

Sloy – Windyhill East 132kV OHL Works Engineering Justification Paper



**Sloy – Windyhill East 132kV OHL Works
Engineering Justification Paper**

1. Executive Summary

Our paper A Risk Based Approach to Asset Management¹ 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 OHL asset between Sloy and Windyhill. The primary driver for the refurbishment works in this project is the asset condition of the existing OHL.

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

- Reconductoring of the phase conductor with Upas AAAC, as well replacement of the earthwire with Keziah OPGW ACSR,
- All tension insulator sets are to be replaced along with earthwire and phase conductor fittings,
- Steelwork members on all towers are to be painted, and all step bolts are to be replaced,
- Foundation upgrade works will take place on all out of alignment towers, and concrete muffs and stubs identified as being in poor condition will be refurbished and painted.

This scheme will cost £16.5m and deliver the following outputs and benefits during the RIIO-T2 benefits:

- A reduction of total network risk of R£343.9m,
- A risk reduction of network risk calculated as R£1.6m,
- Improved operational flexibility and resilience in line with our goal to aim for 100% transmission network reliability for homes and businesses.

The Sloy – Windyhill East 132kV OHL Works project is not flagged as eligible for early or late competition due to it being under Ofgem's £50m and £100m thresholds respectively.

¹A Risk Based Approach to Asset Management



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Name of Scheme/Programme	Sloy – Windyhill East 132kV OHL Works
Primary Investment Driver	Asset Health (Non-Load)
Scheme reference/ mechanism or category	SHNLT203
Output references/type	NLRT2SH203
Cost	£16.5m
Delivery Year	RIIO T2 Period
Reporting Table	C0.7_Non_Load_Master_Data
Outputs included in RIIO T1 Business Plan	No

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2. Introduction

This Engineering Justification Paper sets out our plans to undertake refurbishment works of existing assets during the RIIO-T2 period (April 2021 to March 2026). The planned work is on the Sloy – Windyhill East 132kV OHL as shown on the map in Figure 1:

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

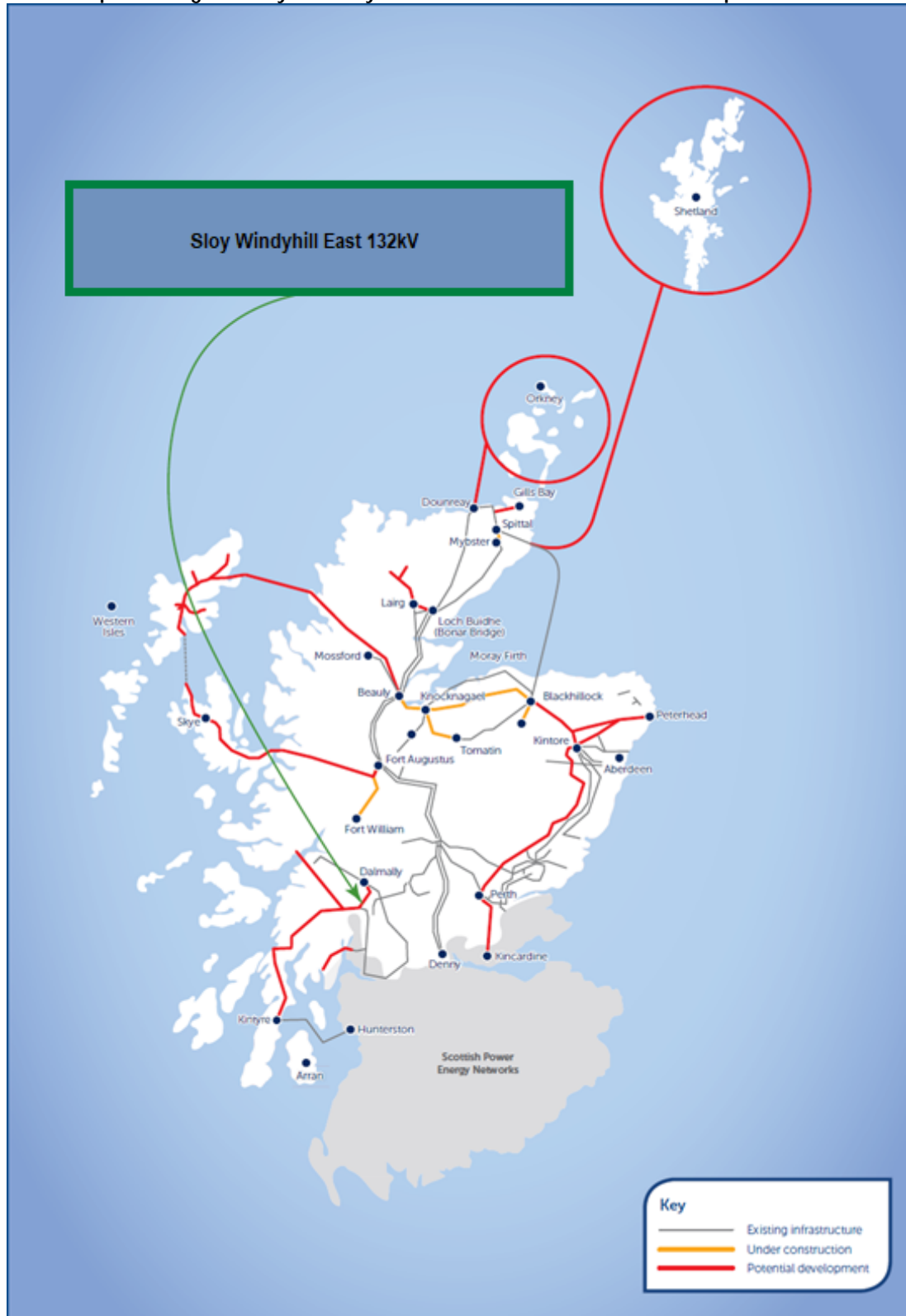
This section provides a view of whether the proposed scheme should be ring-fenced or subject to other funding mechanism.

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.

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Figure 1 – Map showing the Sloy – Windyhill East 132kV OHL works on a map of SHET network.



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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

There are two 132kV double circuit OHLs between Sloy substation and Windyhill substation. This justification paper considers the Sloy – Windyhill East OHL circuit. This is a 132kV double circuit formed of steel lattice towers in the south west region of our network. The circuits were constructed in 1951 connecting Sloy power station to Windyhill substation. We own part of the line and Scottish Power Transmission (SPT) own part of the line, with the ownership boundary being tower 52. This document only refers to proposed refurbishment works on our section of the line.

Our section of the circuit is 14.5km in length and consists of 52 PL16 type steel lattice towers. The circuit is strung with single Lynx ACSR phase conductors and a Horse ACSR earth wire conductor.

In 1978 reconductoring works were undertaken to replace the phase conductors on this line. The earth wire was replaced in 1995. By the end of RIIO T2 the conductors will be 48 years old, while the earth wire will be 31 years old.

3.2. Asset Need

An Asset Condition Report² (ACR) has been prepared for this circuit which identified a need for intervention. The ACR draws upon information from a variety of sources with the key points summarised below.

The ACR details that there is significant steelwork corrosion present throughout the line. The current paint has diminished to an extent where it is largely no longer providing any protection. The corrosion will now be actively reducing the remaining overall service life of the structures and without intervention will deteriorate beyond repair. In addition, step bolts have been identified to be heavily corroded throughout the circuit.

The most recent survey information available demonstrates that there are 13 towers where shackles and u-bolts are showing signs of rust and nine towers where there is evidence of moderate to severe rust on the insulators. The tension insulators are reaching the end of their service life and showing signs of corrosion.

² Sloy – Windyhill East 132kV OHL Works Asset Condition Report T2BP-ACR-0012

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The conductor will be 48 years old by the end of the RIIO T2 period. This is within the industry mean asset life of 54 years, but it is over the component design life of 40 years. SPT has reconducted their section within the RIIO T1 period.

SPT have undertaken refurbishment on their section of the OHL (tower 52 to Windyhill substation) within RIIO T1 period. Lessons learned from this work has highlighted a number of towers that are identified as being out of vertical alignment due to being constructed on steep slopes.

Following the completion of a detailed assessment using finite element analysis modelling tools which were not available during the original design, it has been identified that there are potential clearance infringements present if the conductor reaches maximum operating temperature during the summer months. As such there is a requirement to propose mitigation of the potential infringements in 14 spans to ensure the line is fully compliant with ESQCR clearance requirements.

The recommendations from the condition assessment report for the short term is to undertake conductor assessments to help determine the level of corrosion and mechanical rating of the existing conductors and undertake further assessments of the existing foundation muffs and stubs.

For the RIIO T2 period it is recommended;

- To paint steelwork members on all towers, replace fittings and assemblies that have been identified as degraded, and replace all degraded step bolts.
- Replace all tension insulator sets on the circuit and replace severely deteriorated insulators sets at two towers.
- Refurbish and paint any concrete muffs and stubs as identified by the recommended foundation assessment.
- Work is also required to achieve statutory ground clearances along the circuit to comply with current ESQC Regulations. This solution to be adopted will be a combination of re-profiling the ground under the line, using panel extensions on the existing towers, or replacing the tower completely.

The network asset risk and the condition assessment report have shown the need to undertake refurbishment works on this OHL circuit to prevent further deterioration of the existing assets.

3.3. Growth Need

Currently there is no load related driver to increase the ratings of our section of the Sloy – Windyhill East circuit. The Future Energy Scenarios (FES) out to 2050 have shown very limited growth in embedded generation on Scottish Hydro Electric Power Distribution's (SHEPD) network at Sloy, Clachan, and Ardkinglas GSPs. It is the connection of generation to the network at these nodes that would have the biggest influence on the power flow through the circuits. The proposed long-term



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strategy for the Argyll and Kintyre network will see a decrease in power flows through the Inveraray – Sloy 132kV circuits, which will ultimately lead to a reduction in flows through the Sloy Windyhill double circuits.

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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. Table 1 lists each option and a brief summary.

Table 1 – Option summary table

Option	Option Detail	Taken Forward to Detailed Analysis
Do Nothing Option	Undertake no refurbishment work on the assets.	No
1	Replace tension insulator sets, mitigate potential clearance infringements, steelwork members painted, and step bolts replaced.	Yes
2	Reconductor phase conductors and earth wire, tower foundation upgrades, replace fittings and insulator sets. Steelwork members painted and step bolts replaced.	Yes
3	Reconductor phase conductors and earth wire, tower replacements for out of alignment towers, replace tension insulator sets. Steelwork members painted and step bolts replaced.	No

Do Nothing Option

The do nothing option does not undertake any refurbishment on the OHL circuit. This option has been discounted at this stage as the network asset risk and asset condition assessments have concluded a need to refurbish the assets.

NOT PROGRESSED TO DETAILED ANALYSIS

Option 1

This option considers:

- Following recent finite element analysis carry out tower upgrades and ground clearance mitigations to ensure compliance with minimum statutory clearances. Two tower replacements are required along with eight panel extensions;



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- All tension insulator sets are to be replaced along with earthwire conductor fittings at identified towers;
- Steelwork members on all towers are to be painted, and all step bolts are to be replaced; and,
- Concrete muffs and stubs identified as being in poor condition will be refurbished and painted.

This option will result in the existing route and structures being re-utilised. All of the recommendations from the condition assessment report will be completed. This option is progressed to detailed analysis to be included within the CBA.

PROGRESSED TO DETAILED ANALYSIS

Option 2

Option 2 is an option that seeks to bring forward works that could be completed beyond the RIIO T2 period and coordinate these with the asset intervention works identified by the Asset Condition Report as being required during RIIO T2. This option considers:

- The full reconductoring of the phase conductor with Upas AAAC, as well reconductoring of the earthwire with Keziah OPGW ACSR. As Upas conductor is stronger than Lynx conductor, this option requires tower and foundation strengthening as well as clearance infringement mitigations to ensure minimum statutory clearances are met. Four tower replacements are required along with ten panel extensions;
- A conductor assessment undertaken has identified Upas AAAC as the replacement for Lynx ACSR conductors. 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 become standard products in the future. Upas has been selected as the replacement for Lynx ACSR as it has been widely used on the GB network and meets the electrical and mechanical requirements of the OHL;
- All tension insulator sets are to be replaced along with earthwire and phase conductor fittings;
- Steelwork members on all towers are to be painted, and all step bolts are to be replaced; and,
- Foundation upgrade works will take place on all out of alignment towers, and concrete muffs and stubs identified as being in poor condition will be refurbished and painted.

This option will result in the existing route and structures being re-utilised. All of the recommendations from the condition assessment report will be completed and by completing the reconductoring works the potential requirement to return at a later date will be removed. This option is progressed to detailed analysis to be included in the CBA to determine if there are benefits to undertaking the reconductoring works in T2 rather than beyond T2.



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Option 2 also presents the opportunity to reduce the exposure of operatives to a live network environment thus providing health and safety benefits through avoidance of additional work. Furthermore, the impact of the works to upgrade the network can be reduced through coordination of activities providing benefit to stakeholders and landowners through the reduction of potentially disruptive construction activities.

PROGRESSED TO DETAILED ANALYSIS

Option 3

This option considers:

- The full reconductoring of the phase conductor with Upas AAAC, as well reconductoring of the earthwire with Keziah OPGW ACSR. As Upas conductor is stronger than Lynx conductor, this option requires tower and foundation strengthening as well as clearance infringement mitigations to ensure minimum statutory clearances are met. Six tower replacements are required along with ten panel extensions;
- All tension insulator sets are to be replaced along with earthwire and phase conductor fittings;
- Steelwork members on all towers are to be painted, and all step bolts are to be replaced; and,
- New towers will be constructed to replace all out of alignment towers, and concrete muffs and stubs identified as being in poor condition will be refurbished and painted.

This option will result in the existing route and structures being re-utilised. All of the recommendations from the condition assessment report will be completed, and by completing the reconductoring works the potential requirement to return at a later date will be removed.

However, there is additional costs, associated with the new towers which replace out of alignment towers, compared to Option 2 with no discernible benefits. As a result, this option is not recommended to proceed to detailed analysis.

NOT PROGRESSED TO DETAILED ANALYSIS

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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 and Option 2 have been taken forward to detailed analysis and have been included in the Cost Benefit Analysis (CBA). The non-load asset condition requirement is addressed through the baseline option – Option 1. The CBA is being undertaken to help determine if it is beneficial, from a cost benefit perspective, to advance the reconductoring of the OHL in to the T2 period.

NPV's for the both options were calculated and compared against each other. The output from the CBA is shown in Table 2.

Table 2 – CBA results for the Sloy – Windyhill East 132kV OHL Works.

CBA Reference	Total Forecast Expenditure (£m)	Total NPV (£m)	Delta (Option to baseline £m)	Total NPV (Incl. Monetised Risk £m)
Baseline (Option 1)	-£31.61	-£22.59		£116.88
Option 2	-£29.07	-£22.92	£0.33	£133.32

The CBA has shown that in the analysis of the two options, Option 2 has a higher comparative NPV against the Baseline Option 1. The difference between the total NPV for the Baseline Option 1 and Option 2 is £0.33m. When taking account of the monetised risk benefit provided by each option, Option 2 still has a higher comparative NPV compared to the Baseline Option 1. The proposed solution is Option 2.

In line with the stakeholder feedback presented in A Risk Based Approach to Asset Management, bringing forward the phase conductor replacement works to align with the RIIO T2 tower refurbishment and fitting replacement is cost-effective solution and brings value to stakeholders and consumers. The stakeholder benefits centre around the reduction of SHE Transmission construction activity in the region, security of supply through the optimisation of construction outages and the reputational and safety aspects associated with only accessing the OHL structures once.

Based on the evidence presented in the Asset Condition Report, engineering assessments, consideration of future load requirements and CBA; the preferred solution is Option 2, full refurbishment of existing circuit and reconductoring with Upas conductor.

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5.2. Project Sensitivity

As outlined in our core RIIO-T2 business plan document, “A Network for Net Zero”, we believe we have a critical role to play in delivering Net Zero ambitions in both the UK and Scotland. Therefore, our plan has been carefully designed with the flexibility to deliver pathways to Net Zero. Our policy paper “A Risk-Based Approach to Asset Management” outlines our approach to monitoring and assessing the condition of our assets to maintain the reliable and resilient network that is expected by our stakeholders. Where asset condition deteriorates, we undertake a programme of cost-effective, risk-based interventions to maintain the longevity and performance of the transmission network. Each of our non-load related projects for T2 is underpinned by Asset Condition Reports which clearly outline that the works are necessary and driven by reliability.

Table 3 – Sensitivity Analysis table

Sensitivity	Test and impact observed – switching inputs
Asset Performance / deterioration rates	Switching deterioration assumption: The asset performance / deterioration rates can only improve or deteriorate. As the need for this project is driven by an asset condition report (as outlined in Section 3), the asset condition will not improve in the intervening period. The second option is for the asset performance to deteriorate and therefore the need remains, and the project would be considered for advancement within available outages.
Ongoing efficiency assumptions	Switching efficiency assumption: increased or decreased. Test would have no impact on (feasible) option selection, as the options move in parallel and have no impact on ordering within CBA.
Demand variations	No significant demand forecast.
Energy scenarios	Sensitivity considered in Section 3 (Need) already. As this is a non-load project and the need is driven by the asset condition, the work would be required regardless of any changes to the energy scenarios.
Asset utilisation	Our policy paper “A Risk-Based Approach to Asset Management” outlines our approach to monitoring and assessing the condition of our assets to maintain the reliable and resilient network that is expected by our stakeholders. Where asset condition deteriorates, we undertake a programme of cost-effective, risk-based interventions to maintain the longevity and performance of the transmission network. Each of our non-load related projects for T2 is underpinned by Asset Condition Reports which clearly outline that the works are necessary and driven for reliability.
Timing / delivery	We have considered timing of investments as part of our CBAs.

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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

Based on the output of the CBA the proposed solution we propose to proceed with in RIIO T2 is Option 2 as detailed in the Section 4 Optioneering of this justification report. The NPV within the CBA was higher for Option 2 against the Baseline Option 1. The requirement to re-conductor beyond the T2 period would result in re-mobilising and returning to site in order to carry out the reconductoring works and tower foundation works. This requirement to re-mobilise would be removed by undertaking the works within the RIIO T2 period. The proposed option for this project is Option 2.

This option considers the full reconductoring of the phase conductor with Upas AAAC, as well as reconductoring of the earthwire with Keziah OPGW ACSR. As Upas conductor is stronger than Lynx conductor this option requires tower and foundation strengthening as well as clearance infringement mitigations to ensure minimum statutory clearances are met. All tension insulator sets are to be replaced along with conductor fittings. Steelwork members on all towers are to be painted, and all step bolts are to be replaced. Concrete muffs and stubs identified as being in poor condition will be refurbished and painted.

The cost of the preferred option for works on Sloy – Windyhill East scheme has been developed using rates from existing OHL framework contracts and benchmarks delivered RIIO-T1 projects. The total cost for delivering the scope of works for the preferred solution is £16.54m. The works are planned to be completed within the RIIO T2 period.

Table 4 – Outputs from Preferred Solution

Plant	Size of new plant	Replacement for
132kV overhead line	14.5km Upas AAAC	14.5km Lynx ACSR
	14.5km Keziah OPGW	14.5km Horse ACSR earthwire
	4 x towers	4 x towers
	10 x panel extensions	-

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5.4. Competition

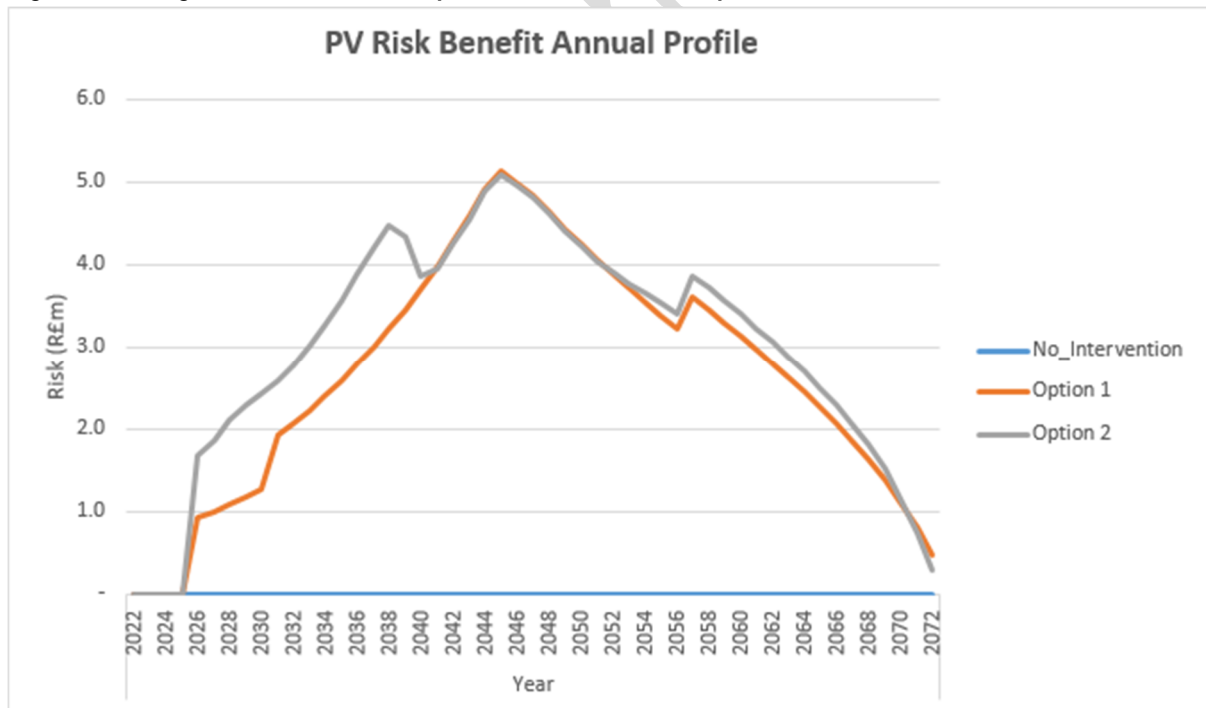
The Sloy – Windyhill East 132kV Works project is not flagged as eligible for early or late competition due to it being under Ofgem’s £50m and £100m thresholds respectively.

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 monetised risk benefit which would be realised through the completion of this project is R£343.9m. 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 1 – Long Term Benefit of Proposed Intervention – Option 2: Full Reconductor



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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€1.6m.

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.

In terms of the results of analysis for this project, which are captured in the carbon footprint results table,

Baseline Option 1 is the option that delivers the lowest comparative carbon footprint, which does not align with our option selection in the CBA. We are still developing our carbon modelling, and through this we hope to be able to identify methods to reduce the carbon impact as the project moves through the development process.

Table 5 – Carbon Footprint Modelling for the Sloy – Windyhill East 132kV OHL Works.

	Project Information	Baseline	Option
Project info	Project Name/number	Option1	Option2
	Construction Start Year	2026	2026
	Construction End Year	2028	2028

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Cost estimate £GBP	Embedded carbon	£ 160,004	£ 166,832
	Construction	£ 288,629	£ 288,934
	Operations	£ 771	£ 771
	Decommissioning	£ 132,142	£ 132,282
	Total Project Carbon Cost Estimate	£ 581,546	£ 588,819
Carbon footprint tCO₂e	Embedded carbon	2,136	2,228
	Construction	3,796	3,800
	Operations	3	3
	Decommissioning	380	380
	Total Project Carbon (tCO₂e)	6,316	6,412
Project Carbon Footprint by Emission Category	Total Scope 1 (tCO ₂ e)	3	3
	Total Scope 2 (tCO ₂ e)	-	-
	Total Scope 3 (tCO ₂ e)	6,313	6,408
SF₆ Emissions	Total SF ₆ Emissions 3 (tCO ₂ e)	-	-

5.7. Cost Estimate

The cost of the preferred option for works on the Sloy-Windyhill East 132kV OHL has been developed using rates from existing overhead line framework contracts and benchmarks from delivered RIIO-T1 projects. The total cost for delivering the scope of works for the proposed solution is £16.5m.

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6. Conclusion

This paper identifies the need for intervention on the OHL asset. The primary driver for the refurbishment works in this project is the asset condition of the existing OHL. Three intervention options were identified for this scheme. Of these, two options were taken forward and considered for detailed analysis.

The CBA concluded that both options had a comparative NPV. Option 2 has been chosen as the best option, which sees the requirement to reconductor being brought forward to T2 to avoid the requirement to re-mobilise and return to site to undertake works later.

The proposed scope of works is:

- Reconductoring of the phase conductor with Upas AAAC, as well replacement of the earthwire with Keziah OPGW ACSR;
- All tension insulator sets are to be replaced along with earthwire and phase conductor fittings;
- Steelwork members on all towers are to be painted, and all step bolts are to be replaced; and,
- Foundation upgrade works will take place on all out of alignment towers, and concrete muffs and stubs identified as being in poor condition will be refurbished and painted.

This scheme will cost £16.5m and deliver the following outputs and benefits during the RIIO-T2 benefits;

- A reduction of total network risk of R£343.9m,
- A risk reduction of network risk calculated as R£1.6m,
- Improved operational flexibility and resilience in line with our goal to aim for 100% transmission network reliability for homes and businesses.

The Sloy – Windyhill East 132kV scheme is not flagged as eligible for early or late competition due to 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.

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.

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8. Outputs included in RIIO T1 Business Plan

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

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Appendices

Appendix A: Network Diagram Sloy – Windyhill East Circuit

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