV cable
Cost	£41.6m
Delivery Year	RIIO T2
Reporting Table	C 0.7 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 Foyers 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.

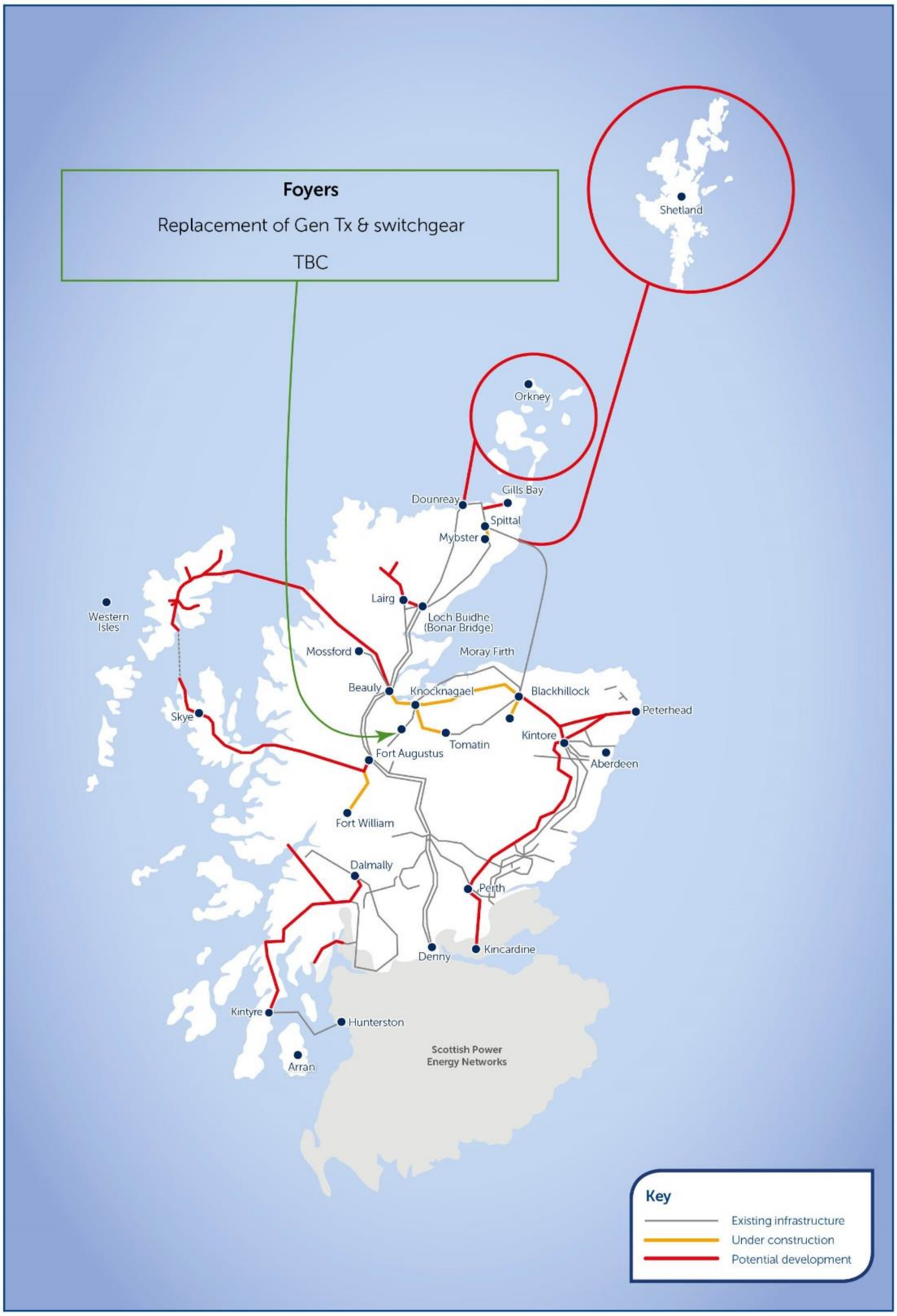

Figure 1 - Network Overview highlighting Foyers Power Station

2.1 Post Draft Determination Update

Since the receipt of feedback from Ofgem as part of their draft determination, this paper has been revised to emphasise the lack of available land at Foyers which restricts in situ replacement, to provide further information on the 275kV oil-filled cables, and to provide further information on options considered.

The option to replace GT2 and refurbish GT1 in situ has been considered in detail. This will only extend the life of the plant by up to ten years – which is only towards the normally expected end of life, as the current plant has been in service for around 30 years. Additionally, this would necessitate a full power station outage for the duration of the project and would, therefore, incur significant constraint costs, as well as removing key black-start equipment for a long period of time.

The option of further deferral of asset replacement works on GT2 has not been considered, primarily as a result of the reported asset health. Furthermore, asset refurbishment of GT2 is not considered a technically viable solution, due to both the asset health and need for additional site upgrades. It is also worth noting that removal of the asset is not acceptable since the hydro scheme require continued connection in the transmission network for generation as well as black start capability.

The option to replace both transformers in situ has been considered in detail. Whilst this is by some considerable margin the lowest initial cost option, this would necessitate a full power station outage for the duration of the project and would, therefore, incur significant constraint costs, as well as removing key black-start equipment for a long period of time. Due to the layout of the substation at the generation site the GTs are very confined and do not meet current standards in terms of adequate fire damage zones, oil containment, operability, maintenance access and business separation.

The 275kV oil filled cable, servicing the generation site from the switching station, puts the generator at single circuit risk. This situation is exacerbated by the routing of this circuit running under GT2. Therefore, a failure of the cable at this point, or a failure of the GT2 could result in an extended outage of the site. Records indicated that there have been oil leaks on this cable.

The power station, substations, cable route and switching station all inhabit land on the banks of Loch Ness. All these items of infrastructure are highly visible, as well as being in very close proximity to the loch itself. As a result, a sympathetic and cautious visual approach should be taken regarding the oil filled cables and transformers.

In addition, the critical nature of the site, network security, resilience, and operability has helped to shape the options reviewed and the recommendations.

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

The Foyers 275/18kV substation (built in 1975) facilitates the connection of the Foyers Pumped Storage Hydro scheme to the transmission network. This scheme has a capacity of 300MW and connects two 150MVA pumped storage units via a single 275kV cable circuit to a 275kV circuit breaker and a single 275kV busbar at Foyers Switching Station. Foyers Switching Station is connected to Knocknagael 275kV Substation via a double circuit 275kV tower line. The Foyers Pumped Hydro Scheme provides generation and demand services to NGESO and no increase in capacity is anticipated.

The substation is currently the only pumped storage connection on SHE Transmission's network and therefore plays a pivotal role in the GB wide Black Start Strategy. More detail on our black start support can be found in our document Black Start System Restoration Support[2] .

There are two generation transformers which are banked together and directly connected to the sealing end of the single 275kV oil filled cable. These GTs and their connection are the subject of this justification paper. GT1 was manufactured and installed in 1991, and GT2 was manufactured and installed in 1982. The banked connection is an unusual arrangement and is shown in Figure 1. As the figure shows, the power station is connected to the Transmission network via a single point of supply. A single cable is used to interconnect the two systems which in itself, introduces risk to not only the Black Start process but also to the routine provision of power to the UK grid.

The transformers are installed at the power station, not within the 275kV switching substation compound. Ownership boundaries and the continued use of shared facilities with the customer (e.g. batteries/ LVAC) are also considered within the project.

[2] Black Start System Restoration Support

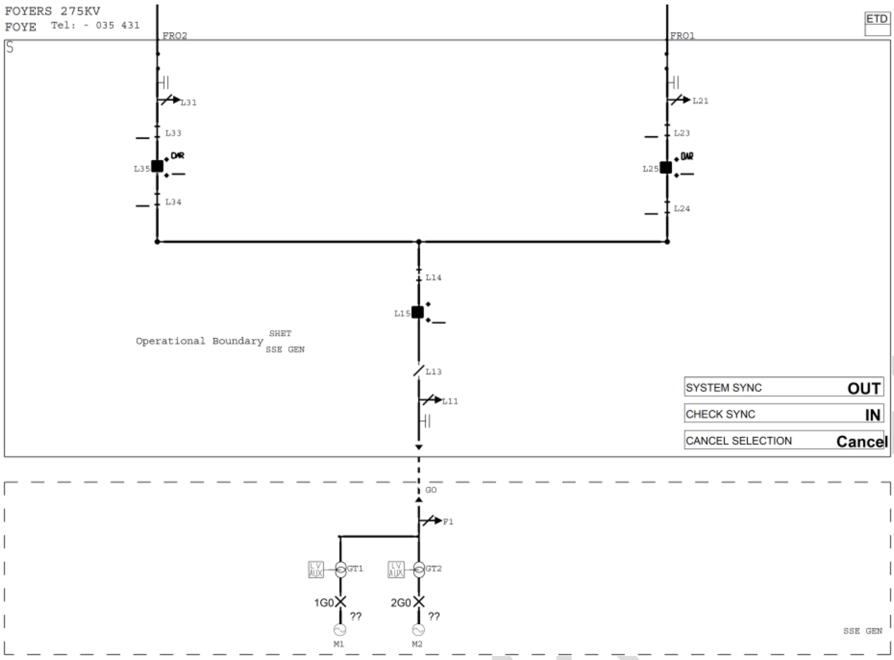

Figure 2 - Foyers Network Diagram

3.2 Asset Need

3.2.1 Generation Transformers

The condition of GT2 (manufactured in 1982) is advanced in its degradation both internally and externally. This condition is in line with its age as well as its early history of vibration and tap changer problems. Oil samples indicate that the unit is experiencing insulation polymerisation and with the historic vibration issues there is concern over the unit's ability to perform as required to the end of RIIO-T2. The gas levels in the oil samples indicate that GT2 has been subject to an electrical fault and there is evidence of a cyclical DGA trend in line with the maintenance interventions[3]. Based on the oil leaks and rusting, as well as the oil analysis, this unit requires replacement during RIIO-T2.

Currently there are no immediate asset health drivers for the replacement of GT1 (manufactured in 1991). Oil samples indicate early signs of insulation breakdown with an increasing trend in analysed gases driving a need for more frequent monitoring this is discussed further in the Foyers Asset Condition Report[3]. There are also external condition issues to be addressed regarding oil leaks and rusting.

As can be seen from Figure 3, Figure 4 and Figure 5, in-line replacement is extremely difficult due to the compact nature of the existing site, lack of available adjoining land and its location adjoining Loch Ness. It is not possible to accommodate replacement transformers, meeting fire damage zone requirements of current specifications, on the site of the existing compound. Under the existing

[3] T2BP-ACR-0019 Foyers Asset Condition Report

network configuration, replacement of GT2 will necessitate a whole station outage. This presents an opportunity to consider the replacement of GT1 while this part of the network is subject to outage.

The existing units cannot be relocated as they are water cooled and are subject to ongoing reliance on a GT cooling water supply from generation business.

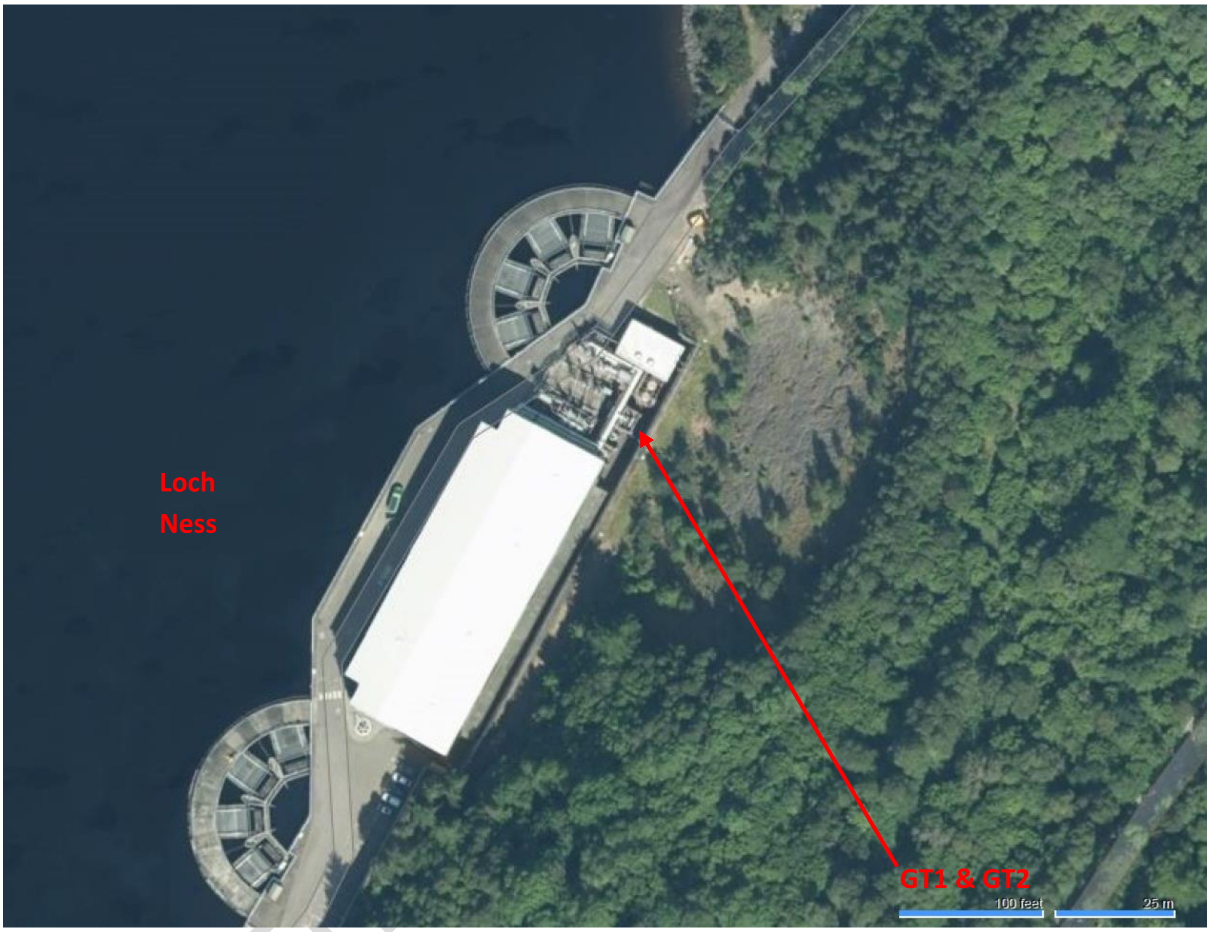

Figure 3 - Birds-Eye View of Foyers Power Station[4]

[4] Imagery ©2020 CNES/Airbus, Getmapping plc

Figure 4 - Proximity of transformers to Loch Ness

Figure 5 - Steep banking behind transformers

3.2.2 275kV Cable Circuits

An oil-filled 275kV cable connects the power station and switching station. This cable is the last 275kV oil filled cable circuit in operation in the network following a long-term strategy of replacement over the years. The power station was originally connected via a single transformer, when one of the windings failed this was replaced with a separate unit, which was installed over the 275kV cable route. This leads to the arrangement we have today with the two GTs providing the necessary total capacity for the power station, and GT2 located over the top of the cable as it enters the site. Retaining the 275kV oil filled cable presents routing issues for any new LV cables whilst separating and maintaining 275kV connection to the power station.

The cable was manufactured by BICC and installed in 1981. It is in close proximity to Loch Ness with a consequential high risk of environmental incident. Propriety joints will be very difficult to procure, and will likely have to be manufactured as bespoke, to allow any GT replacement design to break into this circuit. If GT1 is to be retained till a future regulatory period and GT2 replaced in RIIO T2 this will require switching point to be created at the site of GT2 and a replacement short section of cable to be installed onto GT1.

Any works on either GT or the circuit connecting the power station necessitates a whole station outage. There is therefore an opportunity to minimize longer term disruption and provide a net benefit to the Black start strategy in the replacement of both GTs the circuit feeding them and an upgrade to reduce the single circuit security to this site.

Under the existing network configuration, replacement of GT2 will necessitate extended outages on GT1. Due to the space constraints of the cable route it is likely that the existing cable will need to be removed to create space for the new circuit therefore there will be a whole station outage required. This presents an opportunity to consider the replacement of GT1 while this part of the network is subject to outage. As discussed in section 3.1 above the power station is a key part of the transmission black start strategy.

Issues with fluid-filled cables

Fluid-filled cables inherently bring a risk of fluid leakage into the environment and also have maintenance requirements for the fluid feed and monitoring system. The fluid itself is presumed to be synthetic straight-chain alkylbenzene, which is usually considered to be biodegradable under aerobic conditions; however, leakage into the environment is clearly to be avoided. There is an Operating Code for the Management of Fluid-Filled Cable Systems promulgated by the Energy Networks Association, which gives guidance on the reporting and repair of leaks once detected. The monitoring system for these circuits includes alarms to detect a low-pressure condition which may be an indication of loss of fluid from the system. In this event, or whenever a more modest loss of pressure is detected during routine maintenance, the feed tanks are topped up from an external supply.

Leaks developing in the middle to late life of a previously healthy fluid-filled cable system typically result from

- Metallurgical changes in the cable sheath, accessory (joint or termination) metalwork, fluid feed pipework, and metal-to-metal (typically plumbed) joins between them;
- Corrosion due to localised failure of the secondary insulation system that insulates the metallic cable sheath, associated pipework and bonding connections from earth; or
- Failures of flexible seals between rigid components.

Issues with obsolescence

The fluid-filled insulation system of HV cables has largely been superseded by other insulation systems. This transition has been driven mainly by the issues of fluid leakage and of maintenance, referred to above. For systems above 33 kV in the UK, the XLPE (cross-linked polyethylene) insulation system is now almost universally used for new installations. This system involves a solid (but somewhat flexible) extruded polymeric insulation structure, with no requirement for pressurisation.

Most cable manufacturers have discontinued manufacture of fluid-filled cables and accessories, and many cable installers and other service providers no longer support their installation and maintenance. Thus, any diversion or repair of an existing fluid-filled installation becomes problematic. Supplies of compatible fluid-filled cable and joints are generally not available. It is possible to divert or repair using modern XLPE cable by the use of transition joints to adapt between the two systems

3.2.3 Shared Assets

The existing configuration of the GTs is not in line with our current practices and guidelines as the transformer LV circuit breakers are owned by the customer. Therefore, in the design of the replacement works this business separation issue is addressed along with other shared assets. It is also worth noting that GTs cannot be taken out of service independently as there are no points of isolation on the HV side of the transformer. The only switching point is the 275kV power station breakers at the switching station which results in a full power station outage.

3.3 Growth Need

A meeting was held on 3rd October 2019 with SSE Generation to discuss the portfolio of hydro generation schemes that would be affected by our works during the RIIO T2 period. This confirmed that there are no plans for increasing the output at in the foreseeable future.

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.

The asset health requirement for Foyers Generation Transformers is replacement of the 165MVA 275/18kV GT2 due to a condition-based driver. There is also a requirement for an upgrade of the transformer bund arrangement and auxiliary assets to align with current engineering standards and to achieve satisfactory business separation. This transformer is showing signs of advanced ageing and is approaching the end of asset life; therefore, a replacement unit is deemed necessary.

The option of further deferral of asset replacement works on GT2 has not been considered, primarily as a result of the reported asset health. Furthermore, asset refurbishment of GT2 is not considered a technically viable solution, due to both the asset health and need for additional site upgrades. It is also worth noting that removal of the asset is not acceptable since the hydro scheme require continued connection in the transmission network for generation as well as black start capability.

Due to the layout of the substation at the generation site the GTs are very confined and do not meet current standards in terms of adequate fire damage zones, oil containment, operability, maintenance access and business separation.

The 275kV oil filled cable, servicing the generation site from the switching station, puts the generator at single circuit risk. This situation is exacerbated by the routing of this circuit running under GT2. Therefore, a failure of the cable at this point, or a failure of the GT2 could result in an extended outage of the site. Records indicated that there have been oil leaks on this cable.

The power station, substations, cable route and switching station all inhabit land on the banks of Loch Ness. All these items of infrastructure are highly visible, as well as being in very close proximity to the loch itself. As a result, a sympathetic and cautious visual approach should be taken regarding the oil filled cables and transformers.

In addition, the critical nature of the site, network security, resilience, and operability has helped to shape the options reviewed and the recommendations.

Table 1 – Options considered

Option	Option Detail	Cost (£m)	Taken forward to Detailed Analysis?
Baseline	Replace GT2 only in situ and refurbish GT1	51.21 T2 – 22.8 T3 – 28.4	Yes
1	In situ build of direct replacement for both 275/18kV transformers at the Power Station	20.81	Yes
2	Offline build of direct replacement for both 275/18kV transformers near the Power Station.	41.57	Yes

Baseline

This option considers the replacement of GT2 and the refurbishment of GT1. As discussed earlier in section 2, these transformers are banked with no method isolating either one individually. The transformer GT2 cannot be replaced in-situ with a solution that meets current engineering standards, therefore GT2 needs to be accommodated in a new compound outside of the power station boundary. If GT2 is installed in an off-site compound the option to make the 275kV connection is by breaking into the existing oil filled cable. This will require the design and supply of a specialised joint, and a new section of cable back to the power station. If a propriety joint cannot be sourced the alternative would be to replace the circuit with a new XLPE cable. There would also continue to be issues of business separation or the lack of SSEN controlled and owned LV circuit breaker. The limited space at the power station also means that fire damage zones of GT1 if retained in its current location compromises the security of the GT2 connection.

Due to the configuration of the GTs, whereby they are banked onto the 275kV circuit, it is not possible to take only one unit out of service at a time which would result in an outage to the customer of approximately 50 weeks. Not only does this result in a long Emergency Return to Service (ERTS) and removes key black-start equipment for a long period of time, but it results in significant constraint costs. Using an estimated cost of £70/MWhr, constraint costs for this option would be in the region of £180m.

PROGRESSED TO DETAILED ANALYSIS

Option 1

This option assumes a replacement of current assets in the existing space. This option does not deliver a solution which is aligned with current standards due to space constraints and is therefore not technically acceptable. This option also does not address the single circuit risk of the power station, nor the business separation requirements. Due to the configuration of the GTs, whereby they are banked onto the 275kV circuit, it is not possible to take only one unit out of service at a time which would result in an outage to the customer of approximately 50 weeks. Not only does this result in a long Emergency Return to Service (ERTS) and removes key black-start equipment for a long period of time, but it results in significant constraint costs. Using an estimated cost of £70/MWhr, constraint costs for this option would be in the region of £180m.

PROGRESSED TO DETAILED ANALYSIS

Option 2

This option assumes an offline replacement of the transformers in an area to be developed just outside the current Power Station compound approximately 150m away. This new compound allows all current standards to be achieved as well appropriate business separation. The transformer compound would contain the new GTs, with two new 18kV cable circuits installed back to the power station and terminated at two new 18kV breaker bays situated in the vacated GT enclosures. An 18kV resin coated busbar connection will be considered during the refinement of the project as an alternative to the cable connection.

This option also presents the opportunity to address the risks presented by the 275kV oil filled cable in a sensitive location as well as single circuit risk to the connection of this key operational site. To address these issues this option proposes the installation of two XLPE 275kV cable circuits from the new GTs to two new 275kV circuit breaker bays at Foyers switching station. The switching station will need to be extended to accommodate the new bays, and the exiting power station breaker bay can be developed into a bus section bay providing additional security to the site.

With the bulk of the work completed off line this option presents minimal disruption to the customer and maintains the black-start capability of the substation during construction as far as is practicable.

PROGRESS 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[5] 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 Capital Expenditure (£m)	Total NPV (£m)	Delta (Option to Baseline)	Total NPV (inc. monetised risk) (£m)
Baseline	Replacement of GT2 and refurbishment of GT1	51.21 T2 – 22.8 T3 – 28.4	-£340.85		-307.64
Option 1	In Situ Replacement of GT1 and GT2. 18/275kV	20.81	-£214.05	-£126.8	-157.84
Option 2	Offline replacement of GTs1 and 2, 2 x new 275kV cable circuits and new AIS bays	41.6	-76.63	264.2	-47.44

[5] Cost Benefit Analysis Methodology

The results of the CBA demonstrate that Option 2 is the best option from an NPV assessment as it delivers £264.2m of additional value compared to the baseline option, largely through the significantly reduced outage durations. This option has been taken forward as the proposed solution to the needs for intervention that were identified.

5.2 Proposed Solution

The scope of the selected solution is to build an offline 18/275kV transformer compound housing two new generation transformers with two new 275kV circuits to the Foyers switching station with new 275kV bays. The project will be energised with the RIIO-T2 period. The table below details the outputs.

Table 6: Outputs from preferred option

Plant	Size of new plant	Replacement for
18/275kV Transformer	2 x 165MVA units	2 x 165MVA units
275kV cable circuit	2 x 275kV XLPE cable (850m)	1 x 275kV oil filled cable
275kV circuit breaker	4 x 275kV feeder bays 1 x 275kV bus section	1 x 275kV feeder bay
18kV circuit breaker	2 x 18kV cable bay	-

5.3. 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 Network For Net Zero – A Risk Based Approach to Asset Management[6]).

The immediate monetised risk benefit which would be realised through the completion of this project is R£1.8m.

In addition to assessing the immediate risk reduction achieved, a long-term benefit has also been determined. 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"

[6] A Network For Net Zero – A Risk Based Approach to Asset Management

scenario. The "no intervention" scenario assumes that when the asset experiences a catastrophic failure the asset is replaced. The long-term benefit of this project is R£53.1m.

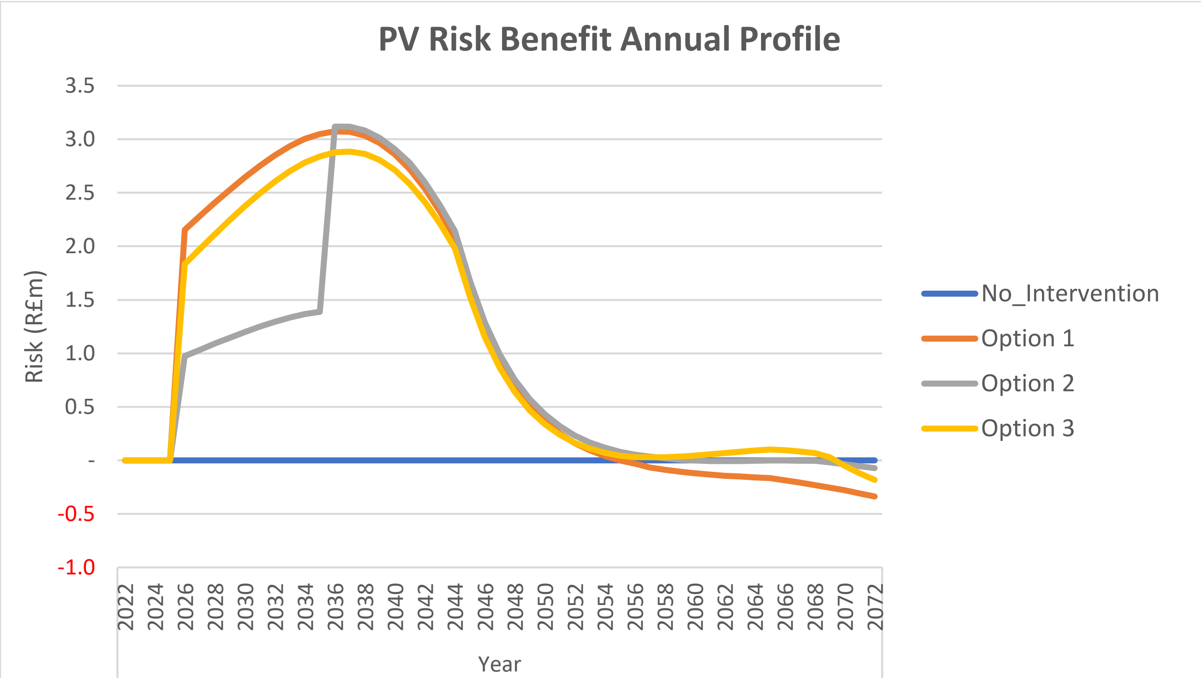

Figure 6 - Long Term Benefit of Proposed Intervention

5.4. 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 for reliability.

Table 5: 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 demand at this site and none 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.

5.4. Innovation & Sustainability

In support of our Sustainability and Environmental policies, the replacement of 850m of oil filled cable on the banks of Loch Ness will remove the last oil filled cable circuit from our network.

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, it is clear that the preferred option does have the largest carbon footprint due to the installation of new switchgear. However, given that this option also removes the environmental risk to Loch Ness, this does not affect preferred option selection.

Table 7: Carbon Modelling

	Project Information	Baseline	Option 1	Option 2
Project info	Construction Start Year	2024	2024	2024
	Construction End Year	2026	2026	2026
	Embedded carbon	£ 124,553	£ 249,106	£ 286,623
Cost estimate £GBP	Construction	£ 2,695	£ 5,389	£ 27,104
	Operations	-		£ 29,907,783

	Decommissioning	£ 1,263	£ 2,525	£ 12,699
	Total Project Carbon Cost Estimate	**£ 128,510**	**£ 257,020**	**£ 25,234,209**
	Embedded carbon	1,679	3,359	3,865
Carbon footprint tCO2e	Construction	36	72	360
	Operations			112,540
	Decommissioning	4	7	36
	Total Project Carbon (tCO2e)	**1,719**	**3,437**	**116,800**
Project Carbon Footprint by Emission Category	Total Scope 1 (tCO2e)			111,072
	Total Scope 2 (tCO2e)			1,428
	Total Scope 3 (tCO2e)	1,719	3,437	4,260
SF6 Emissions	Total SF6 Emissions 3 (tCO2e)			111,046

5.7 Cost Estimate

The cost of the preferred option for works at Foyers has been developed using rates from existing substation framework contracts and benchmarks from delivered RIIO-T1 projects. These have been applied to indicative quantities obtained from layout drawings. The total cost for delivering the scope of works for the proposed solution is £41.6m.

6 Conclusion

The proposed solution to address the asset health and of Foyers generation transformers, also delivers improvement in the configuration of the connection of a power stations critical to the black start strategy for the network, as well as removing the last oil filled 275kV oil filled cable circuit from the system.

The proposal justified in this document delivers the follow scope of work:

- Remove the existing 2 x 165MVA 275/18KV GTs form Foyers Power Station
- Install 2 x 18kV circuit breakers in the vacated GT bays at the power station
- Install 2 x 18kV circuits from the power station to a new GT compound 150m away
- Construct a new GT compound near the power station and install new 2 x 165MVA 275/18kV GTs with associated bases, bunds and ancillary plant and 275kV switchgear
- Install 2 x 275kV cable circuits from the new GT compound to Foyers Switching Station
- Install new 3 x 275kV bays at the switching station to provide a bus section and 2 feeder bays

This scheme will deliver an immediate reduction of total network risk of R£2.2m for a cost of £41.6m and the works are planned to be completed within the RIIO-T2 period. The Long-Term Monetised Risk Benefit is calculated as R£64.571m.

The Foyers 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.