BU ROUTE 132kV OHL MAJOR REFURBISHMENT	
Name of Scheme/Programme	BU Route 132kV OHL Major Refurbishment
Primary Investment Driver	Asset Health
Scheme reference/ mechanism or category	SPNLT2018/Overhead (Tower) Line
Output references/type	NLRT2SP2018/132kV OHL (Tower) Conductor, NLRT2SP2018/132kV OHL Fittings, NLRT2SP2018/132kV OHL Tower
Cost	£5.1M
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
July 2019	Issue 1	First issue of document
December 2019	Issue 2	Gross cost, NPV, Monetised Risk, Long Term Risk Benefit and Delivery Year values updated.

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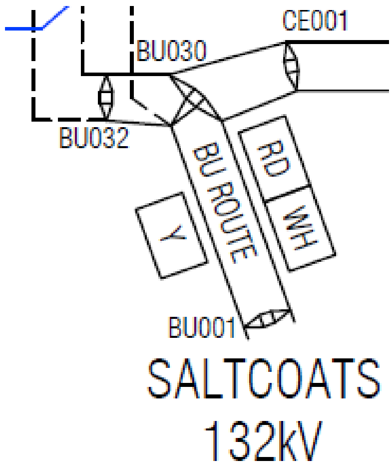
1. Introduction

This paper supports a proposal to carry out a major refurbishment of the BU route, 132kV transmission overhead line between Saltcoats substation and tower BU030.

The BU route was commissioned in 1974 and consists of a double circuit single ACSR 400mm^2 'Zebra' phase conductor and single AACSR 190mm^2 'Keziah' equivalent OPGW supported on 32 steel lattice towers of J.L.Eve designs with an approximate route length of 8.55km and circuit length of 17.14km. The driver proposal is the asset health of phase conductors 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	17.1 cct. Km	17.1 cct. Km
132kV OHL Fittings	Replacement*	64 sets	64 sets
132kV Tower	Refurbishment Major	-	32 each

**OHL Fittings outputs refer to vibration dampers and not to the replacement of the whole insulator set.*

2. Background Information

The existing system (BU Route) is a double circuit overhead line that forms a 132kV connection between Saltcoats, Kilwinning and Hunterston / Hunterston Farm 132kV substations which traverse predominately through agricultural land. No alterations to the system configuration have been proposed.

The existing phase conductors is 400mm2 ACSR 'Zebra' with a configuration of one conductor per phase while earth wire is a single AACSR 190mm2 'Keziah' equivalent OPGW conductor.

BL route circuits are single conductor between towers BU001 and BU032:

Phase Conductor Type:

- BU001 – BU032 (ACSR 'Zebra' installed in 1974).

Earthwire Conductor Type:

- BU001 – BU032 (AACSR 190mm2 'Keziah' equivalent OPGW installed in 2008).

Insulators Type:

- BU001 – BU032 (Glass installed in 2010).

Tower Type:

- BU001 – BU032 (steel lattice J.L.Eve designs installed in 1974).

BU route has 2 no. operating circuits with circuit nomenclatures and colours as follows:

- HUER-HUNF-SACO. Circuit Colour: Yellow.
- HUER-KILW-SACO. Circuit Colour: Red / White.

BU route presents a number of critical locations adjacent to railways, main roads and HV OHL's, namely:

- 3no. 33kV OHL crossings.
- 4no. 11kV OHL crossings.
- 1no. A Road crossing.
- 1no. Railway crossing.
- Terrain comprising of open undulating farmland with some locations in excess of 250m high (A.O.D.).

The route traverses through a heavily polluted 5km zone adjacent to the coastline (Environmental class A).

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, and foundation intrusive have been employed to provide a detailed condition analysis of the OHL components.

- Aerial photographic inspection.
- Cormon testing (conductor and earthwire).

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 and Earth wire conductors:

Conductor samples collected from highly polluted areas over the SP Network indicates that the anticipated life following an ageing profile (internal galvanic corrosion) of an ACSR 'Zebra' (all inner greased) conductor is 55-60 years.

However, additional factors including quality, manufacturing and design can accelerate the typical ageing profile of the conductors:

Cormon testing was carried out on the bottom phase conductor over several span locations throughout the route in 2008 indicating a deterioration of the steel wires' galvanic protection (zinc layer) from 'partial' to 'severe' readings.

A summary of the condition ratings is shown below:

Activity	Span	Summary Result	Condition Rating Value*
Cormon Phase conductor: 400mm2 ACSR 'Zebra'	BU001-002	"Partial"	4
	BU002-003	"Severe" / "Al Loss"	5

**Note: condition rating derived from the Overhead Lines Technical Asset Life and CBRM Methodology.*

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 BU Route 132kV	1974	8.92	2,742,372.48

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

Note: no replacement proposed to phase fittings and steel towers along BU Route; however allowance to replace sporadic heavily corroded or damaged steelwork and foundation upgrades have been made.

3. Optioneering

Four options have been considered based on the requirements identified within the condition assessments produced for the existing BU 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	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 these circuits within 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 Replacement: • Major refurbishment intervention (replacement of phase conductor and earth wire) in RIIO-T2 (2026).	Considered and Proposed	-
Option 2 - Full Refurbishment • The replacement of phase conductor, earth wire and insulators in RIIO-T2 (2026).	Rejected	Insulators along BU Route were installed in 2010 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 and earth wire while refurbishing the OHL Towers and thereby 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 conductors and earthwire 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 between BU001-032 with single 'Totara' 425mm2 All Aluminium Alloy Conductor (AAAC) EHC at maximum 90C.
- Replace all tension and suspension conductor end fittings.
- Replace tower muff foundations as required per condition.
- Upgrade foundations where as required per condition.
- Replace downleads and fittings at Saltcoats substation and tower BU032.
- 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, single 425mm2 AAAC (Totara) EHC system thermal ratings*:

Season / State	Amps	MVA
Winter Pre Fault	1215	277
Winter Post Fault	1445	330
Spring/Autumn Pre Fault	1165	265
Spring/Autumn Post Fault	1385	316
Summer Pre Fault	1085	247
Summer Post Fault	1290	295

**at 90C Maximum Operation Temperature*

<u>Specific factors attributable to this option which results in additional costs are listed below:</u>

- Foundation intrusive inspections programme has 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 build on the 50s-60s could present small pyramid when compared to original designs or non-existent. This present a lack of foundation uplift/compression capacity.
  - 17% of the towers along the PL16 routes build 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.

- Allowances for the undergrounding of distribution crossing have also been made.

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 distribution overhead lines to be addressed by diverting or undergrounding on a temporary basis.
- 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.
- Optimisations of Network access by the introduction of multiple gangs.
- Network operability/wayleave/environmental restrictions which impact on the progression of works as planned.

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	£ 226.15	£ -
1	Conductor Replacement	Y	£ 235.57	£ 9.42

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 and earth wire during the RIIO-T2 period) is the selected option:

- Scheme Total Cost: £5.1M
- Timing of investment: 2021 - 2024
- Declared outputs:

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- Longer term risk benefit (LR£m):

Asset	Long Term Risk Benefit (LR£m)
132kV OHL (Tower Line) Conductor	235.63

- 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