SSEN Transmission

RIIO-T2 Business Plan: T2BP-EJP-0032

Scottish & Southern Electricity Networks

Kilmorack & Aigas Substation Works

Core Non-Load

Engineering Justification Paper

1 Executive Summary

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

This paper identifies the need for intervention on the 132/11kV transformers at Kilmorack and Aigas substations. The primary driver for the scheme is the asset condition.

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

- Offline build of a new 132/11kV substation accommodating two transformers and associated plant for the connection of the Kilmorack and Aigas hydro power stations.

This scheme will cost £27.5m and will deliver the following outputs and benefits during the RIIO T2 period:

- A long-term monetised risk benefit of R£35.8m,
- A reduction of total network risk calculated as R£3.1m,
- Improved visual impact,
- Improved separation of assets between SHE Transmission and the customer,
- Improved operational flexibility and resilience in line with our goal to aim for 100% transmission network reliability for homes and businesses.

The Kilmorack and Aigas 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	Kilmorack & Aigas Substation Works
Primary Investment Driver	Asset Health (Non-Load)
Scheme reference/ mechanism or category	SHNLT207 (Kilmorack) SHNLT206 (Aigas)
Output references/type	NLRT2SH207 (Kilmorack)
Cost	£27.5m
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 associated with Kilmorack and Aigas substations as shown on the maps on the next page.

The Engineering Justification Paper is structured as follows:

Section 3: Need

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

Section 4: Optioneering

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

Section 5: Detailed Analysis

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

Section 6: Conclusion

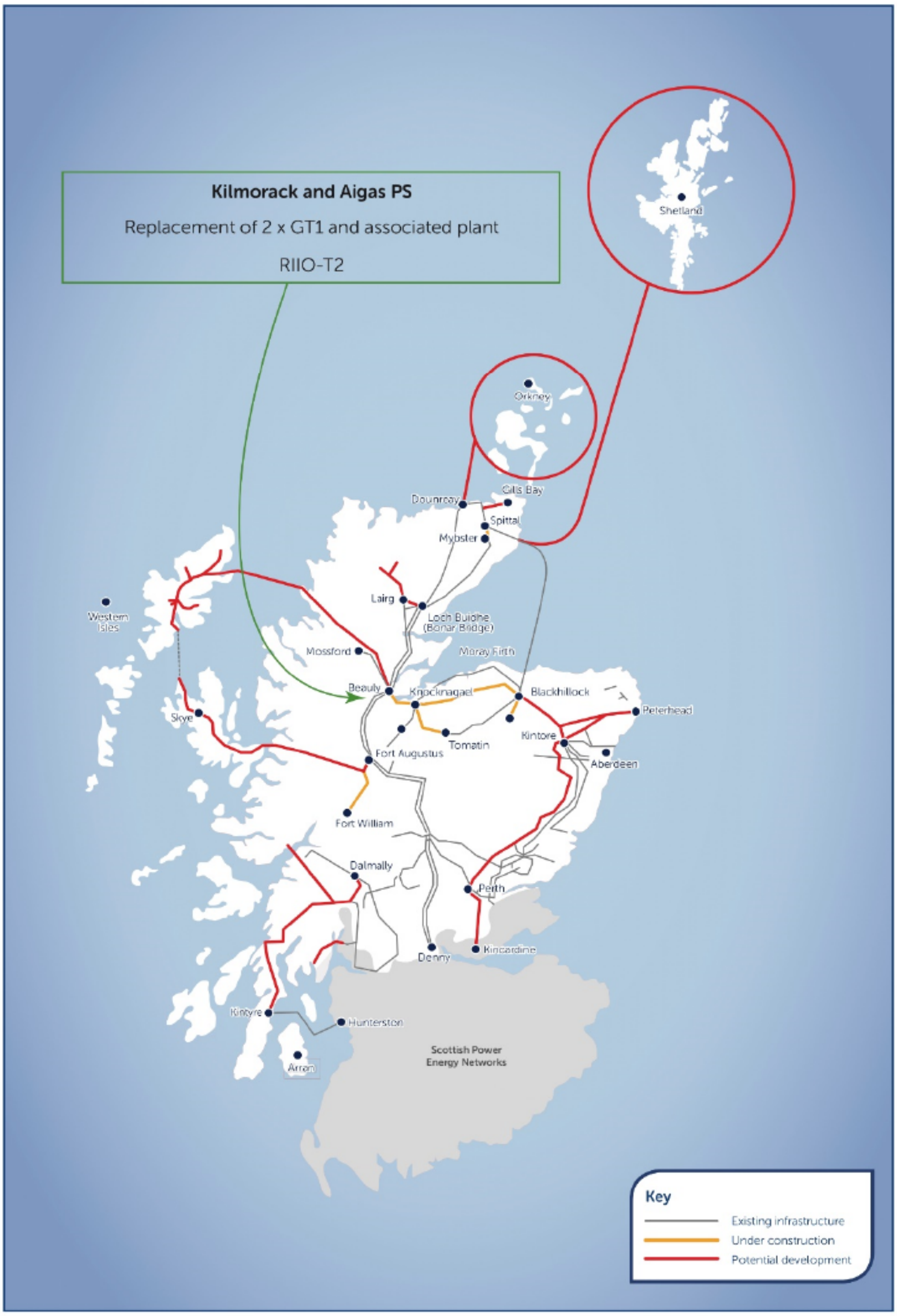
This section provides summary detail of the selected option. It sets out the scope and outputs, costs and timing of investment and where applicable other key supporting information.

Section 7: Price Control Deliverables and Ring Fencing

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

Section 8: Outputs included in RIIO-T1 Business Plan

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


Kilmorack and Aigas PS
Replacement of 2 x GT1 and associated plant
RIIO-T2
Shetland
Orkney
Dounreay
Gills Bay
Spittal
Mybster
Lairg
Loch Buidhe (Bonar Bridge)
Moray Firth
Western Isles
Mossford
Beauly
Knocknagael
Blackhillock
Peterhead
Skye
Kintore
Tomatin
Fort Augustus
Aberdeen
Fort William
Dalmally
Perth
Denny
Kincardine
Kintyre
Hunterston
Arran
Scottish Power Energy Networks
Key
Existing infrastructure
Under construction
Potential development

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

3.1.1 Kilmorack

Kilmorack 132/11 kV substation provides a network connection for Kilmorack hydro generation site which generates 20MW into the transmission system. The unconventionally designed indoor AIS substation is located within the generation building over the River Beauly, approximately 1 mile east of Beauly Substation along the A831. Kilmorack Cable Sealing End remote compound is located on the opposite side of the A831 next to a cemetery. This is the connection onto the 132kV overhead line BDS back to Beauly substation. The site was originally built in 1960 and the transformer was manufactured in 1960 and installed in 1962.

3.1.2 Aigas

Aigas 132/11 kV substation provides a network connection for Aigas hydro generation site which generates 20MW into the transmission system. The unconventionally designed indoor AIS substation is located within the generation building over the River Beauly, approximately 2.5 miles east of Beauly Substation along the A831. Aigas Cable Sealing End remote compound is located on the opposite side of the A831 beside Teanassie Primary School and a small farm holding. This is the connection onto the 132kV overhead line BDS back to Beauly substation. The site was originally built in 1960 and the transformer was manufactured in 1960 and installed in 1962.

3.2 Asset Need

3.2.1 Kilmorack

The requirement for this investment at Kilmorack is triggered by the condition of the plant as detailed in Asset Engineering Condition Report – Kilmorack 132/11 kV Substation[2]. The transformer condition is a main driver of the requirement for replacement. There is also a condition driver to replace the disconnector and earth switch.

The transformer is showing signs of internal ageing which is demonstrated in its oil analysis[2]. The unit is also in poor external condition with several oil leaks in evidence. Partial discharge has been recorded on the yellow phase disconnector.

[2] Kilmorack Asset Engineering Condition Report T2BP-ACR-0021

[redacted] Like other substations of this age and purpose there are several ancillary assets which are either shared or are housed in shared space with the customer. [redacted]

The primary plant compound has an unconventional layout with very limited access and maintenance space. [redacted]. A fold down barrier across the door way completes the bund. The disconnector and earth switch are suspended from the roof of the compound. The cooler banks for the transformer are wall mounted at a high level and exposed externally to the building. The non-standard layout makes access for maintenance challenging.

As is discussed in the Beauly – Deanie 132kV OHL Engineering Justification Paper[3] for the refurbishment of the BDN/BDS line which connects these substations; there is a need to address the pilot wire and PLC communications used by the intertripping schemes for these sites. Under the refurbishment of BDN/BDS a new Optical Ground Wire (OPGW) will replace the earth wire thereby providing adequate protection on these circuits. As well the consequential improvement in the protection provided by the BDN/BDS works, the necessary outages for tower painting and phase wire replacement present a timely opportunity to undertake the upgrading of the ageing assets served by these circuits. This approach presents a coordinated package of work to the impacted local communities and improves the overall network impact, performance and risk.

3.2.2 Aigas

The requirement for this investment at Aigas is triggered by the condition of the plant as detailed in Asset Engineering Condition Report – Aigas 132/11 kV Substation[4]. The transformer condition is a main driver of the requirement for replacement. There is also a condition driver to replace the disconnector and earth switch.

The transformer is in poor external condition with several oil leaks in evidence. High levels of carbon dioxide and carbon monoxide are indicative of voids in the tank and seals.[2]

[redacted]. Like other substations of this age and purpose there are several ancillary assets which are either shared or are housed in shared space with the customer. [redacted]

[3] Beauly – Deanie 132kV OHL Engineering Justification Paper T2BP-EJP-0034

[4] Aigas Asset Engineering Condition Report T2BP-ACR-0020

[redacted]

The primary plant compound has an unconventional layout with very limited access and maintenance space. [redacted]. The disconnector and earth switch are suspended from the roof of the compound. The cooler banks for the transformer are wall mounted at a high level and exposed externally to the building. The non-standard layout makes access for maintenance challenging.

As is discussed in the Beauly – Deanie 132kV OHL Engineering Justification Paper[3] for the refurbishment of the BDN/BDS line which connects these substations; there is a need to address the pilot wire and PLC communications used by the intertripping schemes for these sites. Under the refurbishment of BDN/BDS a new Optical Ground Wire (OPGW) will replace the earth wire thereby providing adequate protection on these circuits. As well the consequential improvement in the protection provided by the BDN/BDS works, the necessary outages for tower painting and phase wire replacement present a timely opportunity to undertake the upgrading of the ageing assets served by these circuits. This approach presents a coordinated package of work to the impacted local communities and improves the overall network impact, performance and risk.

3.3 Growth Need

There are no known load related capacity increases in the immediate network which would drive upgrade work at this site. Therefore, the asset health of the plant, network operability, resilience and the nature of the site are the main considerations for the replacement work.

A meeting was held with the customers to discuss their portfolio of hydro generation schemes that would be affected by our works during the RIIO T2 period. There are no plans for increasing output at either power station in the foreseeable future and no capacity increase is proposed or required.

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.

There is an asset health and condition driver to replace the 132/11kV GTs at Kilmorack and Aigas substations as set out in the Asset Condition reports[2 4]. There is also a requirement for upgrade of the substation compound and auxiliary assets.

The poor asset condition and the need for additional site upgrades means that replacement works in the RIIO-T2 period is the only option. The options of either asset refurbishment or further deferral of these works are not technically viable solutions.

The existing transformers at the power stations are rated at 22.5MVA (naturally) cooled. There is no increase in capacity required by these connections and there is no demand at the sites: there is therefore no driver to install higher rated transformers. The smallest 132/11kV transformer on the transformer framework is rated at 30/36MVA. There will therefore be a consequential capacity increase at the site since it is more economical to procure a standard from our framework range than to order bespoke units.

Like other substations of this age and purpose there are several ancillary assets which are either shared or are housed in shared space with the customer. In line with current engineering standards this scheme seeks to achieve business separation by replacing and re-housing these assets in a transmission owned and operated space.

The following table captures the options considered:

Table 1 – Options

Option	Option Detail	Cost (£m)	Taken forward to Detailed Analysis?
1	In situ replacement (per site)	-	No
2	Offline build for both sites	29.4	Yes
3	Offline combined build (one site)	27.5	Yes

Option 1

Due to the layout of the existing substation arrangements at Kilmorack and Aigas Power Stations, an in-situ replacement of the transformers and the disconnectors and earth switches as well as the installation of an LV circuits breaker cannot be accommodated in a manner that meets our current engineering standards, as well as requiring extended outages of the hydro stations.

These sites at Kilmorack and Aigas, as well as the sites at Culligran and Deanie, form part of a cascade water management system. As a result, any outages compromise the operability of the hydro sites in terms of water management and loss of generation.

NOT PROGRESSED TO DETAILED ANALYSIS

Option 2

An off-line build of both the Kilmorack and Aigas substations is the only option which allows us to achieve our engineering standards for these sites.

KILMORACK

A new substation could be constructed in an area of land near to the existing 132kV cable sealing end compound. The connection to this new substation compound would be facilitated through introduction of a new 11kV cable route, resulting in an increased length of cable between the local generator and transmission connection. Initial cable route assessments conclude that this cable could have a route length of around 0.5km, which is considered achievable with a 22.5MVA generator connection.

This design includes the installation of a new connection to BDS therefore removing the existing cable sealing end compound. The new indoor substation design includes a 132kV circuit switcher, 30/36MVA 132/11kV transformer, 11kV circuit breaker, protection and supplies and ancillary items.

The indoor substation design is proposed in order to mitigate any visual impact on the local landscape and therefore address the consenting risk to this solution. The off-line build contributes to minimised outage requirements, and any outages will be coordinated with the reconductoring of the circuit BDS. The BDS works will deliver a fibre communication channel back to Beauly substation providing the means to improve the protection of this circuit and the intertripping to these sites.

AIGAS

A new substation could be constructed in an area of land near to the existing 132kV cable sealing end compound. The connection to this new substation compound would be facilitated through introduction of a new 11kV cable route, resulting in an increased length of cable between the local generator and transmission connection. Initial cable route assessments conclude that this cable could have a route length of around 0.5km, which is considered achievable with a 22.5MVA generator connection.

This design includes the installation of a new connection to BDS therefore removing the existing cable sealing end compound. The new indoor substation design includes a 132kV circuit switcher, 30/36MVA 132/11kV transformer, 11kV circuit breaker, protection and supplies and ancillary items.

The indoor substation design is proposed in order to mitigate any visual impact on the local landscape and therefore address the consenting risk to this solution. The off-line build contributes to minimised outage requirements, and any outages will be coordinated with the reconductoring of the circuit BDS. The BDS works will deliver a fibre communication channel back to Beauly substation providing the means to improve the protection of this circuit and the intertripping to these sites.

PROGRESS TO DETAILED ANALYSIS

Option 3

This option combines the new substations for Kilmorack and Aigas at a shared site. This option seeks a location for the new site at a point mid-way between the two power stations. This option proposes the same transformer design for each customer as for the separate sites in option 2. However, there are economies to be realised with shared infrastructure that do not compromise the commercial connections. This option means a single planning application to satisfy the connection of these two sites which minimises the impact on the local stakeholders. Like the advantages delivered by option 2 this option proposes an off-line build minimising the outage requirements and the opportunity to coordinate works with the reconductoring of BDS. The BDS works will deliver a fibre communication channel back to Beauly substation providing the means to improve the protection of this circuit and the intertripping to these sites.

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 contributes toward the identification of a selected option. The section continues by setting out the costs for the selected option.

5.1 Cost Benefit Analysis

No CBA has been carried for this scheme. Of the technically acceptable solutions a combined substation approach offers a cost saving for the same asset benefit as well as minimising visual impact. Therefore Option 3 is the preferred solution to address the asset condition needs for Kilmorack and Aigas substations.

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.

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 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.

5.3 Proposed Solution

The scope of the selected solution is to build an offline 132/11kV substation to house the transformers for the connection of both Kilmorack and Aigas hydro power stations. The project will be energised within the RIIO T2 period.

Table 2 – Outputs from Preferred Option

Plant	Size of new plant	Replacement for
132/11kV Transformer	2 x 30/36MVA	2 x 22.5MVA
132kV Circuit Switcher	2 x 132kV circuit switcher (2000A)	NA
11kV Circuit breaker	4 x 11kV circuit breakers (1250A)	NA

5.4 Competition

The Kilmorack and Aigas 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 Management1).

The long-term risk monetised risk benefit which would be realised through the completion of this project is R£35.8m (this is sum of the benefits calculated for the Kilmorack and Aigas asset intervention). 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 2: Long Term Benefit of Proposed Intervention – Kilmorack

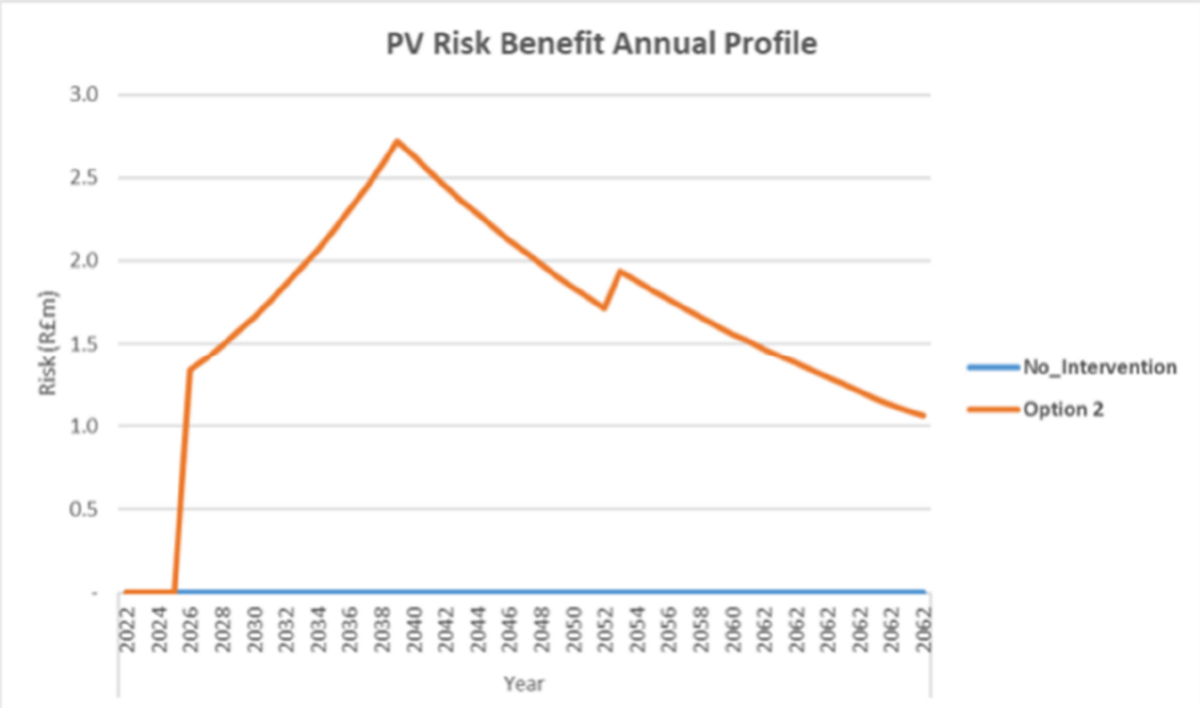
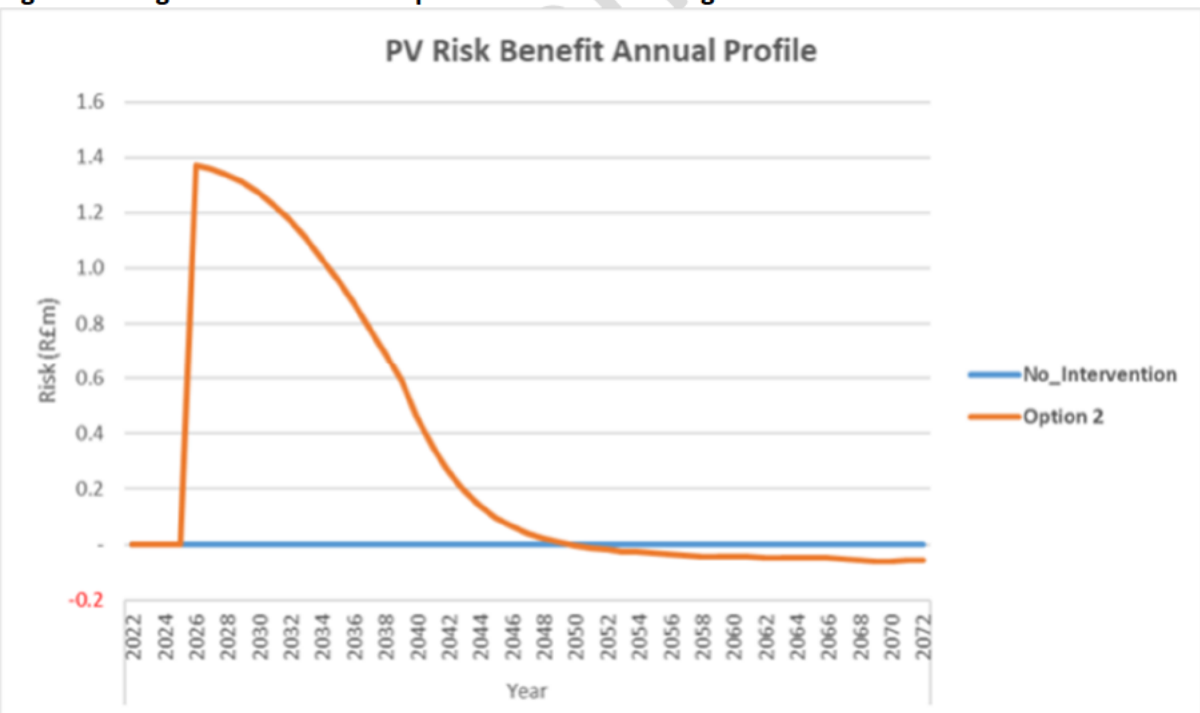


Figure 2: Long Term Benefit of Proposed Intervention – Aigas



The ‘Option 2’ shown in each graph is the intervention for each site for the purposes of the model.

In addition to assessing the long-term risk benefit, a monetised risk benefit has also been determined. The monetised risk benefit which would be realised through the completion of this project is R£3.1m (the sum of the Kilmorack and Aigas benefits calculated for the intervention at each site).

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 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.

The results of the analysis for this project, are captured in the carbon footprint results table,

Table 3 – Carbon Calculation Summary

	Project Information	Baseline
Project info	Project Name/number	0
	Construction Start Year	2026
	Construction End Year	2028
Cost estimate £GBP	Embodied carbon	£ 260,861
	Construction	£ 458,433
	Operations	£ 39,206
	Decommissioning	£ 209,883
	Total Project Carbon Cost Estimate	**£ 968,384**

Carbon footprint tCO2e	Embodied carbon	3,483
	Construction	6,030
	Operations	171
	Decommissioning	603
	Total Project Carbon (tCO2e)	**10,288**
Project Carbon Footprint by Emission Category	Total Scope 1 (tCO2e)	86
	Total Scope 2 (tCO2e)	85
	Total Scope 3 (tCO2e)	10,116
SF_6 Emissions	Total SF_6 Emissions 3 (tCO2e)	68

5.7 Cost Estimate

The cost of the preferred option for works for Kilmorack and Aigas 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 £27.5m.

6 Conclusion

The primary driver for the replacement of the transformers at Kilmorack and Aigas substations the condition of both units. There are consequential benefits of this of work, as this would deliver a substation which meets our current engineering standards as well as delivering improved asset separation between SHE Transmission and the customer.

The options considered to achieve the transformer replacements were either an in-situ or off-line build. The off-line build is preferred, delivering minimal impact on the customer. In addition, the delivery can be coordinated with the refurbishment of the 132kV circuit connecting these sites back to Beauly.

The proposed scope of work is:

- Offline build of a new 132/11kV substation accommodating two transformers and associated plant for the connection of the Kilmorack and Aigas hydro power stations.

This scheme will cost £27.5m and will deliver the following outputs and benefits during the RIIO T2 period:

- A long-term monetised risk benefit of R£35.8m,
- A reduction of total network risk calculated as R£3.1m,
- Improved visual impact,
- Improved separation of assets between SHE Transmission and the customer,
- Improved operational flexibility and resilience in line with our goal to aim for 100% transmission network reliability for homes and businesses.

The Kilmorack and Aigas 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 Plans

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