Scottish & Southern Electricity Networks

TRANSMISSION

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A Risk Based Approach To Asset Management

December 2019

Scottish Hydro Electric Transmission plc

Contents

1 Introduction

Scottish Hydro Electric Transmission (SHET), are the owner and operator of a safe and secure electricity transmission network in the North of Scotland. We strive to meet the expectations of our stakeholders and deliver on our legislative requirements.

Our risk-based approach to Asset Management is underpinned by our commitment to maintain the highest industry standards through our certification to the BS ISO 55001 standard.

There are two main types of investment undertaken by us on our Network – Load & Non-Load related.

Load related investments are usually initiated by a customer-driven need to connect to the electricity transmission network or are associated with reinforcement of the network to allow increased flows of electricity.

This paper focusses on our non-Load related investments. These investments are associated with ensuring our existing assets perform to the standards required by undertaking the appropriate repair, refurbish or replacement intervention at the right time.

In order to deliver these key requirements, we continually monitor and assess the condition of our assets to maintain the reliable and resilient network that is expected by our stakeholders.

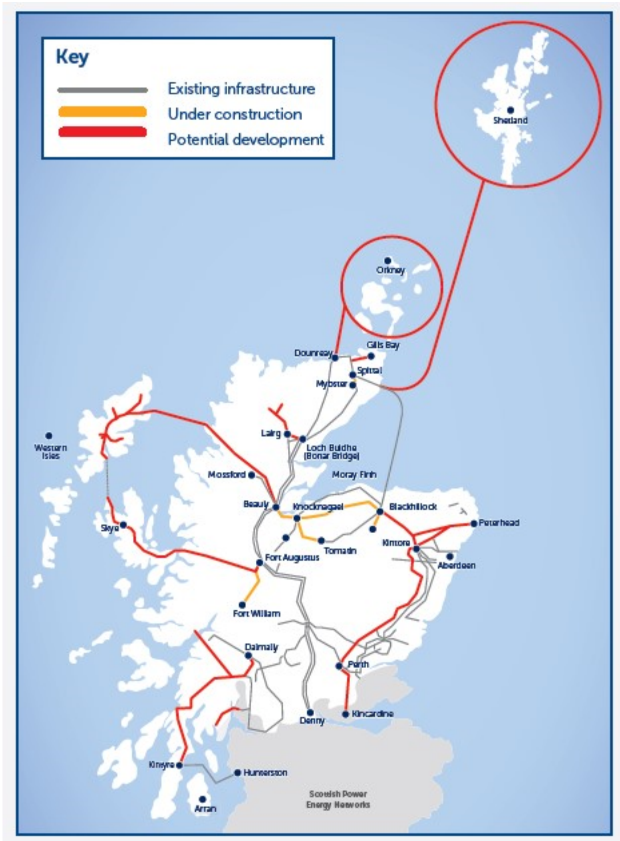


Figure 1 – SHET Network

Where asset condition deteriorates, we undertake a programme of cost-effective, risk-based refurbishment or replacement interventions to maintain the longevity and performance of the transmission network. During the RIIO-T2 period, we are proposing to invest circa £797 million to deliver 28 asset-related interventions to meet this goal.

In addition to our risk-based intervention programme, our stakeholders have made it clear to us that security of supply and resilience are their baseline requirements for an electricity transmission system. During the RIIO-T2 period, we are proposing to invest circa £255 million to deliver 13 projects that will improve our ability to deliver these key stakeholder needs.

The purpose of this paper is to provide insight into the key strategies and decision-making processes that underpin our risk-based approach to Asset Management and how we identify and select the 28 asset refurbishment or replacement interventions and the 13 security of supply / resilience related projects we believe are essential to meet the ongoing requirement to deliver a safe and secure network throughout the RIIO-T2 period and beyond and achieve our ambitious goal of a Network for Net Zero.

Each of the sections in this paper addresses a different phase of our risk-based approach to asset management.

In Section 2, we explore the guiding principles that underpin our approach to managing our assets. Section 3 outlines the strategies we employ for each of our lead asset classes and Section 4 details how we apply these principles & strategies to develop the non-load intervention proposals within our RIIO-T2 Business Plan.

2 SHET Guiding Principles for developing our RIIO-T2 Non-Load Business Plan

Our RIIO-T2 Business Plan identifies five clear goals (Figure 2) to be achieved during the five-year period between 2021 & 2026.

The Business Plan also sets out our proposed strategy, ambitions, targets, activities and costs for the period. It is the result of 2 years of extensive consultation with our customers, consumers, stakeholders and future customers.

Figure 2 – SHET 5 Clear Goals for RIIO-T2

The Non-Load element of the T2 Business Plan was created within this consultation process and has been developed with the clear guiding principles of:

- Cost effective repair, refurbish or replacement interventions, made at the right time, to deliver best value to consumers
- Ensuring the safe and secure operation of our network by improving resilience and continuing to deliver the reliability levels expected by consumers and customers

2.1 Shaping Investment Decisions through Stakeholder Engagement

Stakeholder engagement has been a core component of all aspects of our RIIO-T2 Business Plan and has been instrumental in defining how we approach our proposed asset/non-load related investments.

During our Asset Management and Operations stakeholder workshop, held in March 2019, our engineers and asset managers outlined various alternative investment proposals for discussion, review and feedback.

For asset replacement, stakeholders were informed of the guiding principles and strategies that underpin our risk and condition-based approach to asset interventions and were asked to provide their preferences on how we should develop our intervention options.

We explained that our first option – Do Nothing – was not a long-term viable approach to take, as the resulting outputs of this approach would be unpredictable and increase the risk of asset failures, leading to disruption of supplies to the homes and business connected to the electricity network. Stakeholder feedback was very clear on this issue – reliability and continuity of supply was a key base requirement.

Minimum Standard	Responsible Operator
Replace or refurbish assets forecast to fail during T2, bringing them up to current specifications	Bring T3 enabling works forward when carrying out T2 works

Figure 3 – Definition of SHET RIIO-T2 Approach to Non-Load Investments

Stakeholders were then presented with two options (see Figure 3); minimum standard, defined as **'to replace or refurbish assets forecast to fail during RIIO-T2, bringing them up to current specifications'**; or 'responsible operator', which builds on minimum standard but also includes to **'bring RIIO-T3 enabling works forward when carrying our RIIO-T2 works.'** The rationale for the responsible operator option is to deliver future efficiencies in investments as well as minimising the local impacts of our activities.

Whilst stakeholders supported the ‘responsible operator’ option, they did comment that there was a big leap between the costs in the minimum standard option and those for responsible operator, adding that certain works should be looked at on a case-by-case basis. It is this flexible, case-by-case approach we have adopted for our RIIO-T2 Business Plan.

The stakeholder workshop also covered the security of supply / resilience activities we had developed to support our goal to aim for 100% transmission network reliability for homes & businesses. We presented the stakeholder group with a range of investment options that required increasing levels of investment to deliver an increasing range of ‘security of supply’ benefits. This was in line with our three-tier approach to asset management: ‘minimum standard’, ‘responsible operator’ and ‘progressive network enabler’. The stakeholder groups provided their views on the most appropriate levels of investment needed for each option, which we developed into the 13 security of supply / resilience projects outlined in our T2 Business Plan.

The outcome of this workshop has shaped our approach to maintaining and investing in our existing network, with the results from the stakeholder event reflected in our RIIO-T2 Business Plan. A summary of the topics covered and stakeholders’ response to which option we should progress is provided below.

2.2 Our Network Reliability Ambition

Since privatisation, SHET, as a responsible network operator, has demonstrated a strong history of delivering sustained improvements in network reliability which will continue throughout the RIIO-T2 period. Our reliability goal, as defined in our RIIO-T2 Business Plan, is to aim for 100% transmission network reliability for homes & businesses by making cost-effective investment in new technologies to manage our growing and complex asset base smartly and efficiently. Whilst our non-load investment is not directly driven by this goal, we believe it will contribute towards it.

This long-term network reliability ambition is driven by the output of consumer surveys & customer feedback that have provided us with clear guidance on the high value placed on uninterrupted supply and unconstrained access to electricity network.

The 28 asset interventions and 13 security of supply related projects, proposed within our RIIO-T2 Business Plan, are the output of a rigorous development process, using detailed asset condition and network performance information as the driver to undertake work. Our approach to invest in new technologies and ways of working will ensure that our condition-based interventions also deliver improved asset performance, that will significantly contribute towards our goal to aim for 100% network reliability for homes & businesses by 2026.

An example of this stakeholder led risk-based approach is that all transformers installed during the T2 period will be built to current industry specifications, ensuring that they are equipped with the latest sensor technology, capable of providing real-time asset condition information, as standard.

Use of this technology will provide asset managers with the earliest possible indication of any plant or equipment performance deterioration, allowing interventions to be efficiently & cost effectively planned & delivered at the right time, minimising any disruption to customers.

3 The SHET Approach to Risk-Based Asset Management

3.1 Understanding our Assets and Their Condition

Our network comprises a large number of electricity substations, connected by overhead lines and underground cables. The continuing reliable performance of these assets is essential to the delivery of a safe and secure network for the homes and businesses we supply.

Within our regulatory framework, these assets are grouped into 2 classes – Lead & Non-lead Assets.

<u>Lead Assets</u>

The lead asset classes on the SHET network are:

- Transformers & Reactors
- Circuit Breakers
- Underground Cables
- Overhead Lines
  - Conductors
  - Fittings
  - Towers, inc wood poles

<u>Non-Lead Assets</u>

The non-lead asset classes on the SHET network include:

- Circuit Switchers
- Disconnectors
- Earth Switches
- Busbars, Post insulators & Fittings
- Instrument Transformers
- Ancillary Systems e.g. batteries
- Protection, Control, Telecommunications & Smart Monitoring systems
- Civils & Buildings

All lead & non-lead assets are built with an anticipated design life. Over time, asset condition can deteriorate and unchecked, this can lead to an increased risk of asset failure, as shown in figure 4.

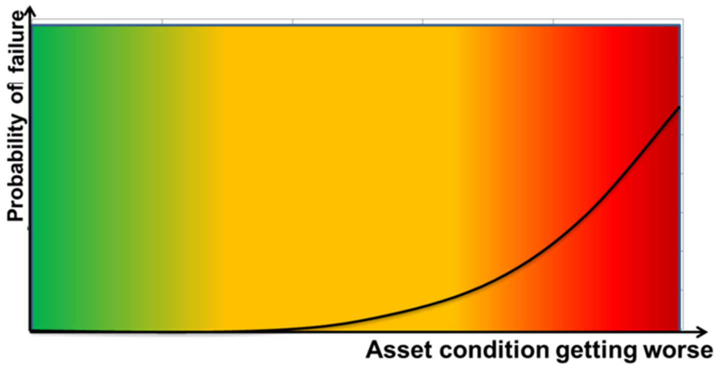


Figure 4 – Typical asset condition deterioration over time

Deterioration of asset condition is normal and expected This occurs due to the operational conditions and stresses that the assets are subjected to during their working life and include:

- Electrical stress – experienced by assets like circuit breakers during the clearance of fault currents
- Thermal stress – experienced by transformers, reactors & tables, due to the heating effect of carrying loads close to their design limits for short or sustained periods to meet network demands
- Mechanical stress – experienced by all assets during fault conditions, but most often seen on overhead line assets as wind-induced vibration
- Environmental factors – these can include landslides, wildfires, salt & industrial pollution, as well as excessive wind, snow & ice

If unchecked, the deterioration associated with our asset base can have a significant detrimental effect on the transmission network and the customers connected to it.

To ensure our understanding of current asset condition is accurate, we undertake periodic inspections and testing of our assets to assess and measure their condition.

Our asset condition information, current and historical, is held within our Maximo asset database and a number of other data-management platforms. This data is a key component in the decision-making processes used to manage our asset base and to identify and select the appropriate interventions to meet our asset management objectives.

3.2 Network Asset Risk Metric

SHET, in collaboration with the other UK Transmission Owners and Ofgem, has developed and is in the process of implementing a Network Asset Risk Metric or NARM, within the broader Network Output Measures (NOMs) methodology, to provide a broadly consistent risk-based model for asset management.

In simple terms, NARM is defined as the relative reduction of long-term monetised network asset risk[1]. It will be used to justify the funding for, and to set the outputs of, asset management work. The NARM will be part of a toolbox assessment approach including other inputs such as engineering judgement." The NARM calculation is applied to our lead asset classes only.

The individual lead asset risk score is a combination of how probable an asset is to fail (Probability of Failure), and the consequences of that failure (Consequence of Failure).

<u>Probability of Failure</u>
Asset condition is monitored using visual inspections and testing regimes, outlined in section 5 of this paper. The outputs of these monitoring activities provide useful early indications of the deterioration of an asset and

[1] Ofgem RIIO-2 Decision on Sector Specific Methodology – Core Document – 24/05/2019
https://www.ofgem.gov.uk/system/files/docs/2019/05/riio-2_sector_specific_methodology_decision_-_core_30.5.19.pdf

allows assessment of when the asset may fail. This information is used to calculate a Probability of Failure (PoF) value for each asset.

Consequence of Failure

Asset and site-specific information is studied to determine the Consequence of Failure, or CoF. This CoF contains assessments of the societal consequences of the asset failing, looking at the environment, safety and the wider transmission network. It also considers the cost of replacing that asset.

Risk Modelling Tool

This complex risk modelling process is undertaken within our Condition Based Risk Management (CBRM) tool. CBRM takes up to date asset condition information from a number of data sources, including our asset database – Maximo and the SHET Geographical Information System.

CBRM undertakes a series of complex calculations to determine the PoF & CoF of each lead asset on our network and combines these values to deliver a NARM score for each lead asset.

At this time, the NARM model is still relatively immature and limited in scope (**Table 2**) and we will continue to develop it during the RIIO-T2 period, with the intention that non-lead asset classes will be included.

In scope	**Not in scope**
Asset-drivers	Growth-drivers
Lead Assets Transformers and reactors Circuit breakers Underground cables Overhead lines (conductors, fittings and towers)	Non-Lead Assets Circuit switchers Disconnectors Earth switches Busbars, post insulators and fittings Instrument transformers Ancillary systems, e.g. batteries Protection, control, telecommunications and smart monitoring systems Civils and buildings

Table 2 – Assets included & excluded from NARM calculations

The output of this risk-based analysis process is a series of data tables that identify the highest risk lead assets in each asset class (transformers, circuit breakers, underground cables & overhead lines), prioritised by their monetised risk or NARM value.

The NARM tables are not used in isolation to select specific assets for intervention. They are one of the tools, used to inform the risk-based, asset intervention decision-making process, outlined in Section 4 of this paper.

Although NARM considers only lead assets, our planning process considers the condition of all associated non-lead assets at the same site as part of our rigorous approach to delivering cost-effective, risk-based interventions that deliver the best value to consumers.

More detail on how we calculate our NARM can be found in the Common Network Output Measures Methodology[2], published on the Ofgem website.

Total Network Risk

As an effective asset manager, it is incumbent upon us to ensure that the level of network asset risk is monitored and managed to ensure the continued safe and secure operation of the network.

The total current Network Risk is therefore a summation of current NARM scores for all lead assets on the SHET network. The NOMs methodology allows us to calculate and model our NARM across a range of different scenarios.

To calculate our asset & network risk, we need to update the CBRM risk models to reflect the network changes that will take place between now and the end of RIIO-T1. We can then use CBRM to forecast an indicative NARM for the start of T2 and use the same model rolled forwards to 2026 to generate a T2 'non-intervention' NARM i.e. the forecast Network Risk if we took no action to refurbish or replace high risk assets during the T2 period.

By applying our proposed T2 business plan interventions to the model, we can also estimate the impact of the proposed intervention plan over the 5-year period.

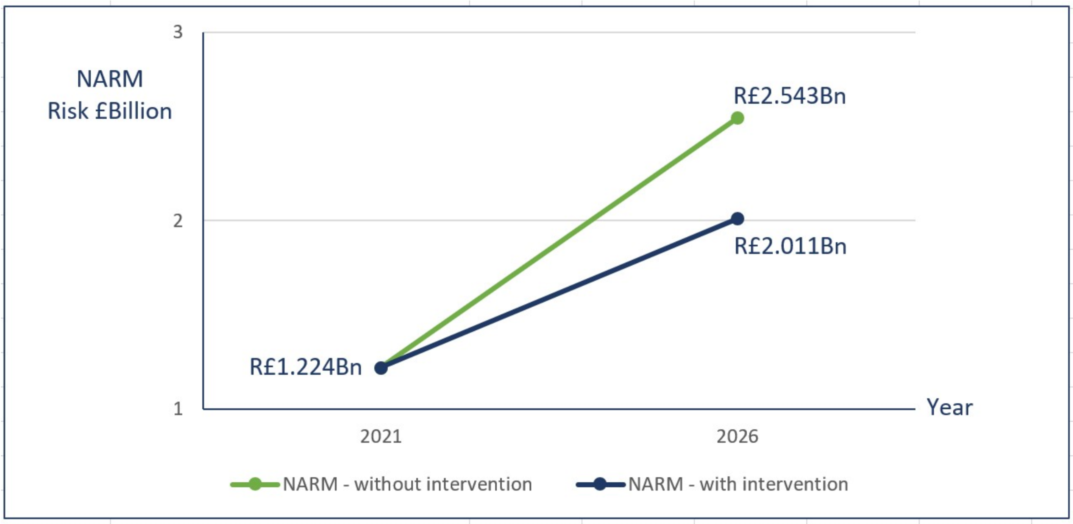


Figure 5 – Monetised Risk Reduction during RIIO T2 Period

Figure 5 shows the impact of our Non-Load Business Plan to be a net reduction of R£532 million on our NARM. This is a summation of the positive impact of the asset interventions on our Lead Assets only.

This overall net increase in lead asset risk over the T2 period is normal and expected but may appear unusual when compared with other network operators.

[2] https://www.ofgem.gov.uk/system/files/docs/2018/08/noms_common_methodology_issue_18.pdf

Typically, the operators of long-life network infrastructure will have a 'steady state' asset management requirement, with the overall size of the asset base staying near constant. In most years, new additions to the asset base will equal assets being removed in that year. In contrast, our network has both that legacy steady state element plus a substantial element of nearly new assets and continued growth from the start of the RIIO-T1 period through to the end of the RIIO-T2 period.

As this volume of new assets begin to age, their contribution to our NARM score is the steady increase forecast in figure 5 above.

Long-Term Monetised Risk Benefit

For each Non-Load related project, proposed in our RIIO-T2 Business Plan, we will calculate the Long-Term Monetised Risk Benefit value for the proposed intervention. This calculation involves the forecasting of the Probability of Failure & the Consequence of Failure over the lifetime of the proposed intervention to determine the relative reduction of long-term monetised network asset risk.

Figure 6 demonstrates the risk benefit of the proposed intervention options on the Sloy-Windyhill West 132kV overhead line circuit over the 45-year period from the delivery of the intervention in 2026, against the 'no-intervention' benefit.

In this example, the proposed investment of £16.8 million on this circuit during the RIIO-T2 period will deliver a long-term monetised risk benefit of R£319.5 million for Option 1 or R£364.8 million for Option 2, over the lifetime of the asset intervention.

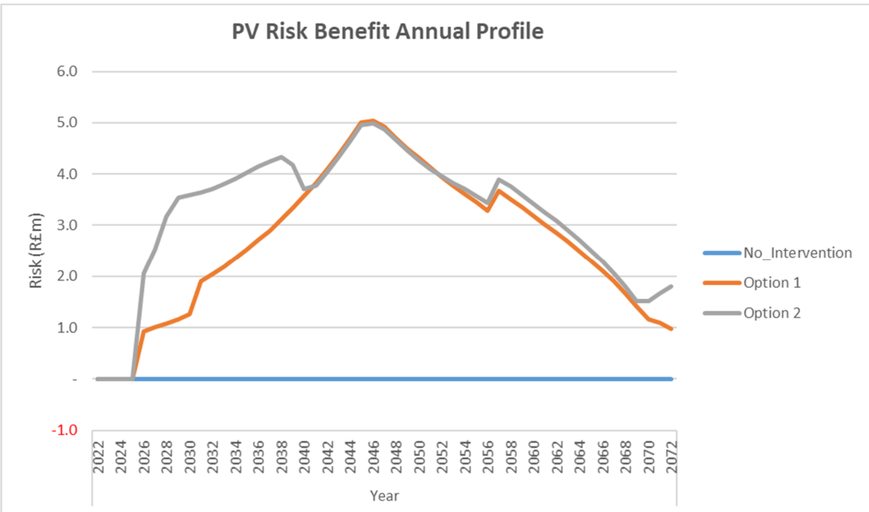


Figure 6 – Long-Term Monetised Risk Benefit Graph for Sloy-Windyhill West OHL Project

In some instances, this long-term monetised risk-benefit value will be a negative number. This would normally be where the lifetime of the proposed intervention in our T2 business plan is less than 45 years. The limitations of the current model will therefore show a steady decrease in the risk benefit of our proposed intervention before the 2072 end date.

Figure 7 shows the long-term monetised risk benefit graph for Redmoss 132kV substation. During the RIIO-T2 period, we propose to invest £0.5 million, which will deliver a negative long-term monetised-risk benefit of R£20.1 million during the 45-year intervention period from 2026 to 2072, within the model.

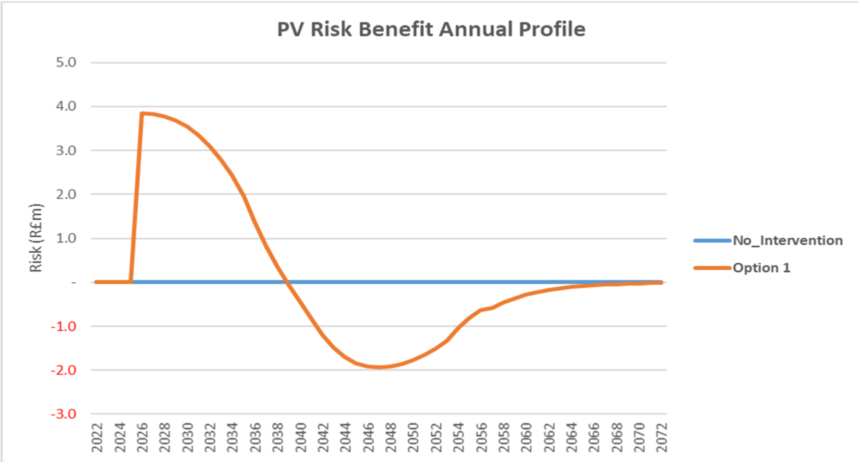


Figure 7 – Long-Term Monetised Risk Benefit Graph for Redmoss 132kV Substation Project

The reality of this situation is that we would plan further interventions at this site, around the 2036-2040 period, indicated in the graph in Figure 7, to ensure that we maintain the overall safe & secure condition of our network.

Across the 28 proposed interventions in our RIIO-T2 Business Plan, we propose to invest circa £797 million, which will deliver circa R£55 billion of long-term monetised risk benefit over the period 2026-2072.

The long-term monetised-risk benefit scores for each project are recorded in Table 9 in this paper.

3.3 SHET Condition-Based Asset Intervention Strategy

As a responsible Network Operator and Asset Manager, we continually monitor the condition and performance of our assets to ensure we operate the safe and secure network expected by our customers and stakeholders.

In previous sections of this paper we explain how the condition of the asset is linked to the risk of that particular asset failing and how we quantify this risk, by applying a consequence of the asset failing using our NARM process.

When we calculate the risk for each lead asset, we can obtain a high NARM score for an asset in good condition, where the impact on the network is high if that asset failed. Similarly, an asset in relatively poor condition will output a low NARM score if the impact on the network is low. This means that when deciding which assets should be considered for intervention during any time period, we look at their condition as the primary driver. Within our asset management system, we categorise the condition of our assets into 4 broad groups (Table 3).

1	Good Condition - No visible or quantifiable signs of deterioration
2	Good Condition – Minor visible deterioration only
3	Significant visible & quantifiable signs of deterioration – increased risk of failure within the medium term
4	Poor Condition – asset is approaching end of life

Table 3 – Asset Condition Scoring Methodology

Assets in groups 1 & 2 above do not require an intervention, even if the impact of their failure is significant to the network. The condition of these assets will be monitored through our normal condition monitoring, inspection & maintenance processes.

Assets in groups 3 & 4 are examined in more detail. This analysis & decisions made in this process are explained in section 4 of this paper, but there is an increased risk that some form of intervention will be required to return the condition & performance of assets in these groups to an acceptable level.

3.4 SHET Lead Asset Strategies

In the previous section, we identified Asset Condition as the primary driver for identifying if an intervention should be considered. In this section we describe the strategies we have developed to manage the deterioration of assets within each of our lead asset classes.

Transformers & Reactors

Transformers & reactors are of similar construction but have very different functions on our network.

Transformers connect parts of the network together that operate at different voltage levels. They are often the interface between our network and the assets of the distribution system and generation customers.

Reactors are used to control voltage on the network or to change power flows. They have a key role to play at critical nodes on the network to ensure we operate a safe and secure network.

Figure 8 – 275, 120MVA Parsons Peebles SGT manufactured in 1970

Our strategy for transformers & reactors is to intervene before the asset fails. The potential consequences of an in-service failure are significant, due to the large volume of flammable insulating oil contained within each asset; the impact of a disruptive failure on the condition of nearby assets; and the impact to customers during the time taken to replace a failed asset.

Our RIIO-T2 Business Plan proposes cost-effective, condition driven, risk-based refurbishment or replacement interventions on 11 transformers from our asset base, operating at 275kV and 18 transformers operating at 132kV. We also propose to deliver an intervention on 1 Reactor during the T2 period.

Circuit Breakers

Circuit Breakers are lead assets that act as switches on the transmission network and break the short circuit currents caused by faults.

There are two main types of circuit breaker on the network:

- GIS - gas insulated switchgear, where the equipment is fully contained within a metal chamber filled with Sulphur Hexafluoride (SF_6) insulating gas.
- AIS – air insulated switchgear (see picture), where the equipment connections are exposed to the air. These circuit breakers also typically contain smaller quantities of SF_6 gas within them.

Figure 9 – 132kV AIS Circuit Breaker

Our asset strategy for condition driven intervention on our circuit breaker population is very closely linked with our environmental strategy.

Leakage of SF_6 insulating gas from our GIS & AIS switchgear assets is a significant factor in our assessment of asset condition. Controlling the leakage of this harmful greenhouse gas is very important to us in our role as a responsible network operator and we closely monitor the performance of all SF_6 insulated assets. Where leakage is detected, immediate reactive interventions are taken to reduce or prevent any further occurrences.

This is a key strategy in our RIIO-T2 Business Plan and forms part of our ambitious target to move towards a network for net zero, outlined in our SF_6 strategy - Our Strategy for the Management of Insulation & Interruption Gases.

To help deliver this ambitious target, we will reduce SF_6 leakage, relative to our network holding and asset growth during the RIIO-T2 period. To achieve this, our RIIO-T2 Business Plan proposes that we will intervene on 4 of our population of 275kV circuit breakers and 51 of our 132kV breakers.

We have been trialling the use of alternative insulating gasses at both 132kV & 275kV during the T1 regulatory period. Where a cost-effective solution can be demonstrated, the intervention strategy for our 132kV circuit breakers will consider the use of these alternative insulating gas switchgear solutions.

Underground Cables

Underground cables comprise a relatively small, but important part of our network. Like our overhead line network, cable systems are used to connect between our electricity substations, enabling the flow of energy around our network, predominantly within our larger population centres, like Dundee and Aberdeen, but increasingly to connect our HVDC assets using a combination of underground and submarine cable systems.

There are 3 main types of underground cable installed on our network:

XLPE – the majority of our cable assets are of XLPE (cross-linked polyethylene) construction. These assets are relatively new, in good condition and are not being considered for intervention during the T2 period.

Fluid-filled – We have a small amount of our cable network constructed from fluid-filled cables that use oil as their insulating medium. Most of our population of fluid-filled cables remaining on the network are in a good condition for their age and are not being considered for intervention during T2, with only 7.5km proposed for replacement with XLPE cable, due to their condition.

Gas-Filled – We have a small amount of gas compression cables still installed on our network in the Aberdeen area. These two cables (approx. 9.6km total length) are at the end of their asset life and it is proposed to replace them with XLPE cable, during the T2 period.

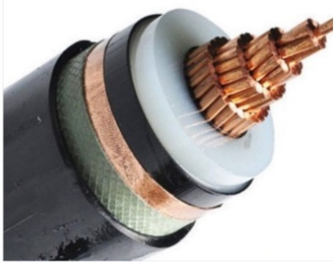


Figure 10 – 132kV XLPE Cable

Figure 11 – 132kV XLPE Cable Installation

Overhead Lines
The most visible of our asset base is our overhead line network, connecting our electricity substations at 132kV, 275kV and 400kV voltage levels. Our network connects substations across the entire North of Scotland and our overhead lines are regularly exposed to the harshest environmental conditions experienced by any transmission assets in the UK.

We identified in section 3.1 that overhead line systems are comprised of 3 lead asset classes. Each of these 3 components plays an important part in the construction of our overhead line network, but due to the different operational stresses they are subjected to, they have very different design lives.

Towers & Poles	Towers OHL towers (or pylons) are typically of steel lattice construction, with concrete foundations. They come in different sizes for different voltage levels and conductor configurations and provide the basic function of holding the conductor system at a safe distance from the ground. They typically 2 electrical circuits, one on each side of the tower, but also come in single circuit configurations.  **Figure 12 – 132kV Steel Lattice Tower & Wood Pole Lines** The anticipated life of a steel tower is 60-80 years, depending upon the environment it is in. Poles A significant part of our OHL network is constructed using wood or composite poles. Pole lines are predominantly single circuit lines, providing a radial feed to substations and our generation customers and have an anticipated asset life of 40 years.

Conductors	Conductors are the current carrying component of our OHL assets and they are attached to our towers and poles by fittings. There are different configurations of conductor on our network, depending upon the voltage of the power line and it's required current-carrying capacity. The vast majority of the conductor installed on our 132kV network is of ACSR (Aluminium Conductor, Steel Reinforced) construction. This type of conductor can suffer from corrosion of the steel core, resulting in reduced strength & increased risk of failure.  **Figure 13 – Example of ACSR Conductor** The typical life of conductor, depending upon location & environment, is 40-60 years.
Fittings	Fittings are the mechanical components that connect the towers and poles to the conductor and also control the inherent vibration of the conductor. The anticipated asset life of fittings depends very much on the environmental conditions they experience, and it is not unknown for assets subjected to sustained periods of strong & extreme wind to reach an end of life condition in less than the 30-40 year anticipated asset life.

The asset strategy for our OHL networks is to replace the earth wire and conductors where we have evidence that their condition has reached the point where further deterioration would increase the risk of failure to unacceptable levels, affecting the safe and secure operation of our network.

Similar detailed condition assessments are undertaken on our tower, wood pole and fittings assets to estimate their remaining asset life and determine the appropriate cost-effective interventions as a 'responsible operator' to minimise the impact of system outages on our customers and stakeholders.

Our RIIO-T2 Business Plan identifies 289.5km of 132kV OHL routes for intervention during the T2 period.

Summary of RIIO-T2 Asset Interventions

Asset Class	Voltage	Intervention	Volume
OHL	132kV	Replace	189km
OHL	132kV	Refurbish	100.5km
Transformer	275kV	Replace	11
Transformer	132kV	Refurbish	2
Transformer	132kV	Replace	16
Reactor	275kV	Replace	1
Circuit Breaker	275kV	Replace	3
Circuit Breaker	132kV	Replace	51
Cable	132kV	Replace	17.1km

Table 4 – Volumes of existing assets proposed for RIIO-T2 interventions

Table 4, above, summarises the volume of assets and the type of intervention we propose to undertake as part of our RIIO-T2 non-load business plan.

It should be noted that these volumes represent existing electricity transmission assets, physically operational on the network in 2021, with a condition driver or additional engineering justification for an intervention to be undertaken during the RIIO-T2 period.

The volumes in Table 4 do not represent the final solutions developed, using the decision-making processes we describe throughout this paper and summarise in our suite of Engineering Justification Paper documents, to address the condition/engineering justification drivers we have identified.

3.5 SHET Non-Lead Asset Strategies

In section 3.1 of this document, we classified the assets on our Network into Lead & Non-Lead asset classes. While our NARM score & targets are currently based on Lead asset classes only, a large portion of our proposed investment of circa £1052 million during RIIO-T2 (to deliver the 28 Asset-Related refurbish & replace interventions and 13 projects that will improve our security of supply / resilience) will be made on Non-Lead assets. In some instances, it is Non-Lead assets that are the key driver of the proposed intervention, necessitating the replacement of Lead assets at the same time to deliver a safe, efficient & cost-effective intervention.

Non-Lead Substation Plant Assets

Our asset strategies for non-lead substation plant assets is broadly in line with the strategies outlined above for transformers & circuit Breakers – to intervene as close to, but before, the end of life of the asset.

The condition of the assets is monitored and assessed in line with our policies and industry best practice and is combined with that of lead assets to form a complete assessment of the overall substation asset condition, as part of the risk-based intervention process, detailed in section 4 of this document.

The non-lead asset classes included within this strategy include:

- Circuit Switchers – devices that combine some of the functionality of a circuit breaker with the isolating functionality of a disconnector. These assets are typically used in sites where space is constrained.
- Disconnectors – isolating devices, also used to select circuits onto the appropriate busbar within a substation. They need to be used in conjunction with circuit breakers within the Transmission system to clear any faults that occur.
- Earth Switches – devices that provide a solid connection to earth, allowing interventions to be safely undertaken on the adjacent assets.
- Busbars, Post insulators & Fittings – the equipment that is used to connect substation assets together within a substation.
- Instrument Transformers – these are the devices that accurately measure the current flows and voltages within a substation, providing the measurements needed by the protection & control systems within the Transmission network.
- Ancillary Equipment – this includes the substation battery systems that ensure supplies are maintained to equipment during emergency situations; and the protection, control & telecommunications equipment that allows us to remotely monitor & control our assets and efficiently switch out equipment when there are faults on the network.

3.6 Asset Strategies to improve Security of Supply

The development of the SHET RIIO-T2 Business Plan was heavily influenced by the feedback obtained through an extensive period of stakeholder consultation. One of the key pieces of feedback received during this period was that a Safe & Secure Network was a fundamental requirement across all stakeholder groups.

In parallel with stakeholder consultation, we were a key contributor to a cross-industry Energy Research Partnership collaborative group[3] to examine, understand and develop strategies to improve the resilience of the UK Electricity System. This need to consider ways to enhance the Security of Supply to customers was brought to the attention of all UK electricity consumers during the disruption to the electricity network in

[3] http://erpuk.org/wp-content/uploads/2018/11/4285_resilience_report_final.pdf

England & Wales in August 2019 and the subsequent knock-on impact to consumers and other critical national infrastructure as a result.

We developed and presented a number of measures to improve the security of supply and resilience of our network to our stakeholders in early 2019. The direct feedback on these proposals has resulted in the development of a series of 13 projects, at a cost of circa £255 Million, to deliver a safe & secure network that will strive to deliver 100% network reliability for homes & business by 2026.

The projects proposed by us during the RIIO-T2 period to enhance network resilience and the security of supply to consumers includes the following strategic investments, with a full summary included in Appendix 2 of this paper.

- Materials Management & Warehousing
  We propose to establish a warehousing & logistics function to efficiently manage our Transmission strategic spares holdings. This investment will ensure that we hold the right equipment spares and can quickly dispatch them to support the restoration of the network, following an asset failure.

- Emergency Response & Contingency Planning
  Temporary masts can be used to support a range of transmission overhead line activities, including the fast & efficient restoration of overhead line circuits following a failure like that experienced by consumers in late 2018, due to a landslide that destroyed a transmission tower in the North of Scotland. This investment will increase our holding of these assets, allowing us to quickly deploy them to any part of the network when required.

- Protection, Control & Telecommunications
  The investments proposed in this area to replace obsolete equipment & enhance communications between sites will significantly enhance our ability to monitor, control & react to potential network disturbances as they begin to develop, limiting the impact to the network by any single occurrence. This will include the development of a standalone, modern Transmission operations centre room as the central hub to monitor & react to the information & data provided by our transmission assets.

- Integrated Condition & Performance Monitoring
  The application of the latest senor & measuring technologies, to our existing and new asset fleets – combined with the investments in protection, control & telecommunications technologies will allow us to remotely monitor the performance & condition of our assets, ensuring that any asset deterioration is detected, investigated and managed to ensure minimal disruption to the network.

The driver to many of the above technology investments is outlined in our Digital Strategy document, published in November 2019. This document describes our ongoing journey to become a more digitalised business, reflected in integrated data, systems, processes and ways of working, which support & enable delivery of our strategic objectives. We have developed this strategy in response to the Ofgem & BEIS commissioned, Energy Data Taskforce, which published its report[4] in July 2019. The five recommendations in this report have significantly informed our Digital Strategy and which we will continue to evaluate through the Energy Networks Association Data Working Group, which we are members of.

[4] A Strategy for a Modern Digitalised Energy System, Energy Data Taskforce, 2019, available at https://es.catapult.org.uk/news/energy-data-taskforce-report/

4 Developing the Non-Load/Asset Intervention Plan

The previous sections of this paper have outlined the stakeholder-led principles and asset strategies that underpin our asset intervention decision-making process.

In this section, we map (see Figure 12) our rigorous, risk-based approach taken to apply these principles and strategies to identify, evaluate & select the cost-effective asset interventions that deliver the optimum value to consumers and ensure the safe and secure operation of the transmission network.

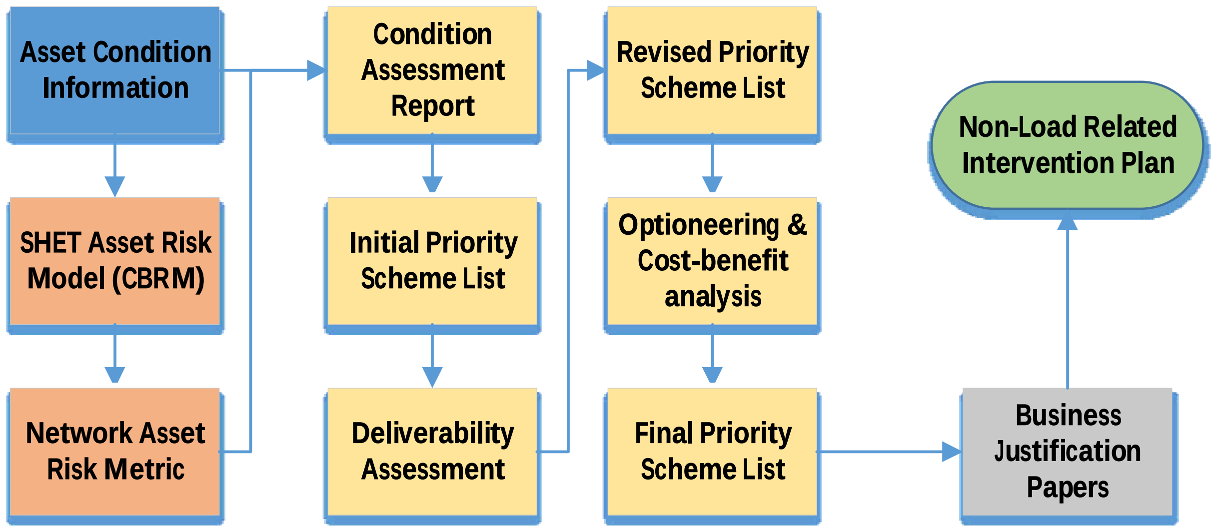


Figure 12 - Determining the SHET Non-Load Intervention Plan

Our asset intervention decision-making process is undertaken in 4 distinct & comprehensive phases, reflected in the colour-coded steps in Figure 12 above.

Phase 1 – Data Gathering, underpins our approach to cost-effective, intervention decision-making by ensuring that accurate, up to date, asset condition information is the starting point for all projects.

Phase 2 – Risk-based Analysis demonstrates our commitment to risk-based intervention decision-making by using our accurate asset condition information, within the complex CBRM risk modelling tool to calculate a monetised risk NARM score for all SHET lead assets.

Phase 3 – Optioneering is the lengthiest & most complex phase in our asset intervention decision-making process. It involves the exercise of engineering & commercial judgement to develop the outputs of our Data Gathering & Risk-based Analysis phases into a portfolio of asset intervention options and associated lifetime benefits for consideration in our T2 Business Plan.

Phase 4 – Non-Load Plan involves the development of the 28 Business Justification Papers that comprise the T2 Non-load Intervention Plan. These papers summarise the outputs of the complex and rigorous assessments undertaken in Phases 1, 2 & 3 and propose the intervention that provides the most cost effective, safe & deliverable solution that delivers the highest lifetime benefit to consumers.

The key decisions made & outputs delivered from each of these intervention decision-making phases are examined in greater detail in the following sections of this paper.

4.1 Phase 1 – Data Gathering

Effective asset management requires accurate, up to date asset condition information. This is a primary requirement of our intervention decision-making process as, over time, normal degradation of asset condition can lead to an increased risk of asset failure. If unchecked, this can have a significant detrimental effect on the transmission network and the homes and businesses connected to it.

To ensure our understanding of current asset condition is accurate, we undertake periodic inspection and testing of our assets to assess and measure their condition, in accordance with our inspection, maintenance and condition assessment policies & guidance documents.

During a visual condition assessment of a substation or linear route asset, an experienced engineering team member will record the current inspected condition of each asset and sub-component of that asset, using the SHET Cyberhawk, tablet-based recording system. This system has 2 separate areas; iHawk, for the storage of all overhead powerline asset information; and iSims for the storage of all substation and cable asset information.

A score of 1-4 (see Table 5) is applied to each item inspected and where the score is 3 or 4, additional information is recorded and a digital images of the observed condition taken.

Figure 13 – SHET Inspection, Maintenance & Condition Assessment Timescales

During the RIIO-T1 period, we undertook an innovation project with Cyberhawk to trial the use of drone technology for overhead power line inspections. This technology is now fully embedded within the our OHL operations & maintenance team toolkit – a great example of innovation making the transition to 'business as usual'.

1	No visible/quantifiable deterioration or damage
2	Apparent normal wear, intervention to be done in the next refurbishment
3	Significant deterioration or damage that requires some specific action or indicates increased risk of failure in the medium term.
4	Serious deterioration or damage that requires specific action in the short term. Also applies to any item found to be missing which would normally be expected to be present.

Table 5 – Asset Condition Scoring methodology

Visual Condition assessments are then reviewed, within the Cyberhawk system, by a senior member of the our field engineering team before the asset condition information is loaded into the SHET Asset Database - Maximo.

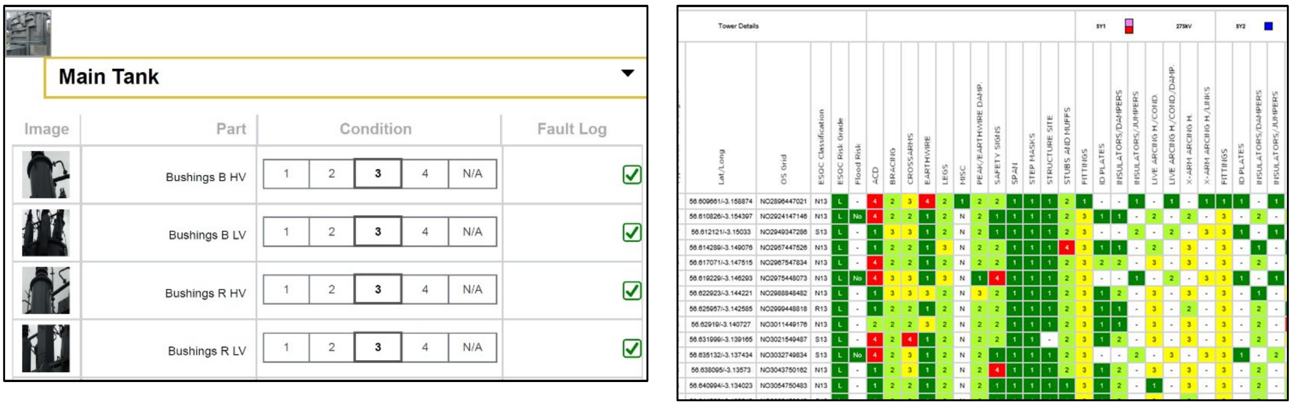


Figure 14 – Cyberhawk Data Inputs & associated Site Condition Matrix

In addition to visual condition assessments, we also undertake inspections/testing to assess the internal condition of assets. This testing includes oil sampling & dissolved gas analysis for transformers & reactors and CORMON analysis of overhead line conductors & earth wires.

All asset condition information, current and historical, is held within our Maximo asset database and is a key component in the decision-making processes used to identify and select the appropriate interventions to meet our asset management objectives.

4.2 Phase 2 – Risk-based Analysis

The risk-based analysis phase of our asset intervention decision-making process involves the calculation of the NARM for each lead asset. This process is detailed in section 3.2 of this paper and the output of this risk-based analysis phase is a series of NARM tables for each lead asset class, identifying the highest NARM score assets.

As previously stated, condition is the prime driver for us to consider intervention on an asset. The first step taken by our Asset Management team in analysing the output of the NARM process is to determine the condition driver element of the NARM score for each asset.

Asset ID	Transformer Name	NARM £Risk Score	Probability of Failure Likelihood
100373342	GRID (2 WINDING) TFMR <> DYCE 132KV TRANSFORMER	£2,891,179	138%
100373434	GRID (2 WINDING) TFMR <> DYCE 132KV TRANSFORMER	£2,891,179	138%
100373592	GRID (2 WINDING) TFMR <> REDMOSS 132KV TRANSFORMER	£2,200,162	138%
100373502	SUPERGRID TRANSFORMER <> PETERHEAD 275KV TRANSFORMR	£1,978,648	138%
100373572	SUPERGRID TRANSFORMER <> PETERHEAD 275KV TRANSFORMR	£1,978,648	138%
100373497	GRID (2 WINDING) TFMR <> WILLOWDALE 132 TRANSFORMER	£1,433,602	94%
100373528	GRID (2 WINDING) TFMR <> WILLOWDALE 132 TRANSFORMER	£1,433,602	94%
100373532	REACTOR <> TEALING SGT3 CCT 33KV REACTOR	£661,979	85%
100373494	GRID (2 WINDING) TFMR <> BROADFORD 132 TRANSFORMER	£3,964,146	81%
100373435	GRID (2 WINDING) TFMR <> CLAYHILLS 132KV TRANSFORMER	£1,361,553	81%
100373492	GRID (2 WINDING) TFMR <> GLENAGNES 132 TRANSFORMER	£1,233,958	81%

Table 6 – Extract from SHET Transformer NARM table – filtered on Condition Score

This process removes those assets that are in good condition, but have a high consequence of failure, from consideration for intervention during the T2 period. The process also highlights those assets with low consequence of failure scores that are in poor condition and need to be considered for intervention during the T2 period – see Table 6 above.

4.3 Phase 3 - Optioneering

The next phase of our asset intervention decision-making process (see Figure 12) involves the completion a number of different engineering assessments to:

1. Group potential asset interventions on a site/scheme basis within a detailed asset engineering condition report
2. Identify potential T3 enabling works that could be cost-effectively delivered at the same locations, within the T2 period
3. Consider the internal & external constraints on efficient delivery of the portfolio of proposed asset interventions and prioritise accordingly
4. Develop a range of intervention delivery options & undertake cost benefit analysis to determine the intervention that safely delivers the best lifetime benefit to consumers, within the deliverability constraints of the overall T2 Draft Business Plan portfolio of works

4.4 Optioneering Step 1 - Asset Engineering Condition Reports

The NARM tables (extract in Table 6) generated by the NOMs asset risk assessment process were reviewed by our Asset Engineering team to group the asset NARM scores on a site or linear route basis, forming an initial list of 43 asset intervention schemes for further development.

The asset engineering team then undertook detailed site inspections to:

- Review the asset condition information used in phases 1 & 2 against the current observed & measured asset condition on each site.
- Consider the range of potential asset interventions on each site that would maintain the condition & performance of the assets at the level required to maintain safe & secure operation of the network.
- As a responsible network operator, identify potential asset intervention options that could be brought forward from future regulatory periods as part of a single cost-effective project that minimises the impact of interventions to local stakeholder communities.
- Highlight potential constraints to be overcome in the delivery of the different asset intervention options identified.

The output of this process is a series of 43 Asset Condition Reports that provide the next phase of our intervention decision-making process with a series of proposed risk-based intervention options, grouped on a site/linear route basis, to enable cost-effective delivery solutions to be developed & selected to deliver the highest lifetime benefit to consumers and ensure safe & secure operation of the transmission network.

Case Study: Port Ann-Crossaig 132kV Overhead Line

The Port Ann to Crossaig (PR1/PR2) 132kV overhead line (OHL) is located in Kintyre, connecting the Port Ann OHL Tee-off and Crossaig substation. Constructed in 1960, the circuits connected Inveraray to Carradale and were later tied in to Crossaig substation during its construction in 2015.

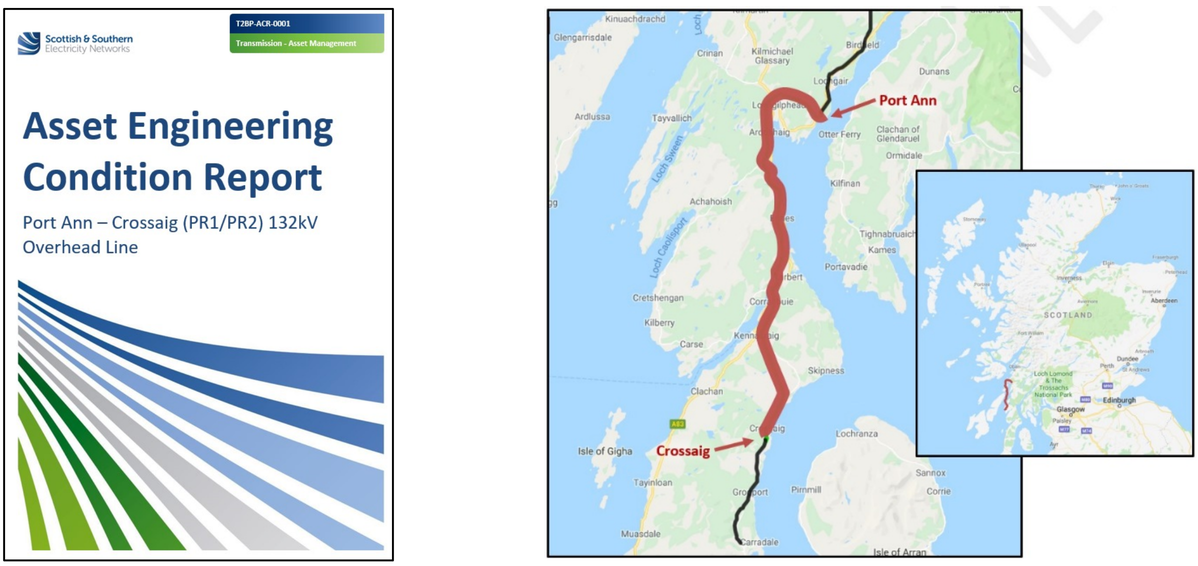


Figure 15 – Extract from Port Ann – Crossaig Asset Condition Report

A review of the asset condition information associated with Tower, Conductor & Fittings lead asset classes on this overhead line route produced the following results.

Towers

The overall condition of tower steelwork is poor with high levels of corrosion indicated throughout. A small number of damaged steelwork members are noted including one leg member. Replacement of any poor condition member should be addressed alongside a tower painting programme to preserve the remaining steelwork life.

Assessments carried out in 2018/19 have indicated the following corrosion condition:

Grade 1	Grade 2	Grade 3	Grade 4
1%	69%	19%	11%

Foundations

There are several foundations which require remedial works to address deterioration to both muff and stub concrete. Cracking, spalling and under-cutting have been identified which will require repair works to make right. Foundation assessment studies carried out in December 2014 identified the bitumastic coating to be poor throughout along with a number of additional historic design and construction issues relating to the below-ground foundation structure.

Visual assessment of the **tower foundations** has provided condition scorings of both foundation muffs and foundation stubs as follows:

Grade 1	Grade 2	Grade 3	Grade 4
61.5%	35.1%	1.8%	1.6%

Fittings

With the exception of one broken insulator dish, all other insulator sets are in sound condition both mechanically and electrically with only minimal rusting present.

There is significant deterioration on approx. 23% of U-bolts & shackles, which will require replacing.

The assessment of **fittings** has identified the following condition gradings based upon assessment of U-bolts and shackles:

Grade 1	Grade 2	Grade 3	Grade 4
76.9%	0%	17.0%	6.1%

Conductor

The phase conductors have been assessed in 2018 by testing of samples. This identified a remaining service life of 15-20 years indicating an expected end of service-life in 2033/38. All samples tested exceeded the required number of turns-to-breakage and minimum breaking load values. Grease coverage was found to be adequate and remained in a golden, pliable state.

There is no earth wire provision on the route.

Extract from External Consultant Condition Assessment Report

"The external surface of both conductor samples exhibited typical levels of grey discolouration caused by the surrounding environment and pollution effects. Internally the conductor was found to be relatively free from both debris' ingress and corrosion product. The conductor was found to be adequately greased throughout. This grease was overall both golden in appearance and pliable. There was no evidence of steel core strand degradation."

"When torsion tested, a new aluminium conductor strand is expected to give greater than 25 turns before failing. Both conductor samples achieved average turns to failure greater than 25. This suggests that no significant reduction in the ductility of the conductor strands has occurred. "

"The calculated breaking load of both conductor samples were found to exceed the British Standard specified minimum breaking load of 57.87kN for ACSR conductor of type Tiger."

"The thermal properties of the grease were found to be satisfactory, with no significant grease loss observed after prolonged exposure to 100°C."

If SHET were to consider this OHL route as a collection of individual assets only – the following interventions should be developed for delivery during the RIIO-T2 period:

a. Replacement of tower fittings including but not limited to U-bolts, shackles and links.
b. Surface preparation and repainting of tower steelwork.
c. Replacement of damaged steelwork.
d. Foundation remedial works to stubs & muffs
e. Replace broken insulator dish at tower 169.
f. Replace degraded tower signage.
g. Repair Anti-Climbing Device's as identified.

As a responsible Network Operator, we consider both the condition of the individual assets that comprise the overhead line route and the overall performance of the overhead line route within the wider SHET network, in our intervention decision-making processes. This approach is highlighted by two key route performance assessment analyses, within the Asset Condition Report:

1. There are significant issues with the protection arrangements and the general fault performance on the IAE/AEP/PR2 and IDW/DPW/PR1 circuits between Inveraray and Crossaig inclusive of the Port Ann to Crossaig line sections. The Circuits are some of the worst performing circuits on the network and require future **provision of an earth wire** and **Category 1 communications** link to address the identified limitations. The continued long-term use of the current protection arrangements is inadvisable.

2. The year 2013 saw failure of the overhead line system following a severe weather event in the Argyll and Bute region. A regional network outage was caused by the structural failure of multiple lattice support structures which were subsequently restored by installation of short sections of wood pole trident OHL within the impacted spans. The occurrence of this failure has highlighted **the higher 'risk of failure' present because of the inherent design limitations of the bespoke tower suite utilised in this construction**.

One of the Guiding Principles for our stakeholder led, asset intervention decision-making process, outlined in Figure 3 of this paper, is to ensure that, as a minimum, our proposed interventions result in an asset that meets current engineering technical specifications, so the Project Optioneering phase (section 4.6) will address these key findings. To deliver our 'Responsible Operator' obligations, the optioneering team will also determine if there are any load-related drivers associated with the network that could impact this asset, to ensure that they are addressed to ensure minimal disruption to our customers & stakeholders.

4.5 Optioneering Step 2 - Project Deliverability Assessment

The initial prioritised intervention scheme list was taken to a project deliverability assessment review panel containing subject matter experts from all areas of the transmission business including: Asset Management, Project Development, Finance, Outage Planning, Capital Delivery, Commissioning & Operations.

The list of proposed interventions and their associated asset condition report were subjected to a comprehensive & rigorous review, by the expert panel, against a series of criteria associated with the overall deliverability of each intervention option.

These criteria included:

- An assessment of safety associated with the most cost effective and efficient methods of delivery for each of the proposed intervention options
- The impact of Load or Customer driven projects proposed for delivery on the network during the T2 period
- An assessment of system outages required to deliver each asset intervention and associated constraints with other proposed portfolio of T2 interventions on the network.
- Potential cost efficiencies that could deliver significant consumer benefits by grouping or clustering interventions.
- Internal and supplier resource requirements to efficiently and cost-effectively deliver each phase of the proposed intervention portfolio

The initial output of this detailed assessment process was the identification of 10 proposed asset interventions that could not be considered for further development during the T2 period. Table 7 identifies the specific interventions and the reason why no further asset-related intervention development works would be undertaken for the non-load element of the RIIO-T2 Business Plan.

In 9 of the 10 projects listed in table 8, the asset-related condition risk will be addressed by the intervention works proposed by load-related projects, within the SHET RIIO-T2 Business Plan. The asset condition risk associated with the proposed Persley substation interventions will be managed through the use of a programme of asset inspection & condition monitoring interventions by our Field Operations team.

Proposed Intervention	**Reason for Removal**
Kintore/Persley/Peterhead 275kV	Inclusion within North-East Coast Load Strategy
Persley	Outages not available due to Kintore Scheme
Alyth / Kincardine 275kV	Inclusion within North-East Coast Load Strategy
Tealing / Lunanhead 132kV	Inclusion within North-East Coast Load Strategy
Kintore / Fetteresso / Alyth 275kV	Inclusion within North-East Coast Strategy
Fiddes / Brechin 132kV	Superseded by Load-Related Works
Craigiebucker / Fiddes 132kV	Superseded by Load-Related Works
Arbroath T / Brechin 132kV	Inclusion within East Coast Load Strategy
Tealing / Alyth 275kV	Inclusion within East Coast Load Strategy
Glenfarclas/Boat of Garten 132kV	Superseded by Load-Related Works

Table 7 – Proposed asset-related interventions – removed from T2 Business Plan

Following this initial filtering process, the project deliverability assessment review panel then geographically 'clustered' the remaining asset interventions to ensure that all potential delivery efficiencies could be explored during the detailed Optioneering & Cost-benefit analysis phase of the asset intervention decision-making process.

Scheme Cluster	No of Proposed Schemes in Cluster
Skye	7
Beauly - Deanie	6
Aberdeen	4
Dundee	2
Non-clustered Projects	16

Table 8 – Proposed Geographical Scheme Clusters

After the clustering was completed, a wider business review was carried out on the entire RIIO-T2 portfolio to consider further potential efficiencies of scale. This review highlighted a significant number of proposed works in the Skye region of the network, including the Skye Cluster listed in Table 8. It was determined that there was opportunity to make significant efficiency savings for the consumer if all these works were "ring-fenced" and managed as one, larger strategy. Accordingly, the Skye cluster was removed from the Non-Load Intervention Plan, leaving 28 schemes proposed for further development by our Engineering team.

4.6 Optioneering Step 3 - Project Optioneering & Cost Benefit Analysis

The decision-making processes we have undertaken to this point have identified a portfolio of asset refurbishment & replacement interventions that will undergo further engineering assessment, to determine the most cost-effective way to safely deliver these potential projects.

This process, known as optioneering, develops and costs all practical delivery methodologies for each of the intervention options identified.

These deliverability options will typically include asset refurbishment or replacement solutions as 'do nothing' or 'maintain' options will have been discounted due to the asset condition information assessment undertaken prior to optioneering.

It is at this phase that some potential asset intervention options may be rejected for a number of reasons, including:

- **Safety and the ability to undertake the works in a safe, efficient manner.**

  An example of this could be the design of the existing substation, built in the 1960s/70s, within a constrained area. In-situ replacement of the existing assets could result in excessive risk of infringing safety clearances to adjacent circuits.

- **Outage requirements and associated impact on the overall portfolio of works & customers.**

  An example of this could be the refurbishment option for a transformer. While refurbishment is a viable technical option, the outage timescales required to facilitate this option could have a significant and unacceptable adverse effect on customers connected to that section of the network.

- **Adverse environmental impact to local community & other stakeholders**.

  An example could be related to the in-situ replacement of assets within an urban environment. The noise and disruption caused by major construction works could be considered unacceptable by local communities and stakeholders.

A fully costed engineering solution is then developed for all remaining delivery options. In some cases, the most cost-effective & deliverable solution could involve the removal of assets that are in good condition. In all instances where this happens, we will look to redeploy the recovered asset, elsewhere on our network or retain the asset as a strategic spare.

Case Study – Beauly 275kV & 132kV Substation

The Asset Condition Report for Beauly 275kV & 132kV substation recommended the following interventions be considered and options developed:

- Replace SGT2, SGT4 and SGT6.
- Replace the 132kV substation with a new fully selectable double busbar with the addition of bus couplers and bus sections to improve network operability and resilience. This should include for appropriate associated ancillary plant and equipment to current specifications including the 132kV protection scheme. The protection replacement should include relevant remote end work.

The Engineering development team undertook a detailed optioneering analysis of the site and concluded that there were a number of alternative solutions available to meet the Asset Condition Report recommended interventions.

Option	Option Detail	Taken forward to CBA?
1	**In-situ replacement of SGT 2, 4 & 6 and offline GIS 132kV board build to west of existing**	**Yes**
2	**In-situ replacement of SGT2, 4 & 6 and offline GIS 132kV board build relocating telecoms building**	**Yes**
3a	**Offline replacement of SGT2, 4 & 6 and offline GIS 132kV board build to west of existing**	**No**
3b	**Offline replacement of SGT2, 4 & 6 and offline GIS 132kV board build relocating telecoms building**	**No**

The report identifies that options 3a & 3b do not go forward for further consideration, due to the limitations that the proposed cable installations would place on any future substation development.

Cost Benefit Analysis
Where we have identified multiple options for the delivery of a project (see Beauly project - Options 1 & 2, above) we undertake a Cost Benefit Analysis on each option to determine the Net Present Value (NPV) of the investment needed to deliver them.

This calculation is then one of the criteria used to determine the preferred option, proposed for delivery in our RIIO-T2 Business Plan.

4.7 Developing our Security of Supply Projects

As we have outlined in earlier sections of this paper, one of our key RIIO-T2 goals is to "Aim for 100% transmission network reliability for homes and businesses."

In order to make the necessary changes to our network infrastructure to help achieve this goal, we engaged in some cross-industry collaboration through our involvement in the Energy Research Partnership Future Resilience of the UK Electricity System Project[5]. The outputs of this project informed the development of the SHET Resilience Policy, which identified 13 potential initiatives to develop in support of our T2 resilience target.

A further driver to help deliver our resilience targets is our Digital Strategy, developed during 2019 in response to the Ofgem/BEIS commissioned, Energy Data Taskforce report, published in July 2019. This document provided further clarity on the potential benefits of specific technology developments, identified through our Resilience Policy works, and how these initiatives could deliver benefits to our stakeholders & customers.

Our Asset Management and Operations teams undertook significant industry research into each target initiative; consulting with other industry groups, utilities & technology providers to develop and cost our initial proposals. As outlined in section 2.1 of this paper, we presented these proposals to our stakeholder groups to assist in determining the appropriate approach for each project to be developed into a final Business Justification paper.

4.8 Phase 4 – The Non-Load Plan for RIIO-T2

The final phase of our asset intervention decision-making process is the development of a Business Justification paper for each of the 28 proposed asset intervention schemes and the 13 Security of Supply projects.

The Business Justification Paper brings together the key decisions and justifications, from each phase of the asset intervention decision-making process into a single document.

Each deliverable and costed intervention option will undergo a cost-benefit analysis to determine the overall lifetime benefit of the intervention to consumers.

[5] Energy Research Partnership – Future Resilience of the UK Electricity System Project - http://erpuk.org/project/future-resilience-of-the-uk-electricity-system/

The conclusion of the Business Justification paper is the intervention that we can evidence, provides the best lifetime value to consumers and forms part of the SHET RIIO-T2 Business Plan.

Tables 9 & 10 identify the 28 schemes that comprise the circa £797M of proposed asset interventions and the 13 'Security of Supply' projects that comprise the circa £255M of investments we believe are necessary to deliver value to the consumer and ensure the safe and secure operation of the electricity transmission network.

Scheme Name	Scheme Description	RIIO-T2 Cost (£million)	Long-Term Monetised-Risk Benefit (£million)
Beauly Substation Works	GIS Substation build & replacement of GTs	89.8	363.7
Beauly / Aigas-Deanie 132kV OHL Works	Refurbishment of OHL	19	26.0
Broadford Substation Works	Replacement of circuit breaker	1	-401.0
Elmwood - Glenagnes Cable Works	Replace existing 132kV undergound cable	11.4	917.3
Culligran Substation Works	Replacement of GT1 & associated plant	14.3	24.7
Deanie Substation Works	Replacement of GT1 & associated plant	14.6	14.9
Foyers Substation Works	Replacement of Gen Tx & switchgear	41.6	82.6
Glenmoriston Substation Works	Replacement of GT	5.7	28.4
Harris - Stornoway 132kV OHL Works	Rebuild of existing 132kV OHL	35.8	47,681.0
Invergarry T 132kV OHL Works	Refurbishment of OHL	2.4	1.4
Keith Substation Works	Replacement GIS switchgear	39	22.4
Kilmorack Aigas Substation Works	New substation, incorporating replacement of GT1 & associated plant at both sites	27.5	35.8
Kintore Substation Works	Replacement GIS switchgear & Transformers	74.2	450.3
Peterhead Substation Works	Replacement of GTs	36.7	3.1
Peterhead - Inverugie 132kV OHL Works	Refurbishment of OHL	10.3	1,388.7
Port Ann - Crossaig 132kV OHL Works	Rebuild of existing 132kV OHL	138.2	1,089.5
Quoich Tee Substation Works	Replacement of switchgear & OHL refurbishment	13.6	-42.7
Redmoss Substation Works	Refurbishment of GTs	0.5	-20.1
Redmoss - Clayhills Cable Works	Replace existing 132kV undergound cable	13	2,156.0
Sloy Substation Works	Replacement of 132kV GTs	45.3	43.8
Sloy - Windyhill East 132kV OHL Works	Refurbishment of OHL	16.5	343.9
Sloy - Windyhill West 132kV OHL Works	Refurbishment of OHL	16.8	364.8
St Fergus Mobil	Replacement of 132kV switchgear & underground cable	12.7	-110.0
St Fillans Substation Works	Replacement of GT1 & associated plant	6.8	37.2
Tealing Substation Works	Replace SGT3 & Reactor R3	9.3	56.0
Tummel Bridge Substation Works	Switchgear & Transformer replacement	14.8	16.0
Whistlefield - Dunoon 132kV OHL Works	Rebuild of existing 132kV OHL	40.8	464.3
Willowdale Substation Works	Replacement of GTs & switchgear	45.4	-80.3
TOTAL		**£797 Million**	**£55 Billion**

Table 9 – SHET Draft RIIO-T2 Non-Load Business Plan

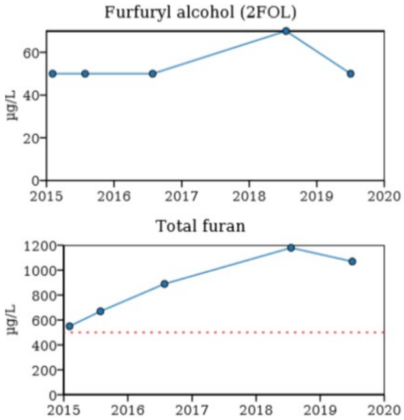
Scheme Name	Scheme Description	RIIO-T2 Cost (£million)
Materials Management and Warehousing	Warehousing & Strategic Spares	40.3
Physical Site Security	Physical Site Security Upgrades	9.6
Black Start System Restoration Support	Black Start Capability Improvements	0.2
Climate Change and Sustainability	Flood Protection, EV Charging infrastructure	18.0
Resilience - Operations Centre	New Transmission Control Centre	16.3
Transmission Communications Upgrade	Installation of fibre connections	31.1
Protection Modernisation	Replacement of obsolete protection systems	22.0
Transmission Substation SCADA Replacement	Replacement of obsolete SCADA systems	11.9
Substation Resilience – Low Voltage Supplies	Upgrading of site battery systems	48.9
Resilience - Personnel Communications	Provision of radio communications systems	1.9
Emergency Response & Contingency Planning	Provision of Temporary Masts	1.6
Integrated Condition & Performance Monitoring	Installation of on-line monitoring technologies	45.5
Persistent Organic Pollutants Management	Replacement of assets containing PCBs	7.3
TOTAL		**£255 Million**

Table 10 – SHET Draft RIIO-T2 Business Plan 'Security of Supply' projects

Appendix 1 – The Non-Load Project Summary

1	<u>Beauly Substation Works - £89.8M</u> There is a clear condition-based need to replace the switchgear & concrete support structures in Beauly 132kV substation. The compact nature of the existing substation layout necessitates the off-line construction of a 132kV GIS substation as the only viable & safe alternative. In line with the SHET environmental strategy, this will be a non-SF_6 gas insulated substation. The condition of Supergrid Transformers SGT2, SGT4 & SGT6 has deteriorated between 2012 & 2018 as the load demand on them has increased. This project will replace the 3 120MVA transformers with 3 new 360MVA transformers, capable of meeting the load demands of the network for the foreseeable future.	 Beauly SGT4
2	<u>Beauly / Aigas-Deanie 132kV OHL Works - £19M</u> Constructed in 1960, the 22.9km long overhead line circuit is in need of refurbishment. The proposed condition-driven works include steelwork replacement & refurbishment on a number of towers; tower painting; the upgrading of foundations on 2 towers; and the replacement of the earth wire, conductors & fittings on the route. These interventions will ensure that the asset will be fit for service without further disruptive intervention for approx. 15 years.	 Beauly – Deanie OHL Tower 73 - Foundation
3	<u>Broadford Substation Works - £1M</u> Broadford substation requires the targeted replacement and refurbishment of assets, due to the poor condition of the equipment. Circuit Breaker 305 is a 132kV Brush DB145 type – an asset with significant family SF_6 leakage problems. The breaker is in poor condition and will be replaced. Transformer GT1 oil sampling results indicate that some intervention is required. It is proposed to recondition the transformer oil to remove the high moisture content. In conjunction with this work, the Transformer Protection system and Neutral Earthing Resistor will be replaced due to their poor condition & performance.	
4	<u>Elmwood - Glenagnes Cable Works - £11.4M</u> The 132kV fluid-filled cables between Elmwood & Glenagnes in Dundee were installed in 1959, are in poor condition and have a history of oil leaks. In line with our engineering policies, it is proposed to replace these cables with solid insulation XLPE cables.	

5	<u>Culligran Substation Works - £14.3M</u> Culligran 132kV substation provides a transmission connection to the adjacent Hydro-electric power station. The asset condition assessment reports identify that the transmission assets at the site are in poor condition & require replacement. The least disruptive (to the Customer) and most cost-effective deliverable solution is the off-line build of a new substation on a nearby site, allowing quick transfer of the connections to the customer assets & the adjacent Transmission OHL connection.	 Culligran 132kV Substation Compound
6	<u>Deanie Substation Works - £14.6M</u> The 132kV substation at Deanie Hydro-Electric power station site is a sister site to Culligran and is showing similar signs of asset condition deterioration. A similar solution is proposed to that of the Deanie site – an off-line substation build to minimise customer disruption and deliver the most cost-effective & deliverable solution.	
7	<u>Foyers Substation Works - £41.6M</u> The pumped-storage power station connecting to the existing Foyers 275kV substation is a key component in the UK Black Start strategy and requires a safe & secure transmission network connection. The condition assessment of the assets on the 275kV site indicate a replacement intervention is required. Due to the tight physical constraints of the existing compound, the safest and most cost-effective delivery solution is the off-line build of a new compound. This will also allow improved circuit configuration of the connections to the power station, supporting the critical black-start requirements of the site for the UK Transmission network	 Foyers AEI 275kV CTs – potential PCB risk

8	<u>Glenmoriston Substation Works - £5.7M</u> The condition assessment report for GT1 at Glenmoriston substation indicates an increase in the level of FURANs within the transformer oil samples. These indicate that the paper insulation of the transformer windings is in an advanced state of deterioration, requiring replacement of the transformer during the T2 period.	 Glenmoriston GT1 oil analysis results – FURANs
9	<u>Harris - Stornoway 132kV OHL Works - £35.8M</u> The 132kV overhead line between Harris and Stornoway is part of the Western Isles circuit that is the only Transmission connection that runs from Stornoway to Fort Augustus. This route is a 58km single-circuit wood pole line that was constructed in 1990. The circuit has a history of storm pole damage and the condition reports highlight concerns over the extent of deterioration measured on the wood poles. The significant constraint costs on this route support the solution of an off-line rebuild of the OHL circuit, with 'H' poles to replace the single-pole trident configuration to increase the resilience of the circuit to storm damage.	 Harris – Stornoway – Steel Cross-Arm
10	<u>Invergarry T 132kV OHL Works – £2.4M</u> This is a single circuit OHL (2.4kM) and underground cable (150m) connection that tees off the Fort Augustus – Fort William circuit to connect Invergarry Power Station. The asset condition report indicates that the circuit is in poor condition and requires refurbishment of the towers and replacement of the conductors & fittings. This will provide an asset life of 40 years on the new conductor & will minimise any further intrusive interventions on the line for at least 15 years.	 Invergarry T – Insulator Corrosion

11	<u>Keith Substation Works - £39M</u> The asset condition report for Keith substation clearly identifies that the non-lead assets on the site (disconnectors & earth switches) are in poor condition, as are 2 of the 132kV circuit breakers. The offline replacement of the 132kV substation with a non-SF_6 gas insulated substation will address these significant condition drivers and increase the overall resilience of the network in the Keith area by increasing the substation to a double busbar configuration.	 Keith CVT – Poor Visual Condition Assessment
12	<u>Kilmorack Aigas Substation Works - £27.5M</u> The hydro-electric power station sites at Kilmorack & Aigas were constructed in 1960, with the 132kV transmission assets installed within the power station building. At both sites the 132kV transformers are in poor condition and require replacement, which is not feasible within the tight constraints of the power station buildings. The proposed solution is to construct a combined Kilmorack/Aigas 132kV substation offline and connect back to each power station with underground cables. This solution is the most cost-effective solution and offers the least disruption to the Customer connections at each site.	 Kilmorack PS – Earthing Transformer showing evidence of bird infestation within PS Building
13	<u>Kintore Substation Works – £74.2M</u> The asset condition report for Kintore substation identifies several condition-based intervention needs. The condition of the 132kV substation non-lead & ancillary assets is poor, with replacement the only viable option. Due to the compact nature of the 132kV site, offline build of a 132kV non-SF_6 gas insulated substation is proposed as the only safe, deliverable option that avoids significant impact to the wider network. There are similar condition drivers for the 275/132kV supergrid transformers, SGT1, SGT2 & SGT3 and the 132kV/33kV GT1. Following a review of the options available, the only solution available is replacement of all 4 transformers.	 Kintore SGT3 – evidence of oil leaks & corrosion

14	<u>Peterhead Substation Works - £36.7M</u> Peterhead 275/132kV substation is an indoor AIS site on the North east coast of Scotland, with the SGT cooler banks situated outside the substation building. The asset condition report clearly shows significant deterioration of the SGT1 cooler banks from corrosion. DGA also identifies signs of insulation deterioration on both SGT1 & SGT2 and low energy discharge within the tap-changer selector tanks. To maintain a safe & secure network for the connected Power Station and other Customers, it is proposed to undertake offline build of 2 new transformer buildings to allow fast & efficient transfer of connections from the existing assets to the new.	 Peterhead SGT1 – cooler bank corrosion
15	<u>Peterhead - Inverugie 132kV OHL Works - £10.3M</u> Constructed in 1977, the Peterhead-Inverugie 132kV power line will have been in service for 49 years by the end of RIIO-T2. The proximity of the line to the coast of Scotland means that the assets are considered to be in a 'heavily polluted' area. The asset condition report identifies the need for significant condition-based refurbishment works during the T2 period. These include replacement of the earth conductor & fittings; refurbishment of selected tower foundations; replacement of all phase conductor shackles & U-bolts; and tower steelwork refurbishment and painting. The condition of the phase conductors is relatively good, there is a forecast increase in demand for the 132kV network in this area during & after the RIIO-T2 period. In order to prevent a return to undertake works on the same assets during the T3 period, it is proposed that the phase conductors are replaced at the same time as the essential T2 works.	
16	<u>Port Ann - Crossaig 132kV OHL Works - £138.2M</u> The findings of the Port-Ann-Crossaig asset condition report are summarised in section 4.4 of this document. The combination of condition drivers and the history of wider network failures, due to the lack of an earth-wire and the limitations of the existing tower design have resulted in a proposal to undertake a complete off-line circuit rebuild to deliver an asset that will meet network needs for the next 40 years.	
17	<u>Quoich Tee Substation Works - £13.6M</u> The Quoich-Tee 132kV substation is part of the radial transmission circuit from Fort Augustus to the Western Isles. There are no circuit breakers at Quoich-Tee substation, but the asset condition report has identified that the non-lead asset condition has deteriorated, and intervention is required. Due to the criticality of the circuit, off-line build of a new substation is the preferred option to minimise the outage impact of the works. The solution will also introduce circuit breakers to the site, providing greater operational flexibility for the isolation 7 clearance of system faults.	

<table>
<tr><td>18</td><td><u>Redmoss Substation Works - £0.5M</u>
The asset condition report for Redmoss 132kV substation has indicated there is deterioration in both the lead & non-lead assets on the site.
The deterioration is recoverable, and it is proposed that a refurbishment intervention be applied to the assets on this site.
This intervention option will include addressing the oil leaks on GT1 & GT2; mitigation of the operational restrictions on the GT Tap changers; refurbishment of the Transformer Bunding; replacement of the NERs for each GT; and the refurbishment of the disconnector mech boxes on the site.</td><td>
Redmoss GT1 – oil leaks</td></tr>
<tr><td>19</td><td><u>Redmoss - Clayhills Cable Works - £13M</u>
The RFE/RFW 132kV cables between Redmoss & Clayhills substations were installed in 1964 and are of gas compression construction.
The RFW circuit has been out of service for some time, due to poor condition & increased risk of failure. The RFE circuit condition has also deteriorated and requires regular gas pressurisation top-ups to remain in service.
These 2 cables are an integral part of the Aberdeen 132kV ring and asset replacement with modern XLPE cable is the only viable option.</td><td>
Redmoss – RFW – Cable Sealing Ends</td></tr>
<tr><td>20</td><td colspan="2"><u>Sloy Substation Works - £45.3M</u>
The transmission assets connecting Sloy Power Station to the grid are installed in 2 separate compounds – the power station site and the nearby SHET 132kV substation site.
The asset condition report identifies deterioration of the paper insulation in all 4 Grid Transformers on the site, giving an increasing risk of failure during the T2 period.
Due to the size constraints of the power station compound, it is proposed to undertake offline build of GT1-4 in a new SHET 132kV compound. This will include the installation of new switchgear, protection & control equipment and the installation of 11kV cables to connect to the Power Station compound.</td></tr>
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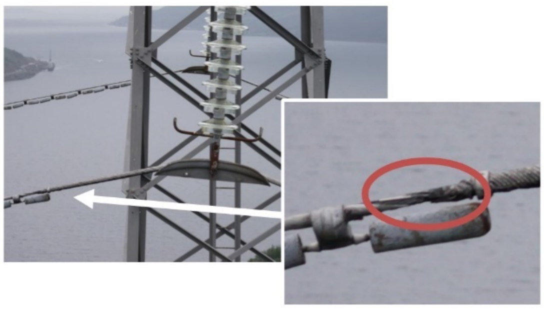
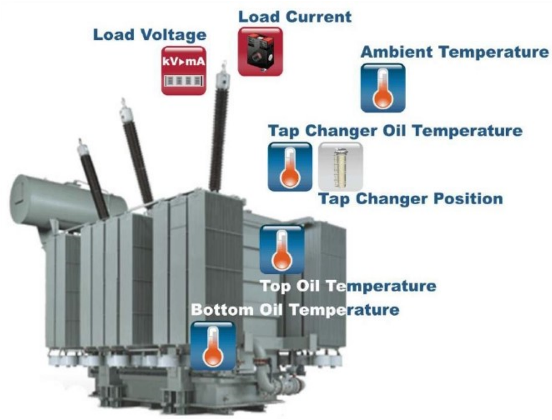
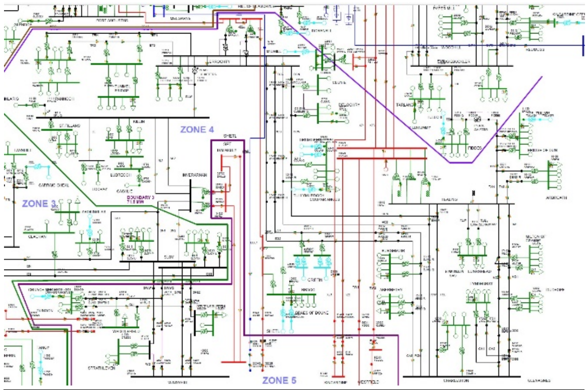
21	Sloy - Windyhill East 132kV OHL Works - £16.5M The 2 132kV double circuit OHLs, between Sloy & Windyhill substations were constructed in 1951 and ownership is shared with Scottish Power Transmission (SPT). SPT undertook condition-based refurbishment of their section of this OHL during RIIO-T1. Our asset condition report identifies the need to undertake a range of condition-driven interventions on both the East & West double-circuit routes. While the SHET ACR identifies that the phase conductors will not require replacement until RIIO-T3, it is proposed to minimise disruption to stakeholders & customers by undertaking the conductor replacement concurrently with the other condition-based works – in line with our stakeholder guidance & feedback.	 Example of a Condition Grade 4 Insulator
22	Sloy - Windyhill West 132kV OHL Works - £16.8M The works proposed for the Sloy-Windyhill West OHL circuit are detailed in the section above for the adjacent East OHL circuit.	
23	St Fergus Mobil - £12.7M The St Fergus Mobil substation is situated at a key point of supply to the UK's oil & gas infrastructure. This is an outdoor site, close to the coast in a 'high pollution' area. The current assets are in very poor condition and require intervention to ensure the safety & security of supply to this critical Customer connection. The proposed solution is the offline build of a new 132kV indoor substation & replacement of the existing fluid-filled cables with XLPE. This solution will provide longer-term environmental protection to the assets and ensure minimal disruption to the existing site supplies during the intervention works.	 ABB LTB145D1 circuit breaker 210 – significant SF_6 gas leaks
24	St Fillans Substation Works - £6.8M St Fillans 132kV/11kV substation was built in 1957 and there have been no significant interventions undertaken on the assets since construction. The asset condition report provides the evidence that the lead & non-lead assets at the site are approaching their end of life, with replacement the only viable intervention.	

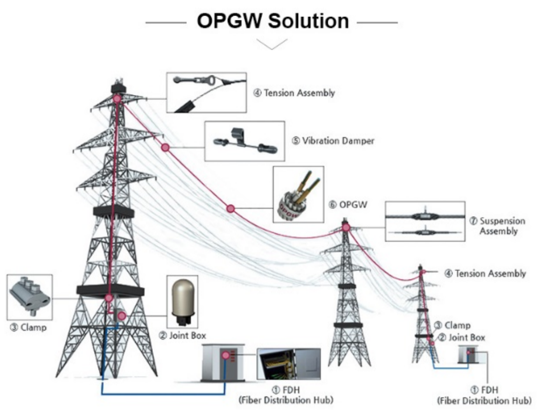
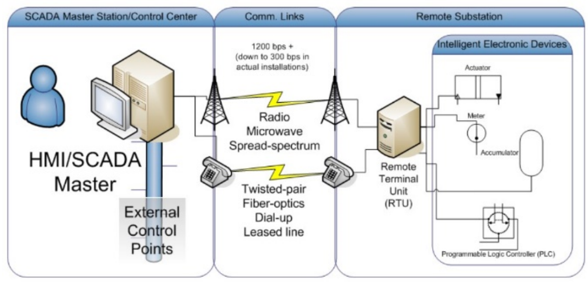
25	<u>Tealing Substation Works - £9.3M</u> SGT1 at Tealing substation was replaced in RIIO-T1 due to condition. The sister unit – SGT3 and associated plant – is now exhibiting similar signs of deterioration that indicate a high risk of failure during the RIIO-T2 period. It is proposed to replace SGT3, Reactor 3 and all associated non-lead assets during the T2 period.	 Tealing SGT3 Bay
26	<u>Tummel Bridge Substation Works - £14.8M</u> There are two main drivers for intervention works at Tummel Bridge Substation. The asset condition report shows that there is deterioration of the paper insulation in GT1 & GT2, indicating that they are approaching the end of their serviceable life. THE ACR also records that the condition of the 132kV circuit breakers and associated non-lead assets is also poor, with replacement being the only viable option. The existing site is space constrained and shared with other parties. An analysis of the demand profile at Tummel Bridge has indicated that the connected generation equates to 130% of the current capacity limit, indicating that increased capacity is required in the GTs. The proposed solution is to replace the existing assets and relocate their position to the nearby Errochty substation and cable back to Tummel Bridge.	
27	<u>Whistlefield - Dunoon 132kV OHL Works - £40.8M</u> The asset condition report indicates that this circuit is rated as one of the worst performing circuits on the SHET network, with an average of 10 outages per year to undertake fault repairs. There are also a number of potential infringements on this route (at maximum operating temperature), requiring intervention to ensure the route is ESQCR compliant. When the asset condition driver is combined with a driver to increase the load capacity of the route, the option proposed by SHET for T2 is the offline replacement of the circuit.	 Tower 14 – Example of Conductor damage
28	<u>Willowdale Substation Works - £45.4M</u> Constructed in 1963, Willowdale 132kV substation is a strategic part of the Aberdeen ring. The asset condition report clearly shows that GT1, GT2 and the associated substation lead & non-lead assets are approaching end of life and require intervention in RIIO-T2. The current configuration of the Aberdeen Ring indicates a high risk of asset failures resulting in substantial parts of the ring being out of service. The proposed solution is a new 132kV non-SF_6 substation & replacement transformers.	

Appendix 2 – The Non-Load Non-Core Project Summary

1	<u>Blackstart System Restoration Support - £0.2M</u> This Blackstart System Restoration Support paper seeks funding to allow us to undertake a detailed study on how to use renewable sources of generation, like wind farms, to support the recovery of the transmission network from a Black Start situation.	
2	<u>Climate Change and Sustainability - £18M</u> The Climate Change and Sustainability paper supports the “Network for Net Zero” Business plan. This driver requires the carbon footprint and greenhouse gas emissions at electrical substations to reduce in order to minimise their impact on climate change.	
3	<u>Emergency Response and Contingency Planning - £1.6M</u> The Emergency Response and Contingency Planning paper outlines our plan to respond to fault scenarios, such as landslides and wildfires, and restore the network to normal operation as soon as is possible.	
4	<u>Integrated Condition & Performance Monitoring - £45.5M</u> The Integrated Condition & Performance Monitoring paper outlines the need for Integrated Condition & Performance Monitoring on critical assets in line with our strategy to reduce operational risk. This driver requires that additional monitoring equipment is installed for all substations, OHL and Cable equipment.	 Transformer – potential remote monitoring capabilities

5	Materials Management and Warehousing - £40.3M The Materials Management and Warehousing paper outlines measures to address the limitations of the current inventory management system and to drive the changes needed to improve network resilience through the reliability, availability and maintainability of asset and spares inventory. This will improve repair times, reduce network and customer risks, rationalise spares holdings and reduce the consequences of system failures through improved logistics and inventory management.	
6	Persistent Organic Pollutants Management - £7.3M The Persistent Organic Pollutants Management paper outlines the need for intervention on assets on our network which may contain Polychlorinated Biphenyl (PCBs), a form of Persistent Organic Pollutant. The primary driver for the scheme is compliance with The Persistent Organic Pollutants (Various Amendments) Regulations 2019.	 Oil-filled CT – potential PCB risk
7	Physical Site Security - £9.6M The Physical Site Security paper outlines the need for an increase in physical site security due to our ongoing commitment to the Electricity Safety, Quality and Continuity Regulations 2002 (ESQCR), as well as continued concern over the security of our sites from potentially malicious acts and the impact it might have on the safety and reliability of the network. Our proposals are supported by feedback from stakeholder roadshows and discussions with government agencies such as BEIS.	 Example Palisade Fencing & CCTV installation
8	Protection Modernisation - £22M The Protection Modernisation paper outlines the refurbishment of bay protection at 23 sites including auxiliary tripping and supervision relays to provide support the provision of post-event and real time monitoring in accordance with IEEE C37.118.	

9	<u>Resilience – Operations Centre - £16.3M</u> The Resilience – Operations Centre paper outlines our planned investment in a new purpose-built operational control centre. The day-to-day running of our transmission network is monitored and managed from our Control Centre. The Control Centre is responsible for the commissioning of new assets, commencement and completion of outages on the network, as well as responding to any alarms raised or faults experienced on our assets. It has managed a relatively stable network very well, but the increased dynamics of the network, and the introduction of new asset types all require more real-time management than can be provided in the existing facilities.	 Section of SHET Transmission System Network Diagram
10	<u>Resilience – Personnel Communications - £1.9M</u> The Resilience – Personnel Communications paper outlines our provision of telephony and radio communications for SHE Transmission substations and key operations staff, for both routine and emergency situations. Communication between our staff is essential for Safe and Secure Network Operations (a strategic theme of our RIIO-T2 Business Plan); between substations, our control centre and staff on the ground at any location and at all times.	
11	<u>Substation Resilience – Low Voltage Supplies - £48.9M</u> The Substation Resilience – Low Voltage Supplies paper outlines the approach to ensure that SHE Transmission substations have LV supplies (both AC and DC) which are sufficiently resilient both in terms of autonomy and diversity of supply. This project has been primarily driven by the need to ensure the ongoing resilience of the SHE Transmission Network.	 Substation DC Battery Installation

12	<u>Transmission Communications Upgrade - £31.1M</u> The Transmission Communications Upgrade paper outlines the need for a reinforcement of our existing Communications network. Significant increases in the quantity of system data available, a rise in the volume of asset and network monitoring being undertaken and the growth of IP-based technologies all necessitate the installation of upgraded telecoms infrastructure to provide secure, resilient, dual and diverse fibre optic connections to all substations.	 Substation fibre communications using OPGW
13	<u>Transmission Substation SCADA Replacement - £11.9M</u> The Transmission Substation SCADA Replacement paper outlines the need for a supervisory control and data acquisition (SCADA) replacement program due our ongoing strategy of reducing operational risk. This driver requires that all SCADA which is at the end of its life or has become obsolete must be replaced in order to maintain operational integrity beyond the T2 period.	 Substation SCADA Functionality