SSEN Transmission

RIIO-T2 Business Plan: T2BP-EJP-0034

Scottish & Southern Electricity Networks

Beauly – Aigas/Deanie 132kV OHL 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 the risk over the RIIO-T2 period.

This paper identifies the need for intervention on the 132kV tower lines between Beauly and Aigas, and Beauly and Deanie. 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:

- Replacement of phase conductors, earth wire and fixtures and fittings

This scheme delivers the following outputs and benefits:
- An immediate reduction of total network risk calculated as R£0.205m

The cost to deliver this scheme is £19.0m and the works are planned to be completed within the RIIO-T2 period. The Long-Term Monetised Risk Benefit is calculated as R£15.050m.

The Beauly-Aigas-Deanie 132kV OHL Refurbishment scheme is not flagged as eligible for early or late competition due to it being under Ofgem's £50m and £100m thresholds respectively.

[1]A Risk Based Approach to Asset Management

Name of Scheme/Programme	Beauly – Aigas/Deanie 132kV OHL Works	
Primary Investment Driver	Asset Health (Non-Load)	
Scheme reference/ mechanism or category	RIIO T1: SN-00172 RIIO T2: SHNLT205	
Output references/type	RIIO T1: NLR-0017 RIIO T2: NLRT2SH205 23km 132kV Double Circuit Tower Line reconductoring	
Cost	£19.0m	
Delivery Year	RIIO T2	
Reporting Table	C0.7 Non-Load Master Data	
Outputs included in RIIO T1 Business Plan	No	
Spend profile	**T1**	**T2**
	£2.1m	£19.0m

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 on the 132kV overhead line BDN/BDS as shown on the map 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

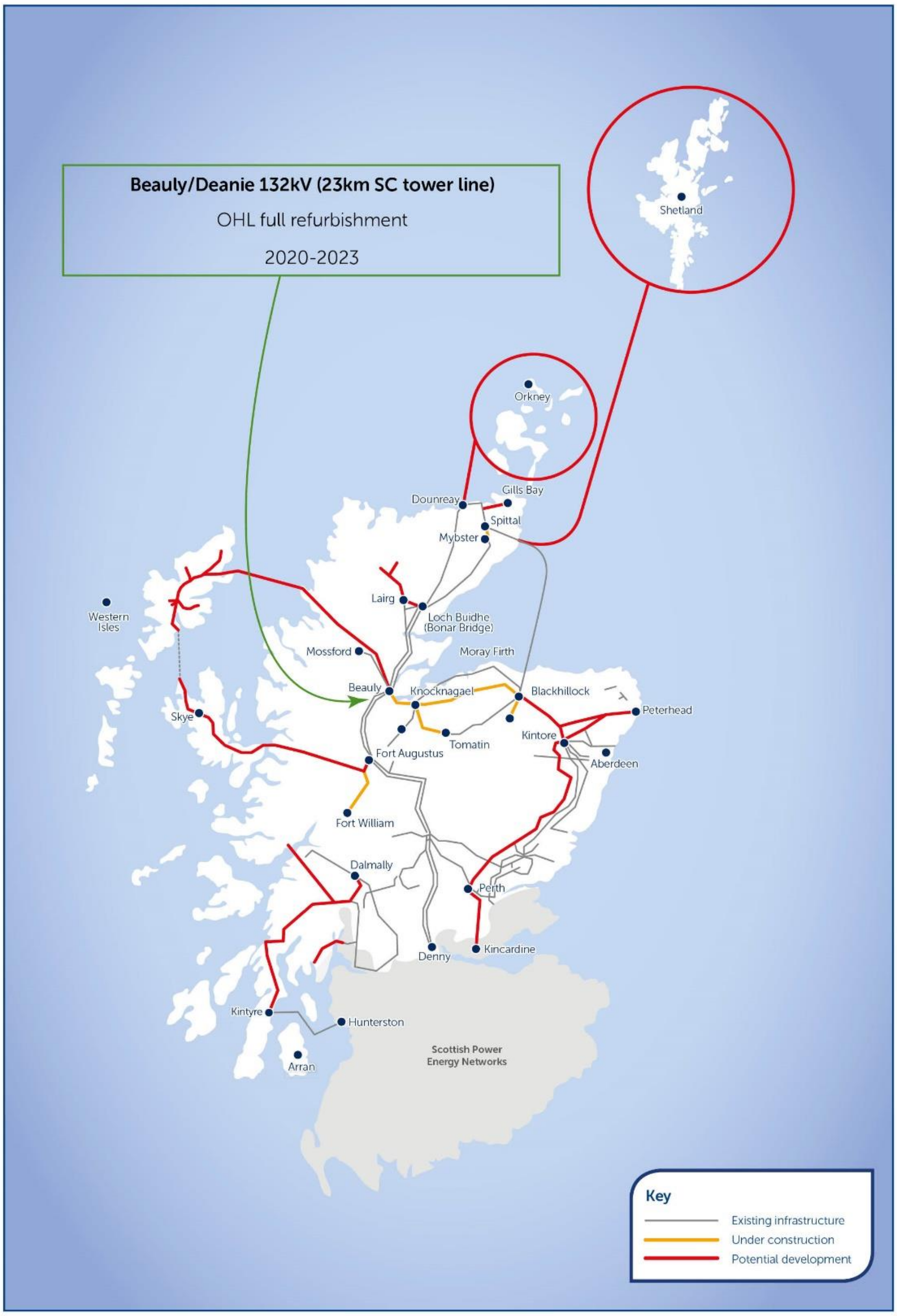
This section provides summary detail of the selected option. It sets out the scope and outputs, costs and timing of investment and where applicable other key supporting information.

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.


Beauly/Deanie 132kV (23km SC tower line)
OHL full refurbishment
2020-2023
Shetland
Orkney
Dounreay
Gills Bay
Spittal
Mybster
Lairg
Loch Buidhe
(Bonar Bridge)
Western
Isles
Mossford
Moray Firth
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

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 include updated condition information on overhead line fittings and to provide further information on options considered.

New fittings condition information has been received since the first submission of this paper which shows continued degradation of the fittings in question, further supporting the need for intervention. Additionally, the BDN/BDS circuits underwent Cormon testing in 2004 where 84% possible corrosion was measured. This translated to an end-of-life score showing that the asset deterioration was consistent, if not slightly better, than would be expected for its age. However, due to the test being 16 years old, CBRM is forecasting this asset to be at end of life by the end of T2 without intervention. CBRM calculates this by considering the information that is available today and projecting that forward by using a linear aging constant. This will vary from span to span as it will also consider the altitude and distance to coast factors.

Options to stagger interventions and delay some aspects until RIIO-T3 have also been considered in detail.

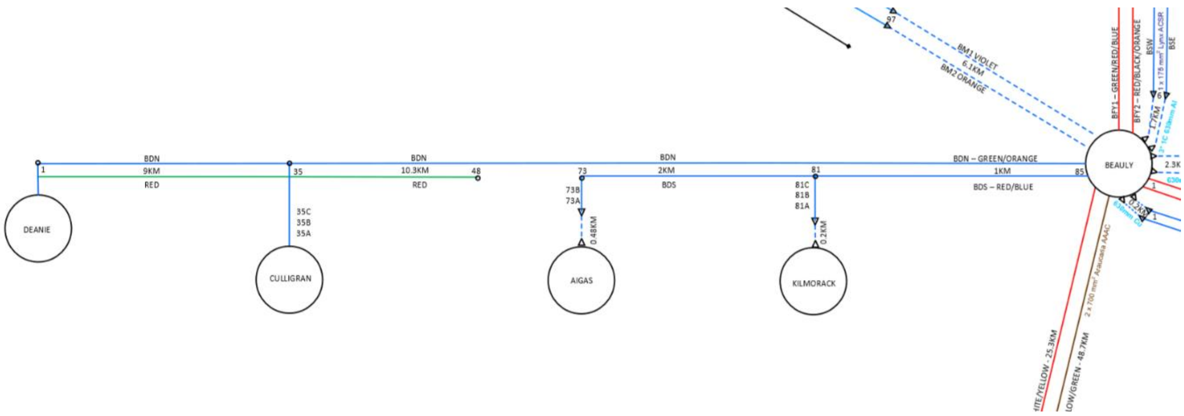
3 Need

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 existing Beauly - Deanie (BDS/BDN) OHL circuit, constructed in 1960, is a 132kV circuit comprising 85 PL16 double circuit steel lattice towers with a total length of 23km. There is currently a double 132kV transmission circuit between Beauly and Aigas (BDS/BDN). In contrast, between Aigas and Deanie (BDN) one side is operated at 132kV providing a single transmission circuit, whereas the other side is operated at 33kV providing a distribution circuit for SHEPD. The circuit is strung with single Lynx ACSR phase conductors and has a Horse ACSR earthwire providing earthing protection on the entire length of the circuit. The circuits are radial connections to four hydro generation sites connecting to Beauly substation. The substation at Beauly and the four hydro connection substations are also subject to upgrade works proposals for the RIIO T2 period.

The circuit is protected by a single distance main protection device at the Beauly end of the circuit for both BDS/BDN, with intertrips over PLC to the Culligran/Deanie and intertrips over pilot wire to Kilmorack and Aigas sites. Neither circuit has DAR.



3.2 Asset Need

The need for intervention on the BDN/BDS circuits is based on current asset performance, age and available condition assessments and is detailed in the Asset Condition Report[2].

By the end of T2 these circuits will be 66 years old, having aged beyond their design life of 40 years and beyond the 54-year industry mean asset service life. At this time the following items are for such a condition that intervention is required on the following items:

- Steel members on 17 towers require replacement
- 62% of earth wire fittings require replacement
- 47% of conductor fittings require replacement
- 2 foundations require upgrading
- All towers require painting
- Earth wire and phase conductors to be replaced

The BDN/BDS circuits underwent Cormon testing in 2004 where 84% possible corrosion was measured. This translated to a mid-life EoL score showing that the asset deterioration was consistent, if not slightly better, than would be expected for its age. However, due to the test being 16 years ago CBRM is forecasting this asset to be at end of life by the end of T2 without intervention. CBRM calculates this by considering the information that is available today and projecting that forward by using a linear aging constant. This will vary from span to span as it will also consider the altitude and distance to coast factors.

3.3 Growth Need

There is 97MW of transmission generation connected to this circuit and no Grid Supply Points serving SHEPD demand. There are no requirements to increase the circuit capacity as there is no new development interest or requests to increase capacity at existing hydro sites.

[2] Beauly Kilmorack Aigas Culligran Deanie 132kV OHL Asset Condition Report

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 final 8km of the route between Culligran and Deanie Substation is situated within several environmental protection areas. This part of the route is in the 'Glen Affric to Strathconon' Special Protection Area (SPA). This area has been designated a SPA due to it being a breeding zone for Golden Eagles. This section is also within the 'Strathglass Complex' Special Area of Conservation (SAC). This has been designated a SAC due to it being a habitat for many protected species of flora and fauna. Finally, this section is also in the 'Glen Strathfarrar' Site of Specific Scientific Interest (SSSI). This area was designated a SSSI due to the presence of breeding birds, dragonflies, lichen, native pinewood and vascular plants.

Table 1 – Options Considered

Option	Option Detail	Cost (£m)	Taken forward to CBA?
1	Full refurbishment of existing circuit, reconductoring with UPAS AAAC conductor.	19.0	Yes
2	Rebuild the line with a new trident line.	-	No
3	Rebuild the line with new technology composite poles	-	No
4	Full refurbishment of existing circuit, reconductoring with Monte Carlo ACCC conductor.	-	No
5	RIIOT2 - Fully reconductor phase and earthwire + replacement of	RIIO T2 - £17.8m RIIO T3 - £4.6m	Yes

	deteriorated fittings only **Return RIIO T3 for remaining fittings**	**Total - £22.4m**	
6	**RIIOT2 – Deteriorated fittings only** **Return RIIO T3 to reconductor and replace remaining fittings**	**RIIO T2 - £4.2m** **RIIO T3 - £18.4m** **Total - £22.6m**	**Yes**

Option 1

The Upas AAAC conductor has been selected for the Lynx ACSR replacement as it has been used widely on the UK Network and meets the electrical and mechanical requirements of the OHL. As the Upas conductor is stronger than the Lynx conductor, the resulting works on the scheme will include tower and foundation strengthening as well as clearance infringements mitigation to ensure that minimum statutory clearances are met. Alternative, smaller, AAAC conductors were assessed which would achieve the required electrical rating, however were ruled out as the mechanic loading would exceed the limits specified by the suppliers.

This option proposes phase and earthwire assembly replacement including insulators, dampers, shackles and U-Bolts. The earthwire will be replaced with an OPGW equivalent and the phase conductors with a UPAS AAAC conductor. All towers will be painted, and concrete muffs repaired as recommended in the Asset Condition Report.

Conductor assessment has taken a Lynx ACSR standard replacement as Upas AAAC. The replacement of ACSR Conductors with AAAC is standard industry practice, as ACSR conductors are gradually being phased out by suppliers and are unlikely to be standard products in the years to come.

This option will re-utilise the existing asset and route. There are 30 towers between Culligran and Deanie which are in a SSSI SPA or SAC. Scottish National Heritage are likely to object to any large scale works in this area and minimal environmental impact must be targeted.

PROGRESS TO DETAILED ANALYSIS

Option 2

This option proposes rebuilding the circuits with two single circuit wood pole lines. The existing circuit is a double circuit tower with a 33kV asset on the opposite tower crossarms from tower 48 to

1. This would therefore impact the distribution 33kV circuit. Replacing the tower line with trident provides a solution with minimum outage requirements. The trident circuits would require an underslung fibre to be installed on the structures to maintain adequate protection communications. While this option is technically acceptable, a new route between Culligran Deanie would require consent within the environmental designations as it is not possible to avoid them. The environmental impact of constructing a new trident line through these areas as well either removing the tower line or this being retained by distribution results in a solution that is unlikely to achieve consent.

NOT PROGRESSED

Option 3

This option proposes rebuilding the circuit with composite poles, an innovative solution deployed during RIIO T1. The benefit of the composite pole compared to the wood pole solution is the longer span lengths which can be achieved. The longer span lengths, therefore reduced structure numbers may be advantageous to the consenting process. However, at this time the technology is not fully developed and there is a risk that proposing a composite pole solution at this stage is premature and will not be acceptable for sign off by SSEN Technical Authority. Like option 3, the re-build would also impact the 33kV circuit which would also need to seek consent for a parallel route through the designated areas and for the same reason has not been further progressed.

NOT PROGRESSED

Option 4

This option proposes phase and earthwire assembly replacement including insulators, dampers, shackles and U-Bolts. The earthwire will be replaced with an OPGW equivalent and the phase conductors with a Monte Carlo ACCC conductor. All towers will be painted, and concrete muffs repaired as recommended in the Asset Engineering Condition Assessment report.

This option will re-utilise the existing asset and route. There are 30 towers between Culligran and Deanie which are in a SSSI SPA or SAC. Scottish National Heritage are likely to object to any large scale works in this area. While this option does not require the tower extension required for the conventional conductor, recent works show that the cost of the conductor as well as the civil works to install the ACCC are increased. This option was not considered any further as the increased cost does not deliver any benefit to the consent-ability or construction of the asset and would utilise a non-standard conductor where the consequential capacity uplift is not required. Additionally, the performance of the Monte Carlo ACCC under heavy ice conditions would lead to unsafe clearance levels when compared to alternative standard conductors.

NOT PROGRESSED

Option 5

Option 5 proposes the minimum works during RIIO T2, plus the additional cost to return during RIIO T3 to replace the fittings not yet identified as deteriorating but expected to do so during the next price control. The RIIO T2 works includes the replacement of the phase conductors and earthwire during this period, as well as the fittings identified from the IHawk assessment, (updated from June 2019), graded 3 and 4. The RIIO T3 works include the remaining fittings and components which are expected to need replaced during the next price control period.

PROGRESSED TO DETAILED ANALYSIS

Option 6

Option 5 proposes the minimum works during RIIO T2 excluding the replacement of the phase conductor and earthwire, with the additional cost to return during RIIO T3 to undertake a full refurbishment. The RIIO T2 works includes the fittings and components identified from the IHawk assessment, (updated from June 2019), graded 3 and 4 only. The RIIO T3 works include the full refurbishment of the circuit which is expected by the next price control period.

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

Option 1, Option 5 and Option 6 have been progressed to detailed analysis and have been included in the Cost Benefit Analysis (CBA). Our CBA Methodology[3] sets the process and mechanics of our approach to CBA. The non-load requirement for the RIIO T2 period is addressed through the baseline option – Option 5. The CBA is being undertaken to help determine the benefits of undertaking the full refurbishment in the T2 period as opposed to deferring aspects of the refurbishment until RIIO-T3. Option 1 is considered the baseline option.

A counterfactual NPV analysis has been undertaken. The NPV's for each of the three options were calculated, and then the NPVs for Option 5 and Option 6 have been compared against the Baseline Option 1. The output from the CBA is shown in Table 2.

Table 2 – CBA results for Beauly-Deanie-Aigas.

CBA Option No.	Total Forecast Expenditure *(£m)*	Total NPV	Delta *(Option to baseline)*	Total NPV *(Incl. Monetised Risk £m)*
Baseline (Option 1)	£19.0m	-£17.81		-£12.06
Option 5	£22.4m T2 - £17.8m T3 - £4.6m	-£20.25	-£2.44	-£14.41
Option 6	£22.6m T2 - £4.2m T3 - £18.4m	-£18.19	-£0.38	-£12.64

The CBA has shown that in the analysis of the three options, Option 1 has the highest comparative NPV against Options 5 and 6, both including and excluding monetised risk.

5.2 Proposed Solution

The scope of the proposed solution encompasses the full refurbishment of the 132kV circuits BDN and BDS. The project will be energized within the RIIO T2 period. The table below details the outputs:

[3] Cost Benefit Analysis Methodology

Table 2 – Outputs from the preferred option

Plant	Size of new plant	Replacement for
132kV double circuit tower line refurbishment	26km Upas AAAC phase conductor 23km OPGW Fixtures and fittings	26km Lynx ACSR phase conductor 23km Horse earth wire Fixtures and fittings

The full refurbishment option also delivers fibre communications from end to end of the circuit providing adequate protection communications. The Beauly 132kV substation and the four connecting hydro sites (Aigas, Kilmorack, Culligran and Deanie) are also subject to proposed upgrades during the RIIO T2 period. The timing of this project and the substations it interfaces with will be coordinated such that the fibre is in place ahead of the substation commissioning.

This project and the four hydro substation works proposed for RIIO T2 have been discussed with the generation customers at a meeting held on 3rd October 2019 to ensure that any known future plans from both parties can be considered in the development of the designs and programmes.

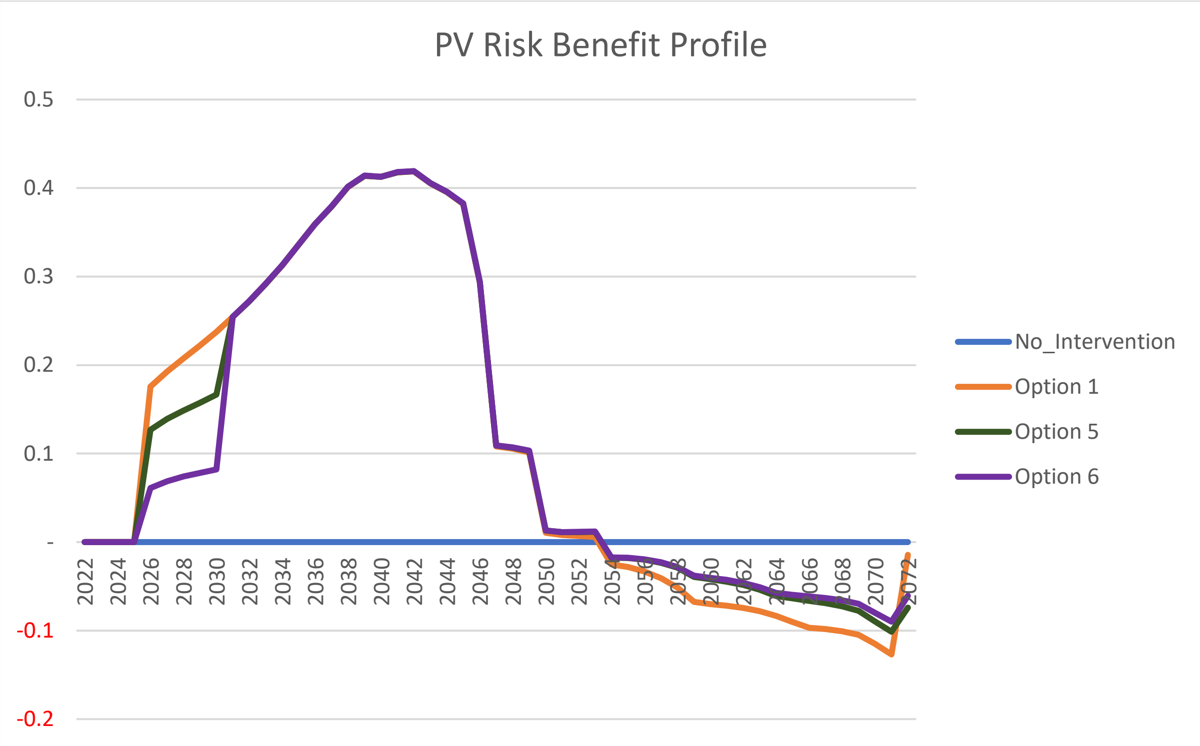
5.3 Risk Benefit

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 Management4).

The immediate monetised risk benefit which would be realised through the completion of this project is R£0.205m. 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" 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£5.8m.

[4]A Risk Based Approach to Asset Management

Figure 1 - 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 3: Sensitivity Analysis table

Sensitivity	Test and impact observed – switching inputs
Asset Performance / deterioration rates	Switching deterioration assumption:

	The asset performance / deterioration rates can only improve or deteriorate. As the need for this project is driven by an asset condition report (as outlined in Section 3), the asset condition will not improve in the intervening period. The second option is for the asset performance to deteriorate and therefore the need remains, and the project would be considered for advancement within available outages.
Ongoing efficiency assumptions	Switching efficiency assumption: increased or decreased. Test would have no impact on (feasible) option selection, only one option was taken forward to detailed analysis and therefore there is no impact on the preferred solution.
Demand variations	No significant demand forecast
Energy scenarios	Sensitivity considered in Section 3 (Need) already. As this is a non-load project and the need is driven by the asset condition, the work would be required regardless of any changes to the energy scenario.
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.

5.5 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.

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

Table 4 – 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	£ 417,107
	Construction	£ 233,851
	Operations	£ 1,337
	Decommissioning	£ 107,063
	Total Project Carbon Cost Estimate	**£ 759,358**
Carbon footprint tCO2e	Embodied carbon	5,569
	Construction	3,076
	Operations	6
	Decommissioning	308
	Total Project Carbon (tCO2e)	**8,959**

Project Carbon Footprint by Emission Category	Total Scope 1 (tCO2e)	6
	Total Scope 2 (tCO2e)	-
	Total Scope 3 (tCO2e)	8,953
SF6 Emissions	Total SF6 Emissions 3 (tCO2e)	-

5.6 Cost Estimate

The cost of the preferred option for works on the circuits BDN and BDS have 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 £19.0m.

6 Conclusion

This paper identifies the need for intervention on the 132kV double circuit tower line from Beauly to Aigas, Kilmorack, Culligran and Deanie. The primary driver for the scheme is asset condition.

The proposal is the full refurbishment of the tower line as follows:

- Reconductoring of the BDN and BDS circuits with UPAS AAAC
- Reconductoring of the earth wire with OPGW
- Strengthening of towers and foundation upgrades in line with latest design standards
- Replacement of damaged and corroded steel members
- Painting of all towers
- Repair and coating of all muffs

The delivery of this scheme will coordinate with other RIIO T2 schemes in this area to deliver on efficient and coordinated portfolio of works for the Beauly network.

This scheme will deliver an immediate reduction of total network risk of R£0.205m for a cost of £19.0m and the works are planned to be completed within the RIIO-T2 period. The Long-Term Monetised Risk Benefit is calculated as R£15.050m

The Beauly – Aigas/Deanie scheme is not flagged as eligible for early or late competition as the scheme is under Ofgem’s £50m and £100m thresholds respectively.

7 Price Control Deliverables and Ring Fencing

As set out in our Regulatory Framework[5] 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 delivers 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.

[5] Regulatory Framework

8 Outputs included in RIIO T1 Business Plan

Although this scheme was originally included in our baseline for delivery during the RIIO-T1 period, changes in asset condition and prioritisation across our portfolio means that our asset program is under continual review.

The deferral was based on additional asset condition information which showed that significant foundation works were required in addition to the identified poor conductor condition and also the re-prioritisation of other overhead line works. At the time of the deferral costs of £2.1m had been incurred on design and material purchase.

Our decision to defer this scheme means that we were able to substitute and deliver other schemes to meet our required absolute output target in line with our license obligation. An assessment will be undertaken at the end of the RIIO-T1 period to validate our performance against our license target and associated Rewards and Penalties guidelines.

Under the methods of scheme identification used for the RIIO T2 business plan Beauly/Deanie has been proposed for intervention based on condition.