Re-opener Report

Bespoke: Tower Steelwork and Foundations (NGET) – ET Special Condition 3.33

Date: 27 July 2022

nationalgrid

Contents

1. Executive summary

The assets covered in this re-opener report are overhead line **tower steelwork** and **foundations** and are bespoke to ET Special Condition 3.33. This report develops the estimates provided in our RIIO-2 submission into a detailed investment request for:

1. The volume of replacement steelwork which was originally based on high-level helicopter assessments.

2. The volume of foundation remedial work which was originally based on assumed levels of intervention ahead of the outcomes of intrusive investigations (planned for RIIO-2).

The primary driver for both tower steelwork and foundations is **condition**, which aligns with our stakeholder feedback priorities for a safe, reliable, and affordable network. Our population consists of around twenty-two thousand towers and the consequence of not completing timely condition-based maintenance (i.e., do nothing) would be to allow our network to become unsafe, unreliable and very costly and time-consuming to rectify leading to considerable and sustained disruption to consumers.

For tower steelwork, we have now completed detailed bar-by-bar climbing surveys for the [redacted] routes identified at Final Determinations. In addition, a further [redacted] individual towers have also been assessed and included within this report on the basis that potentially defective steelwork has been identified during recent routine foot patrol surveys

Overall, the volumes identified from our re-opener climbing surveys represent only ~[redacted] of the volume estimated for our RIIO-2 submission (which was based on HDCA helicopter information) - [redacted] tonnes compared to [redacted] tonnes.

However, a volume of [redacted]m^2 grade 4 steelwork (equivalent to about [redacted] tonnes) was identified for enhanced paintwork recovery, this is indicative of a higher-than-expected proportion of the helicopter zonal assessments being grade 4 or lower. Therefore, less work is required thank was predicted through the desk-top risk assessment data and analysis. This grade 4 steelwork volume has been subsumed into our painting programme, with most routes being painted in 2021 and 2022 (4VN, 4ZA, XM, YXA, ZH & ZZS). We are assessing opportunities to address the ZL and ZX routes during RIIO-2.

Currently, foundation issues are addressed as they are identified, and the objective of our enhanced foundation strategy is to develop a proactive/predictive approach for dealing with these risks.

We have completed [redacted] intrusive investigations out of the [redacted] identified at Final Determinations.

Our investigations found repairs are required on [redacted] of foundations with potentially a further [redacted], (subject to further assessment at the time of next refurbishment) compared to an assumed [redacted] at our RIIO-2 submission. Over [redacted] of these interventions are associated with non-standard/piled foundations. From our analysis, we have concluded the network risk posed by poor condition foundations is very low, and the emergency repairs completed during RIIO-1 were most likely outliers, rather than indicative of wider issues. Further details are contained in Sections 5 and 6.

Our RIIO-2 baseline funding is £5.708m for tower steelwork and £14.381m for tower foundations, a combined total of £20.089m.

In preparation for this re-opener, we have spent a total of £1.910m on steelwork and foundation surveys and our estimate for proposed further RIIO-2 expenditure is £17.211m for condition steelwork replacement, £0.493m for defective steelwork replacement, £0.349m for RIIO-3 climbing surveys and £4.149m for foundation remediation, a combined total of £24.112m.

For this re-opener, our proposal is to apply for the delta between our combined baselines and our combined proposed total expenditure.

Accordingly, we are applying for an additional **£4.023m** of funding (£24.112m - £20.089m).

Our estimated expenditure for RIIO-2 tower steelwork replacement and foundation remediation are summarised in Table 1.1, together with Spend Phasing in Table 1.2.

Table 1.1: Estimated RIIO-2 expenditure for Tower Steelwork and Foundations (2018/19 base)

Description Estimated expenditure	Expenditure pre-reopener submission (surveys)	Steelwork Condition Replacement	Steelwork Defect Replacement	RIIO T3 Tower Climbing surveys	Foundation Remediation
Number of sites	[redacted] (foundation) & [redacted] (steelwork defects)	-	[redacted]	[redacted]	[redacted]
Number of routes	[redacted] (steelwork condition)	[redacted]	-		-
Cost	£1.910m	£17.211m	£0.493m	£0.349m	£4.149m
Total Steelwork	**£19.225m**	Total T2 Baseline: £5.708m		**Delta: £13.517m**	
Total Foundations	**£4.887m**	Total T2 Baseline: £14.381m		**Delta: (£9.494m)**	
Total additional funding required: £4.023m					

Table 1.2: Spend Phasing

Description	2021/22 (£m)	2022/23 (£m)	2023/24 (£m)	2024/25 (£m)	2025/26 (£m)
Steelwork Replacement	1.096	1.158	3.611	6.499	6.860
Foundation Remediation	0.707	0.280	1.162	1.411	1.328
Total	**1.804**	**1.438**	**4.772**	**7.910**	**8.188**

2. Summary Table

Name of scheme	Bespoke Tower Steelwork & Foundations Re-Opener
Primary driver	Condition
Scheme reference / mechanism of category	ET Special Condition 3.33 / Bespoke Re-opener
Output references/type	Baseline Funding
Cost	£24.112m (**£4.023m** total requested over existing combined, existing baseline funding)
Delivery year	2026
Reporting table	RRP – Scheme Cost & Volumes
Outputs included in previous RIIO Business plan	No outputs from RIIO-1
Spend apportionment	100% RIIO-2

Version Control

Version Number	Summary of Changes	Name	Date
0.1	Draft report for review	Doug Galloway	15 June 22
1.0	First Issue	Doug Galloway	22 July 22

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3. Introduction

Overhead line towers form the ‘back-bone’ of the UK’s transmission network by transporting electricity to where it is needed around the country. Maintaining these towers in good condition is essential for meeting our stakeholder priorities for a safe and reliable network.

This report seeks to provide the detailed evidence and analyses to narrow, finalise and justify our original RIIO-2 submission for (i) why these interventions are necessary, (ii) what the scope of these interventions should be, and (iii) how this additional expenditure represents best value for consumers. The scope of this re-opener report includes:

(a) The replacement of poor condition **tower steelwork** and
(b) The remediation of poor condition **tower foundations**, as identified through our RIIO-2 programme of intrusive foundation investigations.

Tower Steelwork Scope

In our December 2019 Business Plan submission, associated Annexes, and information provided through Ofgem’s Supplementary Questions (SQ) a total of 8 routes were identified from our Asset Health Review (AHR) information as requiring replacement steelwork, shown in Table 3.1 below.

Table 3.1: Details of routes surveyed

Route	Route Description	Tower Spec.n	First Tower	Last Tower	No. Towers Climbed
[redacted]					

Subsequent to our RIIO-2 submission and Final Determinations, this application also includes an additional [redacted] individual towers from other routes which have been included on the basis that potentially defective steelwork has been identified during recent routine foot patrol surveys. These have been assessed to determine what, if any, remedial work is necessary at towers:

[redacted]

Tower Foundation Scope

In relation to our RIIO-2 enhanced foundation strategy (which is detailed in our December 2019 Business Plan submission, associated Annexes, and information provided through the Supplementary Question process) a representative sample of [redacted] towers were selected for intrusive inspections, using British Geological Survey (BGS) based risk scoring criteria. This strategy is designed to gain an understanding of the level of risk posed by poor condition foundations and also test if British Geological Survey (BGS) based data can be used to reliably identify our most vulnerable towers.

For this re-opener, a total of [redacted] intrusive investigations have been completed, with the remaining [redacted] planned for completion during RIIO-2 refurbishment schemes (due to the very high access costs associated with ZBC and ZBD routes and because 4VK is already in delivery - 2022/23).

Further details of our enhanced foundation strategy and how we derived our sample size are contained in Section 5 of this report.

A breakdown of the number of intrusive investigations by route is shown in Table 3.2 below.

Table 3.2: Number of intrusive inspections by route

Route Identifier	No. of Intrusive Investigations pre re-opener	No. of Intrusive Investigations post re-opener
4VK	[redacted]	[redacted]
ZBC	[redacted]	[redacted]
ZBD	[redacted]	[redacted]
2AH	[redacted]	[redacted]
4TE	[redacted]	[redacted]
4TM	[redacted]	[redacted]
4VF	[redacted]	[redacted]
4VY	[redacted]	[redacted]
4YB	[redacted]	[redacted]
4YH	[redacted]	[redacted]
4YJ	[redacted]	[redacted]
4YM	[redacted]	[redacted]
4YX	[redacted]	[redacted]
4YZ	[redacted]	[redacted]
4ZB	[redacted]	[redacted]
4ZC	[redacted]	[redacted]
4ZD	[redacted]	[redacted]
4ZE	[redacted]	[redacted]
4ZJ	[redacted]	[redacted]
4ZM	[redacted]	[redacted]
4ZP	[redacted]	[redacted]

Route Identifier	No. of Intrusive Investigations pre re-opener	No. of Intrusive Investigations post re-opener
4ZV	[redacted]	[redacted]
4ZY	[redacted]	[redacted]
VE	[redacted]	[redacted]
VF	[redacted]	[redacted]
VO	[redacted]	[redacted]
XC	[redacted]	[redacted]
YR	[redacted]	[redacted]
YYA	[redacted]	[redacted]
ZA	[redacted]	[redacted]
ZB	[redacted]	[redacted]
ZDA	[redacted]	[redacted]
ZE	[redacted]	[redacted]
ZFB	[redacted]	[redacted]
ZG	[redacted]	[redacted]
ZL	[redacted]	[redacted]
ZO	[redacted]	[redacted]
ZS	[redacted]	[redacted]
ZZK	[redacted]	[redacted]
Totals	[redacted]	[redacted]
Grand Total		

4. Structure of the re-opener submission

This bespoke re-opener submission is structured into the sections shown in Table 4.1 below, which signposts the structure of this report, sets out the purposes of each section and demonstrates alignment with '*RIIO-2 Re-opener Guidance and Application Requirements Document Version 1',* dated 26 February 2021. Further details are also provided in our 'Ofgem Guidance Checklist' which is contained in Annex 14.2.

This submission is for the ***ET Licence Special Condition 3.33 (Bespoke) - Tower Steelwork and Foundation (NGET)***

The options within this submission are aligned to our long-term business strategy, which is to maintain a safe and reliable network at an affordable cost. The need for intervention is assessed at the individual asset level (by tower) in accordance with our policy statements (PS(T)131 & 131.04) and Technical Guidance Note (TGN(AR)004) as detailed below.

A range of intervention options are then developed and assessed to determine the optimum intervention strategy for individual or groups of assets, considering both short-term benefits and long-term outlook. The intervention is assessed for deliverability against the outage plans on the transmission system and possible opportunities to bundle with other works (e.g., other NARM or PCD outputs) to determine confidence levels of delivery.

All of the proposed options have also been assessed against existing outputs within RIIO-2 to ensure no duplication, justify where changes to funding are required and show where bundling with other outputs can provide a delivery opportunity. These aspects are detailed fully in sections 7 – 10 of this report.

The Engineering Justification Reports (EJR's) consist of the survey results, detailed analyses, and conclusions and are contained in Annex 14.1.

A detailed Cost Benefit Analysis is contained in Annex 14.3.

The associated Policies and Technical Specifications covering the tower steelwork and foundation survey works are contained in Annex 14.5 for information and include:

PS(T)102	Issue 4	Overhead Line Tower Steelwork Management
PS(T)131	Issue 2	Equipment Interventions: Inspections, Maintenance, Refurbishment and Replacement (General)
PS(T)131.04	Issue 1	Equipment Interventions: Overhead Lines
TS 2.04	Issue 6	Generic Design Principles for Overhead Lines (section 7 applies)
TS 3.04.15	Issue 6	Overhead Line Support Foundations (section 1.7.3 applies)
TS 3.04.31	Issue 4	Specification for Steelwork Inspection and Condition Assessment of Overhead Line Towers
TGN(AR)004	Issue 8	Asset Replacement of Overhead Lines: Priority Ranking of Replacement Candidates

Table 4.1: Structure of this re-opener report

	Content	Summary
Executive Summary		A high-level summary of the submission.
Introduction		A summary of the information presented across the submission to give an overview of the project.
Business Strategy & Commitments *Re-opener guidance section 3.10*	• Policy statement	Introduces the strategic importance of the project, environmental commitments and Net Zero ambition.
Needs Case *Re-opener guidance section 3.11 & 3.12*	• Emissions & inventory • Asset health • Failure mechanisms and condition • Forecasting	Sets out the current state, drivers for the proposed expenditure
Options *Re-opener guidance section 3.13*	• Intervention options • Intervention strategies • Cost assessment • Option details	Describes the different types of interventions at an asset level, the strategy for choosing optimal asset intervention type and the different portfolio options considered.
Methodology for preferred option *Re-opener guidance section 3.13*	• Intervention prioritisation • Intervention strategies • Cost Benefit Analysis	Describes the method of options considered to address the driver, how the options were appraised and how listed options were shortlisted for CBA.
The preferred option *Re-opener guidance section 3.14*	• Preferred option • Cost details • Risks & contingencies	Summarises the cost of the portfolio. Sets out the assumptions and the methodology used to arrive at a cost and dates.
Project delivery *Re-opener guidance section 3.15*	• Plan Alignment • Future submissions	Describes the timing for the re-opener and how the deliverables are timed, and project managed. including how it aligns with future submissions.
Price Control deliverables *Re-opener guidance section 3.15*	• RIIO-2 Current position	Summarises the existing allowances in RIIO-2.
Stakeholder Engagement *Re-opener guidance section 3.16 – 3.18*	• Stakeholder informed strategy • Independent user group • Ofgem Engagement	Describes the stakeholder engagement to date and how we work with stakeholders to progress the project.
Annexes *Re-opener guidance section 3.19 – 3.22*	• EJR's • Cost benefit analysis • Detailed Costs & Risks • Technical Specifications	Details the list of annexes supporting this re-opener

5. Alignment with overall business strategy and commitments

Strategy for Tower Steelwork and Foundations

Introduction

The objective of our steelwork and foundation strategies are to ensure our assessment of network risk posed by towers is robust, transparent, and defendable and enables us to form a long-term view of asset health. We will deliver this strategy through the implementation of our policies.

Network risk posed by poor condition steelwork is initially assessed using High-Definition Camera Assessments (HDCA) obtained from our helicopter survey platforms. This imagery is used to build up a reliable indication of the 'macro' health of the tower population and indicates specific locations where more detailed inspections are required. A standard visual assessment scoring system is used to assess tower steelwork (TS3.4.31 refers).

The whole network is surveyed on a six yearly rolling cycle in accordance with our policy 'PS(T)102 – Overhead Line Tower Steelwork Management'.

Currently, foundation issues are addressed as they are identified, and the objective of our enhanced foundation strategy is to develop a proactive/predictive approach for dealing with these risks.

The condition of our tower population is reviewed annually in our Asset Health Review (AHR) which identifies areas of concern requiring further investigation (such as climbing surveys).

Overall basis for OHL Towers and Foundations Plan

<u>Tower Steelwork and Painting</u>

Tower steelwork and painting currently follow the Asset Replacement Priority (ARP) approach, with interventions based on AHI scoring and criticality. Details are contained in TGN(AR)004 'Asset Replacement of Overhead Lines: Priority Ranking of Replacement Candidates'.

Accordingly, our RIIO-2 volumes for tower steelwork and painting are based on the above approach, although as can be seen in Table 5.1 below, we are in the process of adopting a standard scoring mechanism (across all asset types) using End-Of-Life (EOL) modifier scoring between 0 – 100.

Table 5.1: Steelwork grades vs. EOL and AHI scoring

Condition Assessment Score	EOL Score	Coating Asset Health Index	Steelwork Asset Health Index	Asset Health Description: Coating	Asset Health Description: Zinc Galvanising	Asset Health Description: Steel (Including Step Bolts)
Grade 1	0	4	4	Overcoat and undercoat fully intact	Fully intact	Assumed no corrosion, fully protected by zinc and paint coatings
	10			Unpainted	Fully intact	No corrosion
	20			Overcoat and undercoat fully intact, enhanced preparation of steel may have been applied at last painting	Partial or full corrosion (in this latter instance an extra undercoat has replaced zinc coating)	Partial surface corrosion
Grade 2	30	3		Overcoat may not be intact and very small patches (≤1% of surface area) of undercoat paint flaked/eroded away	Galvanising exposed and corroded up to full loss where paint coating is lost	Surface corrosion where paint and galvanising is lost
Grade 3	40	2	3	Majority of over and undercoating remains intact (≥75% of surface area) Ideal time at which to paint	Galvanising exposed and corroded up to full loss where paint coating is lost	Surface corrosion where paint and galvanising is lost
	50					Grade 3 extends to Primary steel bars
Grade 4	60	1	2	<75% of over and undercoating intact. Paint coatings no longer effective as breaking down and exposing zinc/steel in increasing areas at a non-uniform rate	Near full loss in areas with no paint	Light pitting and edge roughening in distinct, non-uniform patches. Cleaning of corroded surfaces will dominate preparation prior to painting Bar thickness is still greater than or equal to its specification (minimum tolerance)
	70					Corrosion extends to bolt heads, back to backs and in angles that are difficult to prepare. May require replacement if cannot be cleaned to base metal
Grade 5	80		1		Full loss in areas with no paint	Significant pitting, section loss visible Bar thickness is smaller than specification (minimum tolerance). A structural loading assessment is required
	90					Grade 5 extends to Primary steel bars
Grade 6	100					Perforated element, severe physical damage, or bent

For information, our steelwork grades are illustrated below in Table 5.2 and are defined in our Technical Specification TS 3.04.31 ‘Specification for steelwork Inspection and Condition Assessment of Overhead Line Tower’.

Table 5.2: Tower Steelwork Grades

Grade	1	2	3	4	5	6
Grade description	Fully painted – overcoat and undercoat intact Fully galvanised – coating intact 	Paint coating on all surface, but some overcoat may not be intact. Galvanising intact except for small areas of corrosion 	Very light surface corrosion, majority of coating intact 	Light pitting, with loss of coating and zinc layers. Bar thickness is still equal to its specification 	Significant pitting - loss of section clearly visible Bar thickness is smaller than its specification 	Perforated element with severe physical damage 
Intervention	No action required	No action required. Part of the long-term painting plan (10-15 years)	Optimal time to paint. Plan painting within 5 years – steelwork then reclassified as Grade 1	Recover steelwork via enhanced treatment – steelwork then reclassified as Grade 1	Steelwork measured to identify thickness loss and structurally assessed, then treated to prevent further degradation if required. Replacement of critical steelwork members.	Replacement of steelwork required

Note the above table is for the classification of environment-caused degraded steelwork. Any bent bars are automatically flagged as Grade 6 to identify them for further attention, but this does not mandate their replacement.

Generally, our approach is that intervention is needed above grade 3. The technical specification states to paint grade 3 tower steelwork, recover grade 4 steelwork through an enhanced painting methodology (TS 3.04.34 ‘Overhead Line Tower Spot Surface Preparation and Painting’ refers) and replace grades 5 and 6 steelwork. Grade 5 primary steelwork (such as Leg bars) are further assessed to determine if a more economical in situ repair is feasible. As mentioned above, bent bars, which are automatically graded as 6, are further assessed to determine if the bar is sufficiently damaged to warrant replacement (for example, a bar with a slight localised bend on an outer flange would not be replaced, as it does not compromise structural integrity).

The documents relevant to our ARP approach are listed in Table 5.3 below.

Table 5.3: Relevant NGET OHL Policy and Guidance Documentation

Condition Data Type	References
Steelwork	
HDCA Aerial Photography (photos/tower)	PS(T)102 - Overhead Line Tower Steelwork Management. TGN(AR)004 – Asset Replacement of OHL Priority Ranking of Replacement Candidates PS(T)131.04 – OHL Replacement and Refurbishment
Steelwork Assessment Summary based on HDCA photography and foot patrol information	
Steelwork Climbing Assessment Survey – bar by bar assessment- visual, photographic, measurements and capacity assessment. – see TS3.4.31	Normally completed as part of detailed scheme development/delivery – NDP stages 4.3 & 4.4 of TP500 process
Foundations	
Enhanced Foundation Strategy - (based on BGS geological data)	New enhanced process proposed for RIIO-2: see IDP A9.09A and SQ’s 166, 167, 171 & 178 for further details
Intrusive Foundation Investigation – expose leg foundation, core samples and capacity assessment) – see TS2.04 & TS3.4.15 for details	Normally completed as part of detailed scheme development/delivery – NDP stages 4.3 & 4.4 of TP500 process
Visual Muff Inspections – part of information recorded Foot patrol inspections	TGN(AR)004 – Asset Replacement of OHL Priority Ranking of Replacement Candidates. PS(T)131.04 – OHL Replacement and Refurbishment
Geotechnical Reports- (general or specialist – commissioned as required, normally because of issues identified during inspections) – see TS2.04 & TS3.4.15	

Foundations

Traditionally, foundation interventions have been made on a reactive basis, dealing with issues as they arise. This has led to a number of unplanned and emergency works during RIIO-1. Our proposal for RIIO-2 is to implement an ‘enhanced foundation strategy’.

The objective of our enhanced foundation strategy is to move from a reactive approach of managing network risks posed by tower foundations (fix-on-fail) to a proactive/predictive approach.

To formulate our strategy, we first analysed desktop British Geological Survey (BGS) data to produce a weighted geological risk scoring mechanism at individual tower level for the whole population. These weighted risk scores range from 0 – 26, as shown in Table 5.4 below.

Table 5.4: BGS-based risk scoring

Risk Category	Weighted Score Range
Low Risk	0 - 7
Medium Risk	8 - 12
High Risk	13 - 15
Very High Risk	>15

We anticipated the majority of network risk sat within the ‘High’ and ‘Very High’ categories and this is borne out by recent examples of geotechnical-based foundation remedial works.

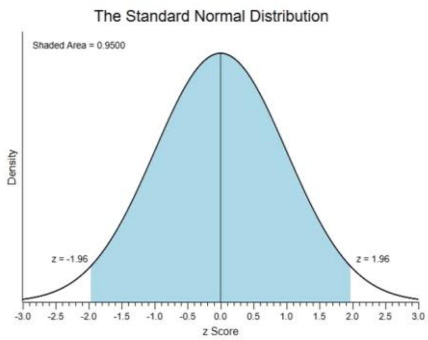
Accordingly, our enhanced foundation strategy is concentrated on investigating a representative and statistically significant sample of the ‘High’ and ‘Very High’ scoring towers, although a sample of ‘Low’ and ‘Medium’ categories have been included to provide further confidence in our categorisation and scoring mechanisms.

In order to have a representative sample size for the tower population, a simple statistical analysis tool was used to determine the required sample size to enable a correlation to be made across the whole population (with an accepted level of error – E).

This is based on a standard normal distribution – and error percentages of 10%, 5% and 1% have been applied for the purposes of this calculation. The results are shown in Table 5.5 below.

Table 5.5: Population Sampling

[redacted]



The [redacted] towers selected for our strategy are based on our conductor replacement schemes, However, due to environmental and access constraints encountered during the survey programme, some re-selections have been necessary to ensure sufficient data was gathered in support this report. Substitutions are detailed in Table 5.6 below.

Table 5.6: Details of Foundation Investigation Substitutions

Tower at FD	Reason for Substitution	Substitute Tower
4TE019	Not accessible by plant required	4TE024
4TE059	Tower located on island, would require specialist access	4TE063
4YZ087	Access blocked by recent construction of gate by 3rd party	4YZ078
4ZB248	Tower duplicated (data error)	4ZB247
4YS028	Remedial repairs recently undertaken	4ZE017
4YV124	Already addressed as part of South Wales urgent repairs	4ZJ036
4TM006	West Burton Power station. No access for plant	YR039
4VF183	3.5T bridge on access route	XC430
4YB054	Site of Specific Scientific Interest (SSSI)	XC435
4YB093	Invasive Species	XC437
4YB096	Invasive Species	XC443
4YB097	Invasive Species	XC444
4YB106	Invasive Species	XC455
4YH034	Tree clearance required	XC460
4YH038	Refused access due to avian flu	XC471
4YH039	Refused access due to avian flu	XC511
4YH040	Refused access by Landowner	XC513
4YH048	Tree and ground clearance required to access tower	XC514
4YM115	Golf course with high costs for trackway/time on site	XC519
4YM175	Great crested newt potential/environmental testing	2AH007
4YV129	Original access not possible due to flooding	ZO180
4YZ050	SSSI	ZO181
4YZ062	SSSI	ZO183
4ZB249	SSSI	4ZD022
4ZE008	Bridge access in poor condition	ZE458
4ZJ033	SSSI	4YJ059
4ZJ034	SSSI	4ZM431
4ZJ036	SSSI	ZG080
VO025	SSSI	ZFB006
ZA296	SSSI/Invasive species	ZFB010
ZV385	SSSI	ZFB011
VO044	Restricted access	VO042
ZB043	Access could not be agreed with landowner	ZB104

The full list of towers selected for RIIO-2 foundation investigations is in Annex 14.1 and quantities summarised by route in Table 3.2.

In summary, our foundation investigations include:

- [redacted] 'Low Risk' towers ([redacted]% of sample size)
- [redacted] 'Medium Risk' towers ([redacted]% of sample size)
- [redacted] 'High Risk' towers ([redacted]% of sample size)
- [redacted] 'Very High Risk' towers ([redacted]% of sample size)

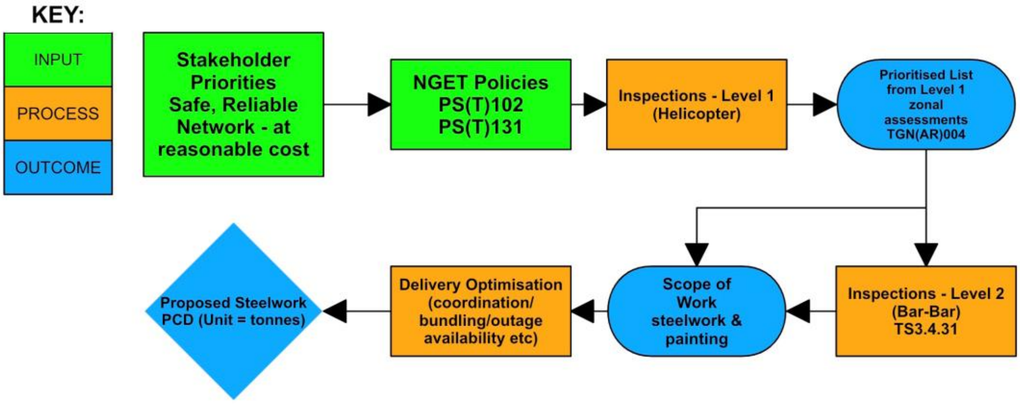
The distribution of risk scores for the whole population is illustrated in Chart 5.1 below. As can be seen, a sample size of [redacted]% of all 'High' Category and [redacted]% of all 'Very High' Category towers are included in the overall sample size of [redacted] towers.

Chart 5.1: Distribution of BGS Risk Scoring for Entire Network (based on 21887 towers)

[redacted]

For clarity, we confirm there is no overlap between this report and our Extreme Weather paper (IDP 10.05) which covers research, pre-works assessments and scheme development for erosion and other flood related natural hazards and is mutually exclusive from our foundation strategy considerations.

Details of OHL Tower Steelwork Assessment Process (Figure 5.1)



Our stakeholder priorities are for a safe and reliable network, at an affordable cost. These priorities inform our policies for inspection and maintenance. Helicopter inspections (level 1) produce an overall view of condition of the tower population using HCDA and the whole tower population is flown approximately every six years.

For HDCA, each tower is split into 30 assessment zones (15 zones per tower side) as per Figure 5.2 below. Each zone is visually assessed using high-definition photographic images, captured by helicopters, and assigned the worst steelwork grade seen within that zone.

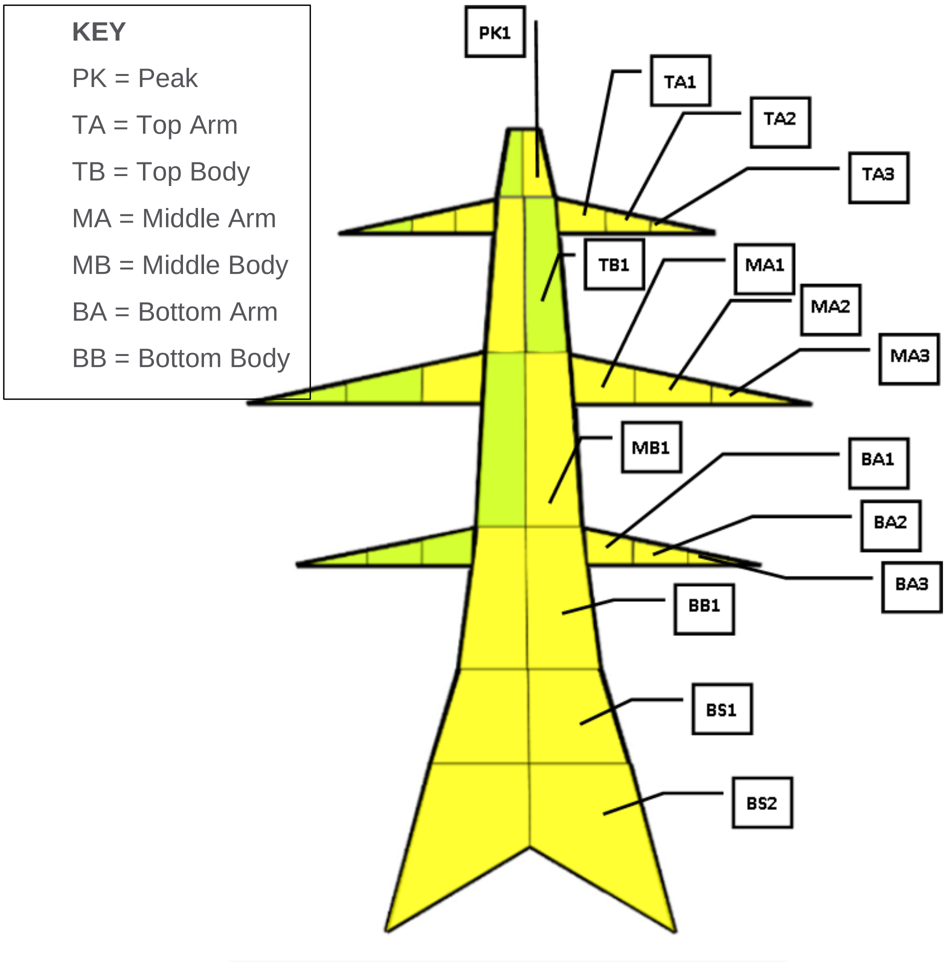
Steelwork condition is assessed in accordance with TS3.04.31 ‘Specification for Steelwork Inspection and Condition of Overhead Line Towers’ and assigned a grade of between 1 and 6.

The Level 1 HDCA enables us to prioritise routes for painting and routes requiring further assessment (level 2). Once the level 2 surveys have been completed and the full scope of replacement steelwork assessed and optimised, a delivery optimisation process ensures the works are delivered as cost effectively and efficiently as possible.

Tower furniture, such as Anti Climbing Devices, tower plating and tower muffs are not included in the steelwork scope as are within the scope of targeted fittings, full fittings and full refurbishment schemes and are replaced on condition, in accordance with PS(T)131.04.

Our proposal for this re-opene~~r~~ and beyond is for steelwork interventions to be delivered as baseline funding, along with the already allowed foundations and steelworks baseline funding (which makes up 83% of the total request).

Figure 5.2: Schematic of overhead line tower broken down into zones for steelwork assessment



Details of OHL Tower Painting Assessment Process

The two-coat vinyl paint system used for tower steelwork degrades by erosion, rather than basic paint breakdown, and has an average life expectancy of 18 years. Accordingly, we plan to paint an average of 1/18th of the network each year (PS(T)102 - Overhead Line Tower Steelwork Management refers) which is equivalent to 2,432 tower sides.

For RIIO-2, we will address [redacted] tower sides (5 years x [redacted] tower sides). This is covered by separate, existing baseline funding and does not form part of this funding request.

Details of OHL Foundation Assessment Process

Every OHL route is walked annually in compliance with ESQCR Regulations (vulnerable towers are inspected more frequently). During these walk-throughs, we also take the opportunity to visually assess the condition of the critical assets associated with the overall OHL system – including above ground aspects of the foundations (for example muff concrete and surface pile caps). These visual inspections also include verticality checks. All noted potential verticality issues are further investigated by completing a desktop check using Network Mapping LiDAR (Light Detection and Ranging (the light equivalent to Radio Detection and Ranging – RADAR) data and/or a site-specific

LiDAR survey and/or long-term monitoring. Individual foundation failures have been addressed on a case-by-case basis.

Recent examples include:

- YW42 - Slope stability
- ZZN18R - Riverbank erosion
- 4ZC30 - Changes to estuarial currents
- 4YW123 & 4VW124 - Tidal flooding

Going forward, these visual and LiDAR inspections will continue but, with an ageing tower population and the intensity and frequency of flooding and other natural hazards increasing due to climate change, there is a risk the number of foundation issues may escalate considerably. We are therefore enhancing our foundation inspection approach to better understand the level of system risk posed by poor foundation condition which cannot be detected from our routine visual inspections or measured using verticality checks. In summary, condition and capacity will be determined by an intrusive investigation, incorporating the following activities, as specified in TS3.4.15:

(a) Visual inspection of surface concrete and core sampling (two per leg) to determine both strength characteristics and chemical analysis

(b) Visual inspection and physical measurement of embedded leg and stub steelwork

(c) Capacity determined by comparison of modelled foundation loading vs. original schedule of foundation loads based on guidance in National Grid Technical Specification TS 3.04.15 'Overhead Line Support Foundations'

(d) Foundation type (e.g., standard foundation) checked for geological misalignment.

A targeted approach will be taken for the intrusive inspections as they are more expensive and time-consuming than visual inspections. Our enhanced strategy prioritises foundations at risk using British Geological Survey (BGS) geological hazard information to quantitively assess the risk of accelerated deterioration of concrete and embedded steelwork within the foundation.

Our existing guidance in section 7 of National Grid Technical Specification TS 2.04 "Generic Design Principles for Overhead Lines" and the guidance in TS 3.04.15 'Overhead Line Support Foundations' will be applied to assess the condition and existing capacity of foundations, which will determine what, if any, interventions are required.

The following criteria would be applied (in accordance with TS3.4.15) to determine if an intervention is required:

1) If the ratio of foundation load to scheduled load is greater than 0.95 - no intervention is required.

2) If the ratio of foundation load to scheduled load is between 0.90 and 0.95 - an intervention may be required, depending upon the outcome of a site-specific desk-top appraisal.

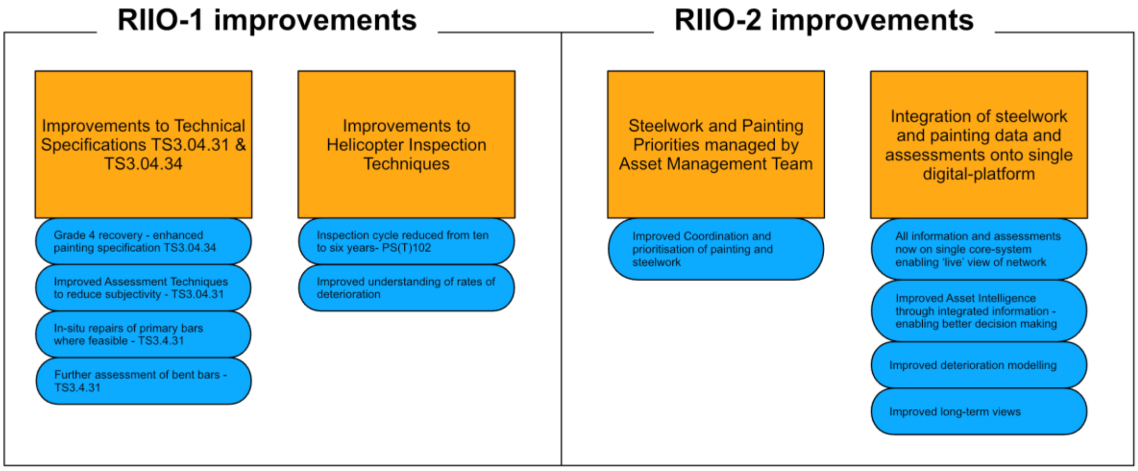
3) If the ratio of foundation load to schedule load is less than 0.90 - an intervention is required.

Note: Our 10% limit for foundation overload is stated in TS 3.4.15 'Overhead line Support Foundations', section 1.7.3.

The solution for each intervention will be site-specific and may range from do nothing, through simple foundation repairs to complex whole tower replacements.

The outcomes of the [redacted] intrusive foundation investigations will also be used to improve our understanding of the level of risk from geological hazards when incorporating these into our FMEA process. Further details of the [redacted] towers selected for our RIIO-2 enhanced foundation strategy are contained in Annex 14.1.

Process Improvements Timeline (Figure 5.3)



- During RIIO-1 we improved our technical specifications. Key improvements included the recovery of grade 4 steelwork instead of replacement, the introduction of measurement and structural assessment of grade 5 primary bars to determine the feasibility of in-situ repair rather than replacement and the re-assessment of identified bent bars to confirm the necessity to replace. We have also improved our helicopter survey techniques which has enabled us to fly the whole network in about six years rather than the previous ten years. This increases the number of data points captured each year, which increases the resolution of our data to improve our understanding of deterioration rates.

- In RIIO-2, we have integrated all our tower condition data, assessments, and outputs into a single web-based digital platform which will ensure our decisions are based on the best available information. We will continue to develop our digital platform throughout RIIO-2, as part of our digital roadmap improvements, including improved functionality and data analytics (e.g., the ability to generate user-defined comprehensive condition reports, inclusive of visual geographically based 'heat-maps', trend information and expanding from tower steelwork to include OHL foundations, conductor and fittings).

- The interval between helicopter condition assessment, climbing assessment and delivery is being minimised through our delivery optimisation process (for example, will deliver the re-opener steelwork volume within the RIIO-2 period).

- Our processes and timeliness for updating our database, post-delivery (e.g., bars addressed during refurbishments) is being improved to ensure our information is dependable. This primarily affects TP221 and the timely production of Technical Data Workbooks and their input onto our Ellipse database.

- We are trialling the use of drones to complete detailed bar-by-bar condition assessments of tower steelwork, for instances where helicopters cannot be used (e.g., fields with horses).

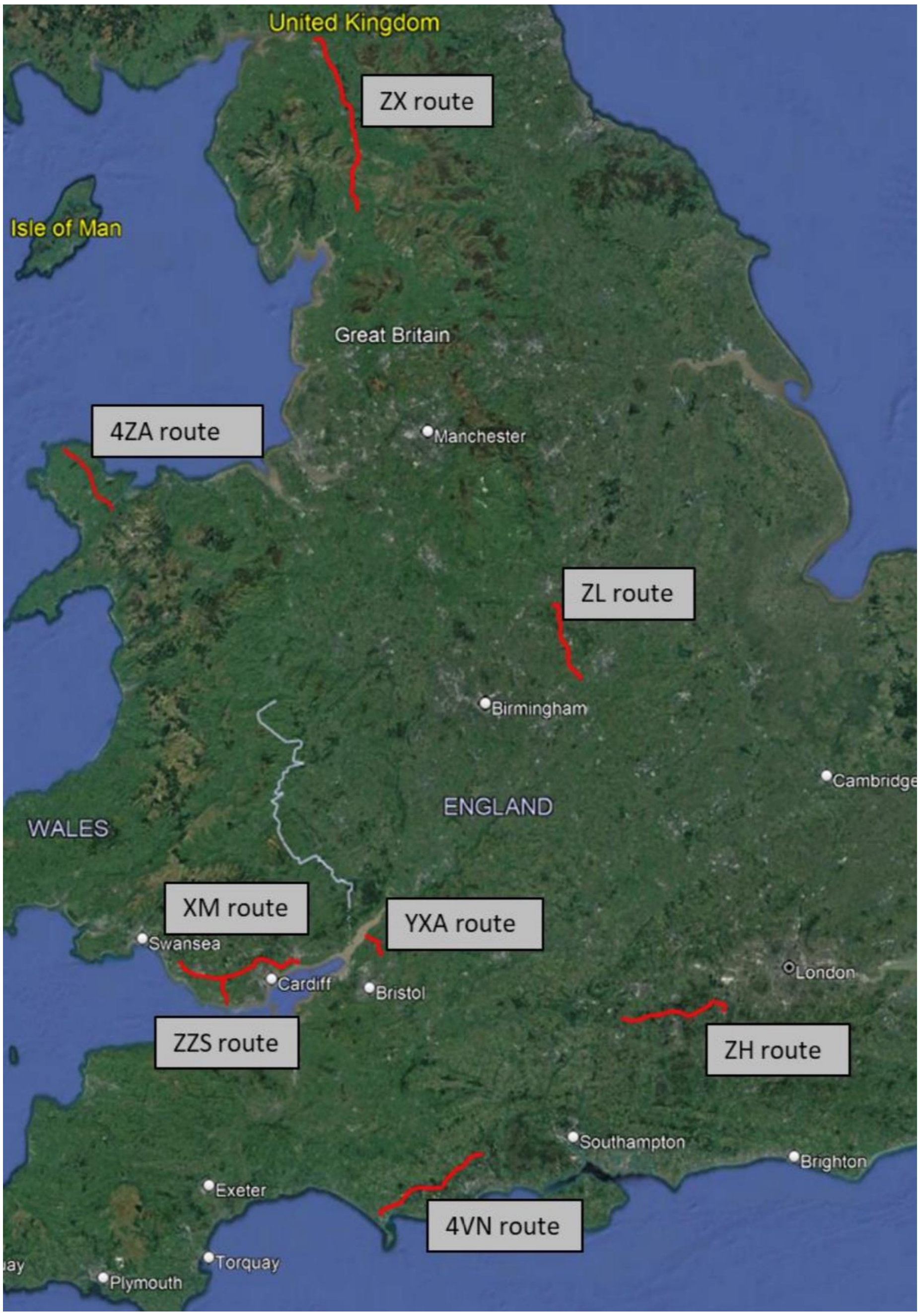
6. Demonstration of the Needs Case

Steelwork Surveys

The eight surveyed routes are shown on figure 6.1 'Route locations' below. In addition, 43 individual towers with defective bars were also assessed.

All climbing survey information was captured digitally on tablets loaded onto a dedicated SharePoint Site (see Annex 14.1 for details).

Figure 6.1: Route Locations



Steelwork Outcomes

Climbing survey information was recorded using specialist software on ruggedised tablet devices. This enabled information to be processed in a standardised and consistent manner. The principal outputs from the steelwork surveys include:

- Annotated Line Diagrams for each tower (figure 6.2 refers)
- A Material List for each tower (figure 6.3 refers)
- A photograph Referencing Spreadsheet for each tower (figure 6.4 refers)
- Photographs for each tower (figure 6.5 refers)
- Defective Steelwork Report for each tower (figure 6.6 refers)

Figures 6.2 – 6.6 can be found at the end of this section. A full set of results can be found on our SharePoint (see Annex 14.1 for details).

Analysis of the survey information resulted in a volume of [redacted] tonnes of replacement steelwork. This is broken down as follows:

- [redacted] of grade 5 & 6 bars (excluding bent bars)
- [redacted] of bent bars (final assessed replacement weight)
- [redacted] of additional steelwork to allow full E/W Peak replacement on [redacted] towers
- [redacted] of tower defect steelwork on [redacted] towers

We propose to deliver the above replacement steelwork as baseline funding. The works to be undertaken for the funding are listed out in Table 6.1 below.

Table 6.1 - Summary of Tower Steelwork Re-Opener Survey Outcomes (weights in tonnes)

Route	**Total RIIO-2 BP submitted Volume**	**Replacement Steelwork (grades 5 & 6) – Piecemeal bar changing (excluding bent bars)**	**Replacement Steelwork (grades 6) – Piecemeal bar changing (bent bars only)**	**Earthwire Peak Replacements (additional weight)**		**Total re-opener Replacement Volume**
				Qty	**Weight (additional)**	
Survey Type	(helicopter visual inspections)	(full bar-bar climbing surveys)				
4VN	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
4ZA	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
XM	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
YXA	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
ZH	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
ZL	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
ZX	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
ZZS	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Defective Bars	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
TOTALS	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Analysis of the survey results indicate no whole or partial tower replacements will be necessary (apart from Earthwire peaks), and further analysis also found approximately [redacted]% of replacement steelwork are body bars which can be replaced under Limited Access Conditions (non-outage) which provides greater flexibility when planning the delivery of these works.

An initial volume of [redacted] of bent bars (automatically grade 6 in accordance with TS3.04.31) was identified from the surveys for further assessment. Subsequent analysis of these bars found over [redacted]% ([redacted]) of defects were very minor in nature, with no impact to structural integrity. Accordingly, these have been de-scoped from the volume leaving [redacted] still to replace.

The 27 towers identified for E/W Peak replacements are spread over five routes, namely:

- 4VN route: [redacted] replacements (4VN004, 021, 022, 023, 024, 026, 031, 032 & 033)
- 4ZA route: [redacted] replacements (4ZA019, 021, 022 & 024)
- XM route: [redacted] replacements (XM053, 078, 100, 112, 126 & 157)
- ZL route: [redacted] replacements (ZL067 & 070)
- ZZS route: [redacted] replacements (ZZS002, 005, 006, 007, 009 & 010)

The remaining steelwork is piecemeal bar changing, the vast majority of which is secondary body bars although there are [redacted] crossarm struts/chords which require replacing. Replacing these will require de-loading the affected crossarm. In addition, there are [redacted] leg bars with localised grade 5 rust patches which, which we have further reviewed and propose to repair in-situ.

Note: Tower XM136 (see below) has very small dents in Legs A, B & C which are minor in nature, no further action is proposed for these bars.

Details of crossarm struts/chords and leg bars:

- 4VN route: 4VN004 (**leg bar**), 4VN009 (top crossarm chord), 4VN015 (top crossarm chord), 4VN018 (**leg bar**), 4VN109 (**leg bar**)

- 4ZA route: 4ZA022 (**leg bar**)

- XM route: XM048 (bottom crossarm strut), XM098 (bottom crossarm strut + **leg bar**), XM099 (middle crossarm strut x2), XM100 (top crossarm strut), XM136 (**leg bars A, B & C – no further action**), XM157 (top & middle crossarm chords), XM161 (**leg bar**)

- YXA route: YXA016 (**leg bar**), YXA017 (top crossarm strut)

- ZH route: ZH336 (**leg bar**)

- ZL route: ZL029 (top crossarm strut), ZL030 (top & bottom crossarm struts), ZL061 (**leg bar**), ZL062 (middle crossarm strut), ZL081 (**leg bar**)

- ZX route: ZX187 (middle & bottom crossarm chords), ZX189 (top crossarm strut), ZX204 (**leg bar**)

- ZZS route: ZZS034 (top crossarm chord), ZZS035 (bottom crossarm chord)

For reference, the photographs (reference number in brackets) associated with the above leg bars are:

4VN004 (DSCF2946 & 2949), 4VN018 (DSCF3404), 4VN109 (DSCF2037), 4ZA022 (DSCF4193), XM098 (no photo available), XM136 (DSCF3375 – 3378), XM161 (DSCF3822 & 3827), YXA016 (DSCF2496), ZH336 (DSCF0049), ZL061 (DSCF9174), ZL081 (DSCF2186) & ZX204 (no photo available).

Photographs are contained on the Steelwork and Foundation Re-Opener SharePoint site, and a link is provided in Annex 14.1, below is figure 6.1 shows a typical small grade 5 rust patch on a leg bar.

Overall, the volumes identified from our re-opener climbing surveys represent about [redacted]% of the volume estimated for our RIIO-2 submission (which was based on HDCA helicopter information) - [redacted] tonnes compared to [redacted] tonnes.

However, a volume of [redacted] grade 4 steelwork (equivalent to about [redacted] tonnes) was identified for enhanced paintwork recovery, this is indicative of a higher-than-expected proportion of the helicopter zonal assessments being grade 4 or lower. This grade 4 steelwork volume has been subsumed into our painting programme, with most routes being painted in 2021 and 2022 (4VN, 4ZA, XM, YXA, ZH & ZZS). We are assessing opportunities to address the ZL and ZX routes during RIIO-2.

The outcome of the [redacted] individual tower inspections resulted in [redacted] towers requiring replacement steelwork, with a total tonnage of [redacted] This is detailed in Table 6.2 below.

Table 6.2 - Summary of Tower Steelwork Defect Re-Opener Survey Outcomes (43 towers) (weights in tonnes)

Tower section	Tower	Tower type	Steel replacement Weight (kg)
Tower leg and leg bracing damage	ZZ051	BKL2DM8	[redacted]
	4YG018	BK L6 D E10	[redacted]
	4YH023	BB L6 D STD	[redacted]
	ZL333	BKL2DE8	[redacted]
	XF048	L3DM8	[redacted]
	4TQ034	BB L6 (M) D M3	[redacted]
	4ZP009	BB L6 D E40	[redacted]
	ZDF034	L2 D E16	[redacted]
	4KG028	L12 D E6	[redacted]
	ZB026	L2 D STD	[redacted]
Cross-arm damage and corrosion	ZD017	BK L2 D60 M12	[redacted]
	ZD068	BK L2 D60 STD	[redacted]
Tower body corrosion and damage	ZX035	BK L2 D10 STD	[redacted]
	4ZF048	BBL6 D E40	[redacted]
	ZL476	BK L2 D E44	[redacted]
	4YC006	BICC L6 D30 STD	[redacted]
	4ZY265	BICC L6 D E20	[redacted]
	4ZY252	BICC L6 D E30	[redacted]
	4ZY288	BICC L6 D E30	[redacted]
	4ZY467	BICC L6 D E20	[redacted]
	ZR078	L8C D E36	[redacted]
	4ZW042	BB L6D E20	[redacted]
	YYT016	L8C D 2xE16, 2XE24	[redacted]
	4ZM422	BICC L6 D E30	[redacted]
	Total Weight		[redacted]

Figure 6.1: Typical grade 5 rust patch on Leg Bars (ZL061 – photo DSCF9174)

Figure 6.2: Typical Annotated Line Diagram (4ZA021)

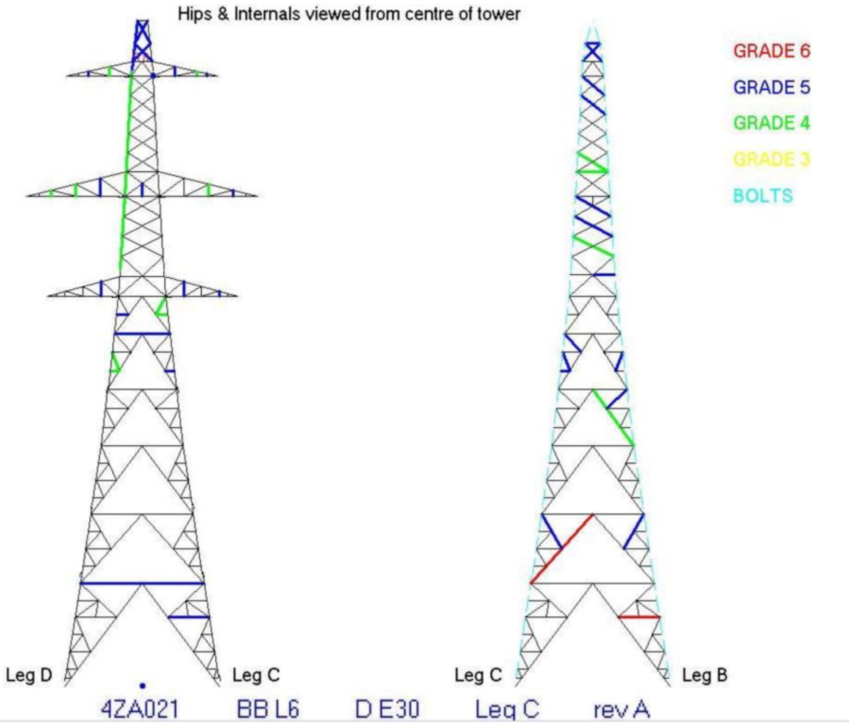


Figure 6.3: Extract of typical Material List spreadsheet (4ZA021)

[redacted]

Figure 6.4: Extract of typical Photo Referencing spreadsheet (4ZA021)

Overview of tower 4ZA021		59.2M					
Inspected By Engineer							
ID Plate photo taken 23/08/2021 11:08:31							
Photo Folder C:\jptowerContracts\SdcDataEast\TowerData\4ZA\Photos\4ZA021\							
Mark	Face	Ht	Gr	UT	Status	Comment	Photos
6D438	CB	6.1	6			Slightly Bent	DSCF4168
6D91	DC	56.9	5	5.8	Critical		DSCF4169
6D92	BA	56.9	5	5.9	Critical		DSCF4170
6D285	AD	56.3	6			Condition	DSCF4171
6D132	CB	12.2	6			Hole	DSCF4173

Figure 6.5: Typical photograph examples (4ZA021)

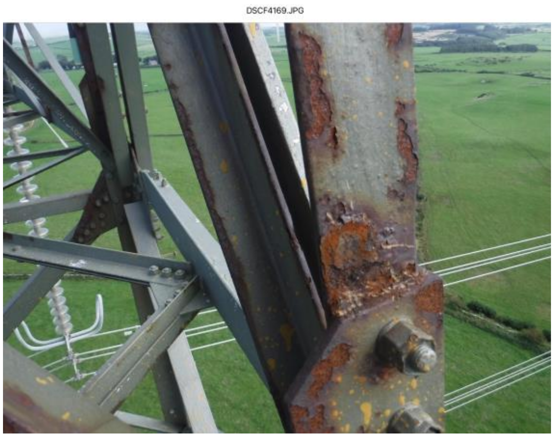
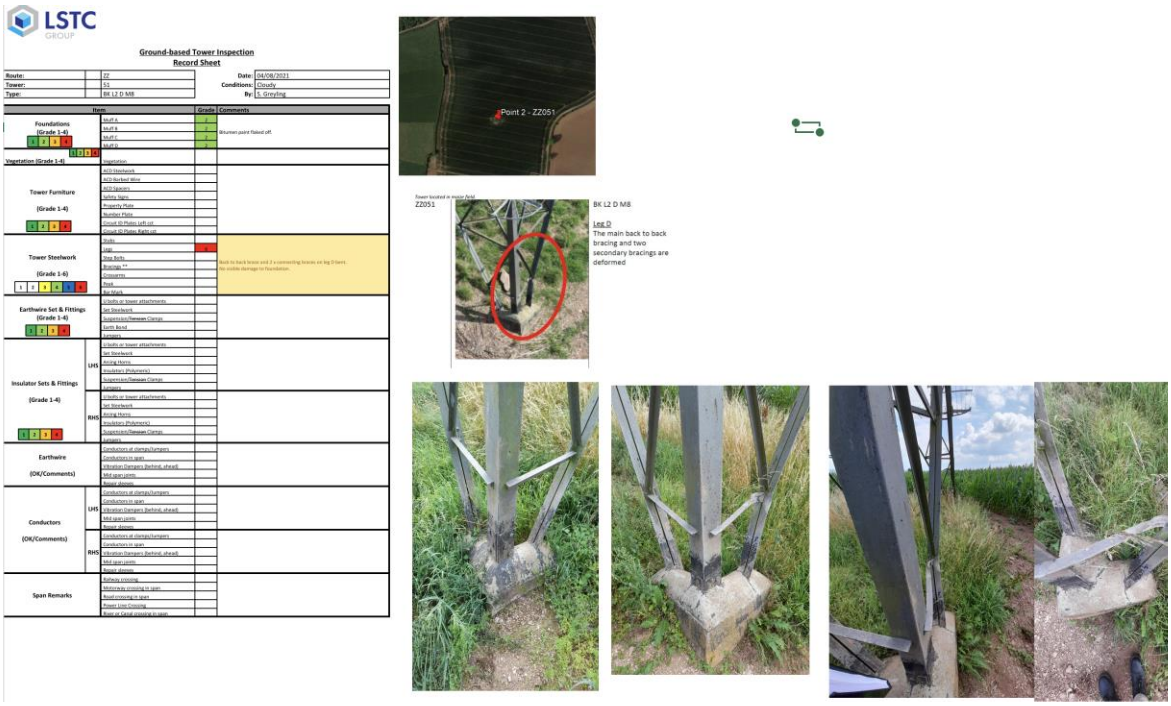



Figure 6.6: Typical defective steelwork report (ZZ051)



Preparation for RIIO-3 Steelwork Volumes

The estimates in our RIIO-2 steelwork volume were made by using helicopter visual zonal assessments (level 1) to calculate our quantities. This has now been confirmed by completing bar-by-bar (level 2) climbing surveys. Accordingly, in preparation for RIIO-3, we propose to base our volumes on (level 2) bar-by-bar climbing surveys and are seeking additional funding within this re-opener to cover these surveys.

The outcomes of the level 2 surveys will be used to directly scope the associated capital schemes, and form part of their front-end working.

Using our latest zonal helicopter assessment information, we have identified a total of [redacted] towers on our network contain zones with grade 5/6 steelwork and require a climbing survey within T2 to confirm whether work is needed in T3. A copy of this assessment is attached in Annex 14.1.

(Note: The above assessment includes [redacted] towers on the VF route, together with [redacted] on the ZBC route. These will be subsumed into their respective RIIO-2 refurbishment schemes and have therefore been excluded from the total).

The [redacted] towers are spread over [redacted] routes, namely:

4KG, 4TF, 4TH, 4YA, 4YJ, 4YL, 4ZB, 4ZD, 4ZG, 4ZH, 4ZM, 4ZQ, 4ZR, PHG, VE, VO, VY, XF, YYA, YYC, YYE, ZA, ZDA, ZDF, ZD, ZE, ZFA, ZF, ZFF, ZG, ZL, ZN, ZPA, ZPC, ZP, ZU, ZZA, ZZB & ZZC.

Foundation Outcomes

The three key objectives for our enhanced foundation strategy were:

(a) determine risk level posed by poor condition foundations on the OHL network,

(b) determine if a BGS-based risk scoring mechanism could be used to identify the most vulnerable towers on our network and

c) determine if low-cost non-intrusive inspections can provide a reliable alternative to intrusive inspections.

We have completed [redacted] intrusive investigations out of the [redacted] identified at Final Determinations.

Our investigations found repairs are required on [redacted]% of foundations with potentially a further [redacted]% (subject to further assessment at the time of next refurbishment) compared to an assumed 75% at our RIIO-2 submission.

The dominant driver for the interventions is poor quality workmanship and/or historical installation practices when the routes were originally constructed, although certain geological factors, such as chemical attack, may be responsible for some of the deterioration. We found some instances of honeycombing (see figure 6.8 for an example). Concrete is vibrated to remove air bubbles and if poorly vibrated, concrete can form 'honeycombs' which is weakens its structure. For many decades after the 1960's we have obtained concrete cubes for 28-day testing, which is the standard practice. Over [redacted]% of interventions are associated with non-standard/piled foundations.

The investigation results are shown in Table 6.3 below, which shows only the towers with proposed intervention, [redacted] + the [redacted] potential future interventions, i.e., [redacted] towers.

Table 6.3. Summary of Foundation Re-opener Survey Outcomes ([redacted] towers)

[redacted]

We propose candidates for foundation strengthening (nineteen) are re-assessed as part of the future conductor refurbishment scheme, as no evidence of subsidence or tower distress was found at any of these towers. We propose the remaining repair works ([redacted]) are completed under baseline funding, as with the existing foundation works allowance**.**

Our analysis of foundation investigations to date is that network risk posed by poor condition foundations is **very low**, since only minor remedial works are necessary on [redacted]% of the towers inspected (even though most samples were selected from 'high' and 'very high' geological risk conditions).

Accordingly, our conclusion is that the RIIO-1 emergency repairs were mostly likely outliers, rather than indicative of much wider issues.

We found the BGS-based risk factors did not provide a reliable method of identifying vulnerable towers, with the distribution of scores for 'no intervention' vs. 'intervention required' being very similar to each other, as can be seen in figure 6.7 and Table 6.4 below.

For the remaining [redacted] towers, in light of the outcomes to date, we propose to check [redacted]% of the pile caps on the ZBC and ZBD routes (which are 100% piled) to establish if poor concrete condition is an issue on these routes.

We have reviewed the line schedules for the 4VK route and found almost 100% of this route has standard concrete foundations and have concluded there will be little value in completing investigations on this route. Accordingly, we propose to complete a further [redacted] foundation investigations ([redacted] each on the ZBC and ZBD routes, which will be delivered as part of the respective RIIO-2 conductor schemes).

Figure 6.7: Comparison of BGS-based scoring

[redacted] towers ([redacted]%) – no intervention required – **Average BGS Score = 13**

[redacted] towers ([redacted]%) – intervention required – **Average BGS Score = 14**

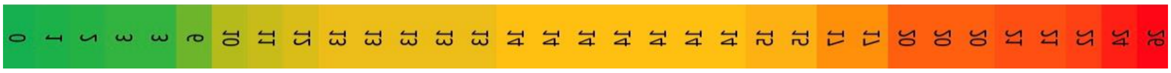


Table 6.4. Range of BGS Risk Scores for each Intervention type (97 surveyed towers)

Intervention Type	Number of Towers	Lowest BGS Score Risk Score	Highest BGS Risk Score	Average BGS Score Risk Score	Average BGS Risk Category
Overall Range	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Do Nothing	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Foundation Strengthening	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Leg Repairs	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Pile Cap Repairs	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Muff Repairs	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Figure 6.8: Extract from EJR for 4ZE015 showing honey-combed concrete

Non-intrusive foundation surveys

Prior to commencing the main intrusive investigations, we took the opportunity to complete two types of non-intrusive foundation surveys to determine if these can provide a reliable and cost-effective alternative to intrusive investigations.

The first test was a Transient Dynamic Response (TDR) test which may detect defects such as joints at the neck/ muff or neck/ pyramid and which impede full depth signals. The second was a Linear Polarisation Resistance (LPR) provides a guide to corrosion potential.

The results were:

<u>TDR Results</u>
[redacted] results to compare TDR with excavated depth.
Variation:-

>[redacted]% ; [redacted] towers. ([redacted]%) possibly neck/pyramid joint
[redacted]% ; [redacted] towers ([redacted]%)
Within [redacted] towers ([redacted]%)

[redacted] results to compare with drawing depths, actual depths unproven-arguably misleading analysis
Variation:-
>[redacted]% [redacted] towers [redacted]%)
[redacted]% ; [redacted] towers ([redacted]%)
Within [redacted]% ; [redacted] towers ([redacted]%)

Our conclusion is that TDR testing does not provide a reliable alternative to intrusive investigations, as there is too much variation in the results, especially when comparing to drawing depths ([redacted]% are above +/-20% of the depth indicated on the drawing).

<u>LPR Results</u>

Whilst [redacted] cases of ongoing corrosion and [redacted] cases of significant corrosion were recorded there was no visible evidence from undertaking the foundation inspections, or correlation with potential chemical attack. Accordingly, we conclude LPR testing does not provide a reliable alternative to intrusive inspections.

7. Options and option costs

Options Overview

Optioneering

The OHL Towers and Foundations schemes are planned on a yearly basis. Changes to the drivers that are identified as part of an annual review are reflected in the investment scheme plans for subsequent years.

Optioneering work is undertaken to provide greater certainty of scope, outage availability, forecast cost and risks associated with a full set of options.

During the RIIO-T2 business plan preparation, a high-level stage 1 optioneering process was undertaken to identify assets which could fall in to one of three possible, high-level, intervention categories. For OHL Towers and Foundations these were: do nothing, refurbishment, and replacement.

Stage 1 Option Development – Tower Steelwork

i. Do Nothing

This option would deviate from National Grid Guidance on both Overhead Line Tower Steelwork Management and Tower Painting and take no action on the OHL tower bodies by either painting or steelwork recovery/treatment/replacement. The result of the decision would greatly reduce tower resilience to extreme weather and/or broken wire conditions and ultimately increase the likelihood of tower collapse due to the ultimate failure of critical steelwork members, requiring an emergency tower replacement. Following National Grid technical guidance, steelwork typically increases by a grade (worsens) every 6 years once the painted coating has degraded, and it is assumed that eventually a tower will collapse without any intervention.

ii. Painting, Grades 4 Recovery, and Grade 5 & 6 Replacement

This option would undertake tower painting as per Policy, and as part of the process any identified Grade 4 steelwork is recovered and able to be re-used, and Grade 5 may be treated to prevent further degradation if deemed suitable. Steelwork bars identified as Grade 5 or 6 have their thickness measured via a climbing survey and the overall tower strength and load capability is modelled to determine whether the structural integrity is compromised. Any steelwork bars that have degraded to below specification and are deemed 'critical' are replaced on a piecemeal approach along the OHL route.

iii. Painting of Grades 1/2/3 & Grades 4/5/6 Replacement

This option would undertake tower painting as per Policy and replace any steelwork bar that cannot be painted using traditional methods, those identified as Grades 4, 5, or 6. Painting costs would decrease marginally, but replacement costs would be significantly higher due to the much higher volume of Grade 4 comparative to Grades 5 and 6.

Stage 1 Option Development - Foundations

i. Do Nothing

No intervention would be taken on any part of the OHL tower below ground level. Historically, it has been National Grid's policy to undertake non-intrusive foundation checks as part of surveys for full refurbishment (OHL Conductor) projects. However, recent issues with the tower foundations (significant stub steelwork corrosion and poor concrete condition) identified on specific OHL circuits have led to emergency foundation works on two towers. If no further intervention is taken on the rest of the network, there as a high likelihood that towers will either fail and require a full emergency replacement or identified after significant damage has already occurred and require an emergency foundation repair.

ii. Intrusive Investigation and subsequent remediation work

The [redacted] towers identified as 'High' or 'Very High' risk of foundation issues will have full-depth intrusive investigations carried out to assess the condition of the below-ground steel and concrete via a visual inspection and laboratory concrete testing. It is expected that results of targeted intrusive investigations will yield a significant number of foundation upgrades, repairs, and potentially full tower replacements.

Interventions and intervention strategies

Steelwork

The intervention strategy pertaining to OHL tower steelwork is to find the most cost-effective and deliverable balance between tower painting and tower steelwork replacement depending on the surveyed grade of the steelwork. The outcome of the cost benefit analysis (CBA) from the IDP with the options listed above is unchanged, and the strategy remains as to only replace bars that cannot be treated or recovered by an enhanced painting preparation, as this method is the cheapest and quickest solution. As detailed in section 5.2, this is typically members categorised as Grade 5 or 6.

For this re-opener submission rather than looking at the portfolio as a whole, the survey information now obtained has enabled a more granular view of each circuit, and a decision can be made on both a route-by-route and bar-by-bar basis.

Foundations

The Investment Decision Pack for the RIIO-2 submission highlighted the proposed requirement to survey a specific set of towers that were selected due to their risk scores. Now the towers have been surveyed, the list of options centres of the potential intervention types for each individual tower based on the results of the survey work.

Stage 2 Option Development - Intervention Refinement

The long list of options are all credible interventions for both Steelwork and Foundations, depending on the condition ascertained by the survey results. In order to suitably compare each option, a cost-benefit analysis was undertaken to demonstrate how a single-strategy approach (e.g. replace all steelwork bars, or upgrade all foundations) compares to a case-by-case option, which may be a combination of the options.

Steelwork

As described above, the list of options for OHL steelwork is for each individual bar or zone of bars on the towers that were identified by the Level 1 helicopter data, and subsequently had Level 2 climbing surveys undertaken. The options include:

Option	Detail
Do Nothing	No action taken on the tower.
Paint or Treat the bar	Bars that are grade 3 or below can be painted, which applies a protective barrier to the steelwork, effectively reducing the condition to grade 1. In typical environmental conditions, no intervention should be required for a further 18 years.

	Bars that are designated grade 4 can have an advanced treatment applied to them. This is a more involved/expensive process than regularly painting but will produce the same result as the grade 3 bars described above.
Replace the bar piecemeal	Bars individually identified as grade 5 or 6 cannot be treated or painted to improve their condition. Individual bars can be replaced on a piecemeal basis with new steelwork members.
Replace tower section	When many bars require replacement in close proximity, an option could be to replace an entire section of the tower. This would typically be for extremities of the tower such as crossarms of earthwire peaks where the material savings of piecemeal replacements would be outweighed by the very long outages and labour costs.
Full tower replacement	In some rare cases, the condition of the bars are worse enough throughout the entire tower that a full replacement might be the most cost-effective option. As above, this is normally when the time taken to replace thousands of bars piecemeal would either be time or cost prohibitive.

Foundations

The list of options for OHL foundations is for each tower that was surveyed as part of the preparation for this re-opener submission. The options include:

Option	Detail
Do Nothing	No action taken on the tower.
Foundation / Pile cap repair	Minor remedial works taken to the above or below-ground foundations, which could include replacements to pile caps, protective muff replacements, or repairs to tower legs.
Foundation strengthening or upgrade	Due to degradation of the existing materials, the current foundation would be increased in size or capacity via the addition of concrete either below or above ground. If it was determined that additional strengthening would not suffice in increasing the capability of the foundations, an in-situ method of converting the foundation type could be employed such as installing piles to a conventional foundation type.
Replace full tower	If the state of the foundation is simply in too poor condition to take any remedial works, the only remaining option would be to construct a new tower in-line to the exist route and demolish the old tower.

8. Methodology for selection of the preferred option

Approach

As discussed in section 7, it is difficult to apply a typical usage of a CBA to the optioneering for these interventions, as the work required for each OHL tower was considered individually rather than determining an option to be applied to the entire route or whole steelwork/foundations portfolios. However, several examples have been built up to compare specific examples where there are at least two valid intervention types in order to demonstrate the cost-differential between the options. These include:

Steelwork

- Comparison of a do-nothing option in relation to whole tower replacements and targeted piecemeal steelwork replacements.
- Piecemeal replacement of earthwire peaks compared to full section replacement
- Replacement of Grade 4 (inclusion in this re-opener) compared to treatment/recovery (subsumed by OHL Painting portfolio)

Foundations

- Comparison of a do-nothing option in relation to in-situ foundation upgrades and targeted foundation repairs

Cost benefit

Steelwork

If no intervention is taken on corroded or damage OHL steelwork, it would greatly increase the likelihood of tower collapse under extreme weather condition due to the ultimate failure of critical steelwork members, requiring an emergency tower replacement. CBA 'A' (see annex 14.3) summarised by figure 8.1 below, demonstrates that a 'fix on fail' approach would result in a significantly higher cost than a proactive intervention. Of the two options, targeted piecemeal replacement of Grade 5 & 6 steelwork is also far cheaper than a planned whole tower replacement.

Figure 8.1: Summary of CBA A – Steelwork Replacement Options

Option No.	Desc. Of Option	Preferred Option	Total Forecast Expenditure *(£m)*	Total NPV	Delta *(Option to baseline)*	10 Years	20 Years	30 Years	45 Years	Total NPV *(Incl. Monetised Risk)*
Baseline	Do Nothing		-£ 1,149.06	-£ 672.12		-£ 88.40	-£ 332.87	-£ 512.15	-£ 659.56	-£ 672.12
1	Full Tower Replacement		-£ 701.75	-£ 574.68	£ 97.44	-£ 244.20	-£ 399.81	-£ 494.02	-£ 569.60	-£ 574.68
2	Piecemeal Steelwork Replacement	Y	-£ 18.16	-£ 16.94	£ 655.18	-£ 9.04	-£ 12.85	-£ 15.13	-£ 16.91	-£ 16.94

Where a significant number of corroded secondary members are present along with the critical Grade 5 or 6 members within a section of OHL tower, it may warrant a full section replacement (see figure 5.2). Although this would involve a larger tonnage of steel, and require crane access to site, it may also significantly reduce the time taken to carry out the work, which would in turn reduce the costs associated with labour, overheads, and system outages. CBA 'B' compares these two options, and the outcome is that in this case, it would be beneficial to replace the entire [redacted] earthwire peaks (section PK1 and equivalent PK2 on figure 5.2) containing significant numbers of corroded bars.

Figure 8.2: Summary of CBA B – Steelwork Earthwire Peak Options

Option No.	Desc. Of Option	Preferred Option	Total Forecast Expenditure *(£m)*	Total NPV	Delta *(Option to baseline)*	10 Years	20 Years	30 Years	45 Years	Total NPV *(Incl. Monetised Risk)*
Baseline	Do Nothing		-£ 64.23	-£39.32		-£ 5.90	-£20.84	-£30.57	-£38.64	-£ 39.32
1	Wholesale earthwire peak replacements	Y	-£ 1.11	-£ 1.04	£38.28	-£ 0.55	-£ 0.79	-£ 0.93	-£ 1.04	-£ 1.04
2	Piecemeal Replacement of Earthwire peak bars		-£ 1.28	-£ 1.20	£38.12	-£ 0.64	-£ 0.91	-£ 1.07	-£ 1.20	-£ 1.20

As demonstrated in IDP A9.09A, a comparison was done on whether to replace the Grade 4 steelwork bars identified by these surveys along with the Grade 5 & 6 bars, or whether to treat and recover the steelwork as part of the OHL Painting programme.

A total of [redacted]tonnes, equating to [redacted]m^2, of Grade 4 bars was recorded during the surveys. CBA 'C' shows that including these volumes within the routine painting programme, where they would form just [redacted]% of the total T2 painting volumes, and recovering the Grade 4 bars is significantly more cost-effective than replacing them within this project.

Figure 8.3: Summary of CBA C – Steelwork Grade 4 Replacement vs Recovery Options

Option No.	Desc. Of Option	Preferred Option	Total Forecast Expenditure *(£m)*	Total NPV	Delta *(Option to baseline)*	10 Years	20 Years	30 Years	45 Years	Total NPV *(Incl. Monetised Risk)*
Baseline	Do Nothing		-£ 1,068.17	-£ 564.15		-£ 98.17	-£ 346.59	-£ 508.38		-£ 564.15
1	Replacement of Grade 4 bars		-£ 26.81	-£ 32.67	£ 531.48	-£ 24.90	-£ 29.48	-£ 32.12		-£ 32.67
2	Treatment/Recovery of Grade 4 bars	Y	-£ 0.53	-£ 0.65	£ 563.50	-£ 0.49	-£ 0.58	-£ 0.63		-£ 0.65

Foundations

During the surveys undertaken for this reopener [redacted] towers were identified with defects. If these were left untouched, it is projected that the tower foundation would eventually become compromised, greatly increasing the risk of collapse during extreme weather conditions. In CBA 'D', this do-nothing option was compared against two types of interventions: the targeted approach set out within this report, and a generic in-situ foundation strengthening/upgrade. As well as having the lowest capital cost, the targeted approach also has the lowest carbon impact, by limiting the amount of concrete used.

Figure 8.4: Summary of CBA D – Foundation Intervention Options

Option No.	Desc. Of Option	Preferred Option	Total Forecast Expenditure *(£m)*	Total NPV	Delta *(Option to baseline)*	10 Years	20 Years	30 Years	45 Years	Total NPV *(Incl. Monetised Risk)*
Baseline	Do Nothing		-£ 17.87	-£ 15.67		-£ 8.22	-£ 12.03	-£ 14.31		-£ 15.67
1	Targeted Foundation Repairs	Y	-£ 4.14	-£ 4.61	£ 11.06	-£ 3.17	-£ 3.94	-£ 4.39		-£ 4.61
2	Full Foundation Upgrades		-£ 11.76	-£ 13.10	£ 2.57	-£ 9.00	-£ 11.20	-£ 12.48		-£ 13.10

9. The preferred option and detailed costs

Preferred option

Steelwork

The preferred option for OHL tower steelwork is to replace all Grade 5 and 6 bars identified as being in poor condition, as per the steelwork grading framework in table 5.2. Of the bent bars categorised as grade 6, the [redacted]% ([redacted]kg) that are bowed, rolled, or deformed due to design related issues are deemed still fit for purpose and will be retained. Those that show deformation to the heel or flange will be replaced along with the bars categorised for condition-related reasons as they are deemed to have failed in terms of structural or strengthening support. The methodology behind this is detailed within the technical EJR in annex 14.1.

Grade 3 and 4 bars identified via the climbing surveys undertaken have been passed over to the OHL Tower Painting portfolio and will be addressed via treatment or recovery of the members as part of that programme of works. As such, no additional costs for those are required under this re-opener.

Where a significant number of critical bars in close proximity to other secondary corroded bars were identified on the earthwire peaks, the whole section will be replaced. Although this may include some members categorised as grade 4 or lower, the costs associated with time taken to replace every critical bar outweighs the savings made from replacing a lower tonnage of steelwork.

In preparation for RIIO-3, it is proposed a number of towers will be climbed that have recently been identified as containing Grade 5 or 6 bars, that have likely degraded to this level since the data was taken for the T2 submission. These include [redacted] towers across 39 routes.

Foundations

The preferred option for OHL tower foundations is to take no action on most towers surveyed to confirm the condition of the assets, following the desktop risk assessment studies performed. Of the [redacted] towers surveyed, [redacted] appeared to be in good condition and were immediately ruled out of the need to take any intervention. A further [redacted] did show minor defects to the concrete or were calculated as being under capacity, but a risk review of historic performance and environmental factors has resulted in a proposal to take no immediate action. These towers have been flagged for further assessment when the entire OHL route requires a full refurbishment, in order to deliver the most efficient intervention.

Of the remaining [redacted] towers, two show structural defects that repair repairs to the tower legs, 8 show defective piles that require replacement pile caps, and 4 had damaged, broken, or degraded muffs that require replacement. For the survey work, a single tower leg was excavated to undertake the full depth intrusive survey as it would be indicative of the condition of the other [redacted] legs. To rectify the issues identified on these [redacted] towers, [redacted] legs will be repaired.

Detailed Cost assessment

Steelwork Costs

Five of the steelwork routes were costed as individual projects, however due to the lower volumes on the ZX, YXA, and ZH routes, along with the ad hoc defective bars, it was decided that this would likely be bundled as a single project for a contractor to deliver, and as such as priced as an inclusive sum. The costs below do not include spend-to-date.

Route / Project	Cost (£)
4ZA	[redacted]
ZL	[redacted]

XM	[redacted]
ZZS	[redacted]
4VN	[redacted]
ZX, YXA, ZH & Defects	[redacted]
T3 Tower Climbing Surveys	[redacted]
Steelwork Grand Total	**£18,053,119**

Foundations Costs

As the remedial actions for the tower foundations were categorised into three distinct intervention types, each was costed as a single project to complete the work on the [redacted], [redacted], and [redacted] towers respectively.

Intervention type	Cost (£)
Muff Replacement	[redacted]
Leg Repair	[redacted]
Pile Cap Replacement	[redacted]
Foundations Grand Total	**£4,137,707**

Estimating and Rates

The costs used for each of the options are built bottom-up by our cost estimating team using our in-house estimating tools. The rates for each physical activity and external project management are based on a combination of current market rates for equipment/materials, contractor rates and fees, and recently completed projects. The final values are then again benchmarked against recent projects to ensure a level of accuracy and consistency is maintained. No National Grid indirect costs have been included in these cost estimates.

Detailed Cost Estimate Breakdown

Annex 14.4 contains a detailed breakdown of the cost estimate for each individual steelwork route and each tower foundation location. This bottom-up estimate is shown in a standard format used for all internal cost estimates and is aligned to National Grid's cost and work breakdown structures.

Although typically included in our internal cost estimates for forecasting purposes, none of the Closely Associated Indirect (CAI) costs that would be applicable to this scheme have been included in the cost build up, and our assumption is that Ofgem will add this to the agreed funding value post consultation conclusion, in line with the Opex escalator mechanism. As such, the 'NG Project Management', 'Optioneering / Development' and 'Closeout' categories will be blank for these estimates.

'Land and Consent Management' includes costs related to 3rd party interactions for site access, grantor management, and forecast compensation payments. 'Internal Procurement' is typically used for materials or services purchased directly by National Grid, but in this instance is solely for public relations management. 'Overhead Lines' captures all external contractor-related costs, including the physical work, purchase of materials, and fee. 'NG Commissioning/NG ET Ops' includes typical commissioning activities, plus all costs related to Safety from the System. Although there are no commissioning activities for these projects, support is required for safety switching for electrical outages, and Senior Authorised Person (SAP) and other supporting site-based staff. Finally, 'Contingency' relates to the Risk & Contingency costs described in the section below.

Site specific considerations

Each tower with a planned steelwork or foundations intervention is reviewed individually, and site-specific access requirements such as length of any trackway or haul roads are taken into account. Variation between routes for steelwork interventions are due to the differing tonnages, proportion of tension to suspension towers, length of access, number of earthwire peaks needing replacement, and number of towers along the route requiring work. In particular, the XM will show a high unit cost as it is the only route made up of the L3 tower type and also requires earthwire peak replacements. The earthwire peaks on other tower types can be safely accessed under single-circuit outage conditions, but the size and shape of this tower type will require a temporary diversion of one circuit (with the other under outage), so the entire main route is not live. These temporary masts add additional cost to the works.

General assumptions

A number of estimating assumptions have been made to cost the proposed works as accurately as possible. These have all been made based on similar, previously delivered works and by utilising the experience of various project managers and engineers. These include:

Steelwork

- Typical delivery rates are [redacted]kg per 5-person gang per day, and utilising two gangs
- Earthwire peak replacements on suspension towers require a full day, with tension towers needing five days
- 2 weeks are allowed for mobilisation of a site yard and receipt of materials, and a further 2 weeks after the works have been completed for demobilisation and close out.
- Plastic trackway has been included to access all tension towers
- Earthwire peak replacement towers have stone access road included to accommodate crane access, along with a crane pad at the tower
- Access lengths have been taken from the ‘red line drawings’ from our wayleave/easement agreements with landowners
- A rate for environmental surveys and sensible monitoring has been included
- Allowance has been included for vegetation clearance at the base of each tower
- Assumption that no materials/equipment left at the tower location overnight, so security is only necessary at the main yards
- Due to the layout of the L3 tower type, the XM route requires a temporary bypass on one of the circuits to safely access the earthwire peak on the 6 towers requiring replacements.
- Scaffolding has been included on XM126 and XM157 due to proximity of a road and railway.

Foundations

- Minimal site setup required at each tower, no security provisions included
- A single gang of 6 people plus necessary plant for each item of work
- Assumed new muffs required after replacement of pile caps
- Allowance has been included for vegetation clearance at the base of each tower
- Access lengths have been taken from the ‘red line drawings’

Risk & Contingency

The costs above for both the Steelwork and Foundations estimates include a small contingency value of between four and seven percent to account for any unforeseen issues during delivery.
For this reopener submission, a high-level quantitative risk assessment (QRA) was done to define the risk pot for each project, taking into account the specific considerations. At this stage in the process, the inputs used for the QRA have been determined from previously delivered projects and the typical risks that occurred during delivery. These include:

- Cancellation of outages due to operational requirements
- Raw materials prices
- Discovery of protected or invasive species

- Access routes differ to red line drawings
- Reprioritisation of resource
- Extreme weather (1-in-10 year events)
- Delays / refusal of permission from 3rd parties
- Theft

The individual QRA results have been included in annex 14.1

10. Project delivery and monitoring

Steelwork

When assessing the deliverability of the OHL tower steelwork replacement a number of factors were considered, including standard project runways (including development/design), historic installation rates of similar projects, and outage availability.

Below is an example of an OHL Steelwork project runway period that aligns with National Grid's TP500 (Network Development Process) procedure that governs our project development.

Stage	Establish Portfolio	Optioneering	Development	Detailed Design	Physical Works	Project Completion	Financial Closure
Weeks	8	8	26	24	26	24	12

As this re-opener required information that would normally be obtained via the TP500 development process, the standard runway profiles would not necessarily apply, as a significant amount of pre-development work has already been undertaken, including surveys (ecological, archaeological, and asset condition), deliverability assessment, and optioneering.

It is anticipated that development (with shortened timescales due to the existing work) can commence as soon as this re-opener has been agreed, which is assumed to be in October 2022.

Works required for possible intervention options for OHL Towers and Foundations often require transmission system outages. As an operational system, a real-time event (e.g. faults or unexpected repairs on our transmission system or a connected network), can cause arranged transmission system outages to be re-prioritised or even cancelled. Interventions that require transmission system outages are kept under review as they may need to be re-planned at short notice.

Our System Access Planners have completed a high-level assessment of the outage availability to deliver our proposed re-opener volumes and confirm these can be accommodated within the RIIO-2 period. We requested double-circuit outages to replace the [redacted] earthwire peaks, however, these will need to be replaced under single circuit outages as double-circuit outages cannot be secured on these circuits. The earthwire peaks on the routes comprised of L2 towers (ZL & ZZS) can still be delivered under single-circuit outage condition with a specific methodology, but due to the clearance distances on the L3 tower type, a temporary bypass will need to be established to gain safe access to these tower tops. This has been accounted for in the total costs for that route.

The outage assessment indicates single circuit outages for the 8 routes can be accommodated in the remainder of the RIIO-2 period, as detailed in Table 10.1 below.

Table 10.1. Assessment of outage duration and availability

Route	Circuits	Duration (days per cct)	Comments	Planning Comment
ZX	Harker – Hutton 1 & 2	7		Possible in 2024
YXA	Iron Acton – Oldbury 1 & 2	6		Disconnected route. No outage required. Need to maintain public safety.
ZH	Bramley - West Weybridge 1 & 2	9		BRLE-WWEY 1 already on outage in 2024 for 12 days or 28 days as part of SGT5B replacement
4ZA	Pentir – Wylfa 1 & 2	28		Currently in development for 2024 opportunities
ZL	Hams Hall – Willington East / Coventry - Ratcliffe	7	L2 towers – double circuit outage required if possible	Possible in 2024 as two single circuit outages

XM	Cardiff East – Uskmouth – Whitson / Aberthaw – Cardiff East – Pyle / Aberthaw - Tremorfa	17	L3 towers – double circuit outage required	Double circuit outage not possible as this leaves Pyle, Margam and Baglan bay at single circuit risk. Possible in 2024 as two single circuit outages
ZZS	Aberthaw – Pyle / Aberthaw – Cardiff East – Pyle	20	L2 towers – double circuit outage required if possible	Double circuit outage not possible as this leave Pyle, Margam and Baglan bay at single circuit risk. Possible in 2024 as two single circuit outages
4VN	Axminster - Chickerell - Mannington / Chickerell - Mannington	16		Possible in 2024 or 2025

A high-level project programme can be seen in Figure 1 below, highlighting the key project milestone dates including contract tender and award, ecology surveys, and proposed start dates of each route. Those with more flexible outage opportunities highlighted in the table above have been planned to provide a more balanced workload throughout the remainder of the T2 period.

Start Development	Sanction/ Governance	Ecology Surveys - 4ZA/YXA	Tender - 4ZA/YXA	Contract Award - 4ZA/YXA	Tender - ZX/ZH/ZL/XM/ZZS	Materials Procurement	Contract Award - ZX/ZH/ZL/XM/ZZS	Ecology Surveys - ZX/ZH/ZL/XM/ZZS	First Site Access - 4ZA/YXA	First Site Access - ZX/ZH/ZL/XM/ZZS	Tender - 4VN/Defects	Contract Award - 4VN/Defects	Ecology Surveys - 4VN/Defects	First Site Access - 4VN/Defects	All Works Completed
Sep-22	Oct-22	Nov-22	Dec-22	Feb-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Apr-24	Feb-24	Apr-24	May-24	Apr-25	Oct-25

Note: September 2022 commence date assumes reopener submission proposals are agreed by this time. Programme will be adjusted, and routes proposed for 2023 delivery may need to be moved to 2024/2025

Figure 10.1 - Steelworks - High Level Programme

Foundations

The interventions proposed on the tower foundations can all be delivered under a limited-access certificate (LAC), which allows the line to remain in service and require no electrical outages. This will allow the project to remain more flexible in terms of delivery, as work can be arranged outside of the typical outage season in the Autumn or Winter and is only dependant on contractor availability and local ground conditions.

At this stage it is assumed site work will commence during the Spring/Summer of 2024 after a suitable framework has been developed and continue until the Autumn of 2025. A high-level project programme has been included below.

Start Development	Sanction/ Governance	Tender	Contract Award	Ecology Surveys	Detailed design	First Site Access	All Works Completed
Sep-22	Dec-22	Jan-23	Apr-23	May-23	Jun-23	Apr-24	Oct-25

Note: September 2022 commence date assumes reopener submission proposals are agreed by this time.

Figure 10.2 - Foundations - High Level Programme

11. Price Control deliverables and ring fencing

We propose to deliver the steelwork and foundation re-opener volumes using baseline funding, since most of the funding (83%) is already allowed within the T2 baseline, for which we are asking for an extension to cover the required additional works, and there is clear historical cost precedent for the interventions.

12. Stakeholder engagement and whole system opportunities

Our strategy is informed by stakeholder priorities

The development of our T2 Business Plan was underpinned by the largest public engagement exercise we have ever conducted, to ensure we deliver on what's important to our stakeholders. From this engagement, delivering a safe and reliable electricity transmission network was identified as the top stakeholder priority. Stakeholder engagement has also informed our approach to deliver and maintain asset reliability in the short, medium and long-term.

Section 9 in our Business Plan describes how stakeholder engagement has informed our overall approach to provide a safe and reliable network. The key outcomes of this process include:

1. Our stakeholders asked us to maintain levels of reliability at an affordable cost.
2. We adopted a tougher RIIO-2 target for Energy Not Supplied (ENS) weighing more heavily on recent performance; and
3. We committed to maintaining a consistent level of network reliability between RIIO-1 to RIIO-2.

We consider these three objectives can be achieved through a balanced consideration of proactive asset condition monitoring, maintenance, repair, refurbishment and replacement in conjunction with the effective application of condition-based risk management.

Our approach to maintaining reliability in non-lead NLR investment

Annex A9.20 Plan Build section 4 (page 7) sets out our general approach for non-lead NLR investment plans, which follows a three-step approach:

1) Identify required asset replacements based on established asset policies and/or statutory requirements.
    a. our main policy follows the Asset Replacement Priority (ARP) approach, through which we prioritise the requirement for replacement actions based on Asset Health Index (AHI) and criticality (safety, environmental and system consequences of an asset failure).
    b. in some specific instances, statutory requirements supersede our main policy.
2) Consider the volume of replacement required, considering the ability to deliver the required volumes and the risk to the network of non-delivery. (e.g., circuit breaker fail-protection volumes have been reduced to improve overall deliverability of the plan, due to the lower risk to the network presented by these assets).
3) Add non-lead asset interventions with drivers not specifically identified by asset policy. This includes works to rationalise sites (e.g., Barking which requires non-lead asset replacement).

In addition to the general approach set out above, we have highlighted in our business plan that National Grid is currently in the process of adopting the Monetised Risk (MR) approach for some of our non-lead assets, focussing initially on substation assets. Currently MR is applied in full only for lead assets, but we have made a firm commitment to deploy this approach in RIIO-2 on the premise that it is rigorously tested against our existing approach, which draws on the same condition-based risk management principles used to calculate monetised risk.

13. Overview of assurance and point of contact

The content and details within this submission have been assessed and checked for quality, alignment, and assurance across the below areas:

- Unit cost data & cost details
- CBA accuracy
- Forecast data used and alignment to model outputs
- Assessment on data analysis and data inputs
- Existing RIIO-2 outputs (cost and assets) assessment

Senior persons in National Grid have provided confirmation of the assurance checks performed, as noted below:

Level one governance completed by:

Mr Paul Gallagher – Asset Manager – Substations & Circuits, Asset Operations, NGET

Completed: 12 July 2022

Level two governance completed by:

Mr Matt Staley – Director of Asset Operations, NGET

Completed: 22 July 2022

14. Annexes

	Description
14.0 Glossary	Not required
14.1 Engineering Justification Reports	List of the Engineering Justification reports supporting this Bespoke re-opener
14.2 Ofgem Guidance Checklist	A summary of the location of each item requested within the guidance
14.3 Cost Benefit Analysis	Table view of the cost benefit analysis
14.4 Cost/Contingency/Quantitative Risk Assessment	Detailed costs and quantitative risk assessment
14.5 Technical Specifications	Technical Specifications used for surveys and analyses

Table 14.1

14.1 Engineering Justification Reports (EJRs)

The full set of data relating to the survey information (which is impractical to embed within this document) can be found within the 'RIIO-2 Re-opener: Tower Steelwork and Foundations' SharePoint Site (access permissions are required) using the link below:

https://nationalgridplc.sharepoint.com/sites/GRP-PROJ-EXT-UK-INVP-RIIO-2Re-openerTowerSteelworkandFoundations/

The EJRs will be included in the submission pack and are titled:

1. NGET Regulation - RIIO-2 Re-Opener Summary Foundation Engineering Justification Report - Rev B.pdf
2. RIIO-2 Re-Opener Steelwork Engineering Justification Report - Rev C.pdf

Steelwork

- Individual Tower Steelwork Defect Inspection Reports (outcomes subsumed into EJR)
- Individual Route folders containing
  (a) Annotated Line Diagrams (grades 3 – 6 marked on diagrams),
  (b) Material Lists for replacement Steelwork (grades 5 and 6),
  (c) Route Summary of weights and quantities (grades 4 – 6)
  (d) Photograph Referencing for each tower on each route
  (e) Photographs for each tower on each route
  (f) Engineering Justification Report for Steelwork

Foundations

- Engineering Justification Report for each intrusive Investigation (one per tower, [redacted] investigations)
- Summary Engineering Justification Report for Foundations ([redacted] investigations)

<u>Candidates for Climbing Surveys in preparation for RIIO-3</u>

- A Spreadsheet summarising all towers with grade 5 and 6 zones

14.2 Ofgem Guidance Checklist

Ofgem Guidance Section	Description	ET Special Condition 3.33 Re-opener report section
1.1	Re-openers are a type of RIIO uncertainty mechanism	1.0
1.2	Requirement to prepare application in accordance with guidance	4.0
1.3	How guidance sets out how licensee must prepare its re-opener applications	4.0
1.4	General requirements in document & Appendix 1. Specific requirements in appendices 2 – 4.	noted
1.5	Failure to prepare application in accordance with guidance may result in its rejection.	noted
1.6	Appendix 1: sets out all RIIO-2 re-opener mechanisms	noted
1.7	Appendices 2-4: Guidance for specific re-opener mechanisms	noted
2.1	High quality information required which is **accurate** (insofar as can reasonably ascertained), **unambiguous**, **complete** and **concise** (keep core narrative brief, avoid duplication and superfluous information).	Annexes
2.2	All re-opener applications require senior manager assurance that it has been prepared in accordance with guidance.	13.0
2.3	Point of contact is required for each re-opener application.	2.0
2.4	Subject to 2.5 & 2.6 – publish re-opener application in prominent place on Company web-site within five working days.	noted
2.5	Redactions – explanation of redactions expected to be published by company.	noted
2.6	No explanation of redaction is expected for items which pose risk risk to national security.	n/a
3.1	Each re-opener application must clearly answer two questions: 1. Why an adjustment is justified 2. What the adjustment should be	All
3.2	Further details required in support of 3.1 set out in guidance.	noted
3.3	Each application must map out how individual sections of guidance are addressed within the application.	4.0
3.4	Requirement to provide justification if required information is not available.	noted
3.5	Chapter 3 should be read in conjunction with relevant mechanism-specific Appendices.	noted
3.6	Gas Distribution Sector requirements.	n/a
3.7	Further Gas Distribution Sector requirements.	n/a
3.8	All re-opener applications must include a needs case.	6.0
3.9	Needs case must align with overall business strategy	5.0
3.10	Application must include clear statement how proposed expenditure aligns licensee's future business strategy	5.0
3.11	Application must include clear statement in context for consumers and network assets	12.0
3.12	Explain why expenditure is efficient	9.0
3.13	Provide clear description of long & short list of options	7.0
3.14	Provide clear description of preferred option	9.0
3.15	Provide clear statement of project delivery and monitoring plan for preferred option.	10.0
3.16	Provide clear statement of how stakeholder engagement contributed to identification of plan/design of preferred option.	12.0

3.17	Provide brief explanation of why stakeholder engagement not considered appropriate (if applicable).	12.0
3.18	Stakeholder engagement not necessary if poses risk to national security.	noted
3.19	Provide cost information to justify level of expenditure.	Annex 14.3
3.20	Provide cost information to 2018/19 prices.	Annex 14.3
3.21	Provide CBA and engineering justifications.	Annex 14.3
3.22	Follow Ofgem's published guidance on CBA and Engineering Justification papers (Sept 2019).	4.0
4.1	Application should follow a style and structure that clearly and concisely sets out evidence licensees wish to present in support of their application.	4.0
4.2	Application should follow a logical structure	4.0
4.3	In addition to Mapping Table (see 3.3), application should also include table of contents and glossary.	Contents
4.4	The core narrative should be clear and concise and avoid duplication and superfluous information.	noted
4.5	Considerations for proportionate amount of evidence provided in support of application.	All Annexes
4.6	Core narrative should be drafted in Plain English.	noted
4.7	Clear and concise principles apply to Annexes.	noted
4.8	Specific requirements in Appendices 2 – 4.	noted
App 1	Complete list of RIIO-2 re-openers.	noted
App 2	Non-operation IT (IT) Capex Re-opener Application Guidance.	n/a
App 3	Coordinated Adjustment Mechanism Re-opener Application Guidance	n/a
App 4	Cyber Resilience IT and OT Re-opener application requirements	n/a

Table 14.2

14.3 Cost Benefit Analysis (CBA)

There are 4 CBA documents included in the submission pack and these are:

1) Reopener CBA A - OHL Steelwork Replacement options v2.1.xlsx
2) Reopener CBA B - OHL Steelwork Earthwire Peak options v2.1.xlsx
3) Reopener CBA C - OHL Steelwork Grade 4 Replacement vs Recovery v2.1.xlsx
4) Reopener CBA D - OHL Foundations Options v2.1.xlsx

14.4 Cost/Contingency/Quantitative Risk Assessment

The detailed cost assessment document included in this reopener pack is included as: OHL Steelwork & Foundations - Cost Summary with Build up Rev2.xlsx

The quantitative risk assessment is outlined in the reopener document pack entitled: OHL Steelwork & Foundations - Risk Register.xlsx

14.5 Technical Specifications

Please click on the hyperlink below to view Technical Specifications
(Note: a SharePoint login is required).

https://nationalgridplc.sharepoint.com/sites/GRP-PROJ-EXT-UK-INVP-RIIO-2Re-openerTowerSteelworkandFoundations/