9. We will provide a safe and reliable network

What you can find in this chapter

1. What this stakeholder priority is about
2. Track record and implications for T2
3. What our stakeholders are telling us
4. Our proposals for the T2 period
5. The justification for our proposals
6. Our proposed costs for the T2 period
7. How we will manage risk and uncertainty

What this stakeholder priority is about

Our main responsibility as a transmission owner is to ensure a safe and reliable electricity transmission network. Our network needs to be available to our customers, when they need it, to provide secure power supplies for consumers. To fulfil this role, we need to maintain high safety standards that protect our employees, contractors, stakeholders and the public. To achieve the level of reliability expected by our stakeholders, we need to keep our assets in a healthy condition. This means monitoring their condition, and intervening at the right time to maintain, refurbish or replace them.

What you have told us so far

We understand that a safe and reliable electricity transmission network is the top priority for you.

Whilst there are uncertainties in how the system may operate over the long term, even in a more decentralised world, you want us to maintain a reliable transmission network to enable future opportunities.

You have told us that, for the T2 period, you want us to maintain reliability similar to the level we currently provide. And you want it at a fair cost. You have also told us that our plans should support the future demands on the network. So the decisions we take in the short term do not limit future opportunities.

What we will deliver

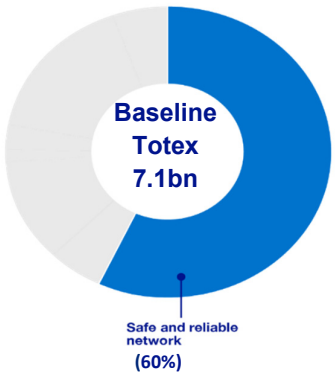
We will deliver world class levels of reliability and standards of safety. **In the T2 period we will need to replace and refurbish more assets** than in the T1 period **to maintain the current level of reliability** that our stakeholders are asking for. We will invest £4.29bn to replenish and modernise the ageing network to keep it healthy and reliable for future generations.

To reduce the bill impact of this increased investment, we will embed innovation developed through the T1 period into our T2 plans, and continue to innovate utilising our advanced asset management capability. Our plan is 14% lower as a result, passing on £707m cost savings to consumers through our T2 plan, by utilising the innovation we have developed.

We will invest in operational and asset management IT systems to help us continue to make the lowest overall cost decisions into the future.

The total cost of delivering these baseline proposals is £4.29bn. This represents 60% of the overall business plan as reflected in figure 9.1.

Figure 9.1 Proportion of expenditure



1. What this stakeholder priority is about

As the electricity transmission owner in England and Wales, we are responsible for the safe and reliable operation of an extensive network of assets. Our role is to protect the public and those who work on our network, from the inherent dangers associated with providing a high voltage electricity transmission supply. We have over 14,000 circuit kilometres of overhead line, 3,000 circuit kilometres of underground cables and over 300 substations, providing the electricity stakeholders and end consumers rely on.

We ensure a safe and reliable network by:

Developing our people, to provide **advanced asset management capability**

Creating **advanced asset condition monitoring** techniques, to understand what needs to be done and when

Maintenance, repair & **refurbishment** of assets to ensure they operate safely

Replacement of our assets at the optimum time, to prevent network outages associated with end-of-life failures

Making sure our **central control and data support systems are robust**

Consumer value proposition (CVP)

The CVP looks at the value we are providing above Ofgem's minimum requirements that we can robustly monetise. This chapter contains the following CVP items:

- CVP4 - Tougher energy not supplied (ENS) target (value of £2.68m)

For more detail, please see chapter 5.4 and the CVP annexes ET.07 to ET.07C.

2. Track record and implications for T2

Safety is our number one priority and we are committed to the wellbeing of our staff, contractors and the public. There are inherent dangers associated with our activities, an incident on our high voltage electricity network could pose a threat to life. Our obligation is to comply with relevant health and safety legislation, monitored and enforced by the Health and Safety Executive (HSE).

We are proud of our safety track record, which is among the best in the industry (ENA Annual Safety Report 2017-2018). Our safety record is measured by our Injury Frequency Rate (IFR). The following figure shows our performance is consistently within the 'UK Energy Industry Safety Leaders' group range of 0.04 to 0.25.

Public safety trends are also continuously improving as a result of the programmes, campaigns, risk management and control measures we have put in place.

Figure 9.2 Injury frequency rate

Year	Injury frequency rate (IFR*)
2013/14	0.16
2014/15	0.16
2015/16	0.10
2016/17	0.13
2017/18	0.12
*Injury frequency rate (IFR), counts the number of injuries sustained for every 100,000 hours worked	

Costs and outputs in T1

Reliability of our network is critical to our stakeholders and end consumers, and we have delivered to a world class level in the T1 period. A measure of reliability in the **short term** is the amount of energy not supplied (ENS) in a year.

With only a few exceptions, our performance in figure 9.3 shows electricity is available whenever people need it.

Figure 9.3 Availability of network

Year	Volume of **unsupplied** energy (MWh) **T1 Target = less than 316 per year**	Availability (or Reliability) of network (%)
2013/14	136	99.999950
2014/15	10	99.999996
2015/16	5	99.999998
2016/17	89	99.999964
2017/18	40	99.999984
2018/19	37	99.999984
1 megawatt hour (MWh) is roughly equivalent to the amount of energy used by 200 UK homes in a year		

Delivering this level of reliability requires maintenance of our assets, to ensure they continue to operate safely and reliably, as designed. In the T1 period, we had allowances of approximately £109m per year to carry out this work. We have undertaken more work than planned, but at a cost approximately £17m per year lower than expected, reflecting significantly improved efficiency in our operating costs.

A **longer-term** measure of reliability are the levels of asset risk on our network. By 'risk' we mean how likely the asset is to fail and the potential impact of its failure. We can influence the level of risk on the network, by investing

in condition monitoring, maintenance, refurbishment and replacement of assets. Investing in this way reduces the risk to our installed assets, ensuring we can maintain a reliable supply of electricity over the long term.

Innovation in the T1 period

Our innovative culture and drive to be efficient has meant we are on track to outperform our network risk targets, whilst **saving £1.4bn compared to our allowances** (£748m saving is the consumer portion (53%) derived from the Totex Incentive Mechanism).

This has been achieved by utilising our expert asset management teams who invested in advanced condition monitoring and modelling techniques to understand end-of-life failure modes of our assets. This investment, in the early T1 period, has enabled us to reduce network risk at a reduced cost through:

New interventions: targeted asset replacement of components driving the asset risk

Life extension of assets: reducing the volume of work needed in T1 and future periods

We have also optimised how we deliver our work; for example working with our operational teams and supply chains to:

Reduce the unit cost of work required in replacing or refurbishing our assets

This provides additional reliability at a lower cost to consumers and is backed by cost benefit analysis (CBA) to show it is in the interest of consumers over the long term.

In the T1 period, over **£500m of this saving is used to avoid any impact on consumer bills**.

T1 benefits are embedded into our T2 plans

In section 5 of this chapter, we show in more detail for each asset category what innovation we have done, and how we have used this **innovation, to reduce costs** in our business plan for the T2 period. Please also refer to annex NGET_A9.04 'T1-T2 interactions for detail on deferral and advancement of work in the T1 period to manage network risk. This includes a description of life extension, implemented through these innovations, impacting a portfolio of assets. This has a significant impact on performance in the T1 period, and also reduces the volume of work required in subsequent periods. The following table shows this saving in the T1 period, split by asset category. These cost savings are 100% reflected into our baseline T2 plan.

Table 9.4 Savings in the T1 period

Category	T1 residual risk target	Target on track	Cost vs allowances (£m)
Transformers	153	✔	-277
Reactors	82	✔	
Switchgear	336	✔	-331
Cables	191	✔	-347
Conductor	4428	✔	-238
Fittings	3919	✔	

Our strategic approach is to keep network risk level over the longer term. This allows us to manage risk over the portfolio of all our assets, optimising across asset categories to lower costs. We build on this in the T2 period through the monetised risk approach (described in more detail in section 5 of this chapter).

Whole system approach

As part of our BAU approach to asset management, we are in constant contact with the Electricity System Operator (ESO) and Distribution Network Operators (DNOs) to check that our plans are aligned and deliver the best whole system solution for consumers. Examples of this relate to the ESO, where we change our construction methods, at additional cost in order to save ESO constraint costs, resulting in an overall cheaper cost for the consumer. We also carry out Joint Technical Planning Meetings (JTPMs) with each DNO at least twice a year, in order to align our work and identify efficiencies.

Learning for the T2 period

The T1 period was the first time the RIIO framework had been used, resulting in some large consumer benefits being realised, and also some areas that could be improved upon for the T2 period. Key learnings are:

- Although our safety record in the T1 period was good, we experienced a fatality in 2016. We have improved our lifting processes following our investigation into this incident.
- An output based RIIO framework incentivised networks to look for no build solutions.
- The longer 8-year T1 period enabled the development of innovations across asset portfolios, whilst delivering against output targets. These innovations have been built in to our T2 plan.
- The RIIO framework incentivised networks to optimise across operational and capital costs. Investment in asset management tools and systems supported innovations over the period.

3. What our stakeholders are telling us

We understand that a safe and reliable electricity transmission network is the top priority for you.

Whilst there are uncertainties in how the network may operate over the long term, even in a more decentralised

world, you have told us there is a role for electricity transmission.

You have told us that, for the T2 period, you want us to maintain reliability similar to the level we currently provide. And you want it at a fair cost. You have also told us that our plans should support the future demands on the network. So the decisions we take in the short term do not limit future opportunities.

Investment associated with a safe and reliable transmission network will have short and long-term impacts on the users of the network and consumer bills. In our engagement on this priority, we set out to understand what our stakeholders needed this service to be both in the T2 period and beyond.

Engagement on this topic covered the breadth of stakeholders associated with the electricity transmission system, along with business and domestic consumers. Whilst engagement questions covered were broad and have a material impact on how we build our business plans, some of the boundaries of engagement on this priority are set by our licence obligations to maintain compliance with the Security and Quality of Supply Standards (SQSS).

Through business as usual engagement, our stakeholders expect us to comply with these obligations, including safety legislation.

As the investments we make on this priority affect consumer bills in the long term, we have aligned our engagement activities with other priorities. Part of the engagement for Chapter 7 *We will enable the ongoing transition to the energy system of the future*, included the future of role of transmission. The outcomes of this engagement are relevant to this priority and stakeholders told us (see able 7.4 in chapter 7):

1. Despite uncertainty, there is a need for electricity transmission in the long term.
2. Decarbonisation, reliability and lower costs for consumers were key priorities.
3. Decisions made in the short term should not limit future opportunities.

In parallel to this engagement, we have conducted bespoke sessions with our stakeholders. We have also conducted broad engagement in conjunction with other priorities, so we can understand the 'ranking' of the safe and reliable priority with the others.

Based on feedback from the Listen Report and the Independent Stakeholder Group, we set out to deliver on a three-step approach when talking directly about reliability:

1. **Educate** – it is important stakeholders and consumers understand this priority; so that they can make the best-informed decision possible.
2. **Bring to Life** – helping stakeholders and consumers 'visualise' the topic using language they are familiar with.
3. **T2 options** – providing real options on different levels of network risk.

A summary of our engagement activities and outcomes is provided in table 9.5 below, alongside what trade-offs have been made and how stakeholders have influenced the plan. The engagement log contains detailed information on our engagement approach and outcomes. This can be found in annex NGET_A9.01 Engagement log.

Transition from NOMs to NARM

The Independent Stakeholder Group requested that we provide more information relating to the transition from NOMs to NARM, which are the changing methodologies between T1 and T2 for measuring network risk outputs.

In T1 the output for our lead assets (Transformers, switchgear, OHLs and Cables) was NOMs (Network Output Measures). This used an asset health and criticality approach to define a replacement priority for each asset (0-2 years, 2-5 years, 5-10 years and 10+ years). The NOM targets were set to maintain a volume of assets in each of these categories.

During the T1 period NARM (Network Asset Risk Metric) was developed by Ofgem in collaboration with the other network companies. NARM uses a monetised value of risk for each asset, which in simple terms is the probability of failure of that asset, multiplied by the consequence of the failure (PoF x CoF = Monetised Risk). In NARM the condition of the asset is the first step in determining the probability of failure (In T1 this was called asset health index) where the condition of our assets is updated annually.

There are a couple of terms used in this chapter:

- **R£m** = Current risk value (in millions of pounds)
- **LR£m** = Long-term risk benefit (term is the duration of the intervention)

Our T1 NOMs targets will be re-baselined as monetised risk NARM targets for the close-out of T1. Our T2 target will be the risk reduction (risk delta) we will deliver through the investments in lead assets in this chapter. Monetised Risk gives us a common currency for reliability to enable better engagement with stakeholders. Stakeholders have asked us to do more in this area, which we explain in section 3, and we propose more NARM outputs in section 4 of this chapter

Table 9.5 Summary of our engagement

Initial engagement	
Purpose and approach	We carried out workshops, online consultations and surveys with academics, large customers, consumer bodies, network companies, regulatory, supply chain, consumers, governmental, small/new customers, other interest groups. Our aim was to understand what our stakeholders' priorities are across the breadth of the electricity transmission landscape.
What stakeholders told us	Two clear priorities emerged regarding what stakeholders need from us: 1) a **reliable network** to provide security of supply 2) **value for money.** Stakeholders told us reliability of the electricity transmission network, both now and in the future, is key to ensuring the required levels of security of supply. They told us we need to explore options with stakeholders in more detail, particularly regarding the cost-reliability trade-off. We are required by the HSE and other regulators to comply with all relevant safety legislation.
Consumer engagement	
Purpose and approach	We recognised the need to undertake more consumer research on this priority as result of: • consumers facing cost pressures from multiple sources, not just energy bills • the priority consumers and stakeholders place on reliability, and its material size of the priority. • challenge from the Independent Stakeholder Group, promoting further consumer engagement. **Reliability** has featured heavily in our consumer engagement, which is the most extensive consumer engagement we have carried out. We sought to: • bring the priority to life and make it accessible through a variety of channels • offer real options for the T2 period, and understand consumers' willingness to pay or accept different levels of service. We carried out workshops, online consultations, surveys, research (qualitative, cultural and attitudinal), acceptability testing, online interactive tools covering domestic consumers, business consumers, and members of the public (targeted).
What consumers told us	Across all gas and electricity priorities, consumers clearly stated: • maintaining and developing a reliable network was their number one priority. • consumers were willing to pay (WTP) the most for this area of the plan. In terms of WTP for specific levels of reliability: • consumers showed a willingness to pay extra on their bill to reduce the risk of powercuts. In our October acceptability testing, we asked if it is acceptable for bills to go up a small amount if it is efficient? The view across the groups was that it was not worth the risk of keeping bills flat. The general consensus was that keeping bills flat would be less acceptable than the proposed plan for electricity transmission.
Stakeholder engagement	
Purpose and approach	We carried out workshops, online consultations, surveys, bi-laterals, bespoke sessions, consultation document, and webinars. We covered a broad range of stakeholders, including OFGEM, academics, large customers, consumer bodies, network companies, DNOs, supply chain, governmental, small/new customers, and other interest groups (incl Energy UK). Based on feedback from the Independent Stakeholder Group, our engagement approach for the safe and reliable priority has been more in depth and far reaching than we have conducted before. We have moved engagement from a predominantly inform approach previously to a consult, involve and collaborate approach which will be used for ongoing engagement. Desired outcomes from this engagement were to: • inform stakeholders on the interactions between our safety and asset management approach; and the impact on services they receive • gather stakeholder views on priorities and investment options we could take to manage reliability over the short and long term • conclude what price control framework targets and business plan investments we should deliver from the insights gained.

What stakeholders told us	In terms of informing/educating, stakeholder polling stated: • 76% agreed the decisions we make in the T2 period will impact the long-term network reliability. • 75% agreed that the measures provided a sufficiently broad representation of reliability. • They had improved understanding of transmission reliability and were interested in further topics. In terms of how we should build our business plans, stakeholders stated: • In all scenarios, there is a future need for a reliable electricity network. • We should take account of specific local forecasts, sensitivities and projects. • We should maintain the network risk position over the T2 period. • For non-lead assets we should consider extending our monetised risk approach to a wider range of asset types (i.e. non-lead assets), and agreed with our targeted approach as long as it did not limit future system requirements. • We should ensure that short term decisions do not limit future growth. • Investment decisions should be subject to a whole system assessment.
Key trade-offs and how engagement influenced our plans	Reliability level feedback: • While the majority of stakeholders agree that reliability levels should not deteriorate, there are mixed views on whether reliability levels should be maintained or improved. • Whilst stakeholders agreed on an increasing dependency on electricity and a need for electricity transmission, there were different views on the impact of a decentralised network. • The majority of consumers (54%) want to maintain transmission reliability, and 33% wanted to see reliability increase, 9% wanted to reduce costs even if it reduced reliability, 5% didn't know. Investment proposal feedback: • 90% of stakeholders polled through recent engagement supported the output of our July plan, to maintain network risk levels despite an increased cost. 10% wanted to see more granularity in how we had optimised the plan and embedded innovation. • The majority of consumers (57%) supported the proposed investments to maintain network risk. For those not supportive; 19% wanted more context, 13% said affordability of the bill was the issue, and 4% did not think the investment was needed. (7% didn't know). Influence on our plans: • The plan will aim to maintain network risk through investment in assets, to avoid costs associated with increasing reliability further. • This approach balances stakeholder views on levels of reliability, and delays investment to reduce network risk further than today's levels. By investing now to maintain risk, flexibility is enabled as we develop future networks, including decentralisation. • Used the feedback received to continuously challenge our investment options, resulting in a plan reduction (-2%) between July and October, through investment timing and scope changes. We have also challenged ourselves hard on costs, resulting in stretching efficiency commitments. • We will also monitor uncertainty during the T2 period, changing our approach to ensure our refurbishment strategies are flexible so they do not limit system development. • The T2 plan balances views on the future, to keep options open for a variety of possible futures. • For those stakeholders and consumers who wanted to see reliability increase, there was a trade-off between affordability and reliability to be made. The proposal to create a tougher target for ENS in the T2 period, whilst maintaining proposed spend, was deemed by our stakeholders to achieve the right balance.
How we've responded to the Independent Stakeholder Group and Challenge Group	**Independent Stakeholder Group** influence: • Who and how we engage. Moved from predominantly inform for this priority, to a consult, involve, collaborate approach which will be used for ongoing engagement. • Challenge and insight enabled broadening scope and reach of consumer and stakeholder engagement, resulting in a rich set of feedback from multiple engagement channels. • Simpler more accessible and transparent narrative now included in our business plan. **RIIO-2 Challenge Group** influence: • Requests for analysis of low totex scenarios, defining further outputs, and cost and volume interactions between periods has helped us improve the analyis and commitments in the business plan and supporting Investment Decision Packs. • Challenge on options (including timing), leading to the plan reduction post July (-2%).

4. Our proposals for the T2 period

The table below outlines how what our stakeholders are telling us links to the proposals we are making and the consumer benefits.

Table 9.6 Our proposals for the T2 period

Stakeholder Feedback	Our proposals	Output type	Target	T2 Baseline Cost (£m)	Consumer benefit
Comply with all relevant safety legislation	Maintain our safety standards, aiming for zero harm to our employees, contractors, stakeholders and the public	Commitment	Injury frequency rate reduced from 0.12 towards zero	n/a	Protected from potential harm relating to the work we carry out on our assets
Safety is, and will continue to be, our top priority. We are committed to maintaining our safety standards, aiming for zero harm to our employees, contractors, stakeholders and the public. We want to further improve our safety record, to reduce the likelihood of anyone being injured by our activities. In our goal for zero harm we will: • simplify and improve work procedures • create new processes to embed learning from near misses • ensure work is always resourced with the right qualified staff • improve our public safety metrics, assurance, transparency & sharing of best practice. Our future safety performance is underpinned by the culture of our organisation and the behaviours of our people. We are committed to embedding a culture for the T2 period where: • high standards are set and we strive to exceed them • failure is used to improve not to blame • management knows what is really going on because the workforce tells them • people are trying to be well informed because it prepares them for the unexpected.					
Stakeholder Feedback	**Our proposals**	**Output type**	**Target**	**T2 Baseline Cost (£m)**	**Consumer benefit**
Maintain levels of reliability, at an affordable cost. Recent Energy Not Supplied (ENS) performance should be weighted more heavily than long-term performance	Create a tougher T2 target for ENS which more heavily weights recent performance Independent Stakeholder Group to provide independent challenge throughout the T2 period NGET_A9.10 ENS Incentive' includes detail on how stakeholders have proposed the T2 target	**ODI**	*T1 target was 316MWh* **ENS target** **Weight performance** **50% (0-5 yrs.)** **30% (5-15 yrs.)** **20% (15+ yrs.)** ~175MWh p.a. based on recent performance Collar: 3% revenue Cap: Natural	n/a	World class levels of reliability Maintain access to critical energy supplies when needed.
Stakeholder Feedback	**Our proposals**	**Output type**	**Target**	**T2 Baseline Cost (£m)**	**Consumer benefit**
Maintain levels of network risk, at an affordable cost Ensure short-term decisions do not limit future system opportunities	We will maintain our network risk position through condition monitoring, maintenance, repair, refurbishment and replacement our assets. We will deliver this work at lowest cost (on average per unit) by embedding innovation.	**PCD (NARM)** Lead assets Conductor Fittings Transformers Reactors Switchgear Cables **PCD (Other)*** Non- lead *Commitment areas below	*No comparable target for T1 as NARM is a new methodology* **Delta risk target** **1,267 LR£m** (Long-term risk benefit of T2 Interventions)	2,251	Long term reliability, at a lower cost, for current and future consumers Modernisation of the network to support decarbonisation, through the renewal of assets

Non-lead asset outputs
We are committing to **deliver more outputs in the T2 period than in the T1 period**, creating **more certainty and transparency**. For the T2 period, we are proposing more outputs for our non-lead areas. Along with NARM, this will provide coverage for over 80% of our plan for this priority. We are committing to develop NARM outputs for the following non-lead areas, to be set early in the T2 period, with an interim reporting volume also identified where appropriate. The costs below are for these outputs only, total costs are in table 9.10. *Please note definition of site is to be agreed.

Non-lead asset outputs		Price control deliverable (Output)	Cost (£m)	Interim reporting
Substation	Instrument transformers	**NARM** (We will develop for the T2 period)	**327**	151 sites*
	Through-wall bushings			24 sites
	Bays			161 sites
	Protection & control	**NARM** (We will develop for the T2 period)	**489**	[redacted] units
Circuits	OHL steelwork replacement	**Bespoke** Equivalent Tonnes = [redacted]t	**53**	N/A
	OHL steelwork refurbishment	**Bespoke** Equivalent Area = [redacted]**km²**	**92**	N/A
	Cable tunnel	***Ringfenced** (NARM category A3)	**407**	N/A

5. The justification of our proposals

Our proposals will be delivered by the investments that have been outlined in this section. These are underpinned by investment decision packs which include engineering justification reports and cost benefit analysis. We have assessed these investments to be the most economic and efficient.

Key driver: Our stakeholders have told us that they want us to maintain current levels of reliability in the T2 period. There are two main cost categories to deliver our proposals in this priority: (1) Operational costs and (2) Capital asset intervention costs. We have operational costs to maintain our assets, to ensure they remain operable and can reach their expected asset life. Our field-force of over 1,000 technicians and engineers monitor and maintain our network and respond to faults 365 days a year. Our asset base is growing, along with a rapid and complex transformation of technologies being utilised across the energy sector. This impacts the amount and type of maintenance we need to carry out.

In the T2 period, we **considered options** to reduce the cost impact of this requirement. We will deliver at a lower unit cost, through:

- standardisation and continuous improvement of repeatable maintenance tasks
- optimised work delivery for operational staff between operational maintenance work, and capital work in the replacement and refurbishment of assets
- implementing new ways of working, allowing staff to be more flexible and mobile
- enabling operational teams through our IT systems.

There are also other operational costs required to maintain a safe and reliable network. This includes training and resourcing our asset management teams who operate and maintain the network. Table 9.7 shows a summary of operational costs in the T2 period. These are reducing by 16% compared to the T1 period, despite the required increase in work required. Please see annex NGET_A14.17 Total Opex for a detailed T1 to T2 cost comparison

Table 9.7 Proposed operational costs for the T2 period

Maintenance category	Description	T2 Cost (£m)	T2 vs T1
Inspections	Asset and site inspections	[redacted]	
Repairs & Maintenance	Maintain assets in line with policy & repair of components	[redacted]	
Vegetation Management	Control vegetation around our assets	[redacted]	
Civils & Safety	Maintain safe infrastructure on our sites	[redacted]	
	Total	**505**	
Support category	**Description**	**T2 Cost**	**-16%**
Health, Safety & Environment	The team that define and implement our policy	2	
Engineering support	Our asset management and engineering teams	141	
Operational training	Training for operational engineering teams	62	
Operational IT & telecoms	Service agreements and running costs	49	
Vehicles & transport	To operate and maintain the network	0	
	Total	**254**	

To enable a clean and reliable network for future consumers over the **longer term**, a different approach to managing reliability is required. Large parts of the high voltage electricity network in England and Wales were built in the 1960s and 1970s. Whilst these assets will have been regularly maintained, inevitably some have reached their end of useful life on the network. Data collected from advanced condition monitoring of our assets throughout their operational lives, informs how their condition deteriorates over time.

To understand which assets should be prioritised for the T2 period, we have used an improved asset risk methodology. This new methodology has been developed over the last three years with our stakeholders and is approved by Ofgem. It ensures the right long-term decisions are made to manage overall network risk at the lowest cost.

The methodology calculates the **probability** of failure and **consequence** of failure of our 'lead' assets. Lead assets are the primary assets on our network. They are the assets that carry the current over long distances, transform the voltage between our network and customers and that break the current during faults or switching. Our approach for 'non-lead' assets follows the same asset management principles; understand the probability and consequence associated with failure of assets.

We have followed a process for optimisation of our plans which ensures the outputs from our stakeholder engagement flows through into the targets we are trying to meet, and hence the amount of work that we need to do.

Figure 9.8 explains the stages of creating a business plan using monetised risk. By following this process, we can align the plan to deliver what our stakeholders want, to **maintain our overall reliability** in the T2 period.

Figure 9.8 Creating a business plan using monetised risk

Options considered

We have built the plan not only to maintain overall network risk, but also to maintain risk within each of our asset categories. Accepting higher risk for asset categories may not result in lower reliability in the short-term; however, over the long term it can become unrecoverable.

The figure below provides an example of how we were able to optimise the plan to manage risk associated with our overhead lines. We can replace the fittings (or 'connections') of our overhead lines, without replacing the main conductor that carries the current. By reviewing the risk associated with each component, and using the new methodology to compare them, we can understand the effect a change in the volumes of fittings and conductor replacements has on overall risk and overall cost. Please see annex NGET_A9.20 NLR Plan Build' for further detail how we have built the plan including consideration of trade-offs between asset classes.

Figure 9.9 Creating a business plan using monetised risk

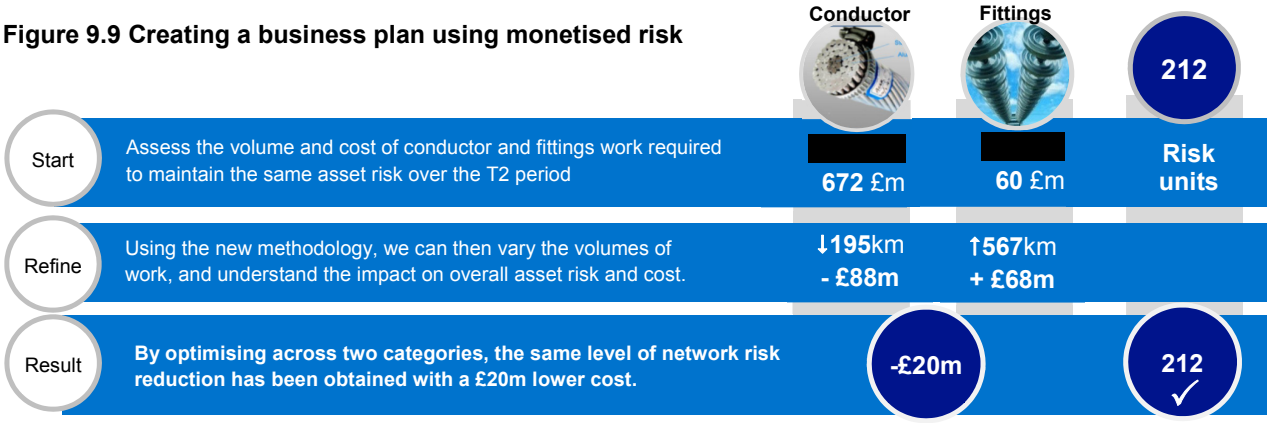
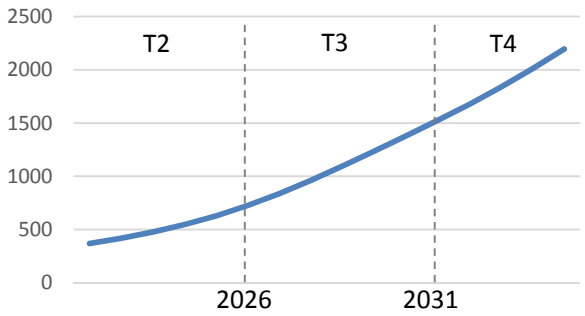


Figure 9.10 network risk (R£m) over time with no intervention



This figure demonstrates the importance of viewing asset risk over the long term, as decisions we take in the T2 period affect the reliability levels we are able to achieve in the future. For example, delaying intervention and increasing risk in the short term, requires even more work in the future if you wanted to recover network risk back to today's levels. How much work we are able to deliver in any given period is limited by resource, the supply chain and the availability of outages whilst managing the supply of energy.

In the T2 period, we will need to replace and refurbish more assets than in the T1 period to maintain the current level of reliability that our stakeholders are asking for.

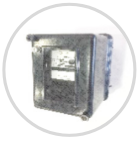
Our OHL network was not installed gradually, but in peaks, over half of this in the 1960s. This creates the need for increases in intervention volumes for certain asset types depending on their original installation date and expected technical life.

Over the past 25 years, we have reduced the peak in this profile through better understanding of the deterioration of our assets, ensuring we manage them to end of life and through our asset management actions such as increasing our intervention options.

We have not been able to completely flatten the profile and some 'peaks' still exist.

In the T1 period, due to the condition of our circuit breaker population, we replaced and refurbished over 1,000 assets. In the T2 period, we therefore need to do over 50% fewer interventions on circuit breakers.

We need to do more overhead line conductor and fittings in the T2 period than in the T1 period, as more of the OHL network is reaching end of life.



For protection and control, we have different technologies both reaching their end of life. Electro-mechanical protection relays (installed primarily in the 1960s with an expected technical life of 60 years) and the first generation of computer based digital numeric protection relays (installed in the 2000s with expected technical life of 15-20 years). This increase continues into the T3 period.

We've minimised the cost of the T2 plan through whole system thinking, innovation and efficiencies.

Whole system We engaged with each DNO, whilst building our T2 plans, to identify efficiencies where our plans could be aligned. In addition, we have shared our plans with the ESO, to identify where collaboration can deliver more efficiencies. For example, on the London Power Tunnels 2 (LPT2) project, we saved £25m through coordinating with UKPN to identify the optimal solution for network replacement work in London. For the Dinorwig-Pentir cable replacement, we co-ordinated with the ESO, stakeholders and customers to undertake a cost-benefit analysis to optimise replacement of cable circuits connecting Dinorwig power station. See chapter 7 *We will enable the ongoing transition to the energy system of the future,* for more detail.

Innovation We have embedded innovation developed in the T1 period into our T2 plans, and continue to innovate utilising our advanced asset management capability. Our total plan cost for this priority is 14% lower as a result, passing on **£707m cost savings** to consumers. We also have a **stretching additional £27m** forward looking efficiency on protection & control, rolling out smart ways of working into further assets types.

Efficiency In Chapter 14 *Our total costs and how we provide value for money,* we outline how these costs benchmark against external metrics. The TNEI report (A14.02) covered 65% of our capital costs. 50% of **costs were below the industry mean**. We are making stretching commitments to future efficiencies by moving our benchmarked capex unit costs to be at or below the TNEI industry mean equating to an **£16.8m reduction** in this stakeholder priority. We have also applied a **£23.6m productivity commitment** to improve the productivity of our people by 1.1% year on year.

Cost confidence**:** We have a long track record of delivery of the projects detailed for this priority. We have used this experience and historic data to inform our forecasts. Following a robust process, using independently assured costs (as outlined in chapter 14), ensures this is a **high cost confidence** area. 100% of new T2 investments are covered by Investment Decision Packs, showing investments proposed are economic and efficient.

In this next section we set out our proposed volumes, costs and risk reduction to provide a safe & reliable network. Table 9.11 describes:

- a summary of overall capital costs
- how those investments deliver against the proposed risk output to maintain overall network risk

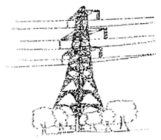
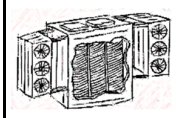
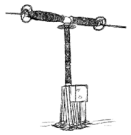
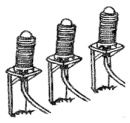
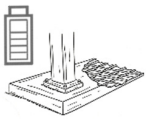
Table 9.13 compares:

- T2 average spend to T1 average spend, including justification summaries from Investment Decision Packs.

Tables 9.14 to 9.20 describe:

- a summary of the driver and options considered at an equipment category level
- whole system thinking and innovation embedded to maintain risk at optimal cost.

Table 9.11 Summary of asset category costs for the T2 period

Asset category spend (£m)						**T2 cost £3.52bn**
						
Overhead lines	Transformers & reactors	Switchgear	Protection & control	Underground cables & tunnels	Other equipment	IT
905	328	352	489	862	409	176
A category level breakdown of **costs compared to T1 averages** has been included in the next sections: Table 9.13 for overhead lines, transformers, reactors, switchgear. Table 9.17 for Protection & Control.				The nature of these projects requires granular analysis. An overview of the T2 scope is included later in this chapter, with detailed T1 comparison in the Investment Decision Packs		

Monetised Risk Target for T2 (Network Asset Risk Metric – NARM)

Our monetised risk target is informed by stakeholder engagement and cost-benefit analysis (CBA). Investment Decision Packs demonstrate how selected investment options efficiently both meet stakeholder-driven objectives and deliver sufficient net benefit for existing and future consumers. To deliver this, we will broadly maintain network risk in the T2 period at the same level as the end of the T1 period. The replacement or refurbishment of our assets is planned at the optimum time, to prevent network outages associated with end-of-life failures. Using end-of-life failure modes to build our plan provides the most efficient method of delivering consumer benefit over the long-term. The T2 NARM target will be based on the lifetime benefit of the interventions in T2 (which includes both non end-of-life and end-of-life failure modes). The non end-of-life failure modes have not yet been rigorously validated and tested across networks. We therefore propose the target will need further refinement once appropriate validation and testing has been carried out.

The risk delta for our T2 plan is £527m (EOL risk delta is £347m)
The long term benefit for our T2 plan is £1,267m (EOL long term benefit is £1,060m)

Figure 9.12 Forecast of total risk over the period without intervention, end of T2 risk and risk deltas

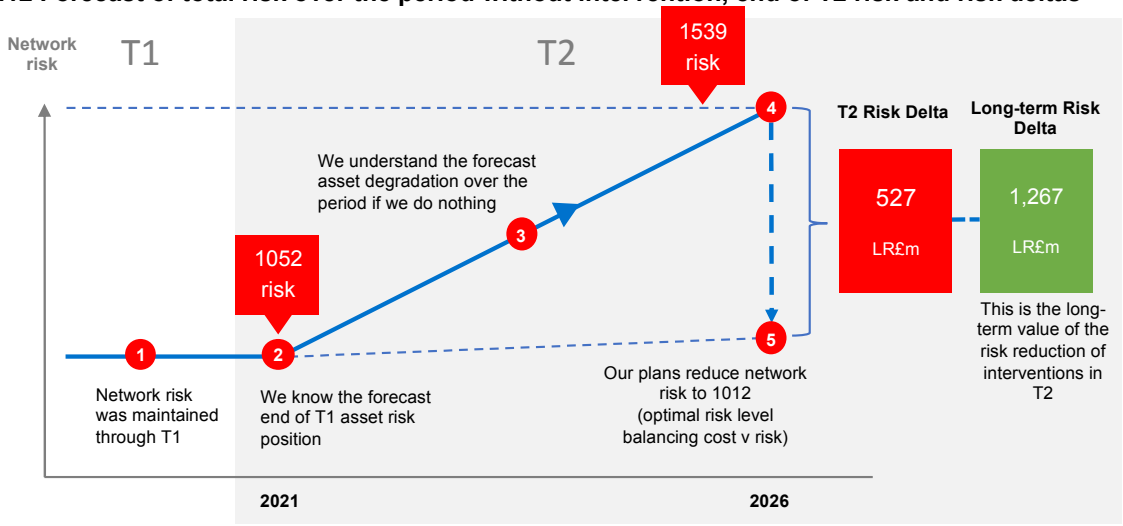


Table 9.13 Lead asset cost drivers T1 to T2

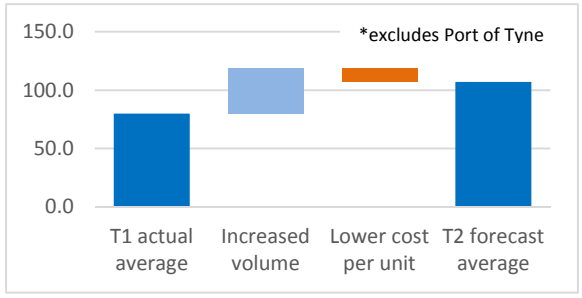
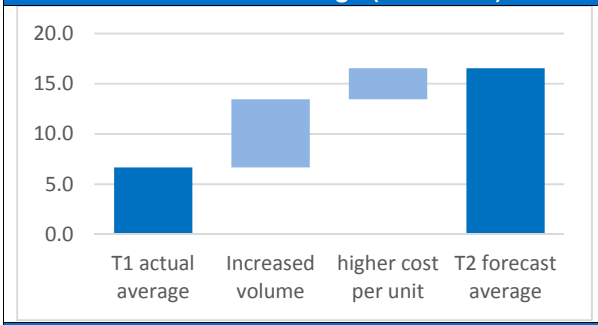
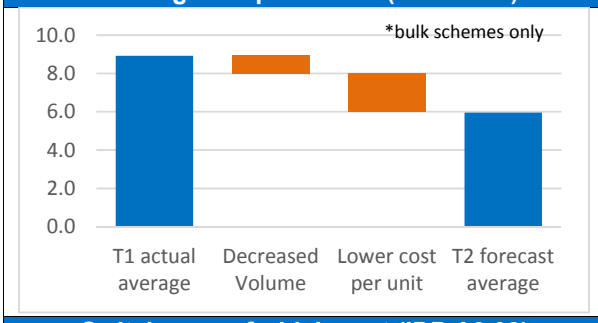
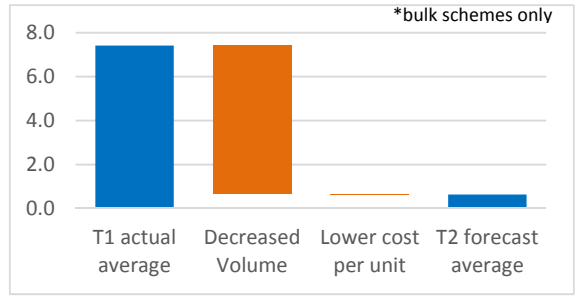
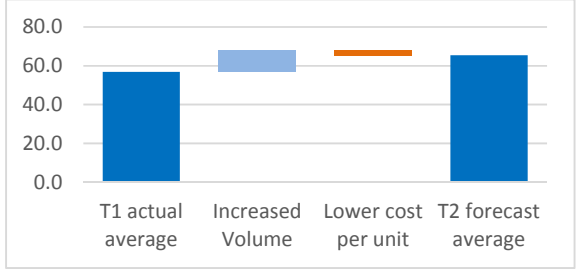
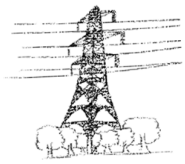
	Compared to T1 **actual** average (first 6 years)	
Overhead line conductor (IDP A9.09)	**volume**	**overall cost**
	**↑ 48%**	**↑ 34%**
• Increased volume reflecting an ageing population and the need to do more to maintain risk. •Volume impact reduced through life extension (reduced cost not shown here, see table 9.14). • Unit costs are lower than the T1 period due to embedded innovations such as improved condition monitoring, delivery efficiencies & less complex urban routes. • Unit costs are also lower than benchmark. • We have considered 3 options – fix on fail, full replacement and partial replacement. • Full replacement provides the best CBA.		
Overhead line fittings (IDP A9.09)	**volume**	**overall cost**
	**↑102%**	**↑148%**
• Increased volume reflecting an ageing population and the need to do more to maintain risk. Risk has been optimised across conductor & fittings saving £20m. • Material decrease in cost per km of replacing fittings through T1 innovation. Unit costs are lower than benchmark. • T2 costs are higher than the T1 period due to the scope of the intervention, and more urban routes (more complex access). • Considered 3 options; fix on fail, full fittings and targeted fittings, with targeted offerring the most economic intervention.		
Switchgear replacement (IDP A9.03)	**volume**	**overall cost**
	**↓ 11%**	**↓ 33%**
• Similar volume compared to the T1 period. • Unit costs are lower than the T1 period due to the type of switchgear being replaced. • Unit costs are are lower than benchmark. • Considered 3 options: The most efficient solution is dependent on the type of Circuit Breaker (CB) hence we have carried out 27 CBAs to cover all the different types of CB. This ensures the optimum mix of replacement and refurbishment in our plan.		
Switchgear refurbishment (IDP A9.03)	**volume**	**overall cost**
	**↓ 91%**	**↓ 91%**
• Lower volume compared to the T1 period as asset types requiring intervention are more cost efficient to replace. • Unit costs are lower than T1 due to the type of switchgear being refurbished. • Unit costs are lower than benchmark. • Considered 3 options: The most efficient solution is dependent on CB type hence we have carried out 27 CBAs to cover all the different types of CB. This ensures the optimum mix of replacement & refurbishment in our plan.		
Transformers & reactors (IDP A9.16 & A9.17)	**volume**	**overall cost**
	**↑ 20%**	**↑ 15%**
• More transformers are planned towards the end of the T1 period (vs first 6 years in this analysis). • Planned volumes overall are broadly consistent across T1 and T2 periods. • Unit costs are lower than T1 period and lower than benchmark • Considered 3 options: CBA preferred solution is replacement (e.g. over refurbishment which has a higher whole life cost) due to most efficient long-term benefit.		

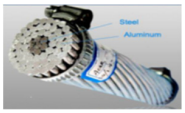
Table 9.14 Overhead line investment in the T2 period

Category: Overhead Lines (OHLs)	EOL Risk delta: **212**R£m	Long term benefit: **531**LR£m



***Key driver*:** We need to do more overhead line conductor and fittings in the T2 period than we did in T1, as more of the OHL network is reaching end-of-life. We have reduced the impact of this peak through innovation (see detail below). Replacement of OHLs has a better CBA than refurbishment. However, 99.6% of our fittings in T2 is refurbishment. The amount of overhead lines we can work on at any one time is mainly restricted by system access, but also by there being only a small number of external delivery companies who can safely carry out this type of work. The work will be delivered by internal and external resources.

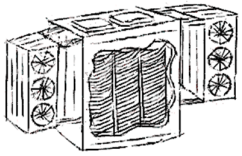
Description	Options considered	Volume	% of asset base	Cost £m
Conductor Wires that transmit power and connect each tower	Complete replacement of sections of OHLs (refurbishment isn't technically viable)	[redacted]	[redacted]	536
Fittings The connection pieces on each tower	Complete replacement of fittings on a section of overhead lines	[redacted]	[redacted]	83
	Refurbishment (targeted replacement) of only the poor condition fittings on a section of OHL	[redacted]		
Port of Tyne Stakeholder driven project to support growth in wind-turbine manufacture	Multiple options considered: Modifying existing OHL, replacing OHL, subsea cable. (**Ringfenced** to protect consumers from uncertainty)	[redacted]	-	89
Towers (or pylons) that the conductor and fittings are attached to	Remove rust and paint steelwork with a protective coating to prevent steelwork from needing to be replaced.			92
	Recover rusted and damaged steelwork, foundation refurbishment, and replacement of towers, only where beyond recovery.			105

Innovation applied to T2 plan	Saving description	Saving £m
Reduction in conductor volumes required ***through asset life extension*** In the T1 period, we have applied a 10-year life extension to 30% of the conductor asset population ([redacted] circuit km). This reduces the amount of assets we need to replace to maintain the same level of network risk. We delivered the volumes we set out to deliver in the T1 period, so the majority of consumer benefit will be realised in the T2 period, by reducing volume and cost required to maintain network risk. This was delivered through 'within span' conductor sampling, incorporated with third party development and expertise in advanced mathematical modelling and insight from accelerated ageing studies.  amey EPRI	Reduced volume of conductor [redacted]	-204
Targeted fittings replacements and life extension ***through enhanced condition monitoring*** We have invested in visual assessment using a new process of helicopter & drone data capture, with dedicated technicians and reviews by subject matter experts. This drives consistency and availability of imagery in order to improve condition data. We have learnt about spacer, damper and suspension clamps through sampling of conductor during outages, and we're subjecting 40-50 year old glass insulation to rigorous mechanical and electrical testing. This allows us to hone in on the components and towers/ spans driving the likelihood of failure. This enables new options for smaller scale targeted investment and allowed for the extension of asset lives.  	Reduced fittings unit cost -[redacted]	- 132
	Reduced volume of fittings [redacted]	- 84
Tower steelwork cost savings ***through recovery of corroded steelwork*** At the beginning of the T1 period, the outcome of an innovation project allowed us to change our policy around the treatment of corroded overhead line tower steelwork. This means that some corroded steelwork which would previously have had to be replaced can now be recovered using an enhanced coating system.	Reduced cost	-124

The Investment Decision Pack(s) related to this category can be found in annexes NGET_ A9.09, A9-09A, A9.12

Table 9.15 Transformer and reactor investment in the T2 period

Category: Transformers (SGTs) and reactors	EOL Risk delta: **59**R£m	Long term benefit: **336**LR£m



Key driver: End-of-life risk is broadly level in comparison to overall T1 volumes. A volume increase has been mitigated by life extension in the T1 period, which has reduced the overall volume required in the T2 period by four units per year.

Transformers are used to increase or decrease voltage in circuits. The reliability of our transformers is critical to customers because failures can immediately lead to supply interruptions and have a long lead time to replace.

Reactors are utilised to reduce the voltage on the transmission network. They help us to maintain voltage compliance within the required standards. They also help us to provide the capability to recover from full or partial network shut downs (a "Black Start") by helping to manage the voltage on the network as more and more demand is being restored. Changes in voltage are due to changes in flows (driven by generation and demand) and the type of assets on the network.

This work will mainly be delivered by external contractors.

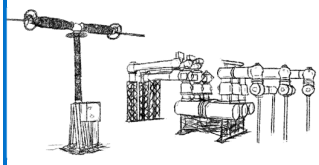
Description	Options considered	Volume	% of asset base	Cost £m
Transformers Increase or decrease voltage in circuits	Replacement and refurbishment have been considered. Optioneering informs us that replacement of SGTs delivers a greater long-term consumer benefit than refurbishment in every case. We commit to replacing transformers and not refurbishing in the T2 period. Optimum timing of intervention ahead of end-of-life failures is crucial, due to their criticality and the lead times associated with replacement. Includes 5 spare transformers.	[redacted] units	[redacted]	273
Reactors Reduce voltage on circuits		[redacted] units	[redacted]	55

Innovation applied to T2 plan	Saving description	Saving £m
Reduction in volumes required ***through asset life extension*** In the T1 period, we have delivered on our continuous asset health monitoring plan. We have: • changed the way we carry out regeneration and prevent the oil becoming corrosive, reducing the risk of transformer failure and unreliability resulting from corrosive sulphur in oil (see our TOPICS innovation project) • enhanced fire-resistant transformers using the synthetic ester based oil (Midel) • developed RESNET methodology which allows us to combine thermal models for transformers with climate data to consider future impact on our assets. These condition assessment results have identified **slower deterioration rates** than predicted. This understanding enables us to reduce the amount of assets we need to replace to maintain the same level of network risk.  *Forensic analysis of a transformer*	Reduced volume of transformers -[redacted] units	-97

The Investment Decision Pack(s) related to this category can be found in annexes NGET_A9.16 & A9.17

Table 9.16 Switchgear investment in the T2 period

Category: Switchgear EOL Risk delta: **65**R£m Long term benefit: **127**LR£m



Key driver: In the T1 period, due to the condition of our circuit breaker population, we are replacing and refurbishing over 1000 assets. In the T2 period, we need to do over 50% fewer interventions on circuit breakers, as the peak was in the T1 period. **37% of our CB plan is refurbishment in the T2 period**, delivering a greater consumer benefit than replacement.

The equipment required to connect and disconnect electrical circuits within substations is collectively known as switchgear. The lead asset is the circuit breaker. Switchgear refers to the circuit breaker and its closely associated equipment (bays) such as disconnectors, earth switches and surge arresters (items of equipment that protect the network from over-voltage events such as lightning). There are more bay assets to refurbish and replace in the T2 period due to condition and age.

This work will be delivered by both internal and external resources.

Description	Options considered	Volume	% of asset base	Cost £m
Circuit breaker only Used to connect and disconnect electrical circuits	**Replacement** – removal of the old circuit breaker and replacement with a brand-new circuit breaker.	[redacted] units	[redacted]	352
	Refurbishment – a lower cost solution to replacement which extends the asset life but does not achieve the same new asset life as replacement.	[redacted] units		
	Repair – one-off activity to address specific issues e.g. SF_6 leakage	[redacted] units		
Bay assets	**Refurbishment and replacement**	[redacted] units	[redacted]	

Innovation applied to T2 plan

Reducing the unit cost of replacement – ***reducing delivery times and install costs***

We have worked hard with our supply chain in the T1 period to reduce the cost of switchgear investments, developing quicker and more efficient ways to do our work. An example is the condition assessment (using core samples, civil inspections) of existing infrastructure to enable its reuse. This reduces the carbon impact, cost and outage time it takes to replace.

Old air-blast circuit breaker, mounted on existing elevated concrete plinth

New circuit breaker installed on existing elevated plinth

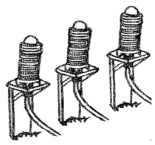
Reducing the global warming potential impact of our assets – ***through different insulating materials***

In order to 'break' the electrical current, our circuit breakers use insulating materials like oil, air, and sulfur-hexafluoride (SF_6). SF_6 has a high global warming potential. In the T1 period at Sellindge 400kV substation we commissioned an insulating gas 'g3' as an alternative to SF_6, **a world first**. This has the potential to reduce the global warming ratio potential from 23,900 to 345 in our equipment (98% improvement). We will investigate further use of this type of technology to decarbonise as we implement our T2 plans.

The Investment Decision Pack(s) related to this category can be found in annexes NGET_ A9.03

Table 9.17 Underground cable investment in the T2 period

Category: Underground cables EOL Risk delta: **11**R£m Long term benefit: **67**LR£m



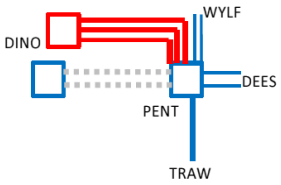
***Key driver*:** In the T2 period, cost increases over T1 levels are mainly driven by investment in cables in London (LPT2). There are also critical and strategic cable projects located in Wales and Sheffield. Underground cables provide crucial 'connections' between our substations, generation and demand. Underground cables were traditionally used where urban development (London and Sheffield) or visual amenity (North Wales) required circuits to be placed underground. This work will mainly be delivered by external contractors.

Dinorwig – Pentir (Ringfenced Project) [redacted]

The Dinorwig–Pentir 1 & 2 cable circuits are critical circuits, they connect the Dinorwig pumped storage power station, which is heavily utilised to balance the national electricity system. The cables were commissioned in 1984, and the asset condition of the circuits is deteriorating. Data from circuit monitoring equipment has shown that due to the way the power station operates, the cables have been subjected to a cycle of thermo-mechanical forces which degrades the cables. This has accelerated the rate of cable degradation beyond that predicted.

The current configuration means that when one circuit is offline for maintenance or a fault, a fault on the second circuit (resulting in loss load of generation) could cause a breach to system frequency levels required under Security and Quality of Supply Standards (SQSS). Dinorwig often represents the single largest loss on the system, so it is necessary for the ESO to hold reserves to mitigate negative effects on the wider system. The cost of holding reserves can be up to £500k per day. Anticipated future changes in the GB Electricity Market are likely to mean that these costs will increase in the future.

The circuits are located on the edge of the Snowdonia National Park, part of the route is a site of special scientific interest (SSSI)



We have engaged with the ESO, our stakeholders and customers on an optimal **whole system** solution, to ensure we deliver the lowest overall cost to consumers. Utilising cost benefit analysis, a 3-circuit offline build provides the lowest overall cost, rather than replacement of the existing 2-circuit configuration. This new configuration (highlighted red in the diagram) minimises expensive system operator constraint costs that would be associated with construction outages in this region.

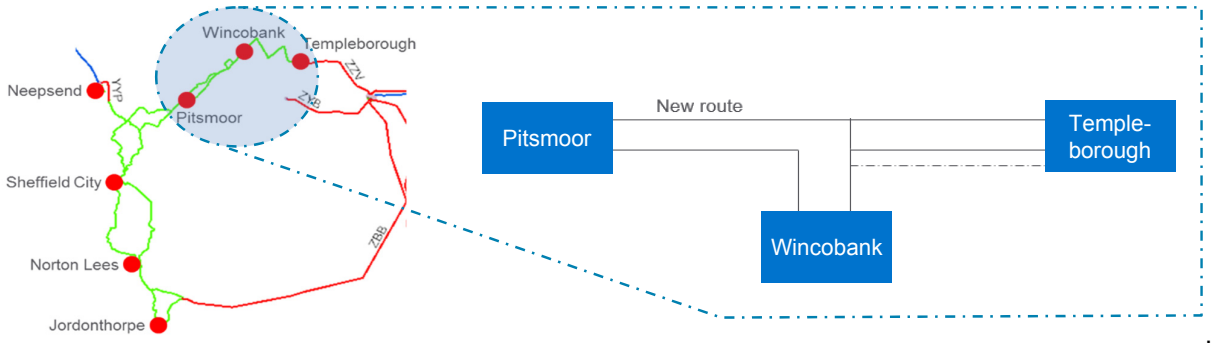
We are **ringfencing** this project to protect consumers from uncertainty. Ringfencing means that this project will not be available for 'risk-trading' in NARM, and so will only deliver a risk benefit if completed.

Sheffield Ring [redacted]

The original strategy in the T1 period for the Sheffield area was based on a like-for-like replacement of the existing 275kV cables. However, as much of the heavy steel industry in the area has closed or has been consolidated, the existing network configuration has been reviewed. We are continuing to undertake system studies and are working with Northern Power Grid (Distribution Network Operator) to consider the most efficient **whole system** solution for the area.

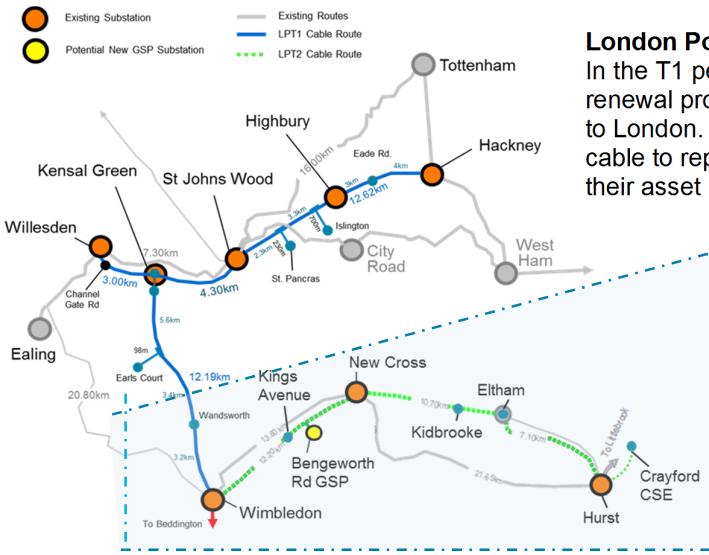
To enable this, a targeted intervention approach has been considered to address the most urgent asset health risk on the existing Sheffield cables. The Pitsmoor–Wincobank–Templeborough cable is prone to oil leaks and sits within a bank of land subject to erosion and subsidence. This subsidence of land puts stresses on the cable outside of its design, accelerating the need to intervene to prevent faults on the network.

Whole system studies have shown that a new circuit configuration could be achieved, at a lower cost to replacement of the existing circuits (-£25m). We are continuing engagement with the DNO in this area to ensure system reconfigurations meet the long-term demand.



Category: Underground cables

London Power Tunnels 2 (Ringfenced Project) [redacted]



London Power Tunnels 1

In the T1 period, we have completed a major cable infrastructure renewal project, critical to maintaining security of electricity supplies to London. The project built new tunnels and installed 192km of cable to replace the existing cables that have reached the end of their asset life.

London Power Tunnels 2

In the T2 period, the second phase of this cable renewal is planned. The aim of the project is to create a secure route for the replacement of high voltage cables connecting 3 substations:

- Circuit 1: Wimbledon to New Cross
- Circuit 2: New Cross to Hurst
- Circuit 3: Hurst to Crayford

The existing LPT2 cable routes form the sole transmission supply to the New Cross and Hurst grid supply points (GSPs) and provide system interconnection between East and West London.

At New Cross, there are existing 132kV and 66kV substations, which supply the distribution network in addition to supplies for Network Rail. Hurst substation feeds Eltham 132kV and Bromley 33kV sites. In order to continue to supply consumers within central and south London, it is essential to maintain connections to these sites. There is insufficient capacity existing within the Distribution Network Owner (DNO) to achieve the connected demand at these sites, as UK Power Networks rely on transmission supplies to meet group demands.

Whole system discussions have taken place with the DNO, to understand future demand predictions on their network. The project team has also consulted on LPT2 with all relevant London and Royal Borough planning teams as well as other key stakeholders including; Greater London Authority (GLA), Environment Agency, Natural England (NE), Transport for London (TfL), Thames Water and landowners. During this engagement, stakeholders have expressed serious concerns about an in-situ replacement due to the level of disruption this would cause to the London road network.

Public consultation and information events took place at six venues in the vicinity of the above ground sites to provide information on LPT2 to members of the public in the local community, Members of Parliament (MPs), local councillors and stakeholders to receive feedback on our proposals.

Cost benefit analysis of all the options has been conducted and consulted on. The chosen option for the route is a new underground tunnel and a new grid supply point to the DNO. This option secures the electricity supply to central and south London through the renewal of the cable network, addressing demand capacity issues and providing diversity of supply at lowest cost. The LPT2 project needs case has been approved by Ofgem in the T1 period and has been through detailed development with delivery starting in the T1 period.

A milestone-based approach has been developed for delivery of this large capital project, using lessons learnt from the successful delivery of LPT1. Further detail of the programme can be found in Investment Delivery Pack annex NGET_A9.19 London Power Tunnels Phase 2.

We are **ringfencing** this project to protect consumers from uncertainty. Ringfencing means that this project will not be available for 'risk-trading' in NARM, and so will only deliver a risk benefit if completed.

The Investment Decision Pack(s) related to this category can be found in annexes NGET_ A9.07, A9.08 & A9.19 This includes justifcation of a number of smaller projects and cross site cables that require replacements as they reach end-of-life, with a total cost of £50m

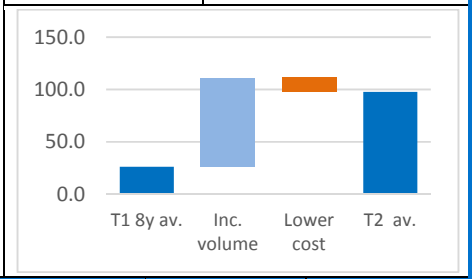
Table 9.18 Protection and control investment in the T2 period

Category: Protection & control

***Key driver*: The volume of protection and control replacements increase in the T2 period. This is due to different technologies reaching their end of life; electro-mechanical protection relays (installed primarily in the 1960s with an expected technical life of 60 years), and first generation computer based protection relays (installed in the 2000s with expected technical life of 15-20 years). This increase in volume requiring intervention continues into the T3 period. 76% of our interventions in T2 are based on refurbishment.**
Protection and control devices are crucial to the safe and reliable operation of the transmission network. They allow for the safe removal of inherent dangers and costly damage associated with faults, including protection for the public and those who work on the network. They also provide safe control, monitoring and operation of equipment both locally and remotely. This work will be delivered by internal and external resources.

Description	Options considered	Volume	% of asset base	Cost £m
Protection Monitors the flows on the network, protecting the transmission system when there is a problem by switching out faulty equipment.	**Replacement** Complete replacement of all associated protection equipment in a cubicle.	[redacted] units	[redacted]	263
	Refurbishment Replacement of only the life limiting protection components, in some instances using an interface between old and new.	[redacted] units		
Control Enables the transmission system to be operated both locally and remotely by control rooms.	**Replacement** Complete replacement of the control asset or substation control equipment.	[redacted] units	[redacted]	214
	Refurbishment Replacement of only the life limiting control components, in some instances using an interface between old and new.	[redacted] units		
Metering Collect data from our assets, for control rooms and for billing purposes.	**Replacement** The nature and cost of this equipment means replacement provides the optimal solution.	[redacted] units	[redacted]	12

Justification summary (A9.14)	Volume	Overall cost
• Increase in volume due to equipment obsolescence driven by modern technological changes to P&C equipment and more equipment coming to the end of their technical asset lives. • A high percentage of refurbishment versus replacement, and alternative methods for replacement ensures these higher volumes are deliverable. • Asset health & criticality has been used to determine volume. • Lower unit costs due to rolling out proven T1 innovation (SPAR). • Considered 5 options and 23 CBAs which cover all the different asset types, the result being a mix of strategies which provides the best long-term risk benefit.	↑ 236%	↑ 218%



Innovation applied to T2 plan	Description	Saving £m
Reducing the cost of replacement – ***through smart interventions*** Our engineers have worked collaboratively with the supply chain, to develop innovative solutions to address the life limiting components of protection and control systems. This has enabled: • replacement of "the brain", retaining associated infrastructure including complex plant wiring • warranty and support periods provided by suppliers, similar to that of replacement sites • less time on site, less resource required, reducing cost • outage times shortened with benefits of reduced system risk and increased system security and reliability.	unit cost reduction < [redacted]	**-66**
	Rolling out smart ways of working into further assets types	**-27** (a forward-looking efficiency)

The Investment Decision Pack(s) related to this category can be found in annexes NGET_A9.15

Table 9.19 Other equipment investment in the T2 period

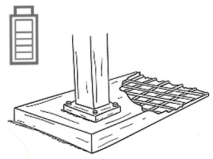
Category: Other equipment		
	***Key driver***: Overall, the volume of equipment requiring intervention to maintain risk in this category increases in the T2 period. The main areas for increased volumes are site supplies, instrument transformers, civils and condition monitoring. This category of equipment includes all the equipment not covered in the previous categories that are needed to ensure a reliable network. They provide crucial support for lead assets, and provide back-up to ensure security of supply and recovery. Work is forecast based on the age, condition information and historic volumes. The work will be delivered by internal and external resources.	
Description	**Investment activity**	**Cost £m**
Condition monitoring Equipment used to assess the health of our assets	We are committed to continually improve our condition monitoring approach, a crucial component of our asset management expertise. Investment in the T2 period will be focused on continuing to grow our current capability and a targeted approach to acquiring new asset performance data by installing integrated condition sensors to our assets. Many of the innovations and costs savings developed in the T1 period, and embedded in our T2 plans, are as a result of investment in condition monitoring. Improving our condition monitoring capability, through a targeted approach in the T2 period, will enable further innovation and consumer savings.	22
Low voltage boards (LVAC), batteries & diesels Provide site supplies and back-up systems	There are two main drivers for investment in the T2 period. Firstly, there is a requirement to ensure compliance with policy on 'back-up' supplies. This includes ensuring sites have fully operational automatic starting/changeover standby generator systems, a fully-rated standby diesel, or an emergency diesel connection point. These assets support the operational resilience of the substation site, in the event the normal incoming supply fails. The second main driver is to replace substation auxiliary systems based on asset health. These assets require interventions during the T2 period to manage the risk to the system and to maintain network reliability.	75
Instrument transformers Measure current & voltage, feeding protection & control devices	Replacement of assets reaching the end of their asset life. In the T2 period, there are more assets reaching end-of-life than in the T1 period. Replacement of these assets are essential to maintain and operate a reliable transmission system. They measure crucial data that feeds and operates our lead assets and our protection and control devices.	63
Civils Supporting infrastructure	The infrastructure on our 346 substation sites is ageing and this is reflected in the condition reported. The health of our substation infrastructure is crucial to ensure our operational assets can perform as designed and protect our staff and the public from the inherent dangers associated with high voltage assets.	84
Plant Status & cable sealing ends	Substation repairs forecast over 150 repairs per annum for plant such as circuit breakers and transformers, plus for emergency repairs required to return assets to service. The activities will reduce the number and duration of reactive, short notice outages arising from deteriorated and unreliable equipment. Cables sealing ends provide a transition from overhead lines to underground cables. The main driver for replacement is asset health condition (individual assets with identified poor condition and asset family issues) where assets are at or beyond anticipated end-of-life.	107
Through wall bushings	Through wall/floor bushings provide a junction for the passage of electricity from internal substation floors and outside of substation buildings.	14
Productive work environment	Main substation sites receiving an appropriate level of refurbishment, in order to improve the working conditions of site staff whilst ensuring compliance with workplace regulations.	15
Spares	Strategic stock holdings; spares purchased and used during emergency replacement activity, usually associated with asset faults.	26
Other equipment	Including portable and free-standing earths and specialist equipment used by field engineers to carry out routines safely.	5
The Investment Decision Pack(s) related to this category can be found in annexes NGET_ A9.05, A9.10, A9.13, A9.14, A9.18, A9.21		

Table 9.20 IT Investment in the T2 period

Category: IT		
	Operational and asset management information systems are essential in enabling us to provide a safe and reliable network. They provide a registry of all of our assets and hold a record of all work undertaken and planned. They also store drawings and documentation and hold geographical information about our current and future planned assets. The transmission network is controlled and switched from the Transmission Network Control Centre (TNCC) using an integrated energy management system. To maintain a safe and reliable operation of the network, it is necessary to replace this aged and shared energy management system with a fit for purpose SCADA system (Supervisory Control and Data Acquisition).	
In the T1 period, we have made significant progress in improving business performance through investments in technology. We have mobilised our field force through investment in work management applications and we have invested in technology platforms that capture and analyse asset performance and condition data, enabling decisions to be made about the health of our assets and overall network risk. **The key driver** for our IT investment in the T2 period is to upgrade and/or replace our core control, work and asset management systems as they reach end of life, whilst at the same time simplifying and rationalising our systems landscape. Our forecast investment on safety and reliability related IT is £177m, which is 85% of our total direct IT investment. This investment is required to ensure that we maintain the capability to deliver capital investment and maintenance activities for our customers in a safe and efficient way. We have commissioned Gartner (an IT consultant) to benchmark our IT costs. In the majority of areas, our costs were below benchmark. Where we were above benchmark, we have reduced our costs.		
Description	**Investment activity**	**T2 cost £m**
Control centre and network management systems	The Integrated Energy Management System (IEMS) is a shared Critical National Infrastructure system with the ESO, which is used to manage and control the electricity transmission system. Investment is planned to separate the system into ESO and Electricity Transmission (ET) specific components. The ESO requires an energy management system, whereas ET requires a SCADA in line with the other Transmission Owners and DNOs. This will benefit customers and stakeholders by; assuring physical separation of ET and ESO data, reducing ET system costs, and creating process efficiencies in the management and control of network access and safety.	■
Asset registry and work management systems	End of life replacement of our asset registry and field force scheduling and mobile working systems. This investment will enable us to implement an industry leading solution and further enhance our ability to develop asset management strategies based on 'monetised risk', delivering benefits to customers through reduced IT system costs and enhanced risk-based maintenance/refurbishment/replacement planning.	■
Condition monitoring and analytics	End of life refresh of our Insights Platform, and extension to cater for an increase in the amount and diversity of data we capture from our assets. This will enable advanced analytics to be used to model the performance and condition of our assets, delivering customer benefits through improved asset intervention planning.	■
Portfolio and plan optimisation capabilities	Development of our portfolio optimisation capabilities and rationalisation of supporting systems to converge on an integrated asset investment planning and optimisation solution. Customer benefits will be realised through lower IT system costs, process efficiencies (through not having to work in multiple systems) and optimised asset intervention decision making.	■
Other asset health driven investments	End-of-life replacement of the following systems: *Network analysis and design* – complex network analysis and modelling for new connections and infrastructure investment decision making. *Project controls* – scheduling, delivery and supplier collaboration capabilities to ensure efficient delivery of our capital projects. *Content management and geo-spatial information* – replacement of secure and auditable drawing and document management systems to safeguard ET, customer and stakeholder intellectual property. Replacement of our geospatial information system and development of 3D capabilities to improve hazard visualisation, risk management and visual amenity.	■
The Investment Decision Pack(s) related to this category can be found in annexes NGET_ A14.10, A14.11 & A14.12		

Projects meeting OFGEM's competition criteria

There are four non-load related projects over £50m which meet OFGEM's initial competition criteria. Due to their non-load nature, these projects are non-separable and only have scope for innovation in delivery. These are therefore not suitable for competition. Further information can be found on the competition criteria in chapter 7 *We will enable the ongoing transition to the energy system of the future.*

Figure 9.21 Contestability assessment and how this has been applied to NLR projects

Project Name	Total Project Costs (£m)	New and Separable	Time criticality	Certainty of need	Scope for innovation	Suitability Assessment Suitability for competition against our criteria Limited suitability ○ ◔ ◑ ◕ ● High suitability
LPT2	xxx	○	○	●	○	Project already in delivery Includes multiple smaller projects (cables, substations, tunnels) Need case approved by OFGEM
Norton-Lees-Pitsmoor Cable	xxx	○	○	◕	◑	Rationalisation of multiple cables Only £2m in T2, rest in T3
Dinorwig–Pentir Cable	xxx	○	○	◕	◑	Joint driver with ESO, could fluctuate Multiple substation, cable & tunnel projects
Substation Site Cables	xx	○	○	◕	◑	Portfolio project covering all our substation cables

6. Our proposed costs for the T2 period

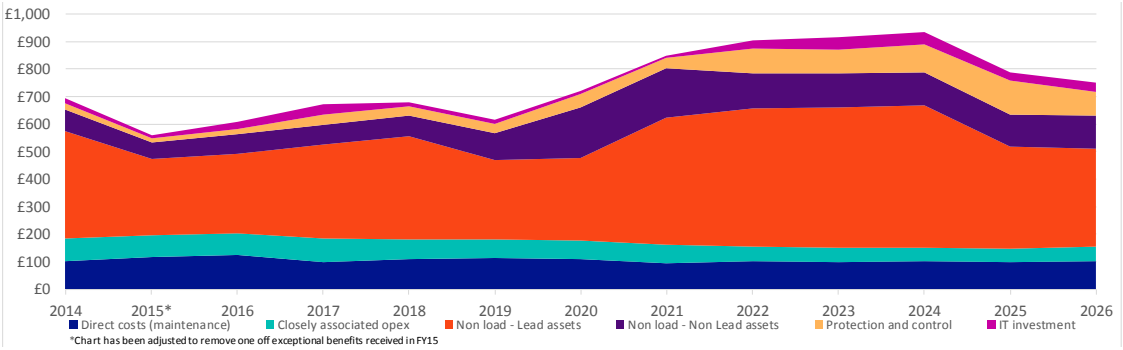
In summary, our proposed costs for delivering against our proposals for the T2 period are detailed in table 9.22 below. Further justification on how these costs have been benchmarked, and how our operational expenditure has been assessed as efficient is detailed in chapter 14 *Our total costs and how we provide value for money.*

Table 9.22 Baseline costs for the T2 period

Baseline cost	21/22	22/23	23/24	24/25	25/26	Total T2	Annual T1	Annual T2	Subject to native competition	Internal historical benchmarks	External benchmarks	Subject to UM
Lead Assets	499	510	515	369	358	**2,251**	340	450	✓	✓	✓	✓ (NARM)
Protection & Control (Non-lead)	88	86	102	124	89	**489**	31	98	✓	✓	✓	
Other (Non-lead)	129	123	120	117	118	**607**	87	121	✓	✓	✓	
Maintenance	103	99	102	98	103	**505**	109	101		✓	✓	
Operational Support	53	52	51	49	49	**254**	75	51		✓		
IT	30	44	42	30	30	**176**	18	35	✓	✓	✓	
Sub Total	902	914	932	787	747	**4,282**	660	856	**Cost certainty: High Confidence**			
						Pension allocation	5					
						Total	4,287					

Business Plan Data Table Reference: Lead asset, P&C, non-lead asset worksheets contained in section C - C2.2a, Maintenance - C2.21-24, Operational Support in section D – D4.5, IT D4.3a

Figure 9.23 Expenditure profile across the T1 and T2 period



The profile of spend to maintain a safe and reliable network relates directly to the volume of work required to maintain asset risk on the network. Sections 4 and 5 in this chapter described how we propose to maintain network risk, in line with what our stakeholders have told us. Due to the nature of our ageing asset base, maintaining the level of risk to the same level as the end of the T1 period results in an overall increase in volume and spend required over the T2 period. The cost impact of this volume of work has been reduced through the innovation, as we are able to deliver the volume at a lower unit cost.

7. How we will manage risk & uncertainty

There are two areas of work which have increased volumes compared to the T1 period, these are OHLs and Protection & Control.

Our planning work has aimed to ensure an even mix of work volumes across each year of the T2 period. This will support the deliverability of the plan from both a resource and a procurement perspective, ensuring that there are no spikes in volumes that might cause a risk to the deliverability of the plan.

We also considered the profile of works in each operational team. Here again, the focus was on ensuring that there is an even volume of works per year for each team, to ensure that teams can be sized appropriately for the duration of the period. We have a flexible delivery model that allows to use contractor resource to mitigate internal resource shortfalls.

Our engineering resources are mobile both zonally and nationally. We have utilised specialist mobile teams to deliver portfolios of work nationally. A new project lead role is being implemented in 2020 which will release ~ 60% of engineering resource time from maintenance activities, thus enabling more resource to deliver capital works. Annex NGET_A16.01 Deliverability includes further detail on how we have ensured these areas are deliverable in the T2 period.

Over the past 25 years, we have learned a significant amount about how our assets deteriorate. This is because during this period many of our assets have transitioned into their end-of-life phase. These decades of data have been used to create our 'Probability of Failure' curves and asset health scores which underpin the justification for our reliability plans in the T2 period. This evidence results in a **low risk of our assets behaving unexpectedly compared to the forecast**. Where assets do behave differently than anticipated, we will adopt Ofgem's framework proposal for managing asset health risk. This framework protects consumers from the risk of higher bills from poor management of asset health.

The types of assets on our transmission network have not changed significantly during the last 25 years, resulting in many years of repeatable work to replace and refurbish our assets. We can therefore have **high confidence in the costs proposed to deliver the required level of reliability in the T2 period**. We also have an externally assured cost estimation process, which uses this historic data to inform our forecasts to give a high confidence in the costs we are proposing.

Following this robust process and using independently assured costs (as outlined in chapter 14 *Our total costs and how we provide value for money*) ensures this is a **high cost confidence** area.

Another factor that may influence the amount of work required to manage network risk in the T2 period is the volume of customer connection related projects. Investment decision packs A8.02 & A8.03 cover this in more detail. If the level of work (required to connect customers) changes from forecast, this may affect how many assets we need to replace as part of maintaining a safe and reliable network. It may also affect how many assets we can work on, as we are constrained by system outages and resources available for all work. The NARM framework prevents networks from benefitting from this uncertainty, by categorising this work separately. Through whole system working with our stakeholders, we will ensure we are flexible in our use of resources and outages to mitigate the impact of changes.

The T1 period was the first RIIO framework which delivered significant benefits to consumers through defining outputs for 'lead' assets, however 'non-lead' areas of work did not have outputs defined, leading to uncertainty about the work which would be delivered. In our submission, we are proposing outputs for all of the work on our assets. In section 4 of this chapter we have proposed new price control deliverables (PCDs) for our non-lead assets to give high confidence of what we will deliver for the investment proposed.

To reduced risk and uncertainty further, and provide further confidence in our plans, we will:

- complete high-quality business plan data tables (BPDTs) each year to provide transparency and make it easier to track and measure our delivery of asset health work
- make sure changes in our asset health activities are managed through a cost benefit analysis process to ensure they provide long term consumer benefit
- ensure consumers are protected by continuing to justify long-term decisions made in managing network risk
- complete high-quality justification reports to provide transparency of the benefits of innovation and reductions in cost of our planned asset health activities
- continue to improve condition monitoring, maintenance and policies to provide long term consumer benefits.
-

These measures provide **high confidence** in the outputs we will deliver, **low risk** of changes and **certainty** of the costs needed to deliver them.