

<b>BC ROUTE 132kV OHL MAJOR REFURBISHMENT</b>	
<b>Name of Scheme/Programme</b>	BC Route 132kV OHL Major Refurbishment
<b>Primary Investment Driver</b>	Asset Health
<b>Scheme reference/mechanism or category</b>	SPNLT208/Overhead (Tower) Line
<b>Output references/type</b>	NLRT2SP208/132kV OHL (Tower) Conductor, NLRT2SP208/132kV OHL Fittings, NLRT2SP208/132kV OHL Tower
<b>Cost</b>	£4.4M
<b>Delivery Year</b>	2023
<b>Reporting Table</b>	C0.7/C2.2a_AP/C2.2a_CI/C2.3/C2.4b/C2.5/C2.5a
<b>Outputs included in RIIO T1 Business Plan</b>	No

<b>Issue Date</b>	<b>Issue No</b>	<b>Amendment Details</b>
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.  Full route fitting replacement rather than partial fitting replacement.

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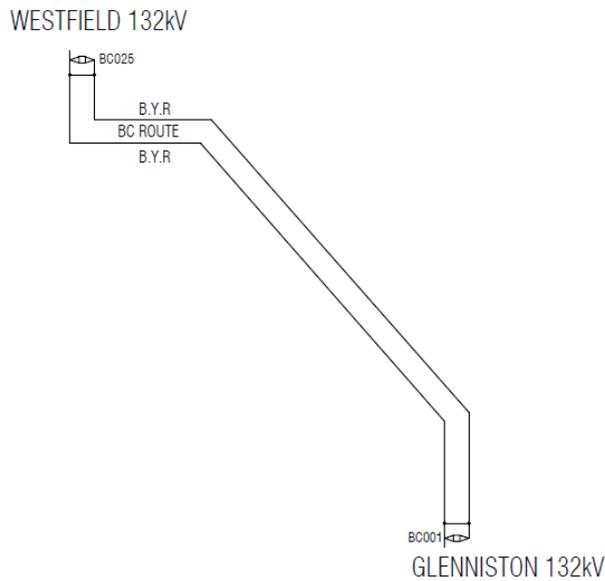
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**1. Introduction**

This justification paper supports a proposal to carry out a major refurbishment of the BC route, 132kV transmission overhead line between tower BC007 at Glenniston end and Westfield substation.

The BC route consists of a double circuit (although it is operating as a single circuit) single ACSR 175mm<sup>2</sup> ‘Lynx’ phase conductor and a single ACSR 70mm<sup>2</sup> ‘Lynx’ earthwire conductor supported on 25 steel lattice towers (BC001 to BC025) of PL16 (BC007-025) / L4 (BC001-006) design with an approximate route length of 7.15km and circuit length of 14.3km. The driver for the proposal is the asset health of phase conductors, fittings (BC001-BC007) and earthwire 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:

<b>Asset</b>	<b>Type of Activity</b>	<b>Disposal (cct. Km/sets/each)</b>	<b>Addition/Activity (cct. Km/set/each)</b>
132kV OHL (Tower Line) Conductor	Replacement	14.3 cct. Km	14.3 cct. Km
132kV OHL Fittings	Replacement	50 sets	50 sets
132kV Tower	Refurbishment Major	-	25 each

## 2. Background Information

The existing system (BC Route) is a double circuit overhead line (although it is operating as a single circuit) that forms a 132kV connection between Glenniston S/S and Westfield S/S which traverses predominately through agricultural land with occasional residential property and outbuildings located in close proximity. No alterations to the system configuration have been proposed.

The existing conductor from towers (BC001 – BC006) is designated as a 175mm<sup>2</sup> ACSR ‘Lynx’ with a configuration of one conductor per phase and 70mm<sup>2</sup> ACSR ‘Horse’ conductor with no optical fibre earth wire installed in 1983.

The existing conductor from towers (BC006 – BC025) is designated as a 175mm<sup>2</sup> ACSR ‘Lynx’ core only greased with a configuration of one conductor per phase and 70mm<sup>2</sup> ACSR ‘Horse’ conductor with no optical fibre earth wire installed in 1961.

Phase Conductor Type:

- BC001 – BC007 (ACSR ‘Lynx’ installed in 1983).
- BC007 – BC025 (ACSR ‘Lynx’ core only greased installed in 1961).

Earthwire Conductor Type:

- BC001 – BC007 (ACSR ‘Horse’ installed in 1983).
- BC007 – BC025 (ACSR ‘Horse’ installed in 1961).

Insulators Type:

- BC001 – BC007 (Glass installed in 1983).
- BC007 – BC025 (Glass installed in 2004).

Tower Type:

- BC001 – BC006 (L4 design installed in 1983).
- BC007 – BC025 (PL16 design installed in 1961).

BC route has 1 no. operating circuits with circuit nomenclatures and colours as follows:

- MOSM-GLNI-WFIE. Circuit Colour: Red / White.

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

- 6no. 11kV OHL crossings.
- 2no. 33kV OHL crossings.
- A Road crossing.
- Railway line crossing.
- Terrain comprising of urban areas, open undulating farmland with some locations in excess of 150m high (A.O.D.).

The route traverses Mosmorrnan chemical works and oil refinery at Glenniston.

## 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, conductor sampling, steelwork inspection and foundation intrusive have been employed to provide a detailed condition analysis of the OHL components.

- Aerial photographic inspection.
- Cormon testing (conductor & earthwire).
- Conductor sampling.
- Steelwork inspection.
- Foundation intrusive investigation.

## 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 ‘Lynx’ (core-only greased) conductor is 45 years (typically 55-60 years for “moderately and low polluted” areas).

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

Cormon and conductor sample testing was carried out on the top phase conductor and earthwire over several span locations throughout the route in 2018 indicating a deterioration of the steel wires’ galvanic protection (zinc layer) within the section BC006-BC025.

A summary of the condition ratings is shown below:

Activity	Span	Summary Result	Condition Rating Value*
Cormon Phase conductor: ACSR Lynx	BC005-006	“None”	1-2
	BC019-020	“Possible”	3
Cormon earthwire conductor: ACSR Horse	BC005-006	“Possible”	3
	BC019-020	“Partial”	4
Conductor Sample	BC019	Negligible grease, zinc degradation, torsion test failed on inner Al wires	5

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

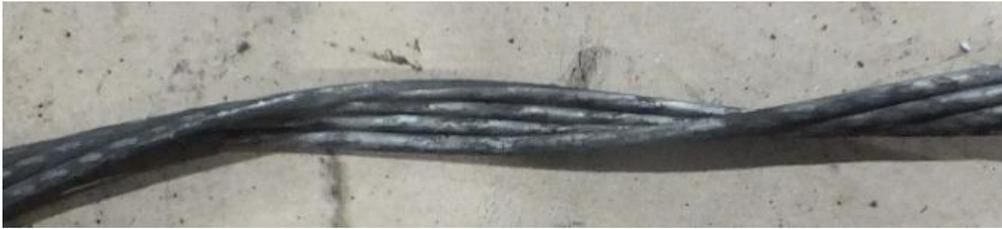


Figure 1: inner aluminium strands exhibit corrosion product.



Figure 2: steel core strands exhibiting rusting.

### Steel Towers:

BC route tower steelwork condition from towers (BC001 - BC025) is considered to be of an adequate condition; however foundation intrusive inspection carried out on 2 towers (BC018 and BC019) presented concrete at the surface over the whole exposed face crumbled away when tapped, signs of cracking above pyramid, concrete turning to mush on stack and significantly smaller dimensions as per original foundation records for this type of structures.



BC018 Tower Foundation



Concrete core sample tower BC019

### 2.3 CBRM Summary

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

<b>Asset Description</b>	<b>Year of Installation</b>	<b>EoL*</b>	<b>Monetised Risk (R£m)*</b>
Phase Conductor BC Route (BC007-BC025) 132kV	1961	10.39	687,315.55
Phase Fittings BC Route (BC001-BC007) 132kV	2004/1983	7.77	1,531,799.04

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

*Note: replacement proposed to phase fittings (BC007-BC025) based on condition and to avoid partial refurbishment along the route. Partial refurbishment will cause early return to the route resulting unnecessary disruption to landowners and the local community and higher capital costs overall.*

### 3. Optioneering

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

<b>Option</b>	<b>Status</b>	<b>Reason for rejection</b>
<b>Baseline - Do Minimum:</b> <ul style="list-style-type: none"> <li>Deferral of the major refurbishment intervention to RIIO-T3 (2026).</li> </ul>	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.
<b>Option 1 - Conductor and earth wire Replacement:</b> <ul style="list-style-type: none"> <li>Major refurbishment intervention (replacement of phase conductor, earth wire and fittings in RIIO-T2 (2026).</li> </ul>	Considered and Proposed	-
<b>Option 2 - Full Replacement</b>	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 BC007-025 with single ‘Poplar’ 200mm<sup>2</sup> All Aluminium Alloy Conductor (AAAC) EHC at maximum 75C.
- Replace earthwire between BC007-025 with a single “Horse” 70mm<sup>2</sup> AACSR equivalent OPGW.
- Replace all tension and suspension insulator sets.
- Replace earthwire fittings.
- Replace tower muff foundations as required per condition.
- Upgrade foundations as required per condition.
- Replace downloads and fittings at Westfield 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<sup>2</sup> 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 75C Maximum Operation Temperature*

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

- Foundation intrusive investigations carried out along BC Route exhibit foundations with significant means of degradation and poor workmanship translating into smaller foundation dimensions when compared to original designs. 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 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) <i>(Incl. Monetised Risk)</i>	Delta <i>(Option to baseline)</i>
Baseline	Baseline	N	£ 137.85	£ -
1	Conductor, earth wire and fitting Replacement	Y	£ 126.86	£ -10.99

The best NPV over the full assessment period is for the baseline, full refurbishment of the route in the T3 period. However, it has been demonstrated that option 1 provides better value for the investment, achieving the primary objectives. The lower NPV for the preferred option is due to the replacement of some fittings that are in better condition (and so result in lower monetised risk benefit) than the sets that are driving the need for intervention. Deferring the replacement of some fittings would require early return to the route. This would result in additional disruption to landowners and the local community. Overall capital costs would be higher as ‘fixed’ costs of site establishment, security and accesses would be incurred unnecessarily.

#### 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 appropriate reduction in risk to the network, giving consideration to the impact on stakeholders and the capital costs of the alternative option.

In line with the costs prepared, the proposed scope of works and CBA analysis (and supplementary commentary), option 1 (replacement of phase conductor and earth wire during the RIIO-T2 period) is the selected option:

- Scheme Total Cost: £4.4M
- Timing of investment: 2020 – 2023
- Declared outputs:

Asset	Type of Activity	Disposal <i>(cct. Km/sets/each)</i>	Addition/Activity <i>(cct. Km/set/each)</i>
132kV OHL (Tower Line) Conductor	Replacement	14.3 cct. Km	14.3 cct. Km
132kV OHL Fittings	Replacement	50 sets	50 sets
132kV Tower	Refurbishment Major	-	25 each

- Longer term risk benefit (LR£m):

Asset	Long Term Risk Benefit <i>(LR£m)</i>
132kV OHL (Tower Line) Conductor (BC007-BC025)	33.43
132kV Fittings	109.43

- Price control period of outputs: 2023

## **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