BM ROUTE 132kV OHL MAJOR REFURBISHMENT	
Name of Scheme/Programme	BM Route 132kV OHL Major Refurbishment
Primary Investment Driver	Asset Health
Scheme reference/ mechanism or category	SPNLT20137/Overhead (Tower) Line
Output references/type	NLRT2SP20137/132kV OHL (Tower) Conductor, NLRT2SP20137/132kV OHL Fittings, NLRT2SP20137/132kV OHL Tower
Cost	£1.00M
Delivery Year	2024
Reporting Table	C0.7/C2.2a_AP/C2.2a_CI/C2.3/C2.4b/C2.5/C2.5a
Outputs included in RIIO T1 Business Plan	No

Issue Date	Issue No	Amendment Details
December 2019	Issue 1	First issue of document

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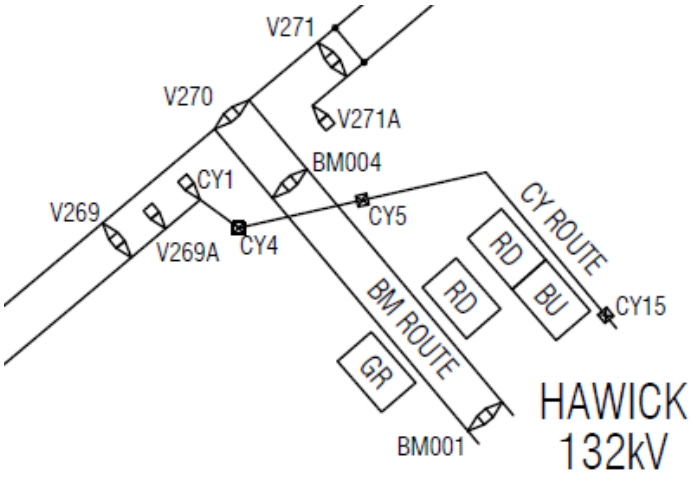
1. Introduction

This justification paper supports a proposal to carry out a conductor replacement of the BM route 132kV transmission overhead line between Hawick substation and the junction with V route, tower (V270) in 2024 of the RIIO T2 period.

The section of route being considered consists of a double circuit single ACSR 175mm2 'Lynx' phase conductor installed in 1965. Earthwire consists of a single AACSR 70mm^2 'Horse' OPGW earthwire conductor installed in 2007. BM route (BM001-V270) is supported on 4 steel lattice towers (PL16 design) with an approximate route length of 1.3km and circuit length of 2.6km.

The driver for this proposal is the asset health of phase conductor which will be approaching the end of the operational life by end of RIIO-T2 without intervention after site specific investigations and data analysis.



SYSTEM DIAGRAM EXTRACT

In line with above, the proposed 132kV outputs to be delivered in this project for the replacement option are:

Asset	Type of Activity	Disposal (cct. Km/sets/each)	Addition/Activity (cct. Km/set/each)
132kV OHL (Tower Line) Conductor	Replacement	2.6 cct. Km	2.6 cct. Km
132kV OHL Fittings	Replacement	8 sets	8 sets
132kV Tower	Refurbishment Major	-	4 each

2. Background Information

The existing system (BM Routes) is a double circuit overhead line that forms a 132kV connection between Gretna, Galashiels and Hawick substations which travels predominately through agricultural land. No alterations to the system configuration have been proposed.

The existing conductors are 175mm^2 ACSR 'Lynx' manufactured with a configuration of one conductor per phase. The existing earth wire is AACSR 70mm^2 'Horse' OPGW conductor installed in 2007.

Circuits are installed as follows:

- Phase Conductor Type (Gretna-Hawick circuit): single ACSR 175mm^2 'Lynx' installed in 1965.
- Phase Conductor Type (Galashiels-Hawick circuit): single ACSR 175mm^2 'Lynx' installed in 1965.
- Earth wire Conductor Type (BM001-V270): single AACSR 70mm^2 'Horse' OPGW installed in 2007.
- Insulators Type: glass installed in 2019.
- Tower Type: steel lattice PL16 installed in 1965.

BM route presents several critical locations, namely:

- 1no. 132kV OHL crossings.
- Terrain comprising of open farmland with some locations in excess of 200m high (A.O.D.).

There are 2 operating circuits on BM route. Circuit nomenclatures and colours are:

- GALA-HAWI (BM001 – V270). Circuit colour: Red.
- GRNA-HAWI (BM001 – V270). Circuit colour: Green.

2.1 Data Collection

As part of the SP Energy Networks (SPEN) OHL inspection regime, aerial photographic information in conjunction with site specific investigations such as conductor corrosion monitoring have been employed to provide a detailed condition analysis of the OHL components.

- Aerial photographic inspection in 2018.
- Corrosion monitoring testing:
    - Phase conductor on spans BM003-004-V270.

2.2 Data Analysis and Interpretation

The collected condition data has been analysed following "ASSET-01-030 Overhead Lines Technical Asset Life and CBRM Methodology" before condition ratings (1 to 5) per asset are defined and subsequently input to the SPEN Condition Based Risk Management (CBRM) tool.

The "ASSET-01-030 Overhead Lines Technical Asset Life and CBRM Methodology" document covers the model describing how overhead line conductors' condition is expected to change over time and its calculated technical asset life based upon a condition data approach, conductor types, grease levels and environment type. It also defines a common way on how condition data is interpreted, removing subjectivity and providing a clear view on how condition ratings have been concluded.

Phase conductors:

BM route conductors from condition information gathered in 2018 indicate conductor to be in good external condition however, it generally recognised that conductor degradation is age related and cormon test measurements would provide a more reliable indicator of conductor condition. Cormon testing was carried out along BM route phase conductor over several span locations (BM003-004-V270) in 2019 indicating a "Possible" deterioration of the steel wires galvanic protection (zinc layer) from readings recorded.

Operating environment is a component of the different Aluminium Conductor, Steel Reinforced (ACSR) families. Grease level ('Core' or 'All Inner') and conductor type ('Zebra', 'Lynx' or 'Horse') are the others. These families have different anticipated lives. Anticipated lives for these families have been forecast using historical condition information from previous OHL replacement schemes, samples taken on existing assets and an understanding of deterioration mechanisms. The methodology followed to derive anticipated lives is detailed in document ASSET-01-030 "Overhead Lines Technical Asset Life and CBRM Methodology". This methodology has been technically challenged by "Elias Ghannoum" (*Hydro-Quebec Chief OHL Engineer 1971-1998 / Lecturer at University of Montreal / IEC "Overhead Line Conductor" Chairman from 1988 to 2016).*

Anticipated Life	Conductor 'Core Greased'	Environmental Area
Anticipated Life (years): material deterioration	50	Low Pollution *(Rural with at least 90% of the route 15Km from a coast)*

The methodology has been used to estimate the condition of the conductors which by the end of the T2 period the phase conductor would be 11 years beyond anticipated life.

The circuits between Gretna, Hawick and Galashiels are carried on V, AL and BM routes. This intervention will make the phase conductor along BM match the type of conductor along V (RIIO-T1 scheme) and will co-ordinate with the outages on these critical circuits as part of the AL Route works (RIIO-T2 scheme).

Steel Towers:

BM route tower steelwork condition from towers (BM001 – V270) is considered to be of an adequate condition; however, foundation intrusive inspection carried out on 1 tower (BM003) presented a reduced pyramid and significantly smaller dimensions when compared to original foundation records for this type of structures.

2.3 CBRM Summary

CBRM extract is shown below indicating End of Life (EoL) for each of the identified asset for replacement:

Asset Description	Year of Installation	EoL*	Monetised Risk (R£m)*
Phase Conductor GALA-HAWI and GRNA-HAWI circuits	1965	9.93	56,436.42

**Values at the end of the RIIO-T2 period with no intervention as per NOMs methodology.*

3. Optioneering

Four options have been considered based on the requirements identified within the condition assessments produced for the existing BM route overhead line, where Option 1 has been recognised as the only viable option which meets the project objectives.

Option	Status	Reason for rejection
Baseline - Do Minimum: • Deferral of the major refurbishment intervention to RIIO-T3 (2026).	Considered but Rejected	This option is unacceptable due to the overall condition of the OHL conductor being at their end of life and no intervention will add considerable risk to the SPT Network. In addition, deferring the investment will accelerate the continual deterioration of the OHL components, in particular the OHL conductor which strength will be compromised preventing its use as pulling bond, significantly increasing the costs for conductor stringing activities.
Option 1 - Conductor and Earthwire Replacement: • Major refurbishment intervention (replacement of phase conductor) in RIIO-T2.	Considered and Proposed	-
Option 2 - Full Refurbishment • The replacement of phase conductor, earth wire and insulators in RIIO-T2 (2026).	Rejected	Insulators and earthwire along BM Routes were installed in 2019 and 2007 respectively with an anticipated life of 50 years.
Option 3 - Full Replacement	Rejected	Replacement of the existing OHL towers is unacceptable due to its condition and anticipated remaining life. Full Replacement will incur in a more onerous cost and delivery timescales due to environmental planning constraints (which is not in the best interests of system security or consumers).

4. Detailed analysis

Option 1 achieves the main objective of replacing phase conductor reducing the overall risks to the network and costs. Baseline and Option 1 have been considered for a CBA analysis including whole life monetised benefits and comparison of respective project option costs.

4.1 Option 1: Full Refurbishment

This option considers replacement of the replacement of all phase conductor assets as identified earlier through condition data, data analysis and interrogation. The following interventions are proposed to be replaced in a staged manner in this option:

- Re-conductor all circuits with single 'Poplar' 200mm^2 All Aluminium Alloy Conductor (AAAC) EHC at minimum 75°C.
- Replace all tension and suspension conductor end fittings (dampers).
- Replace tower muff foundations as required per condition.
- Upgrade foundations as required per condition.
- Replace downleads at Hawick substation.
- Replace heavily corroded or damaged steelwork (above category 4).
- Update all OHL records to reflect the works carried out.
- Carry out condition assessments on sections of removed conductor.
- Provide report to the Asset manager to include condition of all redundant conductors, steelwork and foundations along with associated tests logs for existing/new concrete.

The standard replacement conductor, 200mm^2 AAAC (Poplar) EHC system thermal ratings*:

Season / State	Amps	MVA
Winter Pre Fault	615	140
Winter Post Fault	730	167
Spring/Autumn Pre Fault	590	134
Spring/Autumn Post Fault	700	160
Summer Pre Fault	540	124
Summer Post Fault	645	147

**at 75°C Maximum Operation Temperature*

Specific factors attributable to this option which results in additional costs are listed below:

- Foundation intrusive investigations carried out along BM Route exhibit foundations with no significant means of degradation but poor workmanship translating into smaller foundation dimensions when compared to original designs or lack of pyramid. This is translated into a lack of uplift and compression capacity so careful assessment is needed.

  Additional foundation intrusive inspections have been carried out on a sample of PL16 towers at identified locations across the Network (a total of 29 inspections) in order to further understand its condition and workmanship quality.

Collected information has been analysed, grouped by types of defects and calculated the probability of having those defects across a bigger population following CIGRE 141 "Refurbishment and Upgrading of Foundations". Results are summarised below:

- 45% (for a P50% confidence probability level) of the towers along the PL16 routes built in the 50s-60s could present a small or absent pyramid when compared to original designs. This presents a lack of foundation uplift/compression capacity.
- 17% of the towers along the PL16 routes built on the 50s-60ss could present signs of degradation (honeycombing, fatigue, discolour).

Based on the above and following a risk based assessment, an allowance for foundation upgrade on all towers in close proximity to relevant crossings has been considered (roads, motorways and rail) representing a minimum of 17% of the total towers along the route.

In addition, further exploratory ground investigations to assess the condition of the tower foundations below ground level are included on quantified risk assessments (QRA) approach.

The following specific risks have been identified for this option:

- Conductor condition monitoring before works starts to allow an early indication of the suitability of the conductor and earth wire to be used as pulling bonds.
- Working over existing transmission overhead lines to be addressed by outage co-ordination.
- Railway and road crossings to be mitigated through scaffolding and traffic management systems or deployment of a catenary support system.
- Utilities within working areas to be addressed through procurement of records for duration of the project.
- Access routes to be addressed through early engagement with landowners, employing low bearing pressure ground vehicles and trackway where possible to minimise extents of stone tracks.
- Foundation condition and shape not being able to provide necessary uplift/compression capacity.
- Network operability/wayleave/environmental restrictions which impact on the progression of works as planned.
- Terrain comprising of urban areas, open undulating farmland with some locations in excess of 200m high (A.O.D.).

4.2 Selected Option

Baseline and Option 1 have been considered for a CBA analysis where whole life monetised benefits and comparison of respective project option costs.

Option No.	Description Of Option	Preferred Option	Total NPV (£m) *(Incl. Monetised Risk)*	Delta *(Option to baseline)*
Baseline	Baseline	N	£ 1.79	£ -
1	Conductor Replacement	Y	£ 1.87	£ 0.09

5. Conclusion

The 2 options proposed have been reviewed in terms of scope feasibility, cost, timescales and construction risks with Option 1 demonstrating the primary objective of lead assets replacement whilst affording greatest reduction in risk to the network.

In line with the costs prepared, the proposed scope of works and CBA analysis, option 1 (replacement of phase conductor, earth wire and insulator/fittings) is the selected option:

- Scheme Total Cost: £1.00M
- Timing of investment: 2021 – 2024
- Declared outputs:

Asset	Type of Activity	Disposal (cct. Km/sets/each)	Addition/Activity (cct. Km/set/each)
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- Longer term risk benefit (LR£m):

Asset	Long Term Risk Benefit (LR£m)
132kV OHL (Tower Line) Conductor	2.84

- Price control period of outputs: 2024

6. FUTURE PATHWAYS – NET ZERO

6.1 Primary Economic Driver

The primary driver for this investment is asset condition and risk. The investment does not have a strong reliance on environmental benefits.

6.2 Payback Periods

The CBA indicates that a positive NPV results in all assessment periods (10, 20, 30 & 45 years) which is consistent with the lifetime of the intervention. Consumers benefit from reduced network risk immediately on completion of the project.

6.3 Pathways and End Points

The network capacity and capability that result from the proposed option has been tested against and has been found to be consistent with the network requirements determined from the ETYS and NOA processes. Additionally, the proposed option is consistent with the route-specific capacity requirements from SPT's Energy Scenarios.

6.4 Asset Stranding Risks

Electricity generation, demand and system transfers are forecast to increase under all scenarios. The stranding risk is therefore considered to be very low.

6.5 Sensitivity to Carbon Prices

The CBA inputs are not sensitive to carbon prices.

6.6 Future Asset Utilisation

It has been assessed that the preferred option is consistent with the future generation and demand scenarios and that the risk of stranding is very low.

6.7 Whole Systems Benefits

Whole system benefits have been considered as part of this proposal. The capacity and capability of the preferred option is consistent with the provision of whole system solutions.

7. OUTPUTS INCLUDED IN RIIO T1 PLANS

N/A