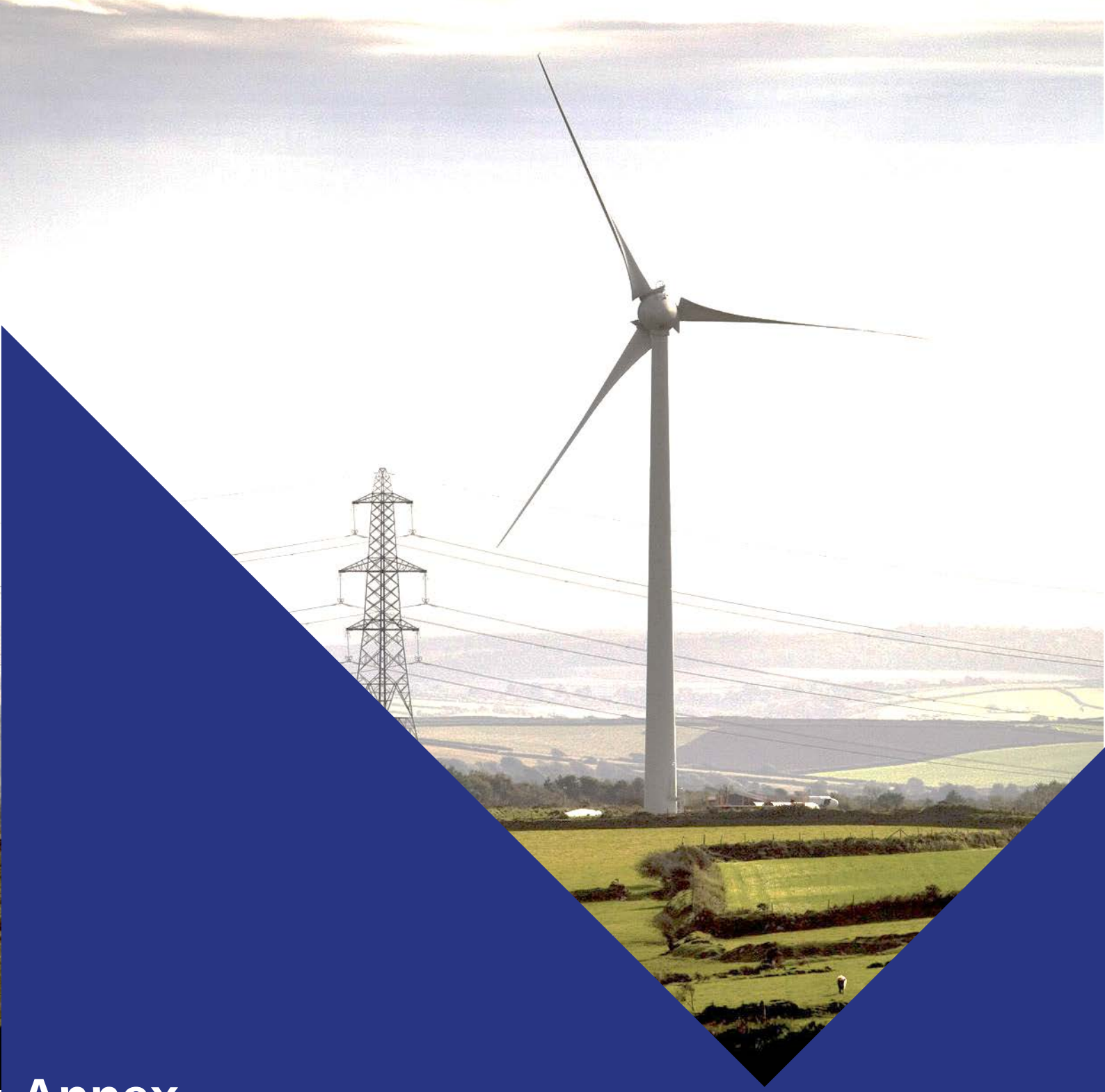


Annex

NGET_A9.19_NLR Plan Build

December 2019

As a part of the NGET Business Plan Submission

nationalgrid

RIIO-T2

nationalgrid
Electricity Transmission

NGET_A9.19_NLR Plan Build

Safe and Reliable
(December 2019)

Submission annex 2019

Contents

1. Introduction

Our stakeholders have told us that a safe and reliable network is one of their main priorities.

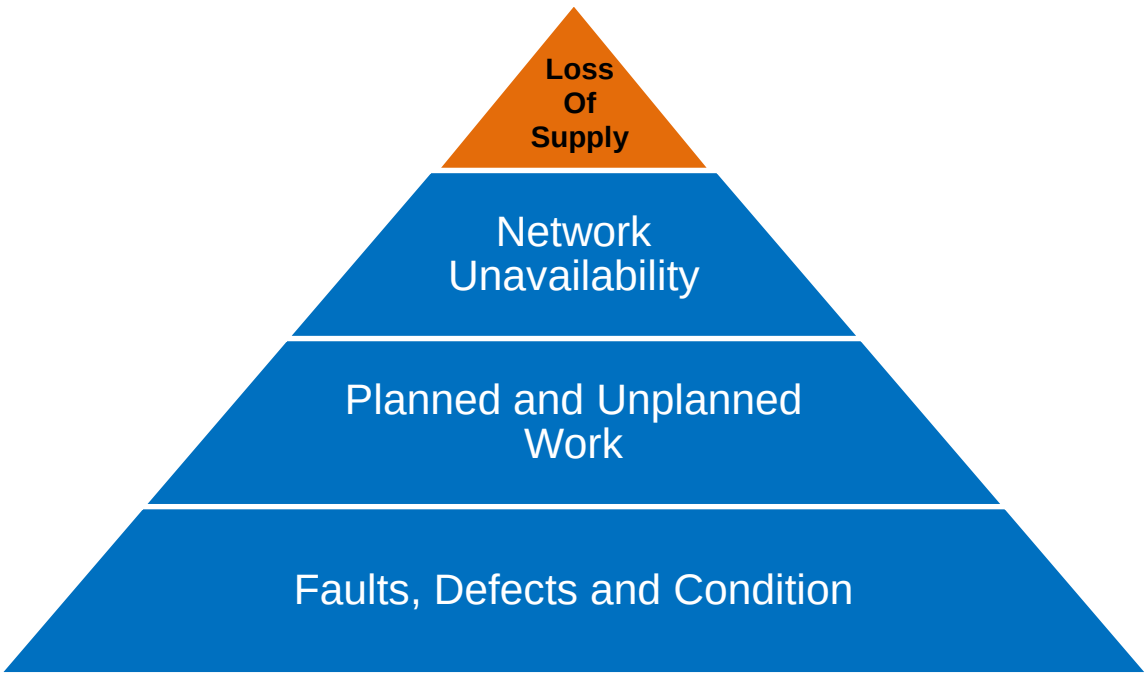
The reliability of a system can be defined as the likelihood that the system will perform its intended function under stated conditions. The “stated conditions” define the “normal” operating parameters for the equipment (e.g. ambient temperature range, age, defined operational duty limits).

Our network is made up of tens of thousands of pieces of equipment (assets) that must all be available to perform their duty when called upon. Some of these operate almost continuously (e.g. current-carrying paths such as cables, overhead lines and transformers) whereas others are only required to operate intermittently (e.g. switchgear and reactive compensation).

To ensure that any system remains reliable in the long term, its components need to be inspected, maintained, refurbished and replaced in a timely manner. However, to ensure economic operation of the electricity network the timing of these interventions needs to be optimised. This also requires balancing how much of the network can be removed from service at any one time. Any decision to undertake an intervention on equipment is based on a balance of cost, risk and performance in line with international asset management standards (e.g. ISO 55001), and best practice.

In 2018/19 our system was 99.999984% reliable. Our performance is world-class, and when you consider the impact of a small percentage change in reliability it becomes clear why reliability levels of the transmission system need to be maintained at the highest level.

In order to assess how reliable a system is it is essential to understand what factors lead to unreliability, the interactions between these factors and how you might measure them. We can express the interaction of the various aspects of network reliability through a “Performance Triangle”. This shows the relationship between the loss of supply events and other network performance metrics.



The performance triangle is made up of 4 main sections:

1. **Faults, Defects and Condition**-This describes the general underlying state of equipment

2. **Planned and unplanned work** -The volume of work (maintenance, construction etc.) that requires access to equipment. Much of this is carefully planned long term but some short-term work will be required to resolve urgent defects and faults
3. **Network Unavailability** - Maintaining and replacing equipment and connecting new suppliers and customers require parts of the network to be switched out of service, thus making it "unavailable"
4. **Loss of supply** - Events that lead to supply being lost to customers (i.e. power cuts)

The interactions between these layers can be complex and create feedback loops:

- The risk of loss of supply events occurring increases as the network availability reduces
- Network availability is reduced whenever a circuit is taken out of operation for either planned or unplanned reasons (e.g. faults)
- Planned outages are required for system construction and new user connections. They are also required for maintenance which is necessary to retain a high level of system reliability
- Faults, failures and defects have an impact on planned and unplanned work and are essential factors in understanding the total work requirements and the performance and condition of the assets that comprise the network. Hence, unreliability outages also contribute to network unavailability

All the elements of the performance triangle have interactions and feedback loops that need to be carefully considered. This can be seen, for example, by considering the need to repair defects, resulting in equipment being switched out, thus increasing network unavailability and increasing the likelihood of loss of supply events. Conversely, not taking suitable outages to resolve defects and carry out maintenance will lead to unplanned events in the future and increase the risk of loss of supply events. It is important to understand the relationship between asset and network performance. Increasing asset unreliability has an impact on system availability and can lead to:

- Reassignment of network access (i.e. what equipment can be switched out), resources and physical assets
- Delays in the maintenance or asset replacement programme

In order to mitigate the impact of unreliability on the network, it is important to:

- Understand asset condition
- Understand asset performance
- Understand future asset deterioration
- Undertake timely investment
- Prioritise and plan asset interventions

Changes to the level of interventions on assets result in a change of asset condition. If asset condition deteriorates and results in an unreliability event which needs an unplanned outage to rectify, this has an immediate impact on system availability, which restricts the ability to operate the system and may result in the cancellation of planned outages, which in turn restrict the level of maintenance and replacement activities, potentially leading to further unreliability events.

2. Background

This annex focuses on how we have built the ‘Safe and Reliable’ capital investment plan for RIIO-T2 which includes our refurbishment and replacement activities for our lead assets and non-lead assets.

We have 6 lead asset categories for T2:

1. Circuit Breakers
2. Transformers
3. Reactors
4. Underground Cable
5. Overhead Line Conductor
6. Overhead Line Fittings

These lead asset categories have not changed since T1 and are assets which are covered by the Network Output Measures (NOMs) and Network Asset Risk Metric (NARM) methodologies, for T1 and T2 respectively, to identify assets that require intervention. Our non-lead assets are the rest of our asset portfolio and have established asset policies to determine asset intervention.

Ofgem has determined that there should be no more lead asset categories in our T2 submission. We are however committing to extend NARM in T2 for some non-lead asset categories so that more than 80% of our assets are covered by outputs.

For both our lead and non-lead assets we use asset condition information where it is available and relevant to support our decision to intervene. The asset condition can be measured in a variety of ways and is dependent on the asset type.

Some asset types have condition information which can be readily collected and understood to inform our decision (e.g. dissolved gas analysis (DGA) on Supergrid transformers). For some asset types (e.g. circuit breakers) it is difficult to collect condition information as more intrusive methods of data collection is required. The cost of collecting condition information, in this case, is greater than the cost of intervening on the asset.

3. Strategy

Our T2 strategy is to keep the current level of reliability of our network in line with our stakeholders' expectation.

As per the agreed Ofgem NARM methodology, we have calculated the risk associated with end of life (EOL) failure modes (i.e. those that drive refurbishment and replacement activities) for the lead assets. This methodology has been tested and validated. Our approach has been to build a business plan that achieves the same level of risk at the end of T2 as the start of T2. Using EOL failure modes provides the most accurate refurbishment and replacement plan for T2.

Ofgem has requested that we report our levels of network risk using 'total risk' rather than 'EOL risk', this includes the risk associated with failure modes which do not result in failure and risk which is reduced through maintenance. We have committed to reporting on total risk, however, our business plan is built on EOL risk as this results in the most accurate and cost-effective business plan.

We propose that validation and testing of 'total risk' are carried out (similar to the work that was carried out for EOL risk) prior to the start of T2 to allow accurate and comparable reporting of NARM across all networks.

We have implemented our established asset policies for identifying the need for intervention for our non-lead assets. These policies have remained broadly the same throughout T1 so it is appropriate to use them to identify investment for T2 to meet our stakeholder expectation of achieving the current levels of reliability. These asset policies are based on age, condition (where available), duty (where available), obsolescence (where relevant) and other known family issues (where appropriate). These policies include anticipated asset lives based on our understanding of how the assets behave during their lifecycle. This allows us to plan our future interventions for non-lead assets.

As part of our stakeholder engagement on reliability, our stakeholders have continued to remind us of the importance of a reliable network. Our stakeholders support our proposal to achieve the same level of network risk for the lead assets. Our stakeholders also expect us to maintain broadly the same level of risk (i.e. intervene by the same amount) in instrument transformers, protection & control and bushings.

4. How we built our plan

To build our T2 plan, we followed the objectives and direction provided by Ofgem and our external stakeholders:

- Build the plan based on the monetised risk approach for lead assets
  - Maintain a stable total network risk
  - While some large assets can cause large movements in monetised risk, we aim to keep the total network risk between the end of T1 and T2 regulatory periods stable

- Increase plan affordability
  - We will identify areas where optimising interventions across asset classes will enable a lower overall cost of intervention whilst maintaining the level of network risk

- Ensure plan deliverability
  - We aim to ensure a realistic and deliverable plan by assessing key constraints (e.g. outage, resource)

Lead Assets

We have used the monetised risk (NARM) methodology for the lead assets. The risk associated with the end of life (EOL) failure modes is determined by generating an EOL modifier score for every lead asset. The EOL modifier is different for each of the lead asset types to cater for the information that needs to be considered to establish the end of life risk. In general, an end of life modifier will consider relevant condition data (e.g. DGA for SGT).

The end of life modifier is mapped onto our established deterioration curves to determine an equivalent age. This equivalent age represents the state of the asset given the life it has experienced. It could be that an asset has an equivalent age greater than its actual age as it has deteriorated quicker than expected.

This equivalent age is mapped to a probability of failure. The probability of failure is combined with the consequence of failure (expressed in £) to give a risk score (also expressed in £) for each asset. The sum of all these asset risks is equal to the network risk associated with the end of life failure modes. It is this level of risk that we aim to achieve at the end of T2.

This is an improvement over the existing NOMs methodology which has been used throughout T1 as it expresses the risk on a continuous scale and enables trading between assets, asset types and voltages. In general, we are not considering or collecting, any new information relating to the assets by transitioning to the NARM methodology.

We have the following main inputs to build the lead assets plan:

- Monetised risk scores for lead assets
- Updated 2019 cost information for T2 unit costs

The following steps were taken to build the plan for lead assets:

1. Prioritise asset interventions based on the forecast monetised risk at the end of T2

2. Select assets with the highest risk on the network to remove risk until the monetised risk position for this asset class matches the start of T2

3. Add asset interventions with drivers not specifically identified by the monetised risk approach
   a. There are three categories of interventions where it was identified as economical to include in the business plan:

i. projects which had a load driver but would trigger a risk reduction
ii. assets having known issues not reflected by the monetised risk methodology (e.g. Dinorwig-Pentir) and have been fully supported by a CBA
iii. asset bundling opportunities, for instance, overhead line interventions which present efficiencies by undertaking an intervention on the fittings along the route (e.g. 4VF Bolney – Lovedean: the fittings monetised risk indicates replacement required in T3, but there is an efficiency to be achieved from bundling the works with the conductor replacement in T2)

4. Explore sensitivities to reduce total intervention cost while maintaining risk level by accepting a higher risk threshold in certain asset classes
    a. The risk between overhead line fittings and conductors has been traded in order to achieve the same level of risk in a more economical and efficient manner for consumers. This reduces investment by £20m across the T2 plan.

Overall, our plan keeps the total monetised risk at the end of T2 to within 3% of the risk at the start of T2.

- Risk trading optimisation was considered across all lead assets categories but has been implemented only in instances where it achieves the same risk level at a lower cost for consumers e.g. across overhead line fittings and conductors replacements

- In general, we intervene on an entire cable route. It is difficult to achieve an exact position of risk on cables as an intervention may remove more risk than required.

Non-lead Assets

We have the following main inputs to build the non-lead assets plan:

- 2019 replacement priorities and volumes, in line with asset policies
- Updated 2019 cost information for T2 unit costs

The following steps were taken to build the plan for non-lead assets:

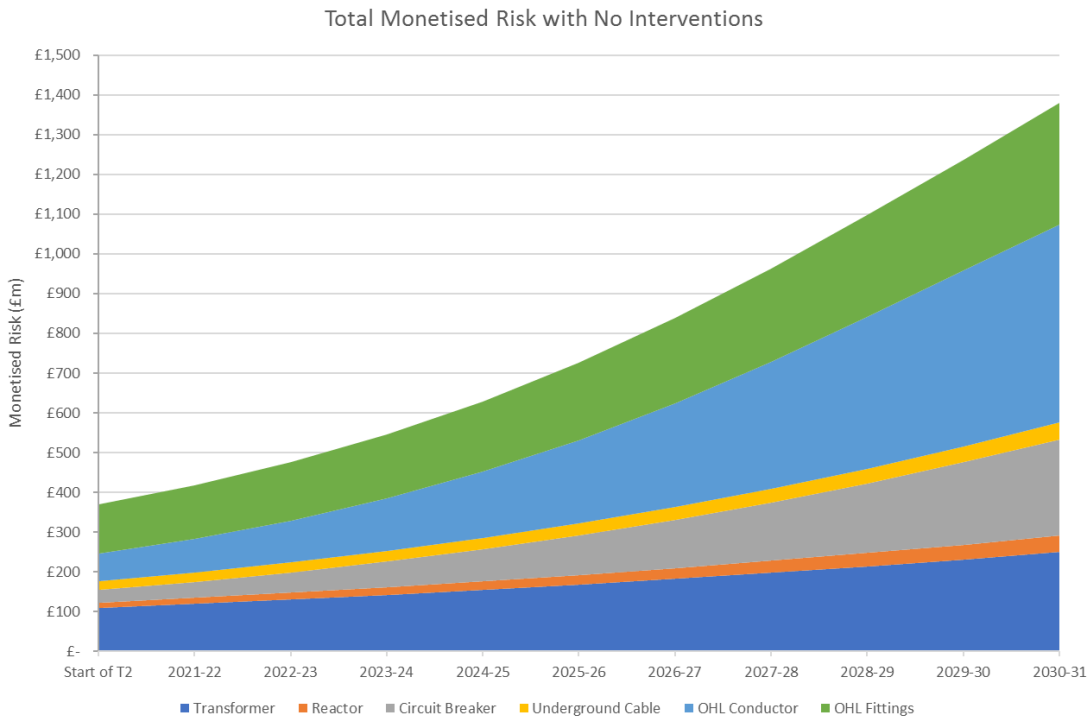
1. Identify required asset replacements based on established asset policies

2. Consider the volume of replacement required, considering the ability to deliver the required volumes & the risk to the network of non-delivery. (e.g. circuit breaker fail protection volumes have been reduced to improve overall deliverability of the plan, due to the lower risk to the network presented by these assets)

3. Add non-lead asset interventions with drivers not specifically identified by asset policy. This includes works to rationalise sites (e.g. Barking which requires non-lead asset replacement)

Output

The chart below highlights that without intervention, the total network risk based on EOL failure modes only on the transmission system would be 725.6R£m by the end of T2, and 1,379.4R£m by the end of T3.



Including the interventions associated with our T2 plan, the risk is reduced by 346.8R£m to a final overall risk position of 378.9R£m. The table below identifies the 'End of Life' risk reduction (all in R£m) per asset class:

	Total End of Life Risk			EOL Delta					
Asset Category	**2020/21 Forecast**	**2025/26 Without Intervention**	**2025/26 With Intervention**	**Long Term EOL Risk-Benefit**	**T2 Risk Reduction**	**Replacement**	**Refurbishment**	**Other Interventions**	**Non-Intervention**
Transformers	109.5	168.2	119.9	302.2	-48.3	-48.3	0.0	0.0	58.7
Reactors	13.6	24.4	14.0	33.9	-10.3	-10.3	0.0	0.0	10.8
Circuit Breaker	30.9	99.9	35.0	126.9	-64.9	-53.8	-10.8	-0.4	69.0
Cable	22.5	30.6	19.6	66.8	-11.0	-11.0	0.0	0.0	8.2
OHL Conductor	69.8	208.1	82.0	234.1	-126.1	-126.1	0.0	0.0	138.3
OHL Fittings	122.5	194.6	108.5	296.5	-86.1	-86.1	0.0	0.0	72.1
Total	**368.7**	**725.8**	**378.9**	**1060.4**	**-346.8**	**-335.7**	**-10.8**	**-0.4**	**357.1**

The table below shows the same information but in terms of total risk (including the non-end-of-life failure modes). Note that 1310.5 is the proposed target for NARM in our T2 plan.

	Total Risk			Total Risk 26 Delta					
Asset Category	**2020/21 Forecast**	**2025/26 Without Intervention**	**2025/26 With Intervention**	**Long Term total risk-benefit**	**T2 Risk Reduction**	**Replacement**	**Refurbishment**	**Other Interventions**	**Non-Intervention**
Transformers	285.5	319.3	263.6	257.5	-55.7	-55.7	0.0	0.0	33.8
Reactors	27.5	35.4	25.1	33.3	-10.3	-10.3	0.0	0.0	7.9
Circuit Breakers	206.6	316.3	154.2	197.9	-162.2	-56.3	-105.5	-0.4	109.7
Underground Cable	142.4	161.0	140.8	-10.5	-20.3	-20.3	0.0	0.0	18.6
OHL Conductors	76.9	221.5	95.2	256.2	-126.4	-126.4	0.0	0.0	144.6
OHL Fittings	240.8	375.5	225.9	576.1	-149.7	-149.7	0.0	0.0	134.7
Total	**979.7**	**1429.0**	**904.5**	**1310.5**	**-524.5**	**-418.6**	**-105.5**	**-0.4**	**449.3**

After identifying assets requiring an intervention, an optioneering process is followed to assess the costs and benefits of the different approaches available (e.g. refurbishment, replacement, reconditioning) given the specific asset and context specificities (e.g. land, timing, intervention life)

5. Alignment of the plan

Further considerations were made to align with other drivers and efficiencies.

5.1 Bundling Opportunities

Interventions across T2 & T3 to identify opportunities for more efficient bundling of works e.g. Circuit Breakers at Rainhill swapped between T2 & T3 (RAIN2250 moved from T2 to T3, RAIN2450 moved from T3 to T2) to align with the replacement of their associated SGTs

5.2 Interactions between load-related and non-load related drivers

There are some instances where customer driven work can create bundling opportunities or trigger asset replacements. Potential opportunities have identified £28m in the T2 plan and £53m in the T3 forecast.

The net impact on total network risk of incorporating these changes is approximately 1%. This is negligible and uncertain. Changes in customer activity will have a larger impact on our plans therefore there is no benefit of making these adjustments. We will continue to monitor the forecasted T2 load-related work to ensure there is no unnecessary or uneconomical non-load related investment made.

We considered the impact of planned load-related works which will replace or remove existing assets on the network:

1. Ensure that we only have one planned replacement/removal per asset for any assets which have both a load and non-lead driver

2. Consider the impact on the monetised risk of removing assets from the network through a load-related driver

5.3 Transformers

Load related interventions on the plan reduce the Transformers monetised risk position for T2 by 1.5R£m and T3 by 2.1R£m.

This represents a variance against our monetised risk position of 1.2% in T2 and 1.8% in T3.

Adjusting the non-load plan volumes to take account of this would cause the following net non-load volume movement:

The load-related plan is uncertain and will have an impact on our T2 plan as customers plans mature and new customer applications are received. By not adjusting our plan to accommodate these small volumes, we are protecting customers from future uncertainty. If these load-related volumes do not materialise and we deliver our plan, we will deliver a small amount (1.2%) of additional reliability, within the transformers asset category than we are currently experiencing.

5.4 OHL Conductor & Fittings

Load related interventions on the plan reduce the OHL Conductor monetised risk position for T2 by -1.4R£m and T3 by -5.0R£m. It would reduce the OHL Fittings monetised risk position for T2 by -2.2R£m and T3 by -11.7R£m.

For OHL Conductor, this represents a variance against our monetised risk position of 1.5% in T2 and 4.3% in T3. For OHL Fittings, the variance is 2.0% in T2 and 12.2% in T3.

To take account of this in the monetised risk position, we would need to reduce the OHL Conductor & Fittings volumes as follows:

For each of the categories, the impact in T2 is low (Transformers 1.2%, OHL Conductor 1.5%, OHL Fittings 2.0%), and the net impact on the total risk position is also low, we have therefore not made any changes to our T2 plan.

For T3, the impact against the total risk position is higher (£18.8m, net 7.5%). However, given the uncertainty surrounding the longer-term view of the load related plan, we will continue to plan non-load interventions until the Load Related interventions for T3 become more certain during T2.