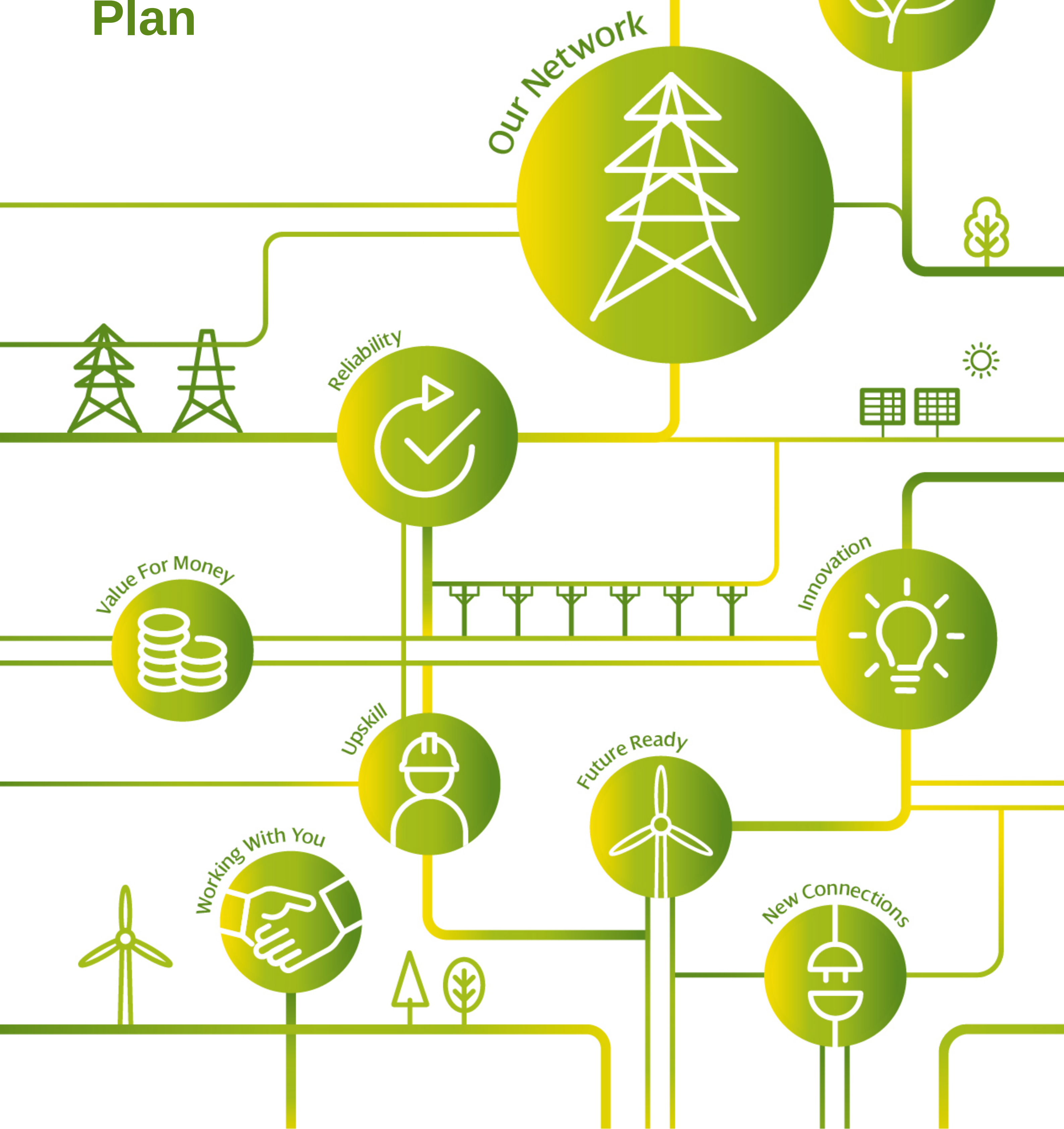
SP Energy Networks, RIIO-T2 Business Plan
December 2019 Submission

SP ENERGY NETWORKS

Annex 3:
Non-Load Related Strategic Investment Plan



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REVISION	Date	Comment
1	09/12/19	Issue for December business plan.

1.0 INTRODUCTION

The management of asset and network risk is a primary objective in continuing to provide a safe and reliable network. The transition to a low-carbon energy system is placing increasing importance on SP Transmission's network. The capacity of renewable energy seeking a route to market is, on average, significantly greater than the demand in Scotland and the network plays a vital role in facilitating the UK and Scottish governments' climate change targets. Equally, there are periods of significant import to Scotland and energy transfers from SP Transmission's area to the north of the country. The transmission network therefore plays a key role in security of supply and is dependent on timely and appropriate investments in asset stewardship activities.

A long-term asset management strategy is essential to allow the efficient prioritisation and planning of interventions. The risk objectives described are founded in detailed knowledge of the function of each asset in the network, and its condition. The basic principles of making timely and appropriate investments are completely dependent on this information. It is essential to understand the composition of the network risk value to target investments in the right assets. It is also necessary to understand the composition of the risk value of each asset to plan the right interventions.

It is essential therefore, that there is a detailed understanding of asset condition. The process, scope and extent of the condition data gathering exercise, both routine and specific for the creation of this plan, are described. This data and the aspects of each asset that describe the consequences of its failure are inputs to the models that create the asset and network risk values.

Detailed network and asset knowledge provides the foundation for identifying and prioritising the investments included in the business plan. It is necessary to demonstrate that the investments included in the plan represent good value for money. This is achieved by undertaking an appropriately detailed engineering design exercise. This demonstrates that the feasible set of options has been considered and that the works are deliverable and appropriate consideration of their environmental impact has been taken. To drive the best value for the consumer, constant innovation is at the core of this exercise.

Effective asset stewardship is not just capital investments. The daily operational activities are at the front line of maximising the performance and lives of the asset base. The changing nature of the assets due to modernisation activities and the low-carbon transition is accounted for in the review of operational practices that was undertaken to support this plan. This ensures that the maintenance, inspection and condition assessment regimes are appropriate to maximise the economic life of the assets, minimise requirements for increasingly challenging network access and to minimise costs to consumers.

This annex to the main business plan provides more detail on our long term risk objectives. We set out the process we have used to determine that the capital investment programme is the right balance of efficient costs and benefits. Finally, we detail the components of our operational expenditure and how we have striven to continually improve efficiency.

SP Transmission is a company that takes pride in and understands its assets and its network. It takes a long-term approach to provide a safe, resilient and reliable network for customers. This is achieved at a fair cost to current and future consumers.

This annex to the main business plan provides additional detail in four key areas:

- Long term objectives for managing asset and network risk
- Network Asset Risk Metric (NARM) data
- The investment planning process
- Review of Network Operations activities

When creating the business plan, we have looked out to the end of RIIO-T3. With the information available, we have identified the interventions that are likely to be needed in RIIO-T3 and an overview is provided in section 5.0

This Annex should be read in conjunction with the core business plan document and other relevant supporting annexes.

2.0 LONG TERM RISK OBJECTIVES

Monetised risk in the RIIO-T1 Network Output Measures[1] methodology has provided a means of objectively and transparently quantifying lead asset condition, consequences of failure and risk. It is a powerful tool in the identification and prioritisation of investments.

Network risk can be taken to be the sum of the risk values of the individual lead asset risks. Using the models for asset deterioration that are an inherent part of the NARM methodology, it is possible to generate a value for network risk at any point in time. At this time, non-lead assets' risk is not monetised. So while non-lead assets contribute to real network risk, this risk is not included in the monetised network risk value.

However, at any point in time, the network risk value alone is not a reliable indicator of network reliability which is measured by Energy Not Supplied (ENS) and Average Circuit Unreliability (ACU). The most significant factor affecting ENS is weather. Examples of this are the Boxing Day 1998 storms in SPT's licence area and the storm of 1987 in National Grid's area. Non-lead assets are also a major influence on ENS and ACU events. It is noteworthy that some of the most significant loss of supply incidents in recent years (for example, London and Birmingham in 2003, north Glasgow and Argyll in 2009 and the north of Scotland in 2014) were caused by non-lead assets. Therefore, there is no direct relationship between reliability and an absolute value of monetised risk as it would neglect significant factors affecting reliability. It is therefore necessary to undertake more detailed analysis to set long term risk objectives.

The core value of making a safe and reliable network available to customers underpins the objectives for management of network risk. This is achieved by prioritising to make the right interventions on assets which are affecting or will affect network reliability or whose failure would present an intolerable threat to safety.

The approach taken in the creation of this plan, supported by stakeholders, is to use the detailed understanding of each asset and how they interact in the network to identify the priorities for intervention. For lead assets, this is correlated with the NARM models to provide confidence in the identification of risks.

The network risk at any point in time consists of

- Assets in good condition in which no intervention is needed.
- Assets that have begun to deteriorate and don't require intervention yet but condition forecasts show that planning for intervention should begin.
- Assets that have deteriorated and have limited remaining lives.

The last category of assets is those that pose the greatest threat to reliability or safety. The asset risk objective is to intervene before either reliability or safety is unacceptably compromised by the condition of these assets. With a large asset base, a significant proportion of which entered service in a short window in the 1950s and 1960s, the interventions have to be prioritised and planned accordingly. The approach taken for this is detailed in subsequent sections.

While the monetised risk methodology for lead assets provides a common basis for assessing asset risk and developing a network level view, non-lead assets must be included in any risk objective. The impacts of lead and non-lead asset failures can be of equal significance. The appropriate management of non-lead assets, either in conjunction with associated lead assets or in their own right is essential to the achievement of a tolerable level of network risk

2.1 Asset Models

[1] The general subject of Network Output Measures has been renamed by Ofgem as Network Asset Risk Metric. The abbreviation NARM will be used throughout this annex.

To determine the level of lead asset monetised network risk at any given time, the asset models developed and approved under the NARM framework are used. These models have been implemented on corporate asset management systems which are linked directly to the asset register. While the introduction of the NARM asset models is relatively recent in the transmission sector, the systems are in place to implement them. It is notable that development of reporting systems will be necessary following the development of the relevant Business Plan Data Tables

The asset models calculate asset health (expressed as the EoL parameter) and probabilities of failure, consequences of asset failure as a monetary value in pounds sterling and a monetised risk value. The models also forecast asset deterioration, providing valuable insight into future condition and risk.

The data inputs to the models to generate the health, consequence and risk values are detailed in the NARM methodologies but can be summarised as follows:

- Asset age, location, situation and environment
- Key operating parameters such as duty relative to design capability
- Condition data particular to each asset category
- Consequence costs associated with safety, environmental impact and repair or replacement
- Consequence costs associated with loss of supply, system constraints and reactive power.

The basic asset data of location and safety, environment, repair and replacement costs are kept under review and will be updated in response to changes in circumstances. The system consequence and duty data are updated regularly. Condition data is updated following asset maintenance, repair, inspection or condition assessment.

The asset health and risk values are a critical parameter in the identification, prioritisation and economic assessment of the business plan's interventions. The implementation of the NARM models has initiated changes to the condition data points that we gather. The new programme of condition data gathering was commenced in early 2018 to ensure the data was comprehensive and accurate.

With regard to the risk values, it should be noted that the derivation of all probabilities and consequences of failure values are TO specific and subject to calibration, testing and validation during the implementation of the methodology within the individual TOs. The SPT Licensee Specific Appendix includes the calibration tables used in the calculation.

While non-lead assets are not within the scope of the NARM methodology, we have created models for disconnectors, earthing switches and instrument transformers. These are derived from the most appropriate lead asset models to generate asset health values on a consistent basis. We have used these models to identify these types of non-lead assets that merit consideration for intervention.

2.2 Asset Data Collection Plan

Condition information gathering is a normal part of our operations. The evolution of the NARM methodology has introduced a new perspective on the method of data gathering. The improved objectivity of this methodology requires the expression of asset condition points in a form suitable for numerical modelling. With this increase in data requirements comes a need for effective management. Our asset data systems have evolved to capture the measured data and link this through to the companion system (CBRM) which implements the NARM models.

The regular update of condition information is detailed in documents ASSET-01-028 (Specification for the Condition Assessments of Transmission Substations) and ASSET-01-029 (Overhead Line Inspection & Condition Assessment). These have been updated to reflect the implementation of the NARM methodology.

The starting point of the specific investment planning exercise to support the RIIO-T2 business plan was the most up-to-date condition data. The updated gathering programme that commenced in early 2018 has refreshed the priority condition data that is necessary to inform and support the investment plan.

The collected data is a key input into both the determination of asset condition and the nature of the intervention to manage condition issues. The comprehensive evidence bank is key to providing certainty of intervention need and efficiency of cost.

2.2.1 Substation Asset Data Collection

The latest condition assessment programme of all substations, reflecting the requirements of the NARM methodology, commenced in early 2018. This exercise was prioritised to start with the sites where there were known lead and non-lead asset issues, finishing with newly commissioned or modernised substations. The prioritisation was informed by previous assessments, maintenance history and operational experience.

The data collection has been undertaken by experienced operational staff using a standardised question set which captures the NARM model data requirements. Each data return has been reviewed for consistency by lead and senior engineers and the NARM models updated with the recorded data. A summary report has been created for each site.

These condition assessments covered all lead assets (circuit breakers, transformers and reactors) and non-lead assets (e.g. instrument transformers, disconnectors and earthing switches, busbars and connectors and ancillary systems such as AC and DC supplies, compressors and air systems).

We have undertaken a full review of the transformer and reactor asset base, considering the external condition, DGA history, bushing and tapchanger condition. This exercise identified 23 transformers and reactors for further investigation. We engaged Polaris Diagnostics and Engineering, an independent specialist, to review these units and provide reports to inform the investment planning process (see section 3.1).

2.2.2 Civil Asset Data Collection

A prioritised programme of civil assessments was undertaken. These covered all sites – substations, cable sealing-end compounds and railway supply compounds – where there were no civil works undertaken during RIIO-T1. This covered 143 sites in total.

A comprehensive and detailed inspection was performed at each site. This covered fences, walls, building fabric and building services, structures, foundations, trenches, bunds, roads and footways and drainage systems.

Every civil asset at each site was individually identified, assessed and a condition score (on a 1 to 5 scale) applied. As civil assets are non-lead assets, there are no NARM models. However, the data has been used in two ways. Where there are electrical works identified at a site, the condition of the civil assets formed an integral part of the optioneering exercise (see section 3.3). Where there were no electrical works required, the condition data has informed stand-alone programmes of civil refurbishments (schemes SPNLT20100 to SPNLT20104)

At sites with identified electrical works, a further stage of condition assessments was undertaken on concrete structures. This work has been informed by the outcomes of the RIIO-T1 NIA Project NIA_SPT_1606 Reuse of Existing Concrete Assets[2]. The assessment was performed on a sample of structures by Concrete Repairs Ltd (CRL), a specialist concrete contractor. This determined the likely remaining life of the structures, proposed initial and ongoing remedial works and assessed loss of strength of the structure. This last element is essential to inform the ongoing suitability of the structure to withstand its duty. This information has informed the optioneering process and the results are summarised in the justification papers for the relevant sites.

2.2.3 Overhead Line Asset Data Collection

[2] https://www.smarternetworks.org/project/nia_spt_1606

The programme of inspections was prioritised to gather condition data on the overhead line asset base. The prioritisation methodology was informed by previous condition assessments, the type of conductor system, focusing on Aluminium Conductor, Steel Reinforced (ACSR), and the time since the last intervention.

The scope of the work included:

- Conductor and earthwire non-intrusive corrosion testing and mid-span or jumper sampling and forensic analysis (19 routes)
- Spacer, spacer-damper and damper removal and assessment (19 routes)
- Tower walking and climbing inspections (16 routes)
- Foundation intrusive inspections (16 routes)

The data has been reviewed by lead engineers for consistency. It is necessary to interpret the condition data to apply the condition scores specified in the NARM methodology. This has been formalised in a methodology document ASSET-01-030: “Overhead Lines Technical Asset Life and CBRM Methodology”. ASSET-01-030 has been independently assessed and the data was used to update the NARM models.

2.2.4 Underground Cable Asset Data Collection

A complete review of the underground cable estate has been undertaken. We have visually inspected fluid-filled cables, focusing on hydraulic and earthing systems, XLPE cables and 33kV transformer LV tails. A programme of partial discharge monitoring of all relevant terminations has also been completed.

2.3 Network Asset Risk

The quantification of network risk is the sum of all risk values of the lead assets. The asset risk values have been generated by the application of version 18 of the NARM methodologies, modified to correct errors in two equations in the system consequence models as agreed with Ofgem[3].

We have forecast the asset risk position at the start of the RIIO-T2 period, the risk at the end of the period with no intervention, the risk reduction provided by our investment plan and the end of period risk with our intervention plan.

As agreed with Ofgem at the cross-sector working groups, the risk benefits from the intervention plan are assumed to apply on the last day of the price control, providing a common reference point.

2.3.1 NARM Reporting

Health and risk bands have been created by Ofgem for NARM reporting tables. The definitions of health bands are common across asset types however the risk bands have been determined for each asset category by voltage level. The risk band values are specific to each asset category and voltage but the approach is consistent for all asset categories.

The approach to define the bands has ensured that asset populations are sufficiently differentiated, are not skewed by outliers in the population and they do not need to be adjusted through the RIIO-T2 period. The risk banding has been designed so that 95% of the asset population risk is contained in equal risk bands R2-R9 in all assets except from fittings where 90 % of the population risk is be contained in bands R2-R9, providing a better distribution of assets when accounting for outliers in this particular asset category. This approach has been introduced through an Ofgem-led transmission sector work group and is intended to provide a basis to allow asset risk movements to be readily identified. Using this methodology allows new assets which may have risk values lower than the current minimum or higher than the current maximum to be incorporated without the need to adjust the risk bands.

The network risk bands are calibrated for each asset category individually due to the degree of variance between categories. The risk bands are essentially a relative measure; an asset being in a particular risk band represents its risk relative to the population in that asset category and the width of the bands is determined by the range of the risks of assets in that category. Therefore, an asset in risk band R2 would have a lower risk than an asset of the same type in band 8 but both assets may have risk values that are high in absolute terms.

There are 10 health bands, from P1 to P10 where P1 represents the best health and P10 the worst health. The health indicator used to create the bands is the EOL value. The health bands' values are defined in the NARM business plan data tables and are common across asset types. The EOL values for any asset are between 0.5 and 15 as per the approved NARM methodology. Any asset with an EOL value less than 1.5 will be in P1 health band, any asset with a EOL value equal to or greater than 9.5 will be in the P10 band. The bands P2-P9 contain the rest of the assets according to their EOL values.

The following risk values are for the non-load related baseline plan only. The values include the risk benefit of consequential interventions, that is, risk changes of assets that are replaced as a consequence of the primary investment driver.

2.3.2 Asset Health and Risk at the Start of RIIO-T2

To generate the start point, we have included the effect of load and non-load activities forecast to be complete at the end of RIIO-T1 in the risk models.

The total network risk is R£2,673.96m. The distribution of risk per asset category is shown in Table 1.

[3] This correction will be addressed at the time of the next methodology update.

Table 1 Start of RIIO-T2 Asset Risk by Asset Category

Asset Category	RIIO-T2 Start Risk (R£m)	RIIO-T2 Start Risk (%)
Overhead Line Fittings	£1,769.63	66.2%
Overhead Line Conductors	£196.34	7.3%
Overhead Line Towers & Poles	£535.39	20.0%
Underground Cables	£55.40	2.1%
Circuit-breakers	£41.70	1.6%
Transformers	£72.71	2.7%
Reactors	£2.79	0.1%
Total	**£2,673.96**	

The distribution of assets in each risk band by asset category is shown in Figure 1.

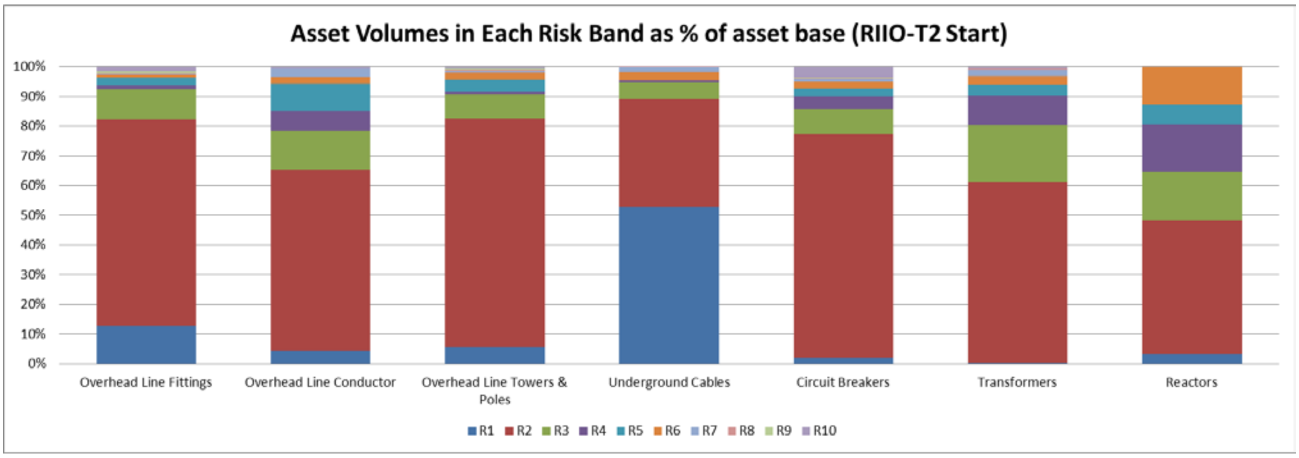

Figure 1 Network & Asset Risk by Risk Band

The total risk can also be categorised by asset health, using the health bands, please refer to section 2.3.1. The total network risk comprises assets at various positions in the range of risk in each asset category, as described in section 2.3.1.

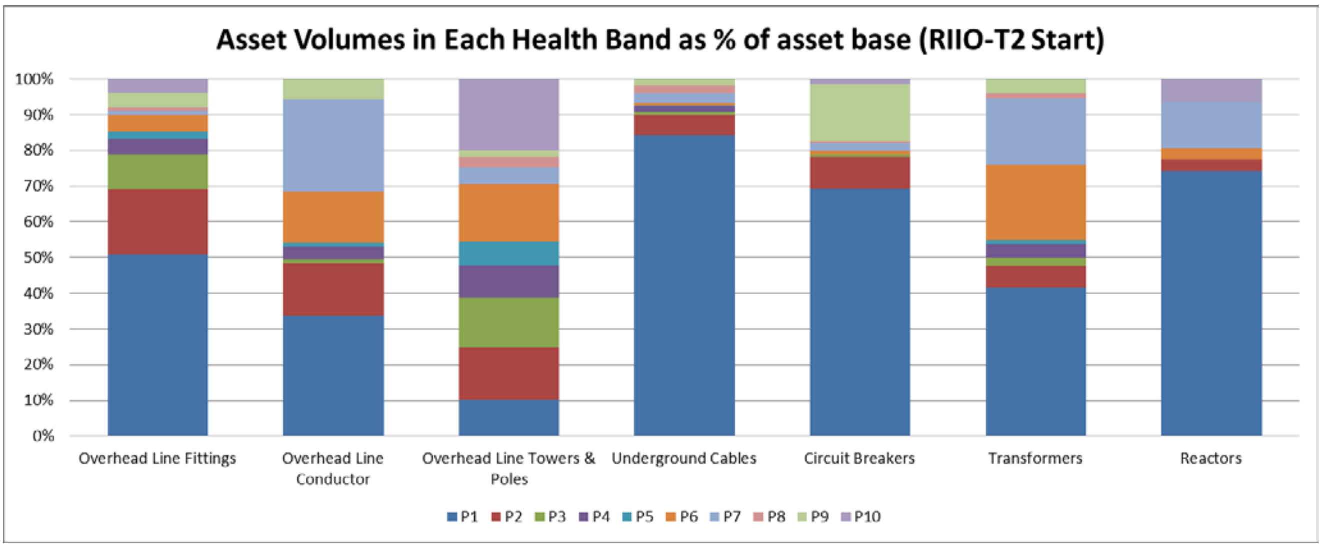

Figure 2 Network & Asset Risk by Health Band

While there is a degree of variance between asset categories, the majority of the asset base will be in the health bands representing good condition at the start of RIIO-T2.

2.3.3 Asset Health and Risk with No Intervention

The end of RIIO-T2 network and asset risk values are generated by the application of the NARM methodology's deterioration model. The asset population at the start of RIIO-T2 is deteriorated by five years to generate the end of period position.

The total network risk with no intervention would increase by 72% to R£4,590.09m. The distribution of risk per asset category is shown in Table 2.

Table 2 End of RIIO-T2 Asset Risk by Asset Category (No Intervention)

Asset Category	RIIO-T2 End Risk (R£m)	RIIO-T2 End Risk (%)
Overhead Line Fittings	£3,130.35	68.2%
Overhead Line Conductors	£305.14	6.6%
Overhead Line Towers & Poles	£904.43	19.7%
Underground Cables	£78.96	1.7%
Circuit-breakers	£57.81	1.3%
Transformers	£109.75	2.4%
Reactors	£3.66	0.1%
Total	**£4,590.09**	**-**

The distribution of assets in each risk band by asset category is shown in Figure 3.

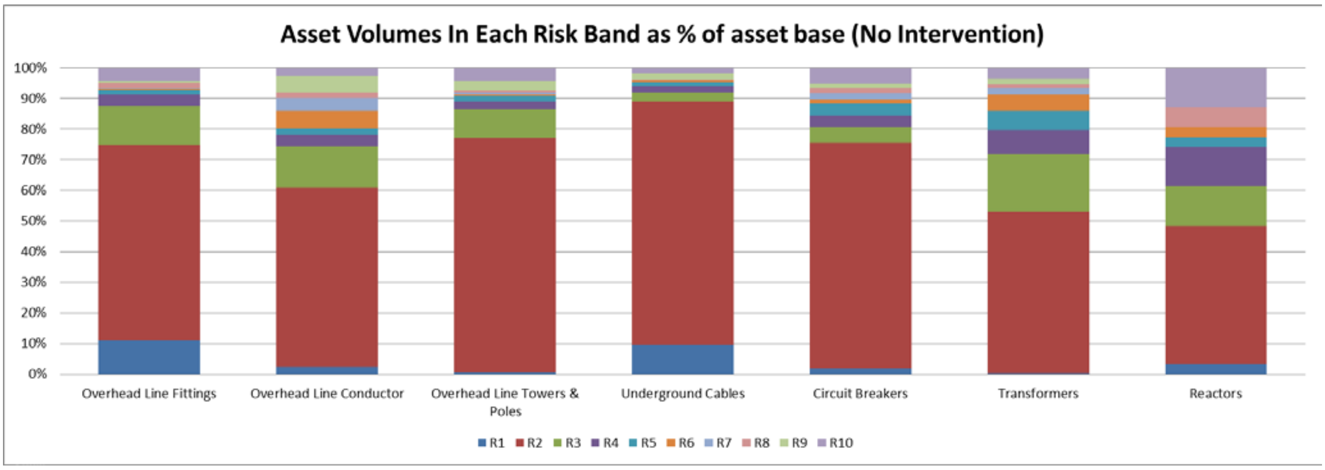

Figure 3 Network & Asset Risk by Risk Band (End of RIIO-T2: No Intervention)

Figure 4 illustrates the percentages of the asset base in each health band.

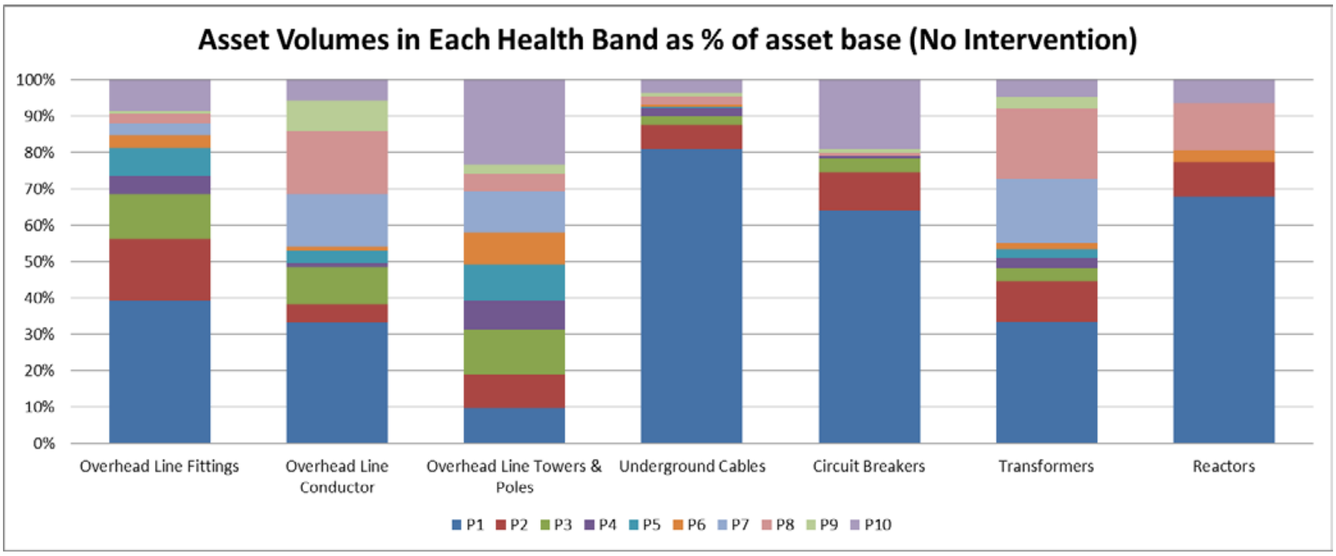

Figure 4 Network Risk by Health Band (End of RIIO-T2: No Intervention)

With no intervention, deterioration occurs in all asset categories, leading to risk increases. The variance in absolute magnitude of risk per asset category is illustrated in Figure 5.

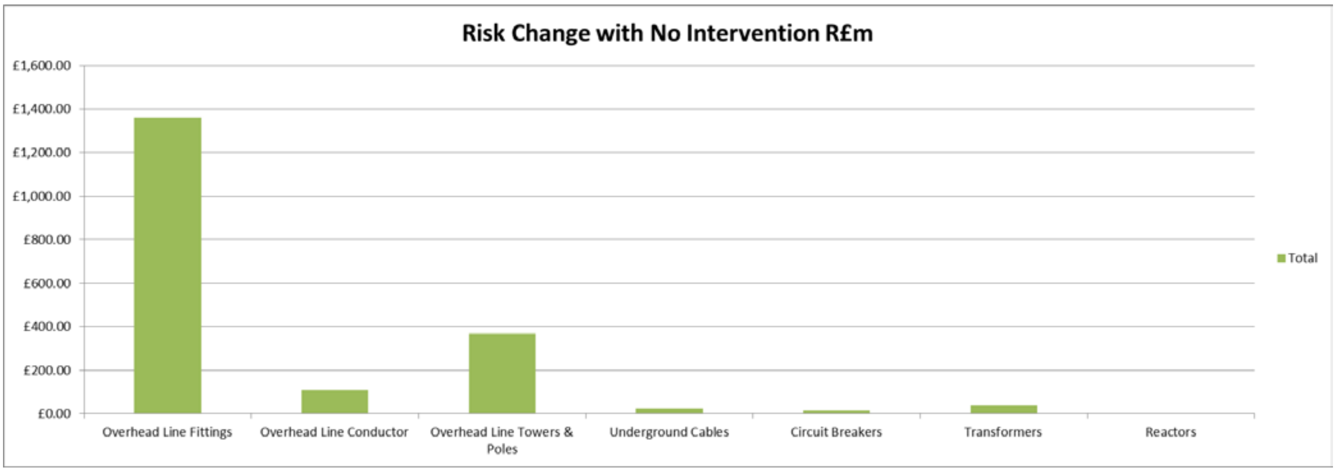

Figure 5 Change in Asset Risk by Asset Category

2.3.4 Asset Health and Risk with Intervention

The NARM interventions proposed in our RIIO-T2 business plan result in the network risk position shown in Table 3, with a total network risk of R£2,696.24. This is an increase of 0.8% in the total network risk so the network risk at the start and the end of the period are approximately equal. One interpretation of this position is that the risk benefit achieved by interventions in the business plan is equivalent to the increase in risk caused by the deterioration of the remainder of the asset base.

Table 3 End of RIIO-T2 Asset Risk by Asset Category (With Intervention)

Asset Category	RIIO-T2 End Risk (R£m)	RIIO-T2 End Risk (%)
Overhead Line Fittings	£1,738.48	64.5%
Overhead Line Conductors	£183.10	6.8%
Overhead Line Towers & Poles	£614.59	22.8%
Underground Cables	£38.16	1.4%
Circuit-breakers	£29.94	1.1%
Transformers	£89.22	3.3%
Reactors	£2.74	0.1%
Total	**£2,696.24**	

The resulting distribution of assets in each risk band by asset category is shown in Figure 6.

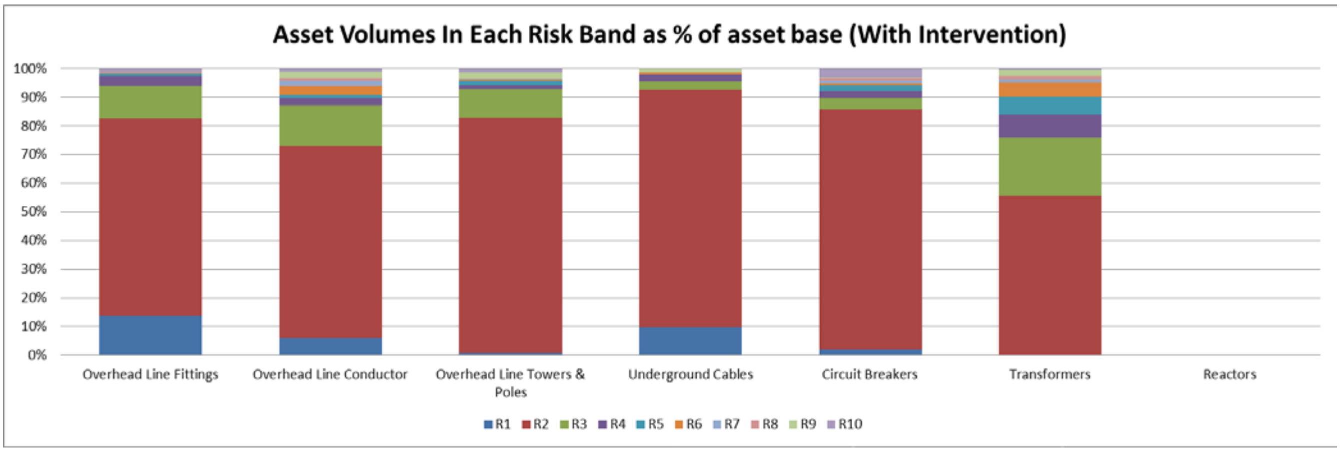

Figure 6 Network & Asset Risk by Risk Band (End of RIIO-T2: With Intervention)

Figure 7 illustrates the percentages of the asset base in each health band.

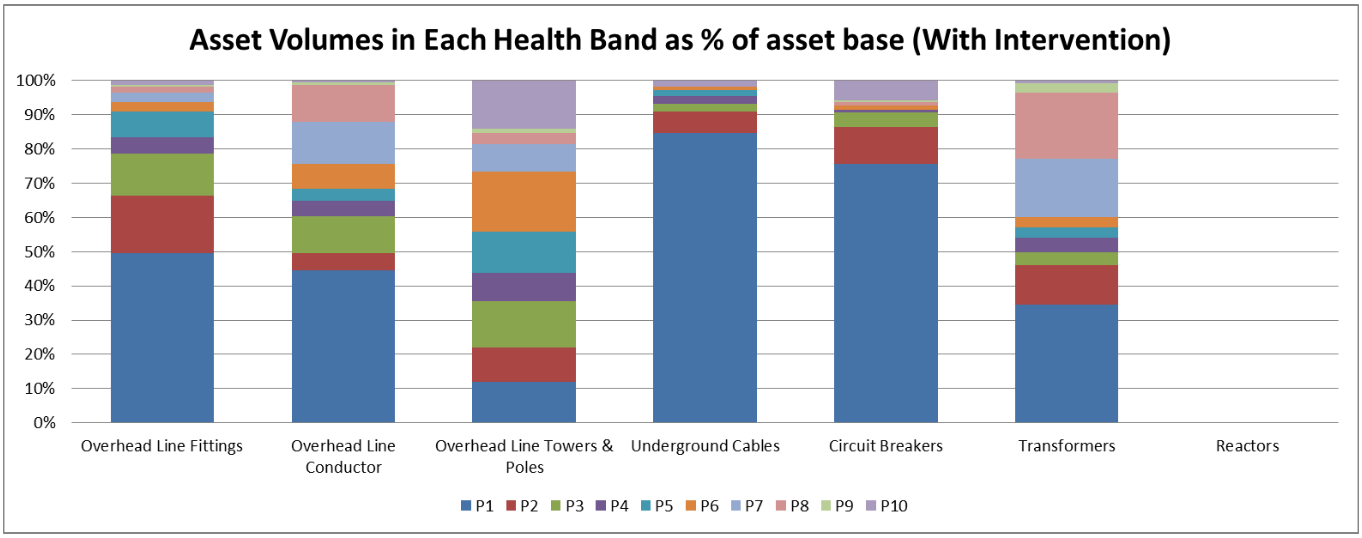

Figure 7 Network & Asset Risk by Health Band (End of RIIO-T2: With Intervention)

The difference between the start and end of RIIO-T2 positions for asset risk with intervention is shown in Figure 8.

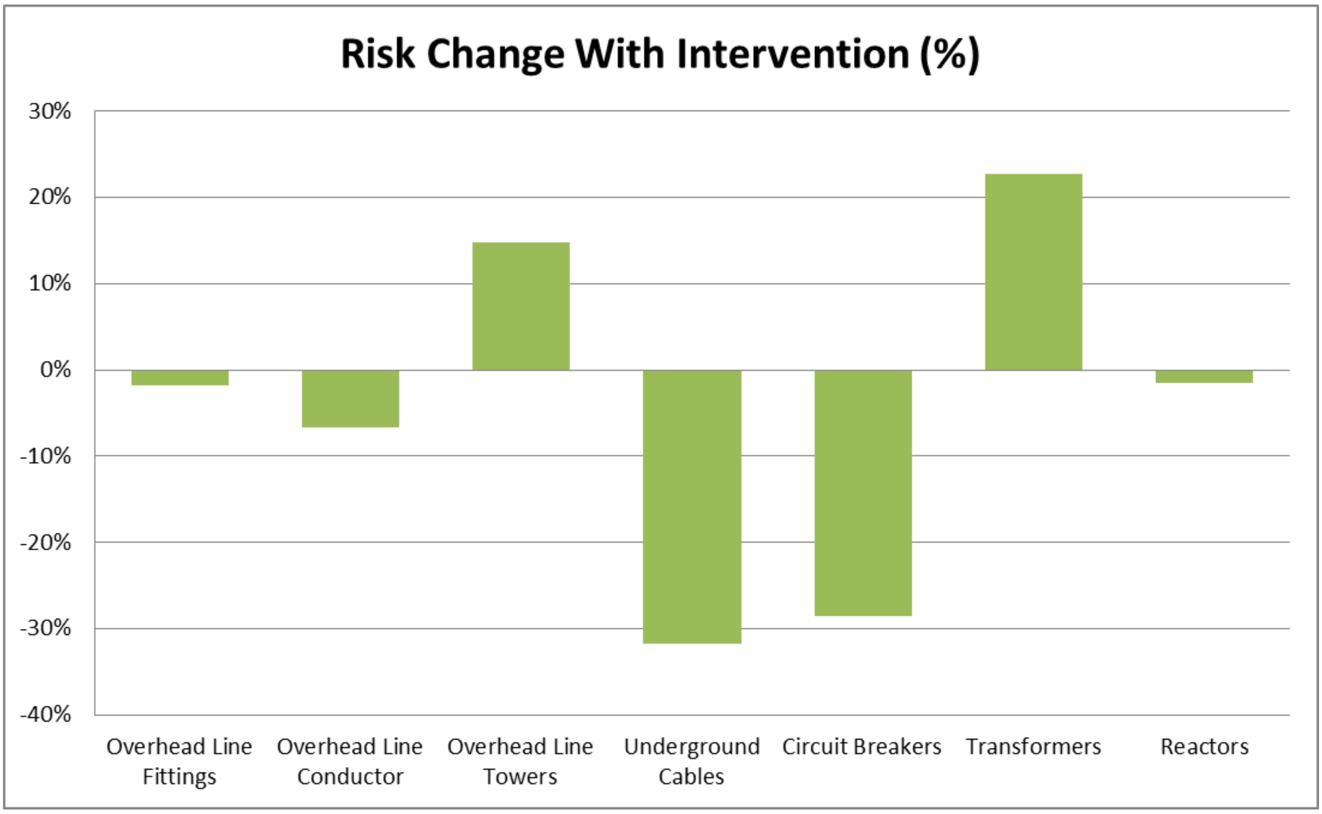

Figure 8 Change in Asset Risk by Asset Category

The variance in risk movements in each asset category is explained in Table 4.

Table 4 Asset Risk Movement Commentary

Asset Category	Commentary
Overhead Line Fittings	Slight reduction in risk due to investment plan
Overhead Line Conductors	Minor reduction. Second phase of modernisation (following RIIO-T1 programme) resulting in wider asset base's deterioration being relatively low.
Overhead Line Towers & Poles	Relatively low level of interventions needed in towers and poles. Increase is acceptable deterioration of the wider asset base.
Underground Cables	Refurbishment of high risk routes and small overall population leads to a large relative reduction
Circuit-breakers	Replacement of poorest condition and highest risk air-blast and bulk-oil units leaves a very small population of non-gas CBs. This leads to a large relative reduction.
Transformers	Improved asset knowledge has introduced a refurbishment programme in addition to traditional replacements with fewer replacements as a result. Increase is acceptable deterioration of the wider asset base.
Reactors	Replacement of two higher risk units in a small population leads to a small relative reduction in risk.

Figure 9 illustrates the risk benefit of the plan in each of the health bands. It is clear that plan has targeted the poorest condition assets. The increase in risk of assets in the lowest health band is due to the deterioration of assets in that band and new assets replacing those in the higher bands. The other bands also exhibit the effects of deterioration of assets in the band which cause risk increases and assets moving up into higher bands, causing reductions.

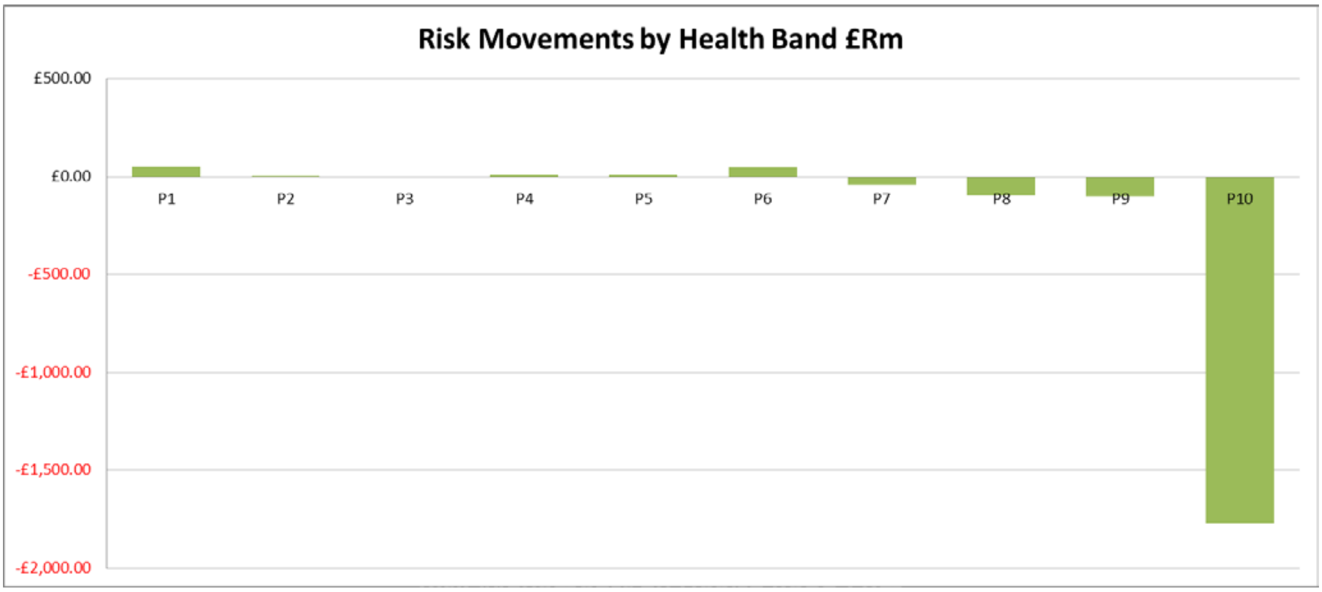

Figure 9 Risk Movements by Health Band

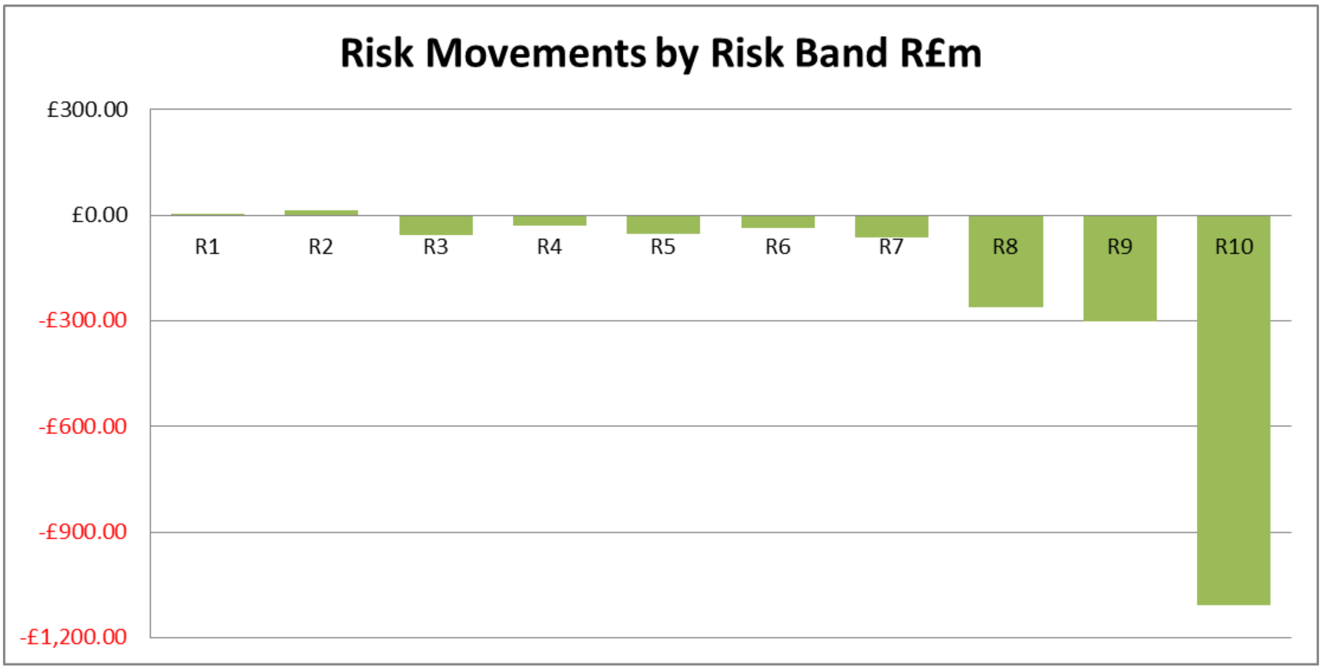

Figure 10 Risk Movements by Risk Band

Referring to Figure 10, the increase in risk in lower bands illustrates the low level of interventions at the lowest risk levels. This is also caused by the expected deterioration of the asset base and the health improvements due to the plan's interventions moving assets from higher risk bands. As discussed in section 2.3.1, the risk bands are relative to the population's range of risk. So while the asset may be in a lower band, its absolute risk may be high and it's health poor. This is evidenced by the reductions in bands R3 to R8.

Referring to both Figure 9 and Figure 10, it is evident that the business plan has focused on managing the poorest condition and highest risk assets

2.3.5 Asset Risk Target

We have expressed the risk target as the sum of the reductions in asset risk delivered by each NARM intervention, measured at the end of RIIO-T2. This excludes ring-fenced interventions classified as Price Control

Deliverables. We have also calculated the Longer-Term Risk Benefit (LTRB) from these interventions and they are presented in the core Business Plan document and in the NARMS tables.

The risk delta from NARM interventions has been calculated as R£1,893.85m; the LTRB target is LR£29,143.82m. It should be noted the LTRB does not include the consequential interventions which have minimal effect on the values of risk.

3.0 INVESTMENT PLANNING PROCESS

3.1 Identification of Assets Requiring Intervention

The NARM models provide a valuable, objective measure of asset condition. The models have been updated as described in section 2.2.

Our engagement with stakeholders resulted in strong support for the principle that investment should not be solely based on the absolute value of the assets' risk but that a health criterion should also be applied.

We therefore have analysed the need for intervention on the assets that are in bands 7 to 10. Assets that would be in bands 7 and 8 at the end of the RIIO-T2 period would have some degree of deterioration and need to be monitored closely, however they do not require an intervention unless they are in the highest risk bands.

We have made a very detailed technical assessment of all assets which will be in health bands 9 and 10 at the end of the RIIO-T2 period, alongside associated non-lead assets. Those assets are considered to be at the end of their operational lives and their probabilities of failure will be high enough to require an intervention before the end of the price control. The technical assessment has produced a shortlist of feasible intervention options to reduce the risk of those assets. Those options have been subject to a structured engineering and economical assessment with a recommendation of the optimal intervention option, as proposed in the Business Plan.

We have also performed the same analysis on non-lead assets' condition although these are not yet included in the NARM methodology. We have developed health models for disconnectors, earthing switches and instrument transformers that are consistent with the NARM methodology and have applied health methodologies for the other non-lead assets to provide an objective measure of condition.

We have also considered the environmental impact of SF_6. Our strategy for managing fugitive emissions and minimising the increase in our inventory has resulted in assets being considered for intervention.

The results of the civil condition assessments (see section 2.2.2) have also been reviewed and incorporated into the next stage of assessment for associated lead assets and for consideration as a stand-alone civil works programme.

3.2 Determination of Asset Interventions

Assets were identified for further examination to determine the options for intervention. This requires a detailed understanding of the assets' condition to ensure that the options addressed the condition issues and allows a tailored or targeted approach.

For example a transformer's health indicator may be driven from deterioration of the winding insulation, the tap changer condition, bushing health, external corrosion or combinations of these. It is therefore prudent to examine the intervention options on a case-by-case basis rather than adopt an approach based solely on the EOL value.

For each asset in this stage of the assessment, the feasible set of interventions were identified and included in the next planning stage

3.3 Optioneering, Design & Costing

The starting point in this stage of the planning process is to establish if there is a current and ongoing need for the asset. We examine alternative ways to provide the function – a distribution solution, for example – if it is needed. When the need for the asset has been established, we reference our energy scenarios and the extensive business-as-usual network planning to determine if the asset's rating remains appropriate or if more or less capacity is likely to be required. This process avoids unnecessary investment in assets that are no longer required, and short-term investments that will have higher overall costs in the long-term.

We also consider if an intervention is necessary in RIIO-T2 or if it can be delayed. We examine whether the known likely modes of failure are manageable (for example, is there a safety consequence that is intolerable) and our ability to recover from the failure. While the NARM methodology quantifies these aspects, it is necessary to undertake an engineering review on an asset specific basis to provide sufficient confidence in the decision. If deferral is possible, we include deferral as one of the options in the next stage of planning.

Some assets have multiple options for intervention while others are limited. For example, we have identified circuit-breakers with options to refurbish or replace them to manage condition issues that are affecting their reliability. Even if there is only one feasible intervention, there are often further options for undertaking that intervention. This is often influenced by the condition of associated assets. We consider the co-ordination of interventions to ensure that the most efficient outcome is achieved.

For every relevant need case, we have identified and appraised a wide range of realistic and achievable options known as the ‘long-list’ and subjected a reduced number of options, the ‘short-list’, to a cost benefit analysis (CBA).

In order to produce the long-list of options, we have defined the desired outcomes, potential scope, and delivery options.

We have undertaken an engineering design exercise to establish the feasibility of the options. The potential options have been assessed against the following points:

- Can it be achieved with the known physical constraints?
- Are there any more innovative design or delivery solutions that could reasonably be applied?
- Is it deliverable with existing/planned resources?
- Is it feasible within our supply chain?
- Does the option represent value for consumers? Is the capital cost efficient?
- Can we maintain secure supplies and network capability during the work or would the network be too depleted?
- Does the option provide the required level of system operability?
- Does the option adequately manage the asset’s condition and risk?
- Is the environmental impact of the option minimised and consistent with the company’s strategy?

Once the feasible options have been identified, we assess the detailed costs, benefits and risk associated with every option and undertake a CBA that will inform the decision-making process.

We also consider the environmental impacts of each option and strive to reduce the use of raw materials, limit electrical losses and the visual and biodiversity impact as far as we can. We aim to only use equipment containing SF_6 where there is no viable, market-ready alternative. The costs of equipment using alternative gases are currently greater than the equivalent asset using SF_6 and both are included in the CBA for assessment.

An inherent part of the design process is innovation. We look for ways to minimise costs, environmental impact and network access requirements using conventional design techniques and new technologies or processes. We have used the outcomes from our own and all other network operators’ RIIO-1 innovation projects in the optioneering process.

Once we have a set of designs for the feasible options, we produce detailed cost estimates. We use our database of costs from similar activities as the basis of these and tailor them to the specific asset or project.

Transmission interventions almost always require the affected assets to be removed from service during the works. This reduces network capability during the works and, in the interconnected system, this can cause some generators to be constrained by the Electricity System Operator (ESO). There is a cost associated with these constraints. Minimising outage requirements is a key consideration in the design process. Where the options for each intervention have different outage requirements and constraint cost may have a significant impact on the most economical solution, we include the costs of the constraints in our overall costs for the project.

3.4 Selection of Preferred Options

At this stage, the options have been designed; costs and outage plans have been produced. We then consider which of the feasible options is the most beneficial for consumers.

An important tool in this process is the Cost Benefit Analysis (CBA). This is a standardised process in the electricity transmission sector and is used according to a template issued by Ofgem. We use the CBA to compare the costs and benefits of every option and identify the most economical solution. The lifetime risk benefit of the intervention and the avoided SF_6 leakage are the main benefits quantified in the CBA.

The output of the CBA is used, in conjunction with a wider co-ordination review, to determine the preferred intervention option for each asset, which may include deferral of the investment to the next price control.

The result is a set of interventions for consideration in the creation of the business plan for the 5 years of RIIO-T2.

3.5 Prioritisation of Interventions

The previous stages of the process have identified the assets where an intervention merits consideration, the feasible options on an asset-by-asset basis and the preferred options following CBA.

The constraints of deliverability such as network access and supply chain capacity need to be considered as part of the planning process. Even though each intervention in the plan has been determined to be the most economic, these constraints will often limit what work can take place in the five years of RIIO-T2 and a prioritisation exercise must be undertaken.

We consider the risk values of each of the identified assets to begin the prioritisation process. We then revisit the options for deferral and assess the feasibility of this approach.

In each asset category, the assets were initially prioritised by their risk values with a further check on the intervention needs of non-lead assets which are not part of the monetised risk methodology. The process to determine the deliverable level of activity considered co-ordination opportunities, internal and supply chain capability and, in particular, system access. This was done at a programme level and also considered load-related activity and operational works. While this process is iterative in nature, with a small number of exceptions, this resulted in the lowest risk assets in each category being deferred to RIIO-T3.

This is a complex process so we engaged an expert party to perform an optimisation process to test our plan and inform check if the proposed combination of interventions produces the best consumer benefit, considering the constraints on delivery.

3.6 Investment Optimisation

We have supplied the costs, timescales, risk benefit and longer-term risk benefits, outage requirements and interactions of the feasible intervention options to SEAMS Ltd and engaged them to undertake an exercise to produce different scenarios to inform the investment plan optimisation.

This process sets out different objectives that the optimisation algorithm uses to select the optimum set of interventions for each scenario considering cost as a ‘tie breaker’ when there are multiple options to reach that objective.

The scenarios are:

- Baseline Plan
- Maximum risk delta
- Maximum risk benefit

- Maximum NPV

The baseline scenario was the absolute minimum set of interventions determined to be necessary based on the risk and condition of the associated assets. This is used as a reference.

The tool generated three optimised scenarios using the data from all assets that had been identified as requiring intervention in RIIO-T2 or RIIO-T3.

The following summarises the outcomes of the exercise.

Overall, the freedom for the algorithm to optimise the investment plan was more limited than observed in other sectors, mainly because:

- The conventional investment planning process will look for opportunities to bundle and group interventions for efficiency. The optimisation algorithm determined few instances where this could be improved.
- As the complexity of power system modelling could not be implemented on the optimisation platform, an extensive outage planning exercise had been applied to the candidate interventions prior to the optimisation exercise. The high levels of interdependence of activities in the SPT network leads to limited opportunities to adjust outage plans. The effect of key load-related programmes has also been considered in the outage planning and optimisation process. These have fixed programmes due to contracted connection dates or optimum delivery dates being determined by processes such as NOA.
- By focusing on the monetised risk benefits, the effects and interactions of non-lead assets cannot be captured in the exercise. The investment planning process takes a holistic view of the asset base and the consideration of lead assets in isolation is a limitation that has affected the outcome.
- The sophistication of the investment planning process in considering future developments allows the business plan to be adjusted to, for example, defer an otherwise justified intervention by a short period to co-ordinate more effectively with a load related project in RIIO-T3.
- ‘Run rates’ or limits on deliverability by asset type need to be applied to ensure that the output is practically achievable. These are set as absolute limits for the intervention period. However, in reality, it would be possible to intervene above this rate for a limited time during the period to generate efficiencies or to take advantage of outage availability but the nature of the optimisation algorithm prevents this.
- Discrete scenario objectives results in outcomes that can be viewed as unduly focused on that particular objective. For example, the maximum risk delta and maximum risk benefit scenarios will prioritise different options for the same asset. Another example is in the maximum benefit example where the algorithm selects the interventions of any asset with the highest longer-term risk benefit until the maximum run rate is reached. This can lead to an imbalance in the chosen interventions when compared to a holistic view of the asset base.

The outcomes of the three scenarios were very similar in terms of the projects chosen and the resultant network risk position. While, for the reasons outlined above, there are a small number of variances, the optimisation process resulted in proposed investment scenarios that are vary only marginally from the submitted RIIO-T2 business plan.

4.0 NETWORK OPERATIONS

The key to all our investment strategies is ensuring we have a resilient network which minimises risks to our customers. We need to ensure we carry out the work necessary to provide the continued levels of service they expect.

Our Network Operations departments carry out maintenance of our assets to minimise risk to our customers, to ensure we can extract maximum value from our assets and mange assets effectively to end of life. We have in place a robust maintenance regime which ensures we can execute these objectives.

We carry out periodic reviews of our maintenance policies to ensure they continue to remain effective and recognise the needs of the equipment that form our transmission network. We have taken the opportunity, provided by the works required to formulate our RIIO-T2 business plan, to carry out a comprehensive review of our maintenance activities to ensure they deliver maximum value for our customers.

4.1 Substations

Historically SPT's substation plant maintenance policy has been a common document with our sister companies and licence holders SP Distribution (SPD) and SP Manweb (SPM). This was due to the similarities between equipment types and an overall holistic view of maintenance activities. Due to the investment activities during RIIO-T1, the types and nature of the equipment on the SPT network has changed significantly from the distribution companies and therefore a stand-alone SPT policy ASSET-01-028 (SPT Plant Maintenance Policy) has been created. Historically our maintenance practices have been time based however the new document enables a risk-based maintenance approach, when appropriate. SPT has also engaged with specialists in the wider Iberdrola group to review what we consider as best practice globally for maintenance of substation plant items.

This review has led to some significant changes in SPT practices. We have introduced voltage regulating technology which uses vacuum switches, which require to be maintained every 300,000 operations, this means new tap changers are virtually maintenance free. We have reviewed how we maintain our circuit breakers and have doubled the maintenance intervals for modern gas circuit breakers as a result. The limiting factor is the need to test gas density monitoring systems as required by statutory legislation. We are examining the use of remote systems to monitor circuit breakers' performance to minimise outage duration and the overall impact on the Main Interconnected Transmission System (MITS).

We have also taken the opportunity during this review to address some of the potential shortcomings of our previous maintenance practices. We use disconnectors and earthing switches to create safe working conditions for our maintenance activities. However these plant items also need to be maintained and the maintenance interval was not ensuring their overall effective operation. We therefore removed a maintenance activity that provided little benefit, but increased our outage based maintenance on these plant items to ensure they operate when required. This will reduce unplanned outages on the MITS due to mal-operation of this equipment.

When considering the impact of the changes in policy on our overall maintenance costs we have carried out a bottom up review of costs for all activities. This bottom up review started with the outage duration for each activity and then built up all costs which contribute to the total. This included staff costs, cost of spares, access equipment, specialist contractor costs, lifting equipment, oil if appropriate and other material costs for each activity based on actual costs borne by SPT for each of these activities. The build-up of our costings in this manner allowed in many instances for SPT to confirm that the costs they have been incurring for activities are efficient and also highlighted some areas of further efficiency, the savings from which have now been built into the business plan.

4.2 Overhead Lines

4.2.1 Inspection and Condition Assessment

Overhead lines are by nature much simpler than substation plant and equipment and our maintenance activities are primarily based around inspection. We inspect all our overhead lines throughout a 12 month period. Many of our overhead line routes are inspected more than once a year to ensure we fully understand the condition of our assets and this allows us carry out any repairs without undue delay.

Like our plant maintenance policy, historically SPT's overhead line inspection policy has been a common document with our sister companies and licence holders SP Distribution (SPD) and SP Manweb (SPM). This was due to the similarities between equipment types and an overall holistic view of maintenance activities. Due to the investment activities during RIIO-T1 and some of the new conductors and associated fittings introduced during this period we have created a stand-alone SPT policy ASSET-01-029 (Overhead Line Inspection and Condition Assessment). Similarly to the substation document, this policy enables a risk based approach to be adopted, where appropriate. SPT have also engaged with specialists in the wider Iberdrola group to review our policies regarding our overhead line assets.

Prior to the publication of ASSET-01-029, SPT already followed a robust inspection and condition assessment process for our overhead line assets. The new document reiterates the requirements of our previous policies and reinforces them in some areas. The condition of our towers, conductor, insulators and fittings have always been critical to an overhead line, however our conductor condition assessment activities have focused on the Aluminium Conductor Steel Reinforced (ACSR) type of conductors. This is due to ASCR being the historically the conductor used on all our overhead line systems and also due to the deterioration mechanisms of this conductor type. Our overhead lines are now made up of ACSR, All Aluminium Alloy Conductor and (AAAC) and Aluminium Conductor Composite Reinforced (ACCR) and the new policy addresses the condition assessment regime required for the new conductor types. The failure modes of overhead lines are well understood and documented. We have taken the opportunity to ensure these issues are presented in a consistent manner with a single point of reference to ensure all our staff and contracting partners understand the failure modes. We have taken steps to ensure the information we gather during our overhead line inspection activities provides us with the information we need, ensuring we have a robust asset management regime for our overhead line systems.

We have also been considering as part of our policy review alternative technologies, which we can use to complement our existing methods. We have therefore included the use of Unmanned Aerial Vehicles, often known as drones, as part of our plans because they can be deployed in areas and take photographs from angles that can't be achieved by a helicopter. The increased flexibility offered by drones may reduce the requirement for our staff to climb towers to inspect fixtures and fittings, reducing requirements to work at height. We also recognise that carrying out surveys by drone currently take much longer than a helicopter-based approach and therefore we will be deploying them when they are the most appropriate choice, for example when we need more detailed photographs of fittings or conductors, or in areas that cannot be flown by helicopter.

When considering the impact of the changes in policy on our overall overhead line costs, we have carried out a bottom up review of all our costs for overhead line activities. This bottom up review started with outage duration for each activity, if appropriate, and then built up all costs which contribute to the overall cost. This included staff costs, cost of spares, specialist contractor costs and other material costs for each activity based on actual costs borne by SPT for each of these activities. The build-up of our costings in this manner allowed in many instances for SPT to confirm the costs they have been incurring for activities are efficient and also highlighted some areas of further efficiency, the savings from which have now been built into the business plan.

4.2.2 Vegetation Management

Trees and vegetation can pose a significant risk to overhead lines if not managed appropriately; it has been well documented than many large scale black outs have been directly attributed to poor vegetation management. SPT manages all the vegetation in the vicinity of our overhead lines in a 3 year planned cycle. This means we manage nearly 800 route km per year and cut, by species, as required to maintain the statutory clearances to our overhead lines. Our experience tells us this is appropriate for our network and we will continue manage vegetation in this manner. We employ specialist contractors to carry out these activities which are managed by internal staff. To ensure we get consistent quality and the best value for money through market testing, our contracts last for the 3 year period. All our costs for vegetation management are from our existing contracts using volumes we will manage in RIIO-T2.

4.3 Cables

We utilise 2 main technologies for cables rated at 132kV and above on the SPT network. These are fluid filled and Cross Linked Polyethylene (XLPE) cables. Our fluid filled cables were installed from the 1940s until the mid-to-late 1990s and since then, with a small number of exceptions, we have installed XLPE cables. Due to a cable being mostly underground, for the most part visual inspection is not appropriate and the condition of the cable is identified by diagnostic testing. The SPT cable maintenance policy CAB-01-007 (Cable Maintenance and Inspection Procedure) has been reviewed as part of our RIIO-T2 programme and found to provide a robust asset management methodology, with only minor redefinition required.

SPT have suffered multiple failures of 132kV XLPE cable terminations during the RIIO-T1 period which most probably could have been detected by partial discharge monitoring. Partial discharge testing already forms part of the SPT cable maintenance policy as an additional test item for consideration. Due to these failures SPT have now introduced partial discharge monitoring as routine for all XLPE terminations. Due to the specialist nature of cable activities at 132kV and above nearly all of this work is outsourced to contracting partners. The costing for the RIIO-T2 cable maintenance activities are therefore derived from our existing maintenance contracts with some additional provision made for partial discharge testing. This has been derived from actual costs incurred by SPT for this activity. Cables can be subject to many different repairs, the costs used for our business plan are based on the average repair cost we have experienced per annum.

5.0 RIIO-T3 OUTLOOK

Interventions on transmission assets can take several years to plan and execute. Our investment planning processes and asset management strategies are designed to manage the longer-term views that are necessary.

The creation of the RIIO-T2 business plan has therefore encompassed the RIIO-T3 period, using the information that is available at this time.

This section provides an overview of the RIIO-T3 non-load related investment plan for lead assets as far as can be forecast at this time. We describe the expected activities at an asset category level. Our regime of condition assessment will continue to inform our understanding of asset condition and the following forecasts will therefore be subject to revision.

5.1 Circuit-breakers

In RIIO-T2, we plan the following actions to manage the risk and condition of the circuit-breaker population.

In the main business plan, we have described the operational issues associated with air-blast circuit-breakers and we plan to replace these in RIIO-T2 as we manage our ability to keep them in service.

Bulk-oil circuit breakers have exhibited failure modes that cannot be addressed by refurbishment and we have continued the programme of replacements in RIIO-T2. We plan to complete the removal of this type of circuit-breaker in RIIO-T3 to manage their operational and safety risks.

We have experienced reliability issues with the earliest installations of SF_6 circuit-breakers which use hydraulic and pneumatic mechanisms. The issues relate to the mechanisms rather than the current-carrying elements and we have worked closely with the vendors to source replacement mechanisms or components. In some cases, we have been unable to obtain the necessary equipment from the vendor; in others, the costs of the mechanisms have not been economical when compared with the cost of a replacement circuit-breaker which has been noted in the Engineering Justification Paper. In these cases, which are for 132kV and 275kV units, we propose to replace them. At 400kV, parts are available and the Cost Benefit Analysis supports the refurbishment intervention. These conclusions are specific to the models of circuit-breakers where there have been reliability issues. We expect these condition issues to continue to arise on the remainder of the asset base and the assessment will be specific to the models of circuit-breakers affected.

By RIIO-T3, we will have managed the condition of all of this type of circuit-breaker at 132kV. There will be 35 275kV units remaining that have not been either refurbished or replaced and our forecast is that we will need to intervene on approximately one third of these. At 400kV, there will be 8 units that have not been refurbished and it is likely that around half of these will require intervention.

In RIIO-T2, we have forecast that we will need to replace some circuit-breakers where it is the correct solution to prevent further instances of SF_6 leakage. We are repairing these units whenever a gas leak occurs but this may become ineffective and we will replace them with circuit-breakers which do not use SF_6 where viable. At present, it is likely only to be possible to procure circuit-breakers using alternative gases at 132kV. It is difficult to foresee what the future performance of the population will be but we forecast that we will undertake similar works in RIIO-T3. At the higher voltages, there are no products available which do not use SF_6 and we foresee that this will be the case throughout the RIIO-T2 period. We will continue to work with the vendors and should there be available products, we will follow the same philosophy we have adopted for 132kV.

Table 5 RIIO-T3 Forward View: Circuit-breakers

Circuit-breaker Type	RIIO-T2 Plan	RIIO-T3 Plan (forecast)
Air-Blast	Replace 7[4] 400kV Units Replace 28[5] 275kV Units Replace 7 132kV Units	All units replaced in RIIO-T2
Bulk-Oil	Replace 8[6] 275kV Units Replace 4 132kV Units	All units replaced in RIIO-T2 Replace 12 132kV Units
Hydraulic/Pneumatic Mechanism SF_6	Refurbish 11 400kV Units Replace 4 275kV Units Replace 17 132kV Units	Refurbish 4 400kV Units Refurbish or replace 12 275kV Units All units replaced in RIIO-T2
Spring Mechanism SF_6	No works planned	No works planned

5.2 Transformers and reactors

Our RIIO-T2 plan for these asset types includes a number of refurbishments and replacements as required by current and forecast condition and supported by CBA.

We have an extensive programme of condition assessments which allows us to assess the expected remaining life of any particular unit. We also inform this assessment by applying data from forensic examination of decommissioned units. From this assessment, we have generated the following view of interventions in RIIO-T3.

Table 6 RIIO-T3 Forward View: Transformers and Reactors

Transformer or Reactor Type	RIIO-T2 Plan	RIIO-T3 Plan (forecast)
400kV Transformers	Refurbish 4 Units	None Planned
400kV Reactors	Replace 2 Units	None Planned
275kV Transformers	Replace 3 Units Refurbish 2 Units	Replace 4 Units Refurbish 4 Units
275kV Reactors	Refurbish 2 Units	None Planned
132kV Transformers	Replace 1 Unit Refurbish 6 Units	Refurbish 5 Units

[4] Disposal of 7 units, replaced with 2 units
[5] Including the 18 units at Longannet that are designated as uncertain
[6] Including the 7 units at Westfield that are designated as uncertain

5.3 Overhead Lines

Our RIIO-T2 programme has continued the strategy of managing the condition of the core-only greased variant of Aluminium Conductor Steel Reinforced (ACSR). Condition evidence has verified the expected asset lives and we have a long-term strategy for each route. We also have plans to replace fittings (including conductor spacers, dampers and spacer-dampers) in conjunction with conductor replacement or as a separate activity. This reflects the different service lives of the two asset types. All of the interventions are supported by CBA.

In RIIO-T3, from the condition data available, we expect to complete the replacement of the core-only greased ACSR conductor, of which some is expected to be replaced by load-related works.

We don't expect to have to intervene on fully-greased ACSR conductor because of corrosion of the steel core until RIIO-T4. However, it may be necessary to undertake works as a result of fatigue and we will continue to monitor this closely.

We do not foresee any requirement to replace All Aluminium Alloy Conductor (AAAC) for a number of years. Our earliest installation of AAAC was in the mid-1980s so we will begin to develop additional condition assessment techniques during RIIO-T2 to understand how this type of conductor ages. However, we will continue to ensure conductor life is maximised by appropriate management of the condition of fittings.

The main driver for major refurbishment projects is conductor condition and these works will consider intervention on fittings. Tower steelwork and foundations are also assessed and, in the main, repairs and upgrades are carried out rather than replacements. It is expected that this will continue in RIIO-T3. Minor refurbishments will be initiated primarily based on the condition of fittings. For RIIO-T3, we do not have any plans for this type of activity other than as part of major refurbishments. Interventions result mainly from observed condition during inspections and it should be expected that some instances of minor refurbishment will be required as a result.

Table 7 RIIO-T3 Forward View: Overhead Lines

Overhead Line Interventions	RIIO-T2 Plan	RIIO-T3 Plan (forecast)
400kV Major Refurbishment	3 Routes	None planned
400kV Minor Refurbishment	4 Routes	Dependent on condition
275kV Major Refurbishment	1 Route	6 Routes
275kV Minor Refurbishment	6 Routes	Dependent on condition
132kV Major Refurbishment	8 Routes	8 Routes

5.4 Underground Cables

Our RIIO-T2 cable investment plans are focused on the refurbishment of some of the earliest fluid-filled cables on the network. Our condition assessments indicate at this stage that we will have no planned refurbishments or replacements in RIIO-T3. We have included one replacement scheme in the RIIO-T2 plan but it is possible that this may be deferred into RIIO-T3. For this scheme in RIIO-T2, we have proposed it as a Price Control Deliverable, meaning that we will only trigger the associated allowance to consumers if it is delivered in to RIIO-T2.

5.5 Deliverability

We have undertaken a high-level assessment of the deliverability of the works that are forecast to be required in RIIO-T3. The level of activity, as shown in the preceding sections is not likely to be greater than RIIO-T2 which indicates that the required internal and supply-chain capability will be available. We have undertaken an initial assessment of system access requirements which also indicates that the current forecast plan is deliverable.