T3 OHL MAJOR REFURBISHMENT DEVELOPMENT PROGRAMME	
Name of Scheme/Programme	SPNLT2024 – XL Route 275kV Major Refurbishment SPNLT2025 – BE Route 132kV Major Refurbishment SPNLT2026 – BV Route 132kV Major Refurbishment SPNLT2027 – BR Route 132kV Major Refurbishment SPNLT2028 – YB & YC Routes 132kV Major Refurbishment SPNLT2029 – XW Route 275kV Major Refurbishment SPNLT2030 – XT Route 275kV Major Refurbishment SPNLT2031 – YF Route 275kV Major Refurbishment SPNLT2032 – XD119-131/XK/XN/XM Route 275kV Major Refurbishment
Primary Investment Driver	Asset Health
Scheme reference/ mechanism or category	SPNLT2024/Overhead (Tower) Line SPNLT2025/Overhead (Tower) Line SPNLT2026/Overhead (Tower) Line SPNLT2027/Overhead (Tower) Line SPNLT2028/Overhead (Tower) Line SPNLT2029/Overhead (Tower) Line SPNLT2030/Overhead (Tower) Line SPNLT2031/Overhead (Tower) Line SPNLT2032/Overhead (Tower) Line
Output references/type	NLRT2SP2024: 275kV OHL (Tower) Conductor/275kV Fittings/275kV OHL Tower NLRT2SP2025: 132kV OHL (Tower) Conductor/132kV Fittings/132kV OHL Tower NLRT2SP2026: 132kV OHL (Tower) Conductor/132kV Fittings/132kV OHL Tower NLRT2SP2027: 132kV OHL (Tower) Conductor/132kV Fittings/132kV OHL Tower NLRT2SP2028: 132kV OHL (Tower) Conductor/132kV Fittings/132kV OHL Tower NLRT2SP2029: 275kV OHL (Tower) Conductor/275kV Fittings/275kV OHL Tower NLRT2SP2030: 275kV OHL (Tower) Conductor/275kV Fittings/275kV OHL Tower NLRT2SP2031: 275kV OHL (Tower) Conductor/275kV Fittings/275kV OHL Tower NLRT2SP2032: 275kV OHL (Tower) Conductor/275kV Fittings/275kV OHL Tower
Cost	SPNLT2024 – XL Route 275kV Major Refurbishment: £7.1M SPNLT2025 – BE Route 132kV Major Refurbishment: £5.0M SPNLT2026 – BV Route 132kV Major Refurbishment: £3.8M SPNLT2027 – BR Route 132kV Major Refurbishment: £13.0M SPNLT2028 – YB & YC Routes 132kV Major Refurbishment: £10.4M SPNLT2029 – XW Route 275kV Major Refurbishment: £3.6M SPNLT2030 – XT Route 275kV Major Refurbishment: £2.2M SPNLT2031 – YF Route 275kV Major Refurbishment: £4.2M SPNLT2032 – XD119-131/XK/XN/XM Route 275kV Major Refurbishment: £32.6M
Delivery Year	2027 – 2030
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
August 2020	Issue 1	First issue of document

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1. Introduction

This paper supports a proposal to initiate the development works on the transmission overhead line routes identified for major refurbishment work during the T3 price control. Major interventions on transmission overhead lines can take several years to plan and execute. The proposed investment is intended to support the development activities required to deliver our long-term asset management strategy for overhead lines, as outlined in supporting document "*EJP_SPT_Overhead Lines Portfolio View*" in Annex 1 of the Business Plan submission.

This asset management strategy for overhead lines focuses on optimising the replacement programme of ACSR core-only greased conductors. This is based on evidence collected across the network for this type of OHL conductor and its corrosion rates.

All overhead line routes within the network have been assessed in detail, prioritising those in worst condition due to environmental pollution and network risk. When viewed over the long term, the optimised profile for replacement results in a rate of 70-90 circuit kilometres per year. The programme commenced in RIIO-T1 and is expected to be completed by the end of RIIO-T3 in coordination with any load-related works.

By following this strategy, replacement of the large volume of ACSR core only greased conductors installed in the 1960s can be well planned through optimising outages and resource availability to carry out the works.

The illustration below provides an overview of the current asset base compared against end of RIIO-T2 period after interventions by 2026. It also shows a projection to 2031 following completion of interventions (excluding load related works).

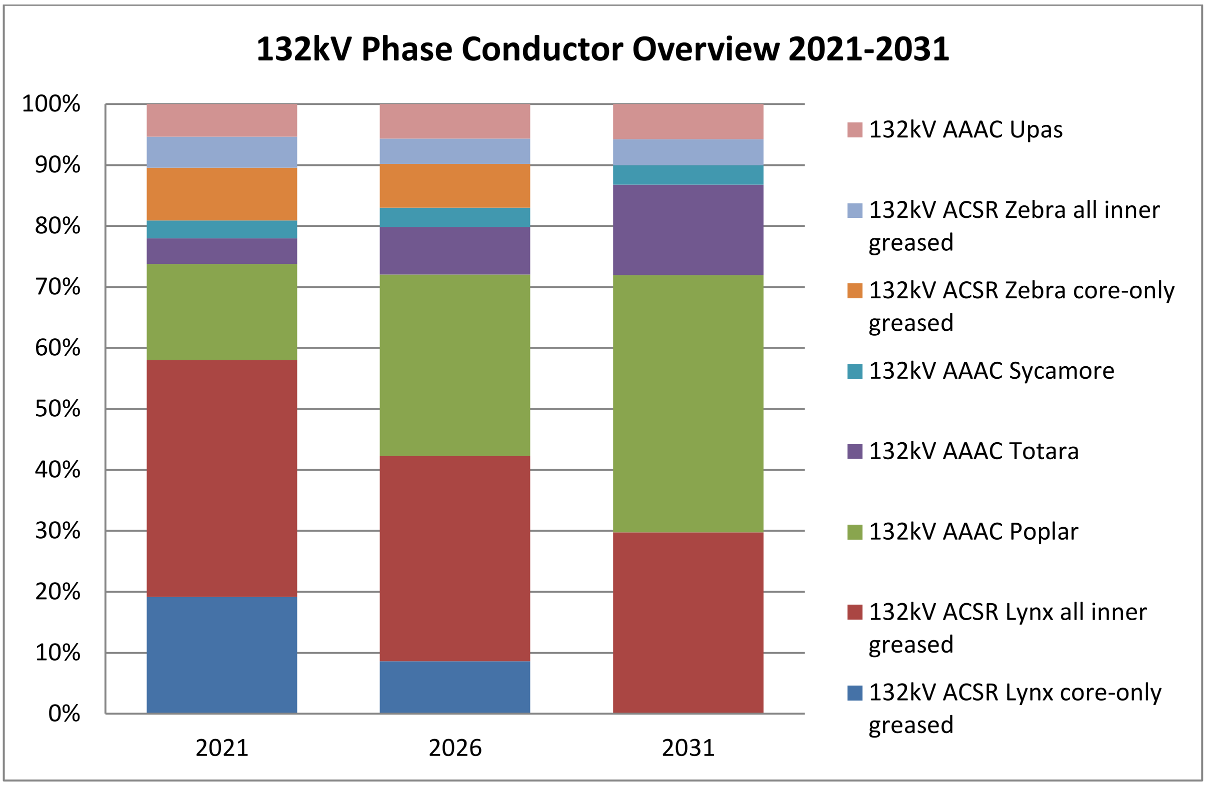

Figure 5: 132kV phase conductor overview 2021-2031.

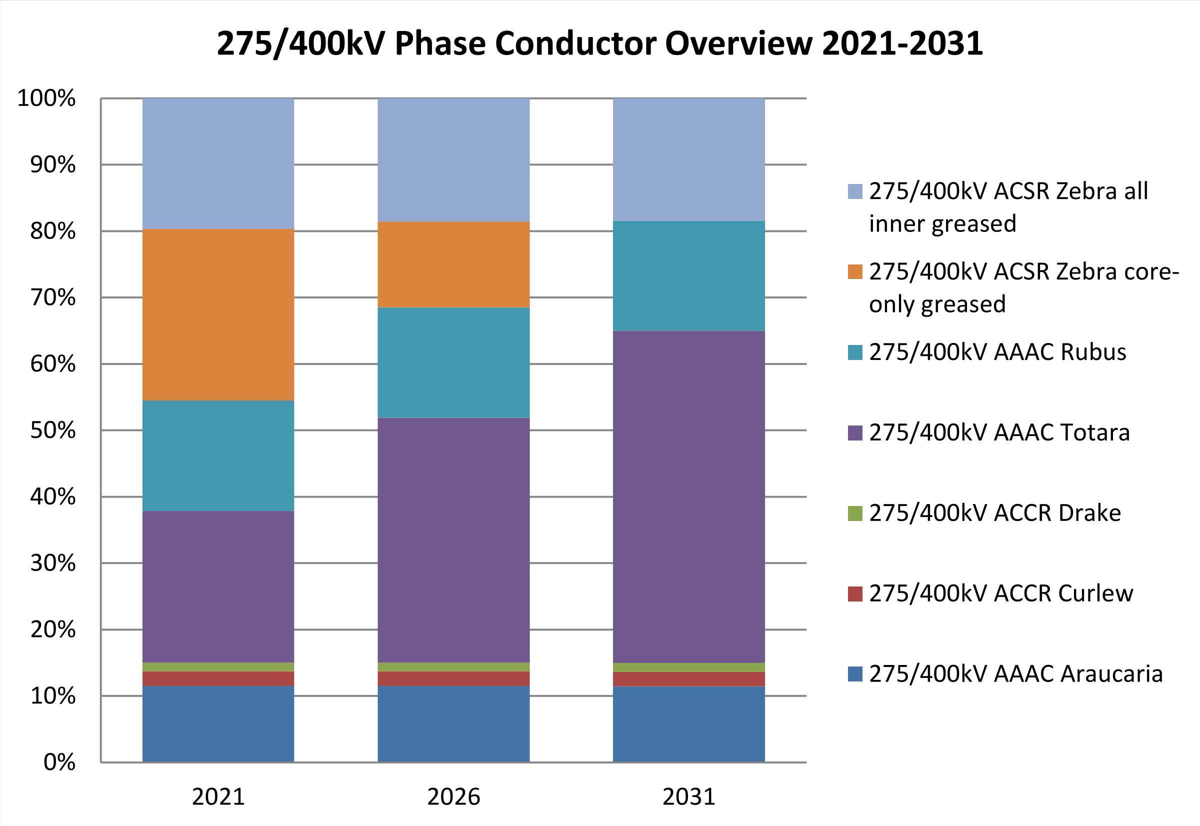

Figure 6: 275/400kV phase conductor overview 2021-2031

As part of the SPT OHL inspection regime, aerial photographic information in conjunction with route specific investigations including climbing inspections have been employed to provide a detailed condition analysis rating of the OHL components.

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 conductor condition is expected to change over time and its calculated technical asset life based on a condition data approach, conductor type, grease levels and environment type. It also defines a common way condition data is interpreted, removing subjectivity and providing a clear view on how condition ratings have been concluded.

This methodology has been informed through extensive conductor sampling and testing and has been validated by an international expert (please refer to Annex 1 of the SPT RIIO-T2 Business Plan).

The following OHL routes and level of interventions are included within this programme:

1.1 SPNLT2024 XL Route 275kV Major Refurbishment

It is proposed to carry out a major refurbishment intervention during the RIIO-T3 period, replacing phase conductors, tension and suspension conductor end fittings, upgrading foundations as required, steelwork modifications as per TGN161 and TGN163, replacement of heavily corroded (above category 4) and damaged steelwork as required.

In line with above, the proposed 275kV outputs to be delivered are:

Asset	Type of Activity	Disposal (cct. Km/sets/each)	Addition/Activity (cct. Km/sets/each)
275kV OHL (Tower Line) Conductor	Replacement	-	21 cct. Km
275kV OHL Fittings	Replacement	70 set	70 each
275kV Tower	Refurbishment Major	-	35 each

The delivery of the project is characterised by multiple gangs (2) working concurrently in order to minimise access and constraints on the network.

1.2 SPNLT2025 BE Route 132kV Major Refurbishment

It is proposed to carry out a major refurbishment intervention during the RIIO-T3 period, replacing phase conductors, earth wire, tension and suspension conductor end fittings, upgrading foundations as required and replacing heavily corroded (above category 4) and damaged steelwork as required.

In line with above, the proposed 132kV outputs to be delivered are:

Asset	Type of Activity	Disposal (cct. Km/sets/each)	Addition/Activity (cct. Km/sets/each)
132kV OHL (Tower Line) Conductor	Replacement	-	15.3 cct. Km
132kV OHL Fittings	Replacement	56 set	56 set
132kV Tower	Refurbishment Major	-	28 each

The delivery of the project is characterised by multiple gangs (2) working concurrently in order to minimise access and constraints on the network.

1.3 SPNLT2026 BV Route 132kV Major Refurbishment

It is proposed to carry out a major refurbishment intervention during the RIIO-T3 period, replacing phase conductors, earth wire, tension and suspension conductor end fittings, upgrading foundations as required and replacing heavily corroded (above category 4) and damaged steelwork as required.

In line with above, the proposed 132kV outputs to be delivered are:

Asset	Type of Activity	Disposal (cct. Km/sets/each)	Addition/Activity (cct. Km/sets/each)
132kV OHL (Tower Line) Conductor	Replacement	-	13.2 cct. Km
132kV OHL Fittings	Replacement	44 each	44 each
132kV Tower	Refurbishment Major	-	22 each

The delivery of the project is characterised by multiple gangs (2) working concurrently in order to minimise access and constraints on the network.

1.4 SPNLT2027 BR Route 132kV Major Refurbishment

It is proposed to carry out a major refurbishment intervention during the RIIO-T3 period, replacing phase conductors, earth wire, tension and suspension conductor end fittings, upgrading foundations as required and replacing heavily corroded (above category 4) and damaged steelwork as required.

In line with above, the proposed 132kV outputs to be delivered are:

Asset	Type of Activity	Disposal	Addition/Activity

		(cct. Km/sets/each)	(cct. Km/sets/each)
132kV OHL (Tower Line) Conductor	Replacement	-	53.8 cct. Km
132kV OHL Fittings	Replacement	174 sets	174 sets
132kV Tower	Refurbishment Major	-	87 each

1.5 SPNLT2028 YB & YC Routes 132kV Major Refurbishment

It is proposed to carry out a major refurbishment intervention during the RIIO-T3 period, replacing phase conductors, tension and suspension conductor end fittings, upgrading foundations as required, steelwork modifications as per TGN161 and TGN163, replacement of heavily corroded (above category 4) and damaged steelwork as required.

In line with above, the proposed 132kV outputs to be delivered are:

Asset	Type of Activity	Disposal (cct. Km/sets/each)	Addition/Activity (cct. Km/sets/each)
132kV OHL (Tower Line) Conductor	Replacement	-	29.2 cct. Km
132kV OHL Fittings	Replacement	92 sets	92 sets
132kV Tower	Refurbishment Major	-	46 each

The delivery of the project is characterised by multiple gangs (2) working concurrently in order to minimise access and constraints on the network.

1.6 SPNLT2029 XW Route 275kV Major Refurbishment

It is proposed to carry out a major refurbishment intervention during the RIIO-T3 period, replacing phase conductors, earth wire, tension and suspension conductor end fittings, upgrading foundations as required, steelwork modifications as per TGN161 and TGN163, replacement of heavily corroded (above category 4) and damaged steelwork as required.

In line with above, the proposed 275kV outputs to be delivered are:

Asset	Type of Activity	Disposal (cct. Km/sets/each)	Addition/Activity (cct. Km/sets/each)
275kV OHL (Tower Line) Conductor	Replacement	-	7.2 cct. Km
275kV Fittings	Replacement	24 sets	24 sets
275kV Tower	Refurbishment Major	-	12 each

The delivery of the project is characterised by multiple gangs (2) working concurrently in order to minimise access and constraints on the network.

1.7 SPNLT2030 XT Route 275kV Major Refurbishment

It is proposed to carry out a major refurbishment intervention during the RIIO-T3 period, replacing phase conductors, earth wire, tension and suspension conductor end fittings, upgrading foundations as required, steelwork modifications as per TGN161 and TGN163 and replacing heavily corroded (above category 4) or damaged steelwork as required.

In line with above, the proposed 275kV outputs to be delivered are:

Asset	Type of Activity	Disposal (cct. Km/sets/each)	Addition/Activity (cct. Km/sets/each)
275kV OHL (Tower Line) Conductor	Replacement	-	3.1 cct. Km
275kV Fittings	Replacement	12 sets	12 sets
275kV Tower	Refurbishment Major	-	6 each

The delivery of the project is characterised by multiple gangs (2) working concurrently in order to minimise access and constraints on the network.

1.8 SPNLT2031 YF Route 275kV Major Refurbishment

It is proposed to carry out a major refurbishment intervention during the RIIO-T3 period, replacing phase conductors, tension and suspension conductor end fittings, upgrading foundations as required, steelwork modifications as per TGN161 and TGN163 and replacing heavily corroded (above category 4) or damaged steelwork as required.

In line with above, the proposed 275kV outputs to be delivered are:

Asset	Type of Activity	Disposal (cct. Km/sets/each)	Addition/Activity (cct. Km/sets/each)
275kV OHL (Tower Line) Conductor	Replacement	-	8.5 cct. Km
275kV Fittings	Replacement	28 sets	28 sets
275kV Tower	Refurbishment Major	-	14 each

The delivery of the project is characterised by multiple gangs (2) working concurrently in order to minimise access and constraints on the network.

1.9 SPNLT2032 XD119-131/XK/XN/XM Route 275kV Major Refurbishment

It is proposed to carry out a major refurbishment intervention during the RIIO-T3 period, replacing phase conductors, earth wire (except XM route), tension and suspension conductor end fittings, upgrading foundations as required.

In line with above, the proposed 275kV outputs to be delivered are:

Asset	Type of Activity	Disposal (cct. Km/sets/each)	Addition/Activity (cct. Km/sets/each)
275kV OHL (Tower Line) Conductor	Replacement	-	110.4 cct. Km
275kV Fittings	Replacement	338 sets	338 sets
275kV Tower	Refurbishment Major	-	169 each

The delivery of the project is characterised by multiple gangs (2) working concurrently in order to minimise access and constraints on the network.

2. Background Information

2.1 SPNLT2024 XL Route 275kV Major Refurbishment

The existing system (XL Route) is a double circuit overhead line that forms a 275kV connection between Kincardine substation and the B4 boundary to the SHE Transmission at tower XL033 which traverses predominately through agricultural land with sections passing through industrial areas. It is proposed to co-ordinate this work with load-related projects in RIIO-T3.

The existing phase conductors are 400mm^2 ACSR 'Zebra' with a configuration of two conductors per phase and the earthwire is a single AACSR 160mm^2 'Keziah' equivalent OPGW conductor.

XL route circuits are twin conductor between towers XL001 and XL033:

Phase Conductor Type:

- XL001 – XL033 (ACSR 400mm^2 'Zebra', installed 1961).

Earthwire Conductor Type:

- XL001 – XL033 (AACSR 160mm^2 'Keziah' equivalent OPGW, installed 2009).

Insulators Type:

- XL001 – XL033 (Porcelain-Grey, installed 2009).

Tower Type:

- XL001 – XL033 (steel lattice L2 design, installed 1961).

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

- KINC-KINT. Circuit Colour: Blue/Yellow.
- KINC-TEAL. Circuit Colour: Red / White.

XL route presents a number of significant crossings adjacent to railways, main roads and HV OHL's:

- 2no. 275kV OHL crossings.
- 1no. 132kV OHL crossing.
- 2no. 33kV OHL crossings.
- 11no. 11kV OHL crossings.

- 2no. A Road crossings.
- 1no. Electrified Railway crossing.

Terrain comprises of open undulating farmland with some locations in excess of 250m (A.O.D.)

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

Data Collection

As part of the SP Energy Networks (SPEN) OHL inspection regime, aerial photographic information has been employed to provide a detailed condition analysis of the OHL components.

Data Analysis and Interpretation

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

<u>Phase and Earth wire conductors:</u>

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' (core-only greased) conductor is 45-50 years, however additional factors including quality, manufacturing and design can accelerate the typical ageing profile of the conductors.

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 XL Route 275kV	1961	11.73	3,175,395.13

**Forecasted values at the end of the RIIO-T3 period with no intervention as per NOMs methodology.*

2.2 SPNLT2025 BE Route 132kV Major Refurbishment

The existing BE Route is a double circuit overhead line that forms a 132kV connection between Dunfermline and Inverkeithing substations traversing arable land and urban areas. It is proposed to co-ordinate this work with load-related projects in RIIO-T3.

The existing phase conductor is a 175mm^2 ACSR 'Lynx' with a configuration of one conductor per phase and earth wire of single ACSR 70mm^2 'Horse' conductor.

BE route circuit is single conductor between towers BE001 and BE028:

Phase Conductor Type:

- BE001 – BE028 (ACSR 175mm^2 'Lynx', installed 1968).

Earthwire Conductor Type:

- BE001 – BE028 (ACSR 70mm^2 'Horse', installed 1968).

Insulators Type:

- BE001 – BE028 (Glass, installed 2011).

Tower Type:

- BE001 – BE028 (steel lattice, PL16 design, installed 1968).

BE route has 2 no. operating circuits with circuit nomenclatures and colours:

- MOSM-DUNF-INKE-1. Circuit Colour: (Blue).
- MOSM-DUNF-INKE-2. Circuit Colour: (Yellow / White).

BE route presents several significant crossings adjacent to railways, HV OHL's and watercourses:

- 1no. 11kV OHL crossing.
- 3no. Watercourse crossings.
- 1no. Electrified Railway crossing.

Terrain comprises of urban areas and open undulating arable land with no locations in excess of 150m (A.O.D.)

Approximately 50% of the route travels within a heavily polluted 5km zone adjacent to the coastline (Environmental class A).

Data Collection

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

Data Analysis and Interpretation

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

<u>Phase and Earth wire conductors:</u>

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 40-45 years, however additional factors including quality, manufacturing and design can accelerate the typical ageing profile of the conductors.

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 BE Route 132kV	1968	9.72	3,367,346.08

**Forecasted values at the end of the RIIO-T3 period with no intervention as per NOMs methodology.*

2.3 SPNLT2026 BV Route 132kV Major Refurbishment

The existing BV Route is a double circuit overhead line that forms a 132kV connection between Chapelcross and Ecclefechan substations traversing mainly agricultural land. It is proposed to co-ordinate this work with load-related projects in RIIO-T3.

The existing phase conductor is a 175mm^2 ACSR 'Lynx' with a configuration of one conductor per phase and earthwire of single ACSR 70mm^2 'Horse' conductor.

BV route circuit is single conductor between towers BV001 and BV022:

Phase Conductor Type:

- BV001 – BV022 (ACSR 175mm^2 'Lynx', installed 1971).

Earthwire Conductor Type:

- BV001 – BV022 (ACSR 70mm^2 'Horse', installed 1971).

Insulators Type:

- BV001 – BV022 (Glass, installed 2016).

Tower Type:

- BV001 – BV022 (steel lattice PL16 design, installed 1971).

BV route has 2 no. operating circuits with circuit nomenclatures and colours:

- CHAP-ECCF-1. Circuit Colour: (Yellow).
- CHAP-ECCF-2. Circuit Colour: (Blue / White).

BV route presents a number of significant crossing locations adjacent to railways, HV OHL's and roads:

- 2no. 11kV OHL crossing.
- 1no.33kV OHL crossing.
- 2no. B road crossings.
- 1no. Non electrified Railway crossing.

Terrain comprises of open undulating arable land with no locations in excess of 150m (A.O.D.).

Approximately 20% of the route is within the heavily polluted zone adjacent to the coastline (Environmental class A).

Data Collection

As part of the SP Energy Networks (SPEN) OHL inspection regime and aerial photographic has been employed to provide a detailed condition analysis of the OHL components.

Data Analysis and Interpretation

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

<u>Phase and Earth wire conductors:</u>

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' (all inner layers greased) conductor is 45-50 years, however additional factors including quality, manufacturing and design can accelerate the typical ageing profile of the conductors.

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 BV Route 132kV	1971	9.97	4,688,491.24

**Forecasted values at the end of the RIIO-T3 period with no intervention as per NOMs methodology.*

2.4 SPNLT2027 BR Route 132kV Major Refurbishment

The existing BR Route is a double circuit overhead line that forms a 132kV connection between Chapelcross and Dumfries substations traversing agricultural land and urban areas. It is proposed to co-ordinate this work with load-related projects in RIIO-T3.

The existing phase conductor is a 400mm^2 ACSR 'Zebra' with a configuration of one conductor per phase and earth wire of single ACSR 175mm^2 'Lynx' conductor.

BR route circuit is single conductor between towers BR001 and BR087:

Phase Conductor Type:

- BR001 – BR087 (ACSR 400mm^2 'Zebra', installed 1967).

Earthwire Conductor Type:

- BR001 – BR087 (ACSR 175mm^2 'Lynx', installed 1967).

Insulators Type:

- BR001 – BR087 (Glass, installed 2013).

Tower Type:

- BR001 – BR087 (steel lattice J.L. Eve design, installed 1967).

BR route has 2 no. operating circuits with circuit nomenclatures and colours:

- CHAP-DUMF-1. Circuit Colour: (Green / Red).
- CHAP-DUMF-2. Circuit Colour: (Black / White).

BR route presents several crossing locations adjacent to roads, railways, HV OHL's and watercourses:

- 5no. 33kV OHL crossings.
- 17no. 11kV OHL crossings.
- 1no. A road crossing (Dual Carriageway).
- 1no. Electrified Railway crossing.
- 9no. watercourses.

- Terrain comprises of open undulating arable land with no locations in excess of 100m (A.O.D.).

The route is located within the heavily polluted 5km zone adjacent to the coastline (Environmental class A).

Data Collection

As part of the SP Energy Networks (SPEN) OHL inspection regime and aerial photographic has been employed to provide a detailed condition analysis of the OHL components.

Data Analysis and Interpretation

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

<u>Phase and Earth wire conductors:</u>

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’ (core-only greased) conductor is 45-50 years, however additional factors including quality, manufacturing and design can accelerate the typical ageing profile of the conductors.

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 BR Route 132kV	1967	12.26	5,773,715.42

**Forecasted values at the end of the RIIO-T3 period with no intervention as per NOMs methodology.*

2.5 SPNLT2028 YB & YC Routes 132kV Major Refurbishment

The existing YB and YC Routes are double circuit overhead lines that form a 132kV connection between Neilston, Paisley and Braehead Park substations traversing open farmland with some sections through industrial and urban areas. It is proposed to co-ordinate this work with load-related projects in RIIO-T3.

The existing phase conductor is a 400mm^2 ACSR ‘Zebra’ with a configuration of two conductors per phase and earth wire of single ACSR 175mm^2 ‘Lynx’ conductor.

YB and YC routes circuit are twin conductor between towers (YB002 & YB041A) and (YC001 & YC005):

Phase Conductor Type:

- YB002 – YB041A (ACSR 400mm^2 ‘Zebra’, installed 1968).
- YC001 – YC005 (ACSR 400mm^2 ‘Zebra’, installed 1968).

Earthwire Conductor Type:

- YB002 – YB041A (ACSR 175mm^2 'Lynx', installed 1968).
- YC001 – YC005 (ACSR 175mm^2 'Lynx', installed 1968).

Insulators Type:

- YB002 – YB041A (Glass, installed 2009/2018).
- YC001 – YC005 (Glass, installed 2012/2014)

Tower Type:

- YB002 – YB041A (steel lattice L2/L8 design, installed 1968).
- YC001 – YC005 (steel lattice L2 design, installed 1968).

YB and YC routes have 2 no. operating circuits with circuit nomenclatures and colours:

- NEIL-PAIS-BRAP. Circuit Colour: (Yellow / White).
- NEIL-PAIS-GOVA-HAGR 1. Circuit Colour: (Green / Red).

YB and YC route presents several crossing locations adjacent to roads, railways, HV OHL's, buildings and watercourses:

- 1no. 11kV OHL crossings.
- 1no. A road crossing (Dual Carriageway).
- 3no. Electrified Railway crossings.
- 2no. Buildings crossings.
- 10no. watercourse crossings.

Terrain comprises of open undulating land with some locations in excess of 200m (A.O.D.)

The route is within the heavily polluted zone adjacent to industrial areas. (Environmental class A).

Data Collection

As part of the SP Energy Networks (SPEN) OHL inspection regime, aerial photographic information has been employed to provide a detailed condition analysis of the OHL components.

Data Analysis and Interpretation

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

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' (core-only greased) conductor is 45-50 years in a high polluted area, however additional factors including quality, manufacturing and design can accelerate the typical ageing profile of the conductors.

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 YB & YC Route 132kV	1968	12.36	5,822,043.10

**Forecasted values at the end of the RIIO-T3 period with no intervention as per NOMs methodology.*

2.6 SPNLT2029 XW Route 275kV Major Refurbishment

The existing XW Route is a double circuit overhead lines that forms a 275kV connection between Kilmarnock South and Kilmarnock Town substations traversing open farmland with some sections through industrial areas. It is proposed to co-ordinate this work with load-related projects in RIIO-T3.

The existing phase conductor is a 400mm^2 ACSR 'Zebra' with a configuration of two conductor per phase and earth wire of single ACSR 175mm^2 'Lynx'(fibre wrap) conductor.

XW route circuit is a twin conductor between towers XW001 & XW012:

Phase Conductor Type:

- XW001 – XW012 (ACSR 400mm^2 'Zebra', installed 1965).

Earthwire Conductor Type:

- XW001 – XW012 (ACSR 175mm^2 'Lynx'(fibre wrap), installed 1965 & 1994 respectively).

Insulators Type:

- XW001 – XW012 (Glass, installed 2011).

Tower Type:

- XW001 – XW012 (steel lattice L2 design, installed 1965).

YB and YC routes have 2 no. operating circuits with circuit nomenclatures and colours:

- KILS-KILT-1. Circuit Colour: (Green / White).
- KILS-KILT-2. Circuit Colour: (Red / Blue).

XW route presents several significant crossing locations adjacent to roads, railways, HV OHL's, buildings and watercourses:

- 1no. A road crossings (Dual Carriageway).
- 2no. A road crossings.
- 1no. 33kV OHL crossing.
- 1no. 11kV OHL crossing.

Terrain comprises of open undulating land with no locations in excess of 100m (A.O.D.)

The route is within an industrial area with moderate pollution (Environmental class B).

Data Collection

As part of the SP Energy Networks (SPEN) OHL inspection regime, aerial photographic information has been employed to provide a detailed condition analysis of the OHL components.

Data Analysis and Interpretation

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

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' (core-only greased) conductor is 50-60 years in a moderate polluted area, however additional factors including quality, manufacturing and design can accelerate the typical ageing profile of the conductors.

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 XW Route 275kV	1965	9.50	934,974.04

** Forecasted values at the end of the RIIO-T3 period with no intervention as per NOMs methodology.*

2.7 SPNLT2030 XT Route 275kV Major Refurbishment

The existing XT Route is a double circuit overhead line that forms a 275kV connection between Currie and Sighthill substations traversing open farmland areas. It is proposed to co-ordinate this work with load-related projects in RIIO-T3.

The existing phase conductor is a 400mm^2 ACSR 'Zebra' with a configuration of two conductors per phase and earth wire of single ACSR 175mm^2 'Lynx'(fibre wrap) conductor.

XT route circuit is a twin conductor between towers XT007 & XT012:

Phase Conductor Type:

- XT007 – XT012 (ACSR 400mm^2 'Zebra', installed 1964).

Earthwire Conductor Type:

- XT007 – XT012 (ACSR 175mm^2 'Lynx'(fibre wrap), installed 1964 & 1992 respectively).

Insulators Type:

- XT007 – XT012 (Glass, installed 2015).

Tower Type:

- XT007 – XT012 (steel lattice L2 design, installed 1964).

XT route has 2 no. operating circuits with circuit nomenclatures and colours:

- CURR-SIGH-1. Circuit Colour: (Black / White).
- CURR-SIGH-2. Circuit Colour: (Red).

XT route presents several significant crossing locations adjacent to railways and HV OHL's:

- 1no. electrified railway crossing.
- 1no. 11kV OHL crossing.

Terrain comprises of open undulating land with no locations in excess of 150m (A.O.D.)

The route is within an industrial area with moderate pollution (Environmental class B).

Data Collection

As part of the SP Energy Networks (SPEN) OHL inspection regime, aerial photographic has been employed to provide a detailed condition analysis of the OHL components.

Data Analysis and Interpretation

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

<u>Phase and Earth wire conductors:</u>

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' (core-only greased) conductor is 50-60 years in a moderate polluted area, however additional factors including quality, manufacturing and design can accelerate the typical ageing profile of the conductors.

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 XT Route 275kV	1964	9.44	510,459.86

**Forecasted values at the end of the RIIO-T3 period with no intervention as per NOMs methodology.*

2.8 SPNLT2031 YF Route 275kV Major Refurbishment

The existing YF Route is a double circuit overhead lines that forms a 275kV connection between Clydesmill and Dalmarnock substations traversing industrial and urban areas. It is proposed to co-ordinate this work with load-related projects in RIIO-T3.

The existing phase conductor is a 400mm^2 ACSR 'Zebra' with a configuration of two conductor per phase and earth wire of single ACSR 175mm^2 'Lynx'(fibre wrap) conductor.

YF route circuit is a twin conductor between towers YF001B & YF014:

Phase Conductor Type:

- YF001B – YF014 (ACSR 400mm^2 'Zebra', installed 1969).

Earthwire Conductor Type:

- YF001B – YF014 (ACSR 175mm^2 'Lynx'(fibre wrap), installed 1969 & 1992 respectively).

Insulators Type:

- YF001B – YF014 (Glass, installed 2004).

Tower Type:

- YF001B – YF014 (steel lattice L2 design, installed 1969).

YF route has 2 no. operating circuits with circuit nomenclatures and colours:

- CLYM-DALM-CHAS-1. Circuit Colour: (Yellow / White).
- CLYM-DALM-CHAS-2. Circuit Colour: (Red / Blue).

YF route presents several significant crossing locations adjacent to railways, roads, buildings and watercourses:

- 2no. Electrified railway crossings.
- 12no. Buildings crossings.
- 1no. Motorway (M74) crossing.
- 1no. A road crossing.

Terrain comprises of open undulating land with no locations in excess of 100m (A.O.D.)

The route is within the heavily polluted area (Environmental class A).

Data Collection

As part of the SP Energy Networks (SPEN) OHL inspection regime, aerial photographic has been employed to provide a detailed condition analysis of the OHL components.

Data Analysis and Interpretation

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

<u>Phase and Earth wire conductors:</u>

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' (core-only greased) conductor is 45-50 years in a heavy polluted area, however additional factors including quality, manufacturing and design can accelerate the typical ageing profile of the conductors.

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 YF Route 275kV	1969	12.47	9,556,895.86

**Forecasted values at the end of the RIIO-T3 period with no intervention as per NOMs methodology.*

2.9 SPNLT2032 XD119-131/XN/XK/XM Route 275kV Major Refurbishment

The existing XD, XN, XK and XM Routes are double circuit overhead lines that forms a 275kV connection between Kincardine, Grangemouth and Currie substations traversing open farmland with some sections through industrial and urban areas. It is proposed to co-ordinate this work with load-related projects in RIIO-T3.

The existing phase conductor on XD is a 400mm^2 ACSR 'Zebra' with a configuration of two conductor per phase and earthwire of single ACSR 175mm^2 'Lynx' conductor.

The existing phase conductor on XN and XK is a 400mm^2 ACSR 'Zebra' with a configuration of two conductor per phase and earthwire of single ACSR 175mm^2 'Lynx'(fibre wrap) conductor.

The existing phase conductor on XM is a 400mm^2 ACSR 'Zebra' with a configuration of two conductor per phase and earthwire of single AACSR 160mm^2 'Keziah' conductor.

XD, XN, XK and XM routes circuits are twin conductor between towers (XD119 & XD131), (XN001 & XN032), (XK004 & XK035) and (XM001 & XM093):

Phase Conductor Type:

- XD119 – XD131 (ACSR 400mm^2 'Zebra', installed 1962).
- XN001 – XN032 (ACSR 400mm^2 'Zebra', installed 1965).
- XK004 – XK035 (ACSR 400mm^2 'Zebra', installed 1964).
- XM001 – XM093 (ACSR 400mm^2 'Zebra', installed 1965).

Earthwire Conductor Type:

- XD119 – XD131 (ACSR 175mm^2 'Lynx', installed 1962).
- XN001 – XN032 (ACSR 175mm^2 'Lynx'(fibre wrap), installed 1965 & 1992 respectively).
- XK004 – XK035 (ACSR 175mm^2 'Lynx'(fibre wrap), installed 1964 & 1992 respectively).
- XM001 – XM093 (AACSR 160mm^2 'Keziah', installed 2020).

Insulators Type:

- XD119 – XD131 (Glass, installed 2020).
- XN001 – XN032 (Glass, installed 2004; except XN030A).
- XK004 – XK035 (Glass, installed 2020).
- XM001 – XM093 (Glass, installed 2020).

Tower Type:

- XD119 – XD131 (steel lattice L2 design, installed 1962).
- XN001 – XN032 (steel lattice L2 design, installed 1965).
- XK004 – XK035 (steel lattice L2 design, installed 1964).
- XM001 – XN093 (steel lattice L2 design, installed 1965).

XD route has 2 no. operating circuits with circuit nomenclatures and colours:

- CURR-KINC. Circuit Colour: (Green / Red).
- GRMO-KINC. Circuit Colour: (Red).

XN route has 3 no. operating circuits with circuit nomenclatures and colours:

- CURR-GRMO. Circuit Colour: (Black / Green).
- CURR-KINC. Circuit Colour: (Green / Red).
- GRMO-KINC. Circuit Colour: (Red)

XK route has 2 no. operating circuits with circuit nomenclatures and colours:

- CURR-GRMO. Circuit Colour: (Black / Green).
- CURR-KINC. Circuit Colour: (Green / Red).

XM route has 2 no. operating circuits with circuit nomenclatures and colours:

- CURR-GRMO. Circuit Colour: (Black / Green).
- CURR-KINC. Circuit Colour: (Green / Red).

XD, XN, XK & XM routes presents several significant crossing locations adjacent to HV OHL's, roads, railways, buildings pipelines and watercourses:

XD Route:

- 5no. 11kV OHL crossings.
- 1no. Buildings crossing.
- 1no. A road crossing.

Terrain comprises of open undulating land with no locations in excess of 100m (A.O.D.)

The routes are within the heavily polluted zone adjacent to coastline (Environmental class A).

XN Route:

- 10no. Pipeline crossings
- 4no. Motorway crossings.
- 4no. A road crossings (Dual Carriageway).
- 3no. A road crossings.
- 1no. Electrified Railway crossing.
- 8no. Buildings crossings.
- 1no. 11kV OHL crossing.
- 1no. watercourse crossing.

Terrain comprises of open undulating land with some urban areas and no locations in excess of 100m (A.O.D.)

The route is within the heavily polluted zone adjacent to coastline. (Environmental class A).

XK Route:

- 1no. Pipeline crossings
- 1no. Motorway crossings.
- 4no. A road crossings.
- 14no. B road crossings.
- 1no. Electrified Railway crossing.
- 8no. Buildings crossings.
- 14no. 11kV OHL crossing.
- 1no. watercourse crossing.

Terrain comprises of open undulating land with some locations in excess of 150m (A.O.D.)

Approximately 50% of the route is within the heavily polluted zone adjacent to the coastline. (Environmental class A).

XM Route:

- 2no. Motorway crossings.
- 8no. A road crossings.
- 22no. B road crossings.
- 8no. Electrified Railway crossings.
- 1no. Non Electrified Railway crossing.
- 6no. Buildings crossings.
- 21no. 11kV OHL crossings.
- 2no. watercourse crossings.

Terrain comprises of open undulating land with some urban and industrial areas and some locations in excess of 200m (A.O.D.)

The route is within the heavily polluted zone adjacent to coastline. (Environmental class A).

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 samples taken from the routes have been employed to provide a detailed condition analysis of the OHL components.

Data Analysis and Interpretation

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

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' (core-only greased) conductor is 45-50 years in a heavy polluted area, however additional factors including quality, manufacturing and design can accelerate the typical ageing profile of the conductors.

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 XD Routes 275kV XN Route 275kV XK Route 275kV XM Route 275kV	1962 1965 1964 1965	9.64	44,927,782.83

**Forecasted values at the end of the RIIO-T3 period with no intervention as per NOMs methodology.*

3. Optioneering

Two options have been considered based on the requirements identified within the condition assessments produced for the existing overhead line routes highlighted within the document, where Option 1 has been recognised as the only option which meets the project objectives.

Option	Status	Reason for rejection
Baseline - Do Nothing in T2 • Development works to be delayed to the start of T3 with the expectation to deliver the refurbishment works for all routes during T4.	Considered	Delaying the development of this programme of works beyond 2026 would not allowed the full scope to be delivered during the assumed RIIO-T3 price control (2027-2031) adding considerable risk to these circuits within the SPT Network. Deferring the investment beyond 2031 will accelerate the continual deterioration of the OHL components; in particular the phase conductor which strength will be compromised preventing its use as pulling bond, significantly increasing the costs for conductor stringing activities.
Option 1 – Development works in T2 • Development works in T2 for a full refurbishment to be delivered within the RIIO-T3 period.	Considered and Proposed	The early development of this programme of works during T2 will enable SPT to deliver its OHL long-term asset management strategy ensuring the OHL network risk is kept within acceptable levels within SPT Network.

4. Detailed analysis

Option 1 achieves the main objective of replacing phase conductor while refurbishing the OHL Towers and thereby reducing the overall risks to the network and costs before the end of RIIO-T3. Option 1 will be refreshed and a full CBA will be undertaken to support the RIIO-T3 business plan. The funding requested by this scheme will be subject to true-up at the end of RIIO-T2 [reference Draft Determination, ET Sector Annex para 3.33].

4.1 SPNLT2024 XL Route 275kV Major Refurbishment

- **Option 1: Full Refurbishment**

This option considers the replacement of all phase conductors as identified earlier through condition data, data analysis and interrogation. The following interventions are proposed for replacement in a staged manner within this option:

- Re-conductor all circuits between towers XL001- XL033 with twin ‘Totara’ 425mm^2 All Aluminium Alloy Conductor (AAAC) EHC at maximum 90C for operation at 275kV.
- Replace all tension and suspension conductor end fittings.
- Upgrade foundations as required per condition.
- Replace downleads and fittings at Kincardine substation.

- Steelwork modifications as per TGN161 and TGN163.
- Replace heavily corroded (above category 4) and damaged steelwork.
- 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, twin 425mm2 AAAC (Totara) EHC system thermal ratings*:

Season / State	Amps	MVA
Winter Pre Fault	2430	1160
Winter Post Fault	2890	1380
Spring/Autumn Pre Fault	2330	1110
Spring/Autumn Post Fault	2770	1320
Summer Pre Fault	2170	1030
Summer Post Fault	2580	1230

**at 90C Maximum Operation Temperature.*

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

- Works also include for exploratory ground investigations to assess the condition of the tower foundations below ground level. Above ground foundation and/or muffs will be repaired or replaced where required by condition.

  The majority of SPT towers use foundations of the pyramid block and chimney design with the remainder being ‘special’ or piled foundations. The majority of well-constructed foundations using the appropriate materials presents no significant degradation of the foundations, however workmanship and past design and detailing can pose potentially serious problems. Insufficient embedment of tower stubs into the foundation and lack of cleats can result in uplift failures where the pyramid block remains in the ground. Corrosion of the tower at the steel stub can occur when moisture and oxygen come in contact with it and is usually only found at the chimney/muff interface where poor construction exposes it to the elements.

  SPT has developed a methodology (applied in RIIO-T1) based on a comprehensive desktop/site intrusive study to undertake a Quantified Risk Assessment (QRA) approach to determine the foundation sites that require refurbishment based on the following criteria:

    - Importance of the circuits.
    - Ground investigation desktop study. Misalignment of installed foundation type with soil type identified on the British Geological Survey (BGS) maps.
    - Tower lean and towers required to have wind stays removed under the contract.
    - Highly loaded towers (in relation to new and design loads).
    - Access difficulties.
    - Proximity to crossings, residential areas, etc.
    - Other high risk factors (e.g. existing damage, relative location to highly distressed towers, etc.).

- Primary investigations (Level 1 inspection): non-intrusive surveys.
- Secondary investigations (Level 2 inspection): foundation intrusive.

Following consideration of the above elements, a risk rating is applied grading the perceived suitability which shall form the basis for any recommendation of foundation refurbishments.

Based on the experience gathered in RIIO-T1 for the same type of towers and age, an allowance of 10% of the suspension towers and all pulling positions shall be allocated to the project for foundation intrusive investigation and potential refurbishment.

- Consideration for body extension modifications and replacement of the suspension insulator cross-arm channels following TGN161 and TGN163 respectively.
- Allowances for undergrounding of distribution crossings have also been considered.

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 operation/wayleave/environmental restrictions which impact on the progression of works as planned.

Option 1 achieves the main objective of replacing conductor, fittings and spacers while refurbishing the OHL Towers and thereby reducing the overall risks to the network and costs.

4.2 SPNLT2025 BE Route 132kV Major Refurbishment

- **Option 1: Full Refurbishment**

This option considers the replacement of all phase conductors and earthwire assets as identified earlier through condition data, data analysis and interrogation. The following interventions are proposed for replacement in a staged manner within this option:

- Re-conductor all circuits between towers (BE001- BE028) with single ‘Poplar’ 200mm^2 All Aluminium Alloy Conductor (AAAC) EHC at maximum 75C for operation at 132kV.
- Replace earthwire, towers (BE001 – BE028) with a single ‘Horse’ 70mm^2 AACSR equivalent OPGW.
- Replace all tension and suspension conductor end fittings.

- Replace tower muff foundations where required.
- Upgrade foundations as required per condition.
- Replace downleads and fittings at Inverkeithing substation and at sealing end platform, Dunfermline substation.
- Replace heavily corroded (above category 4) and damaged steelwork.
- 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 75C Maximum Operation Temperature*

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

- Works also include for exploratory ground investigations to assess the condition of the tower foundations below ground level. Above ground foundation and/or muffs will be repaired or replaced where required by condition.

  The majority of SPT towers use foundations of the pyramid block and chimney design with the remainder being ‘special’ or piled foundations. The majority of well-constructed foundations using the appropriate materials presents no significant degradation of the foundations, however workmanship and past design and detailing can pose potentially serious problems. Insufficient embedment of tower stubs into the foundation and lack of cleats can result in uplift failures where the pyramid block remains in the ground. Corrosion of the tower at the steel stub can occur when moisture and oxygen come in contact with it and is usually only found at the chimney/muff interface where poor construction exposes it to the elements.

  SPT has developed a methodology (applied in RIIO-T1) based on a comprehensive desktop/site intrusive study to undertake a Quantified Risk Assessment (QRA) approach to determine the foundation sites that require refurbishment based on the following criteria:

    - Importance of the circuits.
    - Ground investigation desktop study. Misalignment of installed foundation type with soil type identified on the British Geological Survey (BGS) maps.
    - Tower lean and towers required to have wind stays removed under the contract.
    - Highly loaded towers (in relation to new and design loads).
    - Access difficulties.

- Proximity to crossings, residential areas, etc.
- Other high risk factors (e.g. existing damage, relative location to highly distressed towers, etc.).
- Primary investigations (Level 1 inspection): non-intrusive surveys.
- Secondary investigations (Level 2 inspection): foundation intrusive.

Following consideration of the above elements, a risk rating is applied grading the perceived suitability which shall form the basis for any recommendation of foundation refurbishments.

Based on the experience gathered in RIIO-T1 for the same type of towers and age, an allowance of 10% of the suspension towers and all pulling positions shall be allocated to the project for foundation intrusive investigation and potential refurbishment.

- Allowances for undergrounding of distribution crossings have also been considered.

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 operation/wayleave/environmental restrictions which impact on the progression of works as planned.

Option 1 achieves the main objective of replacing conductor and fittings while refurbishing the OHL Towers and thereby reducing the overall risks to the network and costs.

4.3 SPNLT2026 BV Route 132kV Major Refurbishment

- **Option 1: Full Refurbishment**

This option considers the replacement of all phase conductors and earthwire assets as identified earlier through condition data, data analysis and interrogation. The following interventions are proposed for replacement in a staged manner within this option:

- Re-conductor all circuits between towers (BV001- BV022) with single ‘Poplar’ 200mm^2 All Aluminium Alloy Conductor (AAAC) EHC at maximum 75C for operation at 132kV.
- Replace earthwire, towers (BV001 – BV022) with a single ‘Horse’ 70mm^2 AACSR equivalent OPGW.

- Replace all tension and suspension conductor end fittings.
- Replace tower muff foundations where required.
- Upgrade foundations as required per condition.
- Replace downleads and fittings at Ecclefechan substation and at sealing end platform, Chapelcross substation.
- Replace heavily corroded (above category 4) and damaged steelwork.
- 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 75C Maximum Operation Temperature*

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

- Works also include for exploratory ground investigations to assess the condition of the tower foundations below ground level. Above ground foundation and/or muffs will be repaired or replaced where required by condition.

  The majority of SPT towers use foundations of the pyramid block and chimney design with the remainder being 'special' or piled foundations. The majority of well-constructed foundations using the appropriate materials presents no significant degradation of the foundations, however workmanship and past design and detailing can pose potentially serious problems. Insufficient embedment of tower stubs into the foundation and lack of cleats can result in uplift failures where the pyramid block remains in the ground. Corrosion of the tower at the steel stub can occur when moisture and oxygen come in contact with it and is usually only found at the chimney/muff interface where poor construction exposes it to the elements.

  SPT has developed a methodology (applied in RIIO-T1) based on a comprehensive desktop/site intrusive study to undertake a Quantified Risk Assessment (QRA) approach to determine the foundation sites that require refurbishment based on the following criteria:

  - Importance of the circuits.
  - Ground investigation desktop study. Misalignment of installed foundation type with soil type identified on the British Geological Survey (BGS) maps.
  - Tower lean and towers required to have wind stays removed under the contract.
  - Highly loaded towers (in relation to new and design loads).

- o Access difficulties.
- o Proximity to crossings, residential areas, etc.
- o Other high risk factors (e.g. existing damage, relative location to highly distressed towers, etc.).
- o Primary investigations (Level 1 inspection): non-intrusive surveys.
- o Secondary investigations (Level 2 inspection): foundation intrusive.

Following consideration of the above elements, a risk rating is applied grading the perceived suitability which shall form the basis for any recommendation of foundation refurbishments.

Based on the experience gathered in RIIO-T1 for the same type of towers and age, an allowance of 10% of the suspension towers and all pulling positions shall be allocated to the project for foundation intrusive investigation and potential refurbishment.

- Allowances for undergrounding of distribution crossings have also been considered.
- Temporary ADSS Telecom conductor to provide diversion to the existing earthwire fibre wrap.

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 operation/wayleave/environmental restrictions which impact on the progression of works as planned.

Option 1 achieves the main objective of replacing conductor and while refurbishing the OHL Towers and thereby reducing the overall risks to the network and costs.

4.4 SPNLT2027 BR Route 132kV Major Refurbishment

- o **Option 1: Full Refurbishment**

This option considers the replacement of all phase conductors and earthwire assets as identified earlier through condition data, data analysis and interrogation. The following interventions are proposed for replacement in a staged manner within this option:

- Re-conductor all circuits between towers BR001 – BR087 with single 'Totara' 425mm^2 All Aluminium Alloy Conductor (AAAC) EHC at maximum 90C for operation at 132 kV.
- Replace earthwire with a single 'Keziah' 160mm^2 AACSR equivalent OPGW.
- Replace all tension and suspension and conductor end fittings.
- Replace tower muff foundations where required.
- Upgrade foundations as required per condition.
- Replace downleads including fittings at Dumfries substation and at sealing end platform/slackspan, Chapelcross substation.
- Replace heavily corroded (above category 4) and damaged steelwork.
- 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 425mm^2 AAAC (Totara) EHC system thermal ratings*:

Season / State	Amps	MVA
Winter Pre Fault	1220	280
Winter Post Fault	1450	330
Spring/Autumn Pre Fault	1170	265
Spring/Autumn Post Fault	1390	320
Summer Pre Fault	1090	249
Summer Post Fault	1300	295

**at 90C Maximum Operation Temperature.*

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

- Works also include for exploratory ground investigations to assess the condition of the tower foundations below ground level. Above ground foundation and/or muffs will be repaired or replaced where required by condition.

  The majority of SPT towers use foundations of the pyramid block and chimney design with the remainder being 'special' or piled foundations. The majority of well-constructed foundations using the appropriate materials presents no significant degradation of the foundations, however workmanship and past design and detailing can pose potentially serious problems. Insufficient embedment of tower stubs into the foundation and lack of cleats can result in uplift failures where the pyramid block remains in the ground. Corrosion of the tower at the steel stub can occur when moisture and oxygen come in contact with it and is usually only found at the chimney/muff interface where poor construction exposes it to the elements.

  SPT has developed a methodology (applied in RIIO-T1) based on a comprehensive desktop/site intrusive study to undertake a Quantified Risk Assessment (QRA) approach to determine the foundation sites that require refurbishment based on the following criteria:

  - Importance of the circuits.
  - Ground investigation desktop study. Misalignment of installed foundation type with soil type identified on the British Geological Survey (BGS) maps.

- Tower lean and towers required to have wind stays removed under the contract.
- Highly loaded towers (in relation to new and design loads).
- Access difficulties.
- Proximity to crossings, residential areas, etc.
- Other high risk factors (e.g. existing damage, relative location to highly distressed towers, etc.).
- Primary investigations (Level 1 inspection): non-intrusive surveys.
- Secondary investigations (Level 2 inspection): foundation intrusive.

Following consideration of the above elements, a risk rating is applied grading the perceived suitability which shall form the basis for any recommendation of foundation refurbishments.

Based on the experience gathered in RIIO-T1 for the same type of towers and age, an allowance of 10% of the suspension towers and all pulling positions shall be allocated to the project for foundation intrusive investigation and potential refurbishment.

- Allowances for undergrounding of distribution crossings have also been considered.

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 operation/wayleave/environmental restrictions which impact on the progression of works as planned.

Option 1 achieves the main objective of replacing conductor and fittings refurbishing the OHL Towers and thereby reducing the overall risks to the network and costs.

4.5 SPNLT2028 YB & YC Routes 132kV Major Refurbishment

- **Option 1: Full Refurbishment**

This option considers the replacement of all phase conductors and earthwire assets as identified earlier through condition data, data analysis and interrogation. The following interventions are proposed for replacement in a staged manner within this option:

- Re-conductor all circuits between towers YB002 - YB041A and towers YC001 – YC005 with twin 'Totara' 425mm^2 All Aluminium Alloy Conductor (AAAC) EHC at maximum 90C for operation at 132kV.
- Replace earthwire with a single 'Keziah' 160mm^2 AACSR equivalent OPGW.
- Replace all tension and suspension and conductor end fittings.
- Replace tower muff foundations where required.
- Upgrade foundations as required per condition.
- Replace downleads including fittings at Paisley substation and at sealing end platform tower(YB041A) and Neilston substation.
- Steelwork modifications as per TGN161 and TGN163.
- Replace heavily corroded (above category 4) and damaged steelwork.
- 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, twin 425mm2 AAAC (Totara) EHC system thermal ratings*:

Season / State	Amps	MVA
Winter Pre Fault	2400	550
Winter Post Fault	2860	655
Spring/Autumn Pre Fault	2300	525
Spring/Autumn Post Fault	2740	630
Summer Pre Fault	2150	490
Summer Post Fault	2560	585

**at 90C Maximum Operation Temperature.*

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

- Works also include for exploratory ground investigations to assess the condition of the tower foundations below ground level. Above ground foundation and/or muffs will be repaired or replaced where required by condition.

  The majority of SPT towers use foundations of the pyramid block and chimney design with the remainder being 'special' or piled foundations. The majority of well-constructed foundations using the appropriate materials presents no significant degradation of the foundations, however workmanship and past design and detailing can pose potentially serious problems. Insufficient embedment of tower stubs into the foundation and lack of cleats can result in uplift failures where the pyramid block remains in the ground. Corrosion of the tower at the steel stub can occur when moisture and oxygen come in contact with it and is usually only found at the chimney/muff interface where poor construction exposes it to the elements.

  SPT has developed a methodology (applied in RIIO-T1) based on a comprehensive desktop/site intrusive study to undertake a Quantified Risk Assessment (QRA) approach to determine the foundation sites that require refurbishment based on the following criteria:

  - Importance of the circuits.
  - Ground investigation desktop study. Misalignment of installed foundation type with soil type identified on the British Geological Survey (BGS) maps.
  - Tower lean and towers required to have wind stays removed under the contract.
  - Highly loaded towers (in relation to new and design loads).
  - Access difficulties.
  - Proximity to crossings, residential areas, etc.
  - Other high risk factors (e.g. existing damage, relative location to highly distressed towers, etc.).
  - Primary investigations (Level 1 inspection): non-intrusive surveys.
  - Secondary investigations (Level 2 inspection): foundation intrusive.

  Following consideration of the above elements, a risk rating is applied grading the perceived suitability which shall form the basis for any recommendation of foundation refurbishments.

  Based on the experience gathered in RIIO-T1 for the same type of towers and age, an allowance of 10% of the suspension towers and all pulling positions shall be allocated to the project for foundation intrusive investigation and potential refurbishment.

- Consideration for body extension modifications and replacement of the suspension insulator cross-arm channels following TGN161 and TGN163 respectively.
- Allowances for undergrounding of distribution crossings have also been considered.

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 operation/wayleave/environmental restrictions which impact on the progression of works as planned.

Option 1 achieves the main objective of replacing conductor and fittings while refurbishing the OHL Towers and thereby reducing the overall risks to the network and costs.

4.6 SPNLT2029 XW Route 275kV Major Refurbishment

- **Option 1: Full Refurbishment**

This option considers the replacement of all phase conductors and earthwire assets as identified earlier through condition data, data analysis and interrogation. The following interventions are proposed for replacement in a staged manner within this option:

- Re-conductor all circuits between towers XW001- XW012 with twin 'Totara' 425mm^2 All Aluminium Alloy Conductor (AAAC) EHC at maximum 90C for operation at 275kV.
- Replace earthwire with a single 'Keziah' 160mm^2 AACSR equivalent OPGW.
- Replace all tension and suspension and conductor end fittings.
- Replace tower muff foundations where required.
- Upgrade foundations as required per condition.
- Replace downleads including fittings at Kilmarnock Town substation and at sealing end platform, Kilmarnock South substation.
- Steelwork modifications as per TGN161 and TGN163.
- Replace heavily corroded (above category 4) and damaged steelwork.
- 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, twin 425mm2 AAAC (Totara) EHC system thermal ratings*:

Season / State	Amps	MVA
Winter Pre Fault	2430	1160
Winter Post Fault	2890	1380
Spring/Autumn Pre Fault	2330	1110
Spring/Autumn Post Fault	2770	1320
Summer Pre Fault	2170	1030
Summer Post Fault	2580	1230

**at 90C Maximum Operation Temperature.*

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

- Works also include for exploratory ground investigations to assess the condition of the tower foundations below ground level. Above ground foundation and/or muffs will be repaired or replaced where required by condition.

  The majority of SPT towers use foundations of the pyramid block and chimney design with the remainder being 'special' or piled foundations. The majority of well-constructed foundations using the appropriate materials presents no significant degradation of the foundations, however workmanship and past design and detailing can pose potentially serious problems. Insufficient embedment of tower stubs into the foundation and lack of cleats can result in uplift failures where the pyramid block remains in the ground. Corrosion of the tower at the steel stub can occur when moisture and oxygen come in contact with it and is usually only found at the chimney/muff interface where poor construction exposes it to the elements.

SPT has developed a methodology (applied in RIIO-T1) based on a comprehensive desktop/site intrusive study to undertake a Quantified Risk Assessment (QRA) approach to determine the foundation sites that require refurbishment based on the following criteria:

- Importance of the circuits.
- Ground investigation desktop study. Misalignment of installed foundation type with soil type identified on the British Geological Survey (BGS) maps.
- Tower lean and towers required to have wind stays removed under the contract.
- Highly loaded towers (in relation to new and design loads).
- Access difficulties.
- Proximity to crossings, residential areas, etc.
- Other high risk factors (e.g. existing damage, relative location to highly distressed towers, etc.).
- Primary investigations (Level 1 inspection): non-intrusive surveys.
- Secondary investigations (Level 2 inspection): foundation intrusive.

Following consideration of the above elements, a risk rating is applied grading the perceived suitability which shall form the basis for any recommendation of foundation refurbishments.

Based on the experience gathered in RIIO-T1 for the same type of towers and age, an allowance of 10% of the suspension towers and all pulling positions shall be allocated to the project for foundation intrusive investigation and potential refurbishment.

- Consideration for body extension modifications and replacement of the suspension insulator cross-arm channels following TGN161 and TGN163 respectively.
- Allowances for undergrounding of distribution crossings have also been considered.
- Temporary ADSS Telecom conductor to provide diversion to the existing earthwire fibre wrap.

<u>The following specific risks have been identified for this option:</u>

- 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 operation/wayleave/environmental restrictions which impact on the progression of works as planned.

Option 1 achieves the main objective of replacing conductor and fittings while refurbishing the OHL Towers and thereby reducing the overall risks to the network and costs.

4.7 SPNLT2030 XT Route 275kV Major Refurbishment

- **Option 1: Full Refurbishment**

This option considers the replacement of all phase conductors and earthwire assets as identified earlier through condition data, data analysis and interrogation. The following interventions are proposed for replacement in a staged manner within this option:

- Re-conductor all circuits between towers XT007- XT012 with twin 'Totara' 425mm^2 All Aluminium Alloy Conductor (AAAC) EHC at maximum 90C for operation at 275kV.
- Replace earthwire with a single 'Keziah' 160mm^2 AACSR equivalent OPGW.
- Replace all tension and suspension conductor end fittings.
- Replace tower muff foundations where required.
- Upgrade foundations as required per condition.
- Replace downleads including fittings at Currie substation and at sealing end platform, tower XT007.
- Steelwork modifications as per TGN161 and TGN163.
- Replace heavily corroded (above category 4) and damaged steelwork.
- 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, twin 425mm2 AAAC (Totara) EHC system thermal ratings*:

Season / State	Amps	MVA
Winter Pre Fault	2430	1160
Winter Post Fault	2890	1380
Spring/Autumn Pre Fault	2330	1110
Spring/Autumn Post Fault	2770	1320
Summer Pre Fault	2170	1030
Summer Post Fault	2580	1230

**at 90C Maximum Operation Temperature.*

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

- Works also include for exploratory ground investigations to assess the condition of the tower foundations below ground level. Above ground foundation and/or muffs will be repaired or replaced where required by condition.

The majority of SPT towers use foundations of the pyramid block and chimney design with the remainder being 'special' or piled foundations. The majority of well-constructed foundations using the appropriate materials presents no significant degradation of the foundations, however workmanship and past design and detailing can pose potentially serious problems. Insufficient embedment of tower stubs into the foundation and lack of cleats can result in uplift failures where the pyramid block remains in the ground. Corrosion of the tower at the steel stub can occur when moisture and oxygen come in contact with it and is usually only found at the chimney/muff interface where poor construction exposes it to the elements.

SPT has developed a methodology (applied in RIIO-T1) based on a comprehensive desktop/site intrusive study to undertake a Quantified Risk Assessment (QRA) approach to determine the foundation sites that require refurbishment based on the following criteria:

- Importance of the circuits.
- Ground investigation desktop study. Misalignment of installed foundation type with soil type identified on the British Geological Survey (BGS) maps.
- Tower lean and towers required to have wind stays removed under the contract.
- Highly loaded towers (in relation to new and design loads).
- Access difficulties.
- Proximity to crossings, residential areas, etc.
- Other high risk factors (e.g. existing damage, relative location to highly distressed towers, etc.).
- Primary investigations (Level 1 inspection): non-intrusive surveys.
- Secondary investigations (Level 2 inspection): foundation intrusive.

Following consideration of the above elements, a risk rating is applied grading the perceived suitability which shall form the basis for any recommendation of foundation refurbishments.

Based on the experience gathered in RIIO-T1 for the same type of towers and age, an allowance of 10% of the suspension towers and all pulling positions shall be allocated to the project for foundation intrusive investigation and potential refurbishment.

- Consideration for body extension modifications and replacement of the suspension insulator cross-arm channels following TGN161 and TGN163 respectively.
- Allowances for undergrounding of distribution crossings have also been considered.
- Temporary ADSS Telecom conductor to provide diversion to the existing earthwire fibre wrap.

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 operation/wayleave/environmental restrictions which impact on the progression of works as planned.

Option 1 achieves the main objective of replacing conductor and fittings while refurbishing the OHL Towers and thereby reducing the overall risks to the network and costs.

4.8 SPNLT2031 YF Route 275kV Major Refurbishment

- **Option 1: Full Refurbishment**

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

- Re-conductor all circuits between towers YF001B- YF014 with twin 'Totara' 425mm^2 All Aluminium Alloy Conductor (AAAC) EHC at maximum 90C for operation at 275kV.
- Replace earthwire with a single 'Keziah' 160mm^2 AACSR equivalent OPGW.
- Replace all tension and suspension conductor end fittings.
- Replace tower muff foundations where required.
- Upgrade foundations as required per condition.
- Replace downleads including fittings at Clydesmill and Dalmarnock substations.
- Steelwork modifications as per TGN161 and TGN163.
- Replace heavily corroded (above category 4) and damaged steelwork.
- 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, twin 425mm2 AAAC (Totara) EHC system thermal ratings*:

Season / State	Amps	MVA
Winter Pre Fault	2430	1160
Winter Post Fault	2890	1380
Spring/Autumn Pre Fault	2330	1110
Spring/Autumn Post Fault	2770	1320
Summer Pre Fault	2170	1030

Summer Post Fault	2580	1230

**at 90C Maximum Operation Temperature.*

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

- Works also include for exploratory ground investigations to assess the condition of the tower foundations below ground level. Above ground foundation and/or muffs will be repaired or replaced where required by condition.

  The majority of SPT towers use foundations of the pyramid block and chimney design with the remainder being 'special' or piled foundations. The majority of well-constructed foundations using the appropriate materials presents no significant degradation of the foundations, however workmanship and past design and detailing can pose potentially serious problems. Insufficient embedment of tower stubs into the foundation and lack of cleats can result in uplift failures where the pyramid block remains in the ground. Corrosion of the tower at the steel stub can occur when moisture and oxygen come in contact with it and is usually only found at the chimney/muff interface where poor construction exposes it to the elements.

  SPT has developed a methodology (applied in RIIO-T1) based on a comprehensive desktop/site intrusive study to undertake a Quantified Risk Assessment (QRA) approach to determine the foundation sites that require refurbishment based on the following criteria:

  - Importance of the circuits.
  - Ground investigation desktop study. Misalignment of installed foundation type with soil type identified on the British Geological Survey (BGS) maps.
  - Tower lean and towers required to have wind stays removed under the contract.
  - Highly loaded towers (in relation to new and design loads).
  - Access difficulties.
  - Proximity to crossings, residential areas, etc.
  - Other high risk factors (e.g. existing damage, relative location to highly distressed towers, etc.).
  - Primary investigations (Level 1 inspection): non-intrusive surveys.
  - Secondary investigations (Level 2 inspection): foundation intrusive.

  Following consideration of the above elements, a risk rating is applied grading the perceived suitability which shall form the basis for any recommendation of foundation refurbishments.

  Based on the experience gathered in RIIO-T1 for the same type of towers and age, an allowance of 10% of the suspension towers and all pulling positions shall be allocated to the project for foundation intrusive investigation and potential refurbishment.

- Consideration for body extension modifications and replacement of the suspension insulator cross-arm channels following TGN161 and TGN163 respectively.
- Allowances for undergrounding of distribution crossings have also been considered.
- Temporary ADSS Telecom conductor to provide diversion to the existing earthwire fibre wrap.

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 operation/wayleave/environmental restrictions which impact on the progression of works as planned.

Option 1 achieves the main objective of replacing conductor and fittings while refurbishing the OHL Towers and thereby reducing the overall risks to the network and costs.

4.9 XD119-131/XN/XK/XM Route 275kV Major Refurbishment

- **Option 1: Full Refurbishment**

This option considers the replacement of all phase conductors and earthwire assets on XD, XN and XK Routes only as identified earlier through condition data, data analysis and interrogation. XM Route shall require all phase conductors and fittings replaced as identified through condition data, data analysis and interrogation. The following interventions are proposed for replacement in a staged manner within this option:

- Re-conductor all circuits between towers XD00119-XD131 with twin ‘Totara’ 425mm^2 All Aluminium Alloy Conductor (AAAC) EHC at maximum 90C for operation at 275kV.
- Replace earthwire on XD, XN, XK routes only with a single ‘Keziah’ 160mm^2 AACSR equivalent OPGW.
- Replace all tension and suspension and conductor end fittings.
- Upgrade foundations as required per condition.
- Replace downleads including and fittings at Grangemouth and Currie substations.
- Steelwork modifications as per TGN161 and TGN163.
- Replace heavily corroded (above category 4) and damaged steelwork.
- 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, twin 425mm2 AAAC (Totara) EHC system thermal ratings*:

Season / State	Amps	MVA
Winter Pre Fault	2430	1160
Winter Post Fault	2890	1380
Spring/Autumn Pre Fault	2330	1110
Spring/Autumn Post Fault	2770	1320
Summer Pre Fault	2170	1030
Summer Post Fault	2580	1230

**at 90C Maximum Operation Temperature.*

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

- Works also include for exploratory ground investigations to assess the condition of the tower foundations below ground level. Above ground foundation and/or muffs will be repaired or replaced where required by condition.

  The majority of SPT towers use foundations of the pyramid block and chimney design with the remainder being 'special' or piled foundations. The majority of well-constructed foundations using the appropriate materials presents no significant degradation of the foundations, however workmanship and past design and detailing can pose potentially serious problems. Insufficient embedment of tower stubs into the foundation and lack of cleats can result in uplift failures where the pyramid block remains in the ground. Corrosion of the tower at the steel stub can occur when moisture and oxygen come in contact with it and is usually only found at the chimney/muff interface where poor construction exposes it to the elements.

  SPT has developed a methodology (applied in RIIO-T1) based on a comprehensive desktop/site intrusive study to undertake a Quantified Risk Assessment (QRA) approach to determine the foundation sites that require refurbishment based on the following criteria:

  - Importance of the circuits.
  - Ground investigation desktop study. Misalignment of installed foundation type with soil type identified on the British Geological Survey (BGS) maps.
  - Tower lean and towers required to have wind stays removed under the contract.
  - Highly loaded towers (in relation to new and design loads).
  - Access difficulties.
  - Proximity to crossings, residential areas, etc.
  - Other high risk factors (e.g. existing damage, relative location to highly distressed towers, etc.).
  - Primary investigations (Level 1 inspection): non-intrusive surveys.
  - Secondary investigations (Level 2 inspection): foundation intrusive.

  Following consideration of the above elements, a risk rating is applied grading the perceived suitability which shall form the basis for any recommendation of foundation refurbishments.

Based on the experience gathered in RIIO-T1 for the same type of towers and age, an allowance of 10% of the suspension towers and all pulling positions shall be allocated to the project for foundation intrusive investigation and potential refurbishment.

- Consideration for body extension modifications and replacement of the suspension insulator cross-arm channels following TGN161 and TGN163 respectively.
- Allowances for undergrounding of distribution crossings have also been considered.
- Temporary ADSS Telecom conductor to provide diversion to the existing earthwire fibre wrap.

<u>The following specific risks have been identified for this option:</u>

- 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 operation/wayleave/environmental restrictions which impact on the progression of works as planned.

Option 1 achieves the main objective of replacing conductor and fittings while refurbishing the OHL Towers and thereby reducing the overall risks to the network and costs.

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 delivering an optimised overhead line asset management strategy to replace the ACSR conductors while managing network risk appropriately.

Find below a summary of the total scheme cost, timing of investment and expected outputs delivered for each of the schemes in this paper. Option 1 presented will be refreshed and the associated Risk Outputs and full CBA will be undertaken to support the RIIO-T3 business plan as required.

5.1 SPNLT2024 XL Route 275kV Major Refurbishment

In line with the costs prepared and the proposed scope of works, Option 1 (development of works in RIIO-T2 to deliver a full refurbishment in the RIIO-T3 period) is the selected option:

- Scheme Total Cost: £7.1m (£2.62m in RIIO-T2)
- Timing of investment: 2024 - 2027
- Declared outputs:

Asset	Type of Activity	Disposal (cct. Km/sets/each)	Addition/Activity (cct. Km/set/each)
275kV OHL (Tower Line) Conductor	Replacement	20.7 cct. Km	20.7 cct. Km
275kV OHL Fittings	Replacement*	-	70 sets
275kV Tower	Refurbishment Major	-	35 each

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

- Price control period of outputs: 2027

5.2 SPNLT2025 BE Route 132kV Major Refurbishment

In line with the costs prepared and the proposed scope of works, Option 1 (development of works in RIIO-T2 to deliver a full refurbishment in the RIIO-T3 period) is the selected option:

- Scheme Total Cost: £5.01m (£1.84m in RIIO-T2)
- Timing of investment: 2024-2027
- Declared outputs:

Asset	Type of Activity	Disposal (cct. Km/sets/each)	Addition/Activity (cct. Km/sets/each)
132kV OHL (Tower Line) Conductor	Replacement	-	15.3 cct. Km
132kV OHL Fittings	Replacement	56 set	56 set
132kV Tower	Refurbishment Major	-	28 each

- Price control period of outputs: 2027

5.3 SPNLT2026 BV Route 132kV Major Refurbishment

In line with the costs prepared and the proposed scope of works, Option 1 (development of works in RIIO-T2 to deliver a full refurbishment in the RIIO-T3 period) is the selected option:

- Scheme Total Cost: £3.80m (£0.21m in RIIO-T2)
- Timing of investment: 2025-2028
- Declared outputs:

Asset	Type of Activity	Disposal (cct. Km/sets/each)	Addition/Activity (cct. Km/sets/each)
132kV OHL (Tower Line) Conductor	Replacement	-	13.2 cct. Km
132kV OHL Fittings	Replacement	44 each	44 each
132kV Tower	Refurbishment Major	-	22 each

- Price control period of outputs: 2028

5.4 SPNLT2027 BR Route 132kV Major Refurbishment

In line with the costs prepared and the proposed scope of works, Option 1 (development of works in RIIO-T2 to deliver a full refurbishment in the RIIO-T3 period) is the selected option:

- Scheme Total Cost: £12.98m (0.42m in RIIO-T2)
- Timing of investment: 2025-2028
- Declared outputs:

Asset	Type of Activity	Disposal (cct. Km/sets/each)	Addition/Activity (cct. Km/sets/each)
132kV OHL (Tower Line) Conductor	Replacement	-	53.8 cct. Km
132kV OHL Fittings	Replacement	174 sets	174 sets
132kV Tower	Refurbishment Major	-	87 each

- Price control period of outputs: 2028

5.5 SPNLT2028 YB & YC Routes 132kV Major Refurbishment

In line with the costs prepared and the proposed scope of works, Option 1 (development of works in RIIO-T2 to deliver a full refurbishment in the RIIO-T3 period) is the selected option:

- Scheme Total Cost: £10.37m (£3.79m in RIIO-T2)
- Timing of investment: 2024-2027
- Declared outputs:

Asset	Type of Activity	Disposal (cct. Km/sets/each)	Addition/Activity (cct. Km/sets/each)
132kV OHL (Tower Line) Conductor	Replacement	-	29.4 cct. Km
132kV OHL Fittings	Replacement	92 sets	92 sets
132kV Tower	Refurbishment Major	-	46 each

- Price control period of outputs: 2027

5.6 SPNLT2029 XW Route 275kV Major Refurbishment

In line with the costs prepared and the proposed scope of works, Option 1 (development of works in RIIO-T2 to deliver a full refurbishment in the RIIO-T3 period) is the selected option:

- Scheme Total Cost: £3.56m (1.88m in RIIO-T2)
- Timing of investment: 2024-2027

- Declared outputs:

Asset	Type of Activity	Disposal (cct. Km/sets/each)	Addition/Activity (cct. Km/sets/each)
275kV OHL (Tower Line) Conductor	Replacement	-	7.2 cct. Km
275kV Fittings	Replacement *(spacers)*	24 sets	24 sets
275kV Tower	Refurbishment Major	-	12 each

- Price control period of outputs: 2027

5.7 SPNLT2030 XT Route 275kV Major Refurbishment

In line with the costs prepared and the proposed scope of works, Option 1 (development of works in RIIO-T2 to deliver a full refurbishment in the RIIO-T3 period) is the selected option:

- Scheme Total Cost: £2.25m (£1.42m in RIIO-T2)
- Timing of investment: 2024-2027
- Declared outputs:

Asset	Type of Activity	Disposal (cct. Km/sets/each)	Addition/Activity (cct. Km/sets/each)
275kV OHL (Tower Line) Conductor	Replacement	-	3.1 cct. Km
275kV Fittings	Replacement *(spacers)*	12 sets	12 sets
275kV Tower	Refurbishment Major	-	6 each

- Price control period of outputs: 2027

5.8 SPNLT2031 YF Route 275kV Major Refurbishment

In line with the costs prepared and the proposed scope of works, Option 1 (development of works in RIIO-T2 to deliver a full refurbishment in the RIIO-T3 period) is the selected option:

- Scheme Total Cost: £4.17m (£0.18m in RIIO-T2)
- Timing of investment: 2025-2028
- Declared outputs:

Asset	Type of Activity	Disposal (cct. Km/sets/each)	Addition/Activity (cct. Km/sets/each)
275kV OHL (Tower Line) Conductor	Replacement	-	8.6 cct. Km
275kV Fittings	Replacement	28 sets	28 sets
275kV Tower	Refurbishment	-	14 each

	Major		

- Price control period of outputs: 2028

5.9 SPNLT2032 XD119-131/XK/XN/XM Route 275kV Major Refurbishment

In line with the costs prepared and the proposed scope of works, Option 1 (development of works in RIIO-T2 to deliver a full refurbishment in the RIIO-T3 period) is the selected option:

- Scheme Total Cost: £32.59m (£0.94m in RIIO-T3)
- Timing of investment: 2025-2030
- Declared outputs:

Asset	Type of Activity	Disposal (cct. Km/sets/each)	Addition/Activity (cct. Km/sets/each)
275kV OHL (Tower Line) Conductor	Replacement	-	110.4 cct. Km
275kV Fittings	Replacement	338 sets	338 sets
275kV Tower	Refurbishment Major	-	169 each

- Price control period of outputs: 2030

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

A full CBA will be undertaken to support the RIIO-T3 business plan. The funding requested by this scheme will be subject to true-up at the end of RIIO-T2 [reference Draft Determination, ET Sector Annex para 3.33].

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 will not be 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.

6.8 Outputs included in RIIO T1 Plans

No outputs included in T1