Annex 6.1

NETWORK INVESTMENT STRATEGY

Purpose and scope

Our network investment proposals deliver on our obligations and stakeholder requirements

Our network investment strategy is geared to develop a network that is fit to serve the needs of our region as efficiently as possible.

The nature of the task is such that it has to establish and work out the best way to meet a set of objectives that are independent of each other and, at times, conflicting in nature. Many of those objectives are enduring for a business like ours. As such they have been long-standing considerations we've had to take into account. In contrast, decarbonisation is a fast-changing objective that, although not new, has taken a much more significant place in the mix in recent years.

It is important to recognise that, in general, the decarbonisation agenda adds objectives to our strategic context – it is hard to point to any of the longer-standing priorities that it renders less important in absolute terms. So, we need to respond to the challenge decarbonisation presents in a way that complements our fundamental duty to provide a safe and resilient network, finding alignment between objectives wherever possible.

But it is also important to acknowledge that the decarbonisation objectives cannot be considered in isolation from the others. The challenge is, therefore, to maximise the synergistic benefits to optimise whole life cost efficiency, using flexibility to manage uncertainty and deliverability in the decarbonisation pathways.

Our strategic approach draws together these objectives and the options we have to respond to them. Our overarching aim is to adequately satisfy all of these objectives whilst minimising overall costs for our customers.

In summary, the objectives of our investment strategy are:

- to ensure all the credible pathways to decarbonisation remain open after 2028;
- to maintain a resilient and reliable network, particularly in relation to extreme weather as climate change adaptation becomes increasingly important;
- to contribute to the resilience of the wider system; and
- to adhere to the legal requirements placed upon us by government and regulators.

These objectives drive the main elements of our network investment activities, which are:

- securing customer flexibility services, implementing smart grid solutions and upgrading our existing network to provide sufficient capacity for the demand for electricity in our region;
- replacing and refurbishing our assets when they are no longer fit for purpose, or present an unacceptable safety risk; and
- maintaining compliance with safety and environmental legislation.

This expenditure is essential for delivering continued reliability and security of supply for our customers, and for the continued safety of those working on or near the network.

Many of our investment programmes are enduring activities focused on maintaining asset integrity and also include programmes targeting new risks and emerging requirements.

This document provides details of our overarching network investment strategy for 2023-28 and is underpinned by a series of detailed engineering justification papers (EJPs) that describe the components of our investment plan. Taken together, they provide a comprehensive account of the way that we optimise the development of the network. That process of optimisation is, in our view, the most influential element of the end-to-end process in terms of the overall efficiency of the business. Once those choices are made, there are a number of other important steps in the design to delivery stage that have a bearing on the efficiency. If the wrong choices have been made at the optimisation stage, the prospects of achieving an overall efficient outcome for customers are almost certainly non-existent.

Objectives

Our objectives are independent, differ in scale, can conflict, and the challenge is to find alignment

Our objectives are wide ranging and the majority have been ever present in our considerations when developing the investment strategy for our asset base.

- Those relating to safety and the environment, for example, will always be there, but their importance will vary based on the emerging asset risks or new legislative requirements.

- Likewise, the obligation to provide connections and to economically develop the network has always been there.

However, the drive to electrify heat and transport as part of the UK government legal obligation to achieve net zero has made this transition our most pressing objective, reinforced by recent feedback from our stakeholders. There has been no previous precedent for the scale of ambition being shown and the challenge for our network to respond.

The increased societal emphasis on the use of electricity to decarbonise the wider economy leads to pressure on ensuring that we maintain the resilience of the asset base and improve the reliability of supply for all customers, with particular focus on those experiencing extremes of performance.

Needless to say this has to be accomplished in an affordable manner for our current and future customers, another strong theme that has come out of our stakeholder engagement.

Affordable pathways to net zero

A primary objective of our investment strategy is to ensure we facilitate our region's decarbonisation, whilst maintaining high levels of customer service and keeping costs as low as possible

The government has made a legal commitment to achieve net zero greenhouse gas emissions by 2050. By 2028, the country needs to be well on the way to a fully decarbonised energy system. There is no debate about the fact that electricity distribution networks are a key enabler for decarbonisation.

Stakeholders have told us that they want us to prioritise decarbonisation over other business plan outputs. They have said that we should deliver new net zero pathways as quickly as possible, balancing this against the need to protect against excessive bill increases that negatively impact vulnerable customers. We need to get ahead, and stay ahead, of the curve, allowing our customers to reduce their carbon emissions and maximise the use of low carbon energy.

Responding in an adhoc and reactive manner that results in constraints for customers will impact the level of service they receive as well as the amount of carbon that can be reduced. This could also impact the role customers can play in

offering flexibility to the whole energy system and thereby reducing the overall costs of achieving decarbonisation. We see it as our role to make sure that doesn't happen, but that instead we facilitate the transition to net zero at lowest cost.

That means we need to be efficient in our decision making and delivery in the face of significant uncertainty about the precise nature of the transition. We have guided our work by considering those uncertainties in the form of four key questions about the decarbonisation pathways:

- how electrical;
- how local;
- how flexible; and
- how fast.

Our aim is to create a network investment strategy that is robust and flexible to whichever pathway emerges.

Transitioning to distribution system operation (DSO) is an important enabler in using more granular network monitoring and intelligence on future network requirements. It is worth stating that the DSO transition would be required even if there were no need to pursue decarbonisation. Rather, decarbonisation drives the rate of change required. In technical terms, the DSO processes amount to using a more sophisticated blend of technology and economic tools to optimise the costs and performance of the network. In the context of decarbonisation it becomes orders of magnitude more powerful given the potential to combine the increasingly variable nature of energy supply and demand with the rapid advances in data and digital control technology to bring forward creative solutions to situations that, in previous decades, would have had to be solved by network reinforcement.

There is no doubt that the decarbonisation objectives will require very significant reinforcement. But the DSO processes create the opportunity to optimise those investments – making the most of flexibility in energy use from customers and integrating smart grid solutions into our network operation. These will be important tools in the management of uncertainty. Digitalisation of the lower voltage networks and development of flexibility markets are important in making these changes. This will enable us to respond to:

- alternative and accelerated decarbonisation pathways;
- network impacts of unforeseen localised clustering of customer technology e.g. heat pump deployment on the same street;
- changes in customer behaviour e.g. patterns of electric vehicle (EV) charging; and
- customers contributing to whole system flexibility.

We must take a long-term view to minimise whole life costs for customers. This means maximising the benefit, especially capacity, from traditional network solutions (driven by either asset condition or legislative requirements) in network areas where future load growth will occur out to 2050.

- The risk of wasted investment in the period 2023-28 is very low, as transport and heat must decarbonise by 2050.
- The issue becomes one of deciding when to create the capacity that will ultimately be needed. Getting this judgment right allows us to unlock the synergies that will make our investments affordable over the long-term.

Coordinating with others in the wider energy system development will be increasingly important to minimise the overall customer cost, as well as engaging closely with our stakeholders to keep a constantly evolving view of emerging and changing pathways.

A resilient and reliable network

Maintaining the underlying health of our assets across the network is a fundamental expectation

We need to continue to carefully manage the peaks in the replacement profile of our asset base in relation to the peak installation years that occurred in the 1950s and 1960s. Given that the typical service life of our assets is 50 to 60 years, much of our asset base has reached or is approaching the end of its life. Irrespective of decarbonisation objectives, a major component of our investment program has to address that cycle of renewal.

Our plan for 2015-23 recognised the increasing asset risk associated with these ageing assets and that, in practice over the short-to-medium term, calculated health indicators will fluctuate, to an extent, even for a perfectly serviceable asset base.

We have been focused on this objective for around 20 years, developing long-term plans to keep the asset in good condition and optimise the investment that would be needed. For example, in the first half of the last decade we completed a significant capital investment programme targeted at the most critical assets from those peak installation years, with particular emphasis on higher criticality 132kV and extra high voltage (EHV) assets. That programme delivered substantial improvements in the underlying health of our assets, so we started the 2015-23 period in a strong position. As assets age, the aggregate 'health index' of the network, will inevitably deteriorate slightly. That does not mean that we should be spending money to replace assets just to stop them getting older; what matters is their serviceability – which is a combination of their physical condition, performance and criticality on the network.

Our asset risk forecasts for 2015-23 showed a modest increase in risk relative to the start of the period and this was driven in a large part by our overhead wood pole lines due to their age profile. We recognised that the management of this risk would be an issue for the forthcoming period.

If anything, the importance of these long-term considerations has increased, given that electrical dependency is increasing across all decarbonisation pathways. As such, the basis of our planning is that long-term condition or asset resilience cannot degrade. In other words, saving money now by allowing excessive degradation would be more costly, less efficient, and would adversely impact customer service now and in the future.

The challenge is to manage this investment in a sustainable manner through careful choices with the timing of investment. This is the key competence of an asset management organisation like a distribution network operator (DNO).

The reliability of our network is an important priority for stakeholders and will remain so, especially given the increased reliance on electricity as we decarbonise

We are proud to have delivered significant improvements in reliability for our customers over the course of the last 10 to 15 years, notably a reduction in the number of customer interruptions (CI) by 27 per cent and the length of those interruptions, customer minutes lost (CML), by 37 per cent since we wrote our last regulatory business plan in 2013. The network automation capabilities of our network are behind our peers across the country. Those customers in other regions have bought and paid for those improvements – and our customers have had the benefits that we targeted and that they have paid for. But looking ahead, our customers have made it clear that they place a significant amount of value on reliability. At the same time, our regulator is proposing to set targets for us that require the levels of investment in automation that have been made in other parts of the country.

Simply holding reliability performance constant would save money for our customers in the short-term but would result in our customers falling further behind customers elsewhere in the country at a time when reliability is becoming more important. As this gap increases it will become more difficult and expensive to bridge in the future.

In line with feedback from our stakeholders, we are committing to reduce CI by at least 12 per cent and CML by at least 25 per cent in the 2023-28 period. Our stakeholders also want to see us continue and strengthen our focus on improving performance for customers who experience long duration interruptions or multiple interruptions.

To achieve these objectives we need to install significantly higher volumes of remote switching and network automation on the high voltage networks to match the capabilities of other DNOs so that our customers get the service they deserve.

Network automation will be targeted at our worst performing circuits, thereby improving services for our customers that receive lower than average service levels.

The need for more reliable local low voltage networks will increase due to the electrification of the transport and heat sectors. People will be relying on power for heat, light, cooking and personal mobility. This means improvements through conventional and innovative technology are an important part of our plan.

Wider considerations

Compliance with the legal requirements for health and safety - including our duty of care to both our staff and the public - is not optional…

Compliance with health and safety law is monitored and enforced by the Health & Safety Executive (HSE).

We need to respond to Electricity Safety, Quality and Continuity Regulations (ESQCR) compliance risks as they emerge from our inspection processes.

The discharging of our ESQCR obligations to inspect, maintain, and replace cables in multiple occupancy buildings has become more prominent following the Grenfell tragedy. Through enhanced cooperation with local authorities, we will continue our 2015-23 programme for assessing and replacing these assets with redesigned and more standardised connection arrangements.

… and neither is minimising the environmental impact of our assets

We also have to ensure we comply with environmental legislation. There are more than 50 separate requirements that apply specifically to our operations and which drive and shape how we manage our environment.

Reducing the oil loss from our assets remains the primary environmental objective and most pressing risk.

We have made strong progress, through our fluid-filled cable replacement programmes, in removing risk from our network. However, we still have more fluid-filled cable and more oil in service than most other DNOs.

New obligations on the removal of equipment containing polychlorinated biphenyls (PCBs) came into force on 1 July 2020. The revised regulations mean we must now remove all PCB contaminated equipment from our network by 31 December 2025.

Our stakeholders expect us to set an example in our own carbon footprint reduction

Our objective is to run net zero operations in our business. This has been covered in our environmental action plan section of the plan (decarbonising the network).[1]

In terms of the carbon footprint of the power network itself, some significant factors make that a very different challenge. For example, some level of electrical losses are an unavoidable consequence of running an electricity network because of the physical processes at work in the materials that make up the conducting path that carries the electrical energy.

1. See also annex 4.4 environmental action plan

In addition, some of our equipment uses sulphur hexafluoride (SF_6) gas, which is one of the more powerful greenhouse gases. We work hard to control leaks – but we can never guarantee zero leakage – and there is an amount of embedded carbon in any of the infrastructure we build.

If that infrastructure is enabling the reduction of much higher carbon intensity energy choices (such as the electrification of transport), or those losses on the network are created by zero carbon energy, then in net terms the nation's overall carbon footprint would be lower. In reality, the absolute level of distribution network losses is likely to *increase* as the energy system decarbonises. It is important that our stakeholders understand that this is part of a successful transition to net zero.[2]

Clearly however, we would seek to keep the carbon footprint of the network as low as possible, and in particular to put downward pressure on electrical losses. The way that we design and operate the distribution network impacts the level of electrical losses produced, and as the system moves towards a world in which we maximise local generation, there is a benefit to the overall reduction in energy system losses.

As we develop our plans, we have factored in choices that make use of lower loss solutions that helps to mitigate the increases in network utilisation that we expect to see, and although the use of SF_6 gas is important as an insulator for effective operation of our assets, minimising its usage and targeting leakage will contribute to a reduction in our carbon footprint.

Embedded carbon in our network assets needs to be accounted for, in line with our regulator's (Ofgem) requirements, and effective action in reducing this can only be done in partnership with the supply chain. We will work with others to assess the embedded carbon in our investment projects.

Electricity networks need to be resilient to increasing extreme weather events

In line with Department for Environment, Food and Rural Affairs (Defra) requirements, as a critical national infrastructure provider we produce climate change adaptation reports covering the range of risks and associated mitigations we have.

We use long-term predictions from The Meteorological Office (Met Office) (UKCP18) to understand climate change pathways, predict network impacts, and inform our climate resilience strategy. Our decisions are guided by a number of factors, which include:

- Reacting to changing weather patterns and driving resilience improvements from current performance may not be appropriate for assets that typically have lives in excess of 45 years.
- National standards for flood mitigation drive our flood defence programme and we have responded in the current period to feedback from stakeholders that this is a priority area where they want us to go further.
- National resilience standards drive our management regime for vegetation that impacts our overhead lines.
- Network faults driven by ash tree die-back present an emerging threat.

2. See annex 4.5 losses strategy

We have a role to play in the overall resilience of the electricity system and are working in conjunction with the electricity system operator (ESO) to improve network resilience

The minimum standard of systems resilience is achieved through our compliance with the industry technical codes, such as Grid Code. Where necessary this involves investment in necessary system defence measures such as low frequency load disconnection equipment.

This is a changing environment due to the increase in intermittent generation and societal dependency on electricity. Changes to industry codes take time in response to learning from national system wide events like August 2019 and routine resilience exercises. Therefore, there is an opportunity to be proactive in addressing the learning from the August 2019 national power outage event and implement enhancements in how we manage and recover from system wide disturbances.

Investment Approach

We have a strong track record in managing different investment priorities and delivering synergies between them

We have been successfully managing our asset base through use of asset management principles to intervene at the right time and at the right location. The framework we use for investment planning and delivery is a key component of our overall asset management system, and we believe is one of the main reasons why our total costs benchmark consistently amongst the top DNO groups for totex efficiency in the sector.[3]

Our Asset Management approach achieved BSI PAS55 accreditation in 2008. In 2015 this was superseded when we achieved accreditation against the more modern ISO55000 standard. Each year we are assessed to ensure compliance with the standard's specifications.

We collaborate with our peer companies in our wider group, sharing best practice on asset management processes and systems. This is one aspect of continuing to refine and improve our planning processes because they are at the very core of what we do. Recent initiatives that are particularly relevant to this plan are:

- Development of our load forecasting model and distribution forecast energy scenarios (DFES) which is at the heart of our network development scenario planning.
- Expansion of our asset risk indices and asset portfolio scenario modelling which aids in asset planning.
- Adoption of new asset condition monitoring techniques.

Figure 1 shows our investment planning process which has two main stages to produce a finalised and authorised plan.

3. See annex 6.2 our costs in detail

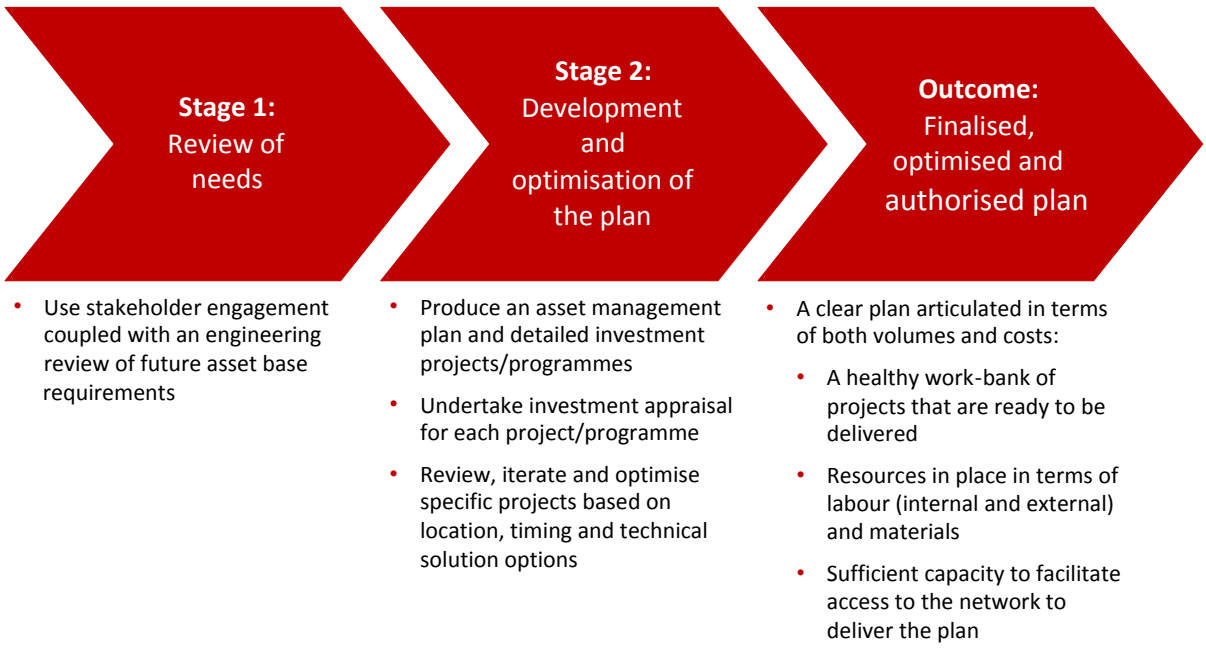

Figure 1: Stages of network investment planning process

Stage 1: Review of needs

Our initial review of our investment needs indicates that decarbonisation presents a step increase in the level of risk exposure

The review of needs is driven by the stakeholder engagement process, coupled with an asset serviceability review (ASR). The ASR is an engineering review that provides an insight into the condition and performance of the electricity distribution network, along with an assessment of any resultant risks that affect our ability to deliver the expected outputs.

Our engineering review, a discrete bottom up analysis of the risks posed by our network and its constituent assets, considers:

- Network risk review: The network impact of DFES and other potential pathways for decarbonisation covering Climate Change Committee (CCC) scenarios and emerging government policy, including development of flexibility markets and the likelihood of future capacity requirements.
    - The review seeks to identify locations where there is a risk that forecast demands exceed the capacity of the substations or circuits, which could cause faults or result in non-compliance with security of supply standards. We take time-stamped demand profiles from our supervisory control and data acquisition (SCADA) system for EHV and 132kV systems and combine demand and time data to give a risk based assessment of capacity sufficiency. The change in demand at these individual sites is produced from our 'load forecasting' model developed in conjunction with Element Energy. Annex 4.1 'scenarios and investment planning' describes this process and input assumptions in detail. Our optioneering considers customer flexibility, smart grid solutions and network reinforcement.
    - We also identify high voltage (HV) and low voltage (LV) reinforcement requirements through techno-economic modelling combined with analysis of network loading and forecast future scenarios of low carbon technologies (LCT) growth.
    - Our fault level review is underpinned by analytical assessments of our present network fault levels and the risk that they represent to network operation.
- Asset risk review: Each individual asset class is assessed to identify its present and forecast condition and performance. This brings together information from multiple data sources covering analytical assessments, condition and performance data sets (e.g. inspection and maintenance data), reliability data analysis, and more subjective, but equally important, operational experience gathering via workshops.
    - Our regulator's network asset risk metrics (NARMS), which give an indication of the underlying health of our assets and associated risk of the likelihood of future capacity requirements, are a key input into this information gathering review stage.
- Reliability analysis: extensive fault performance analysis and benchmarking covering the different voltage levels, asset classes and geographic areas. The review uses data on root causes of faults and their impacts on customer metrics such as CI or CML. This aims to identify parts of the network where underperformance is occurring and how it is forecast to change. Combined with stakeholder analysis this informs our reliability improvement plans.
- New legislation or emerging risks: involving scanning the external environment to identify any emerging issues that may impact the performance of our asset base or influence the outputs that we need to deliver for customer needs or legislative requirements. This also involves consideration of new markets such as flexibility provision and deployment of new customer technologies.

In general, the results of this review set the practical thresholds for tolerable risk on our network. The assessments provide a set of clear benchmarks that we use to challenge and judge potential expenditures. They inform potential

changes to the investment plan, changes to engineering policy, the development of risk management plans, or business process improvements. We therefore collect and update this information on an ongoing basis as part of our asset management policies.

The review that led into this business planning round did highlight a number of relatively detailed changes, which is normal whenever we update our view.

Stage 2: Development and optimisation of the plan

Our plan is output orientated, rather than driven by engineering inputs

The review of needs feeds into the development and optimisation of the plan. The plan is founded on the risks that are being addressed, rather than on activities that are carried out. Investment proposals are linked to the required outputs and for each proposal we consider options to create the required outcome, seeking to produce benefit across multiple outputs where we can.

The plan is constructed in stages (figure 2): first is the production of an asset management plan; second is the production of detailed investment projects and programmes[4] within that plan; and third is authorisation of the plan as a whole.

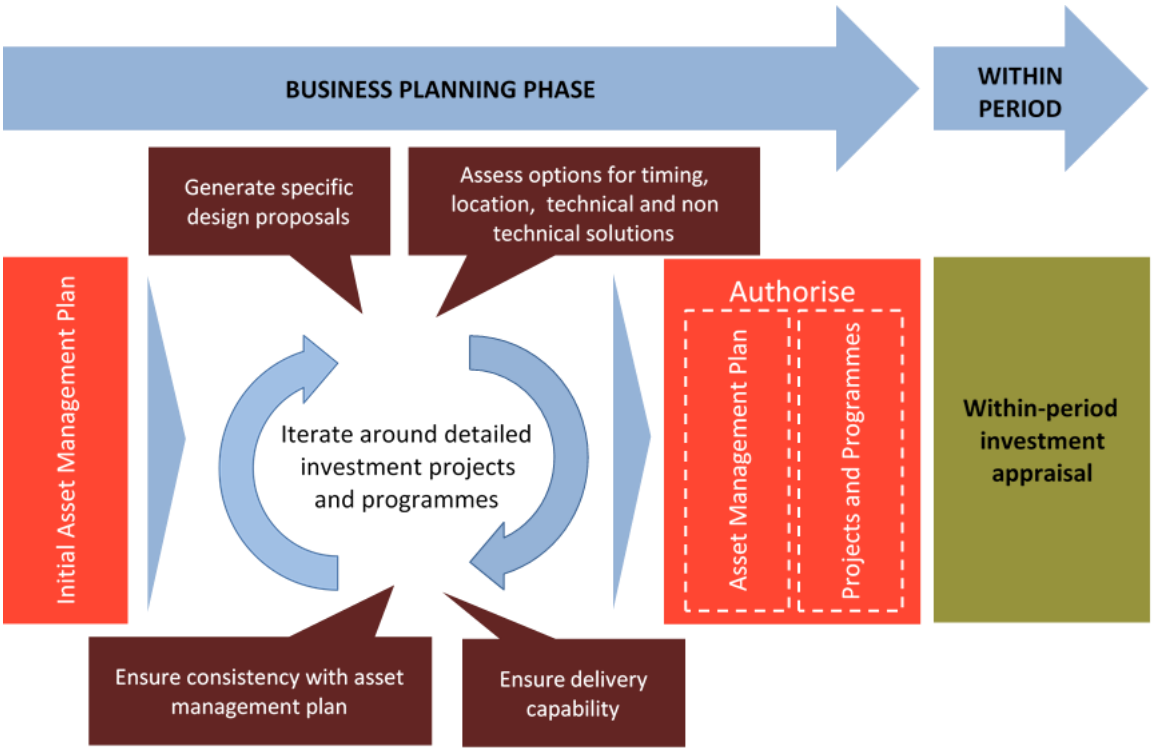

Figure 2: Phases of network investment plan development

The overall investment plan consists of a series of major projects and work programmes. Work programmes are collections of low value projects that all address the same business risks and benefits and deploy the same functional solutions. For example, work programme 76 identifies the risks associated with the indoor distribution substation population and projects costs based on the unit costs of solutions such as the renewal of individual substation components or full substation replacement. The investment appraisal sets out formal 'selection criteria' so that the operational delivery teams can select the best assets to replace and prioritise them so that they are consistent with the quantified benefits set out in the investment appraisal.

[4] Investment programmes consist of groups of small projects such as the replacement of wooden poles for overhead lines, whereas a major substation rebuilding investment would be classed as a specific project.

By contrast major projects are one-off, higher value pieces of work, for example the renewal of a 33kV to 11kV substation. These require a bespoke analysis of the business risks being addressed, an individual design and a site-specific cost/benefit assessment that includes a thorough evaluation of a range of alternative options and scenarios to identify the optimum solution.

Importantly, this part of our process creates a situation where the plan is founded on risks that are being addressed, rather than on activities that are carried out, i.e. the starting point of the plan is fundamentally output oriented, rather than driven by the engineering inputs. This allows us to take a more strategic view, where the proposed solutions are clearly mapped to the outcome that we are seeking to create. This means that we are able to allocate capital investment more effectively across the asset base and form an early view of what activity will be required to deliver the required outputs in the medium-term.

As a result, although we don't yet know every detail of every project that we will carry out in the 2023-28 period, we already have quite a clear view of the work that we expect to have to do.

All of these proposed investments are mapped to specific risk reductions or performance improvements that we have identified as being consistent with the outputs that we are committing to deliver for our customers.

The EJPs produced for our regulator, as part of this business plan submission, provide an explanation of the major categories of investment and the options we considered in their development. They have been built using the approach we adopt for our routine investment appraisal documents.

Producing the asset management plan allows us to develop plans to manage risks to long-term performance

In the asset management plan we develop a preliminary view of the level of investment we need, based on the review of needs described above and other factors, including:

- assessment of future customer and market developments driven by potential decarbonisation pathways;
- requirements of our owners above and beyond simple legal compliance with their priorities and goals, particularly in relation to ethical behaviour and environmental respect;
- regulatory obligations, including an assessment of potential regulatory changes; and
- other statutory requirements, including an assessment of recent and proposed changes.

Taking these elements in the round, we can understand any gaps that might exist, which allows us to develop plans that deliver the required set of outputs and manage any material risks to long-term performance.

For each investment proposal contained in the asset management plan, we consider the interactions between the wide range of drivers influencing work on the specific asset or network area (figure 3).

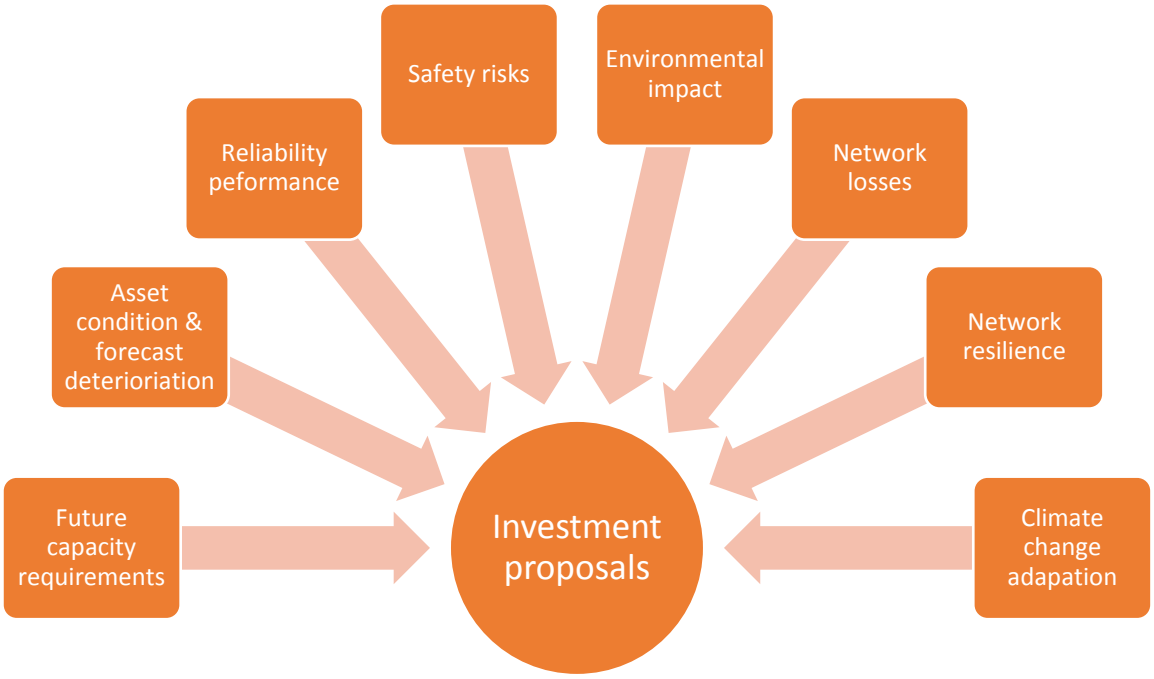

Figure 3: Key drivers considered for investment proposals

Decarbonisation is a key driver and it underpins several of the inputs into the decision making process about the nature of planned interventions.

- It emphasises the need to exploit synergies between investment drivers, increase low cost monitoring, utilise advanced data analytics, and adopt innovative flexible solutions.

- Planning for both net zero and asset resilience should be symbiotic. This optimising for synergies results in a plan that de-risks the decarbonisation pathways whilst making the network more resilient.

Alternatively, we could continue to plan the network with crude assessments of load growth. The output would be to lay our required capacity driven reinforcement on top of the investment for asset resilience and other drivers.

- This could easily result in us becoming a barrier to net zero, requiring immediate investment to remove constraints and catch up.

- It would also fail to capture synergies with asset resilience and other drivers that would increase costs for customers.

For each project we optimise for the best timing, location, synergies, and technical options

In the second stage we perform a detailed investment appraisal for each of the projects and programmes identified within the asset management plan. We will undertake specific design for each of the projects and produce a generic functional specification for each of the programmes. At this stage detailed optimisation occurs, which we believe is central to the delivery of our efficient long-term total cost outcomes.

The optimisation process considers the different engineering options that exist to create the required outcome. In the case of an asset that is in need of renewal, we compare refurbishment, full replacement, and removal with the feasibility of changing the maintenance regime to keep the asset in serviceable condition. The decision comes down to the cost of each option and how long each solution can be expected to last before more intervention is likely to be required. For some assets future network loading adds another layer of complexity into this decision. In most cases, we find that the most realistic choices lie between refurbishing and replacing the asset. We make the decision by analysing the root causes, likelihood, and consequence of failure and comparing the financial, performance, and longevity implications of each intervention.

In creating our investment plan, we have taken into account the requirement to reduce electrical losses, wherever it is prudent to do so, including across the wider electricity system. Our losses strategy is to minimise losses through the selection of equipment and installation designs across the full range of our engineering activity. We are not bringing forward work programmes in this plan solely to target losses reduction since we do not believe it is justified by the cost/benefit analysis we have undertaken.

We are optioneering our network reinforcement plans in a similar manner. We use information on the loading and performance of our assets to identify those that require some form of intervention over the planning period across the range of credible decarbonisation pathways. The plans then need to be optimised for timing and the solution. Timing is driven by the trigger levels, which relate to the point at which the demand would exceed the asset's capability.

Identifying the optimal intervention includes: consideration of demand transfer between parts of the network; commercial flexibility arrangements for existing or new customers to reduce network demand; network flexibility using inherent capacity in the existing assets that can be exploited using a smart grid type solution; and upgrading the capacity of existing assets or constructing new electricity in-feeds for the network. There is no 'one size fits all' solution and, for every potential electrical constraint, our engineers look at that part of network to identify the best solution. Where flexibility solutions are cost-effective in providing additional capacity and/or are optimal for managing uncertainty in demand growth these will be used. We do know that relative to a number of the other network companies in our sector, we have a track record of finding ways to delay reinforcement work, rather than invest heavily before demand materialises. Our approach is in the customer interest – it keeps costs down at a total level, and it means we do not over invest or 'gold plate' in expectation of demand which may never arise.

In constructing our asset replacement and reinforcement plans we look to identify work in the same part of the network that might be initiated for different reasons and that would benefit, in cost and delivery risk, from being delivered together. This step of identifying synergies, has been an important aspect of our decision making process for many years as it has the potential to deliver significant capital efficiencies for our customers before a plan has even been authorised. Examples of these include:

- Poor condition assets in a network area that requires an upgrade in capacity where new assets will be larger capacity units.
- Installation of flood defences for a site with assets in a poor condition where the flood risk would be minimised in the design of new assets.
- Several assets in poor condition at a substation site where it would be more appropriate to do a complete substation replacement.
- Poor condition assets in a network area with limited fault level headroom where it would be more appropriate to install a different specification of asset at a small additional cost thereby providing capacity for future generation connections.

Finally, when we put all the pieces of our plan together, we look for opportunities to combine work on the same part of the network to minimise site set up costs and disruption to customers during the work.

Once authorised, our plan evolves to ensure that our activities remain optimal

The investment plan is a rolling 10 year view of investment and operating cost requirements, and the associated benefits expected from the investment. It is reviewed every year with our shareholders and then formally adopted by our board.

The approved plan then forms the basis of resource planning, supplier contracts, our forecast requirements for financing, and regulatory submissions in respect of our investment and outputs.

Over time, more information is revealed about the health and performance of our assets, and plans must therefore constantly evolve to ensure our activities remain optimal. The plan is updated and authorised annually by a cross-

business team in the light of the changing requirements of our customers, our asset base, and the environment we work in to ensure our response remains current and correct. This review serves two distinct purposes:

- it confirms that the basic principles and objectives of the investment plan remain relevant or proposes changes in the event that they do not; and

- it updates the view of expected volumes of work needed to meet the agreed principles and objectives.

Importantly, this process does not authorise any financial expenditure. Financial expenditure is not approved until each project has been designed in detail and any necessary contracts are in place for delivery. Only then are we able to confirm whether the solution can be delivered within the targeted expenditure – and it is at this point that we make the decision to approve the expenditure.

This process allows us to maintain a clear understanding of our intended expenditure and the benefits that will accrue from it, and to handle both delivery risk and uncertainty in the investment drivers effectively. In our experience, it minimises wasteful expenditure when we commit to it only as close as possible to the point when it is needed.

By withholding approval until the investment decision shows that it is necessary, deliverable, and consistent with the overall plan, we build an extra degree of flexibility and optionality into the plan, which further increases efficiency over the long-term.

We plan to deliver 'two for one' on the synergistic benefits from investment

Our plan is based upon making efficient investment decisions that deliver synergies across our obligations; we will target investment such that we achieve multiple benefits wherever possible.

Finding synergistic benefits across asset investments is key to cost effectively delivering on net zero while managing asset risks to within acceptable levels.

The use of new and existing forms of data analytics to help target investment whilst adopting innovative solutions is fundamental to this challenge.

This is the only way to manage the asset base, otherwise costs will be excessive and unacceptable for customers.

Investment Strategy Options

Affordable pathways to net zero

We need an investment strategy that can adapt to all the potential decarbonisation pathways

We have assessed the impact of a range of credible pathways for decarbonisation over 2023-28, and out to 2050, using our DFES process and obtaining feedback from our regional stakeholders. This has included scenarios based on the government's CCC's Sixth carbon budget.

These scenarios range from high electrification in the heat and transport sectors to other possible states of the world where alternatives to natural gas such as hydrogen are expected to play a greater role.

We have not selected the slowest credible decarbonisation timeline as our planning assumption since this does not align with our stakeholder priorities and would mean we risk becoming a barrier to our customers' decarbonisation aspirations.

We have not selected the system transformation pathway as our planning assumption due to the present uncertainties with hydrogen development and evolving government policy on energy efficiency and electrification of heat.

There is commonality across the pathways over 2023-28 with greater divergence after that.

We have identified a planning scenario that aligns with our stakeholder feedback and the most recent government aspirations to reach net zero, whilst:

- Keeping open all future credible pathways open, to ensure we are not an obstacle to any decarbonisation pathway.
- Is within the range of our regulator's reference scenarios from future energy scenarios (FES) and CCC.
- Aligns with the UK government's Ten Point Plan:
  - 2030 ban of new petrol and diesel cars and vans;
  - 600,000 heat pump installations per year by 2028, considering prioritisation of heat pump deployment in off-gas areas and new homes;
  - growth in low carbon hydrogen; and
  - improvements in domestic and industrial energy efficiency measures.
- Is in line with stakeholder feedback on being an enabler for regional progress with decarbonisation.

We will use a flexibility first approach that means wherever it is possible and cost-effective, we will prioritise investment in activities to facilitate and optimise customer and network flexibility ahead of more costly traditional reinforcement. All routes to decarbonisation require significant investment in our network; taking a flexibility first approach is a means to ensuring that this investment is targeted where our network needs it most and delivered efficiently to maximise value for customers. Our approach can be summarised (figure 4) as:

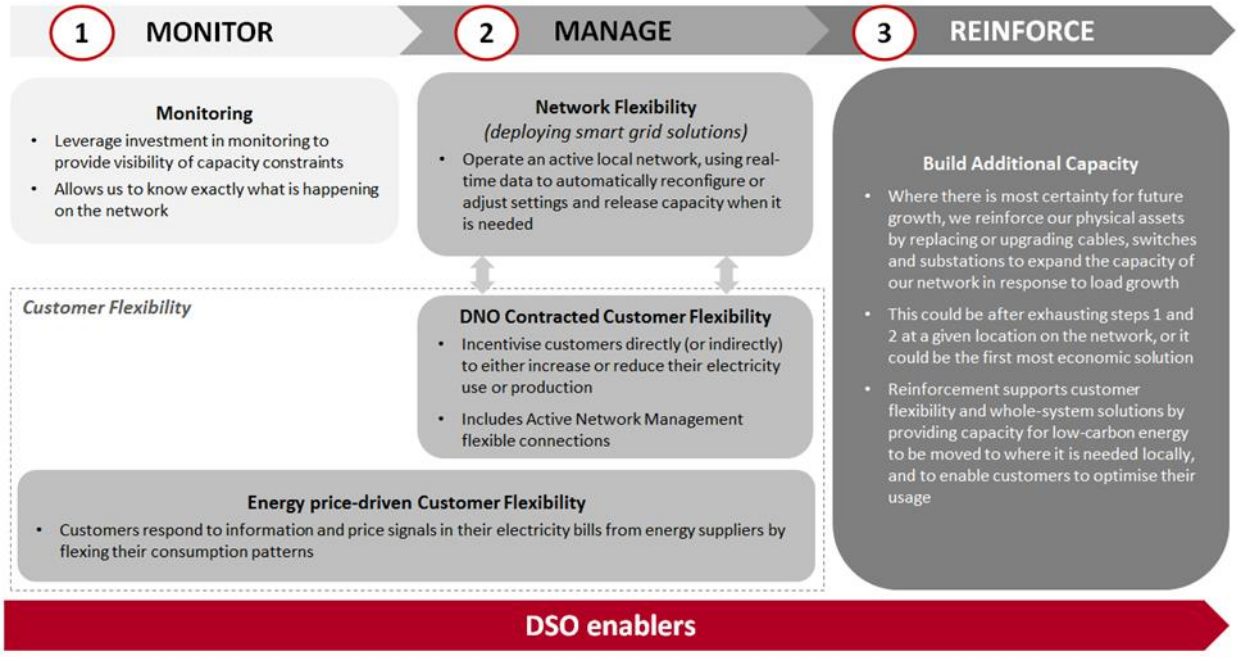

Figure 4: Our flexibility first approach

We will assess high-value EHV projects for need across multiple pathways to minimise asset stranding risk.

The LV infrastructure has a very high probability of requiring additional capacity regardless of the pathway, providing customers the infrastructure necessary to maximise use of low carbon energy and delivering short-term losses benefits, so the risk of stranded assets is very low. The application of increased digitalisation and monitoring helps to ensure this is the case.

An increase in network reinforcement investment contributes towards the management of asset resilience risk helping to mitigate overall cost increases and provides asset health synergy for 'free' savings in asset resilience costs in 2023-28.

Flexibility

We must make use of flexibility to manage uncertainty and ensure we can get the best value out of our existing network

Flexibility will manifest itself in different forms and we need to be ready to harness them all.

- Price driven customer flexibility, where customers respond to price signals in their energy tariffs to flex their energy assumptions.
- DNO contracted customer flexibility services, where customers contract with us to modify their demand or generation.
- DNO contracted customer flexible connections, where customers accept a cheaper and faster connection that can be curtailed at peak times.
- Network flexibility, where we use smart grid solutions to operate the network more actively to use inherent existing capacity through reconfiguration or optimisation.

We cannot ignore the potential changes in customer behaviour in response to time of use tariffs set by other energy market participants or their adoption of smart technology to aid their management of existing and new forms of energy use.

- This could mitigate future peak demands on the network and provide a £113m reduction in reinforcement costs in the 2023-28 period alone.
- The more powerful nature of these price signals could also lead to localised network constraints and we will need to manage this risk through the use of network monitoring.

Our investment strategy is to use a flexibility first approach to defer network reinforcement whenever the customers are available to provide a service.

- Flexibility at the local level will be aggregated alongside larger user flexibility to enable reinforcement deferral at 23 per cent of major substations saving £12m.
- We will provide network data and information to simulate the development of localised flexibility markets.

We will use smart grid technology on the network to maximise capability of existing assets and provide data to manage load uncertainty.

- Smart solutions will be used as an alternative to traditional reinforcement saving £64m. This will involve using:
    - new control technology to use network transfer capacity and manage voltages;
    - fault level management techniques and fault current limiters;

- releasing enhanced asset capacity based on network data; and
- active cooling of distribution equipment to increase asset capacity.

– Building on our 2015-23 smart grid enablers programme using local network (LV) visibility enhancements in conjunction with data analytics will ensure that investment needs are identified and prioritised.

A resilient and reliable network

The condition and performance of the asset base needs to be managed with the aim of maximising the potential capacity benefits for decarbonisation

We have considered a range of potential scenarios for asset resilience and these are detailed in appendix 1. These were contained within six options which ranged from minimum cost solutions, which allowed us to maintain compliance with legal obligations, through to the delivery of all initiatives across all plan output areas.

We will accept a modest increase in short-term risk but with an aim of reducing long-term risk recognising increasing electrical dependence in society.

The adoption of a pure age-based replacement approach would lead to significant cost increases across the period compared to 2015-23 and is not a serious option we would pursue.

Optimising asset replacement investment to maintain a stable level of asset risk over 2023-28 would increase costs by compared to the 2015-23 period but deliver minimal levels of additional capacity benefit.

Whereas targeting asset replacement, at areas of the network which may experience capacity constraints out to 2050 and at the highest priority asset risks that provide no capacity benefit, would increase costs compared to 2015-23. This delivers acceptable levels of asset resilience and with half the investment providing future capacity benefit for decarbonisation.

We will defer asset replacement where there is uncertainty in future network capacity requirements and we are able to manage the risk of ageing assets through enhanced inspections or monitoring combined with asset life extension techniques.

Where we do need to replace assets, we will factor in the capacity and performance requirements for them so that the solution is net zero ready. This results in £396m of synergistic benefits post the 2023-28 period compared to the alternative approach of replacing assets on a like for like basis and then upgrading them in future.

Assets that need to be replaced in 2023-28 due to their condition and risk of failure create future option value in the capacity that they provide regardless of whether we can be certain at this stage of the increased demand for additional capacity.

Network capacity will be increased by installing upsized assets where increased capacity can be provided at low incremental cost and modifying our approach to favour replacement rather than refurbishment in areas predicted to experience future load growth. This will provide mitigation for uncertainties in decarbonisation pathway and flexibility market development.

The use of additional condition monitoring and increased inspections will allow us to achieve further asset life extension. This is on those parts of the asset base where we need to manage an increase in asset risk due to an ageing population and where we have opportunities to push interventions out to align with future capacity needs.

We believe that this approach aligns with the top three priorities for stakeholders in the asset resilience area:

- Reducing the risk or probability of equipment failure on our network through increased replacement and refurbishment, to improve long-term network performance.

- Using technology to monitor equipment, including in real time, so issues can be identified quickly and prioritised according to need.

- Proactively installing equipment that is ready for a low carbon future, and which won't need to be replaced again before 2050, to accelerate decarbonisation whilst also providing marginal improvements in losses.

Network reliability improvements will be delivered through technology deployment and targeted network improvements

Current network performance is a latent product of historical decisions, particularly in the late 1960s and early 1970s, and consequently a step change in the number of faults that our customers experience cannot be affected by investment decisions in the short or medium-term. Good examples of this type of asset are our population of consac and aluminium waveform LV cables.

Long-term management of asset fault rates is accomplished through our asset resilience programmes. Meanwhile incremental improvements to network topology are made as we bring network areas up to present design standards through target reliability improvement programmes and synergies with other investment drivers.

What we can control in the short-term is how we respond to faults and that is done through the use of network technology or operational response.

Increasing the volume of field operatives available 24/7 to undertake switching operations in the event of a potential fault is an inefficient investment once their utilisation reduces. It is also predicated on the operatives being in the vicinity of the fault to ensure timely restoration of supplies, which again, compared to the use of technology, is inefficient.

The key is to have a baseline level of efficient field force response supplemented by an intelligent and remotely operable network.

We will deliver reliability improvements through investment in network automation and network upgrades targeting our worst served customers.

- Use of network automation also provides the future ability to intelligently manage demand and optimise network operating losses.

- We will hold fault rates consistent across most of our asset categories and we will use further condition monitoring technology to minimise asset interventions.

- We will use ground-breaking pre-fault detection and data analytics to better target LV cable replacement and manage long-term replacement costs.

Wider considerations

Our core asset integrity programmes - supplemented by targeted compliance activities – will deliver a safe network

Underlying asset inspection, maintenance and replacement programmes are driven by ESQCR compliance. These are not optional in nature and represent a required baseline of activity for compliance.

The frequency of inspection and maintenance activity are driven by an assessment of the underlying failure modes and consequences of asset failure. The intervals are optimised and we aim to maximise the asset condition information when we do intervene.

Asset replacement selection will continue to be influenced by safety criteria such as operational restrictions and the presence of asbestos.

Overhead line foot patrols and the use of LiDAR inspections has identified a significant programme of overhead line clearance activity, compared to the 2015-23 period. Similar work programmes are being undertaken in other DNOs driven by cyclic nature of inspections.

- There are opportunities for improvements to domestic premises' service connections to mitigate potential decarbonisation barriers, especially with uptake of heat pumps in off-gas areas and areas with looped services.

Post-smart metering rollout, there is a new ESQCR driven requirement for inspection of high risk service cut-outs. Smart metering data will be used to identify potentially overloaded cut-out arrangements in addition to those where the physical location presents a high risk.

Our interventions will cost-effectively maintain present levels of environmental protection whilst addressing new obligations

Stakeholders have expressed the view that protection of the environment is important to them and expected as almost a hygiene factor to be addressed without any significant cost increase.

Not replacing any poorly performing fluid filled cable would not be in line with our stakeholder priorities and would present an unacceptable level of environmental prosecution risk.

There is choice in the level of fluid filled cable replacement. Although we could continue at the levels of the 2015-23 cable replacement, improved oil loss management through use of innovative perfluorocarbon (PF) tagging can be delivered allowing a reduction in fluid filled cable investment compared to the 2015-23 period. Self-healing cable technology may also provide enduring benefits here depending on the success of innovation trials.

This would permit investment to be targeted at the replacement of assets containing unacceptable levels of PCB by 2025. The investment targeted at transformers will also provide asset health and capacity benefits.

Other environmental programmes targeting undergrounding in areas of natural beauty (AONB) and noise reduction will continue at 2015-23 levels.

We will achieve network carbon footprint reductions through asset replacement and upgrading work

Whilst some losses are unavoidable, losses do represent a significant cost and carbon impact. We are obliged to manage and reduce network losses as part of our investment decision making. Our approach is to seek to optimise whole system losses whilst facilitating net zero. What this means in practice is allowing distribution network losses to increase where necessary when connecting more LCT and allowing customers to maximise their use of the network. Carbon savings are delivered from the decarbonisation of other sectors, such as transport or heating, or by reduction in transmission losses due to the more localised nature of generation.

The use of oversized assets aids in losses management, providing whole system benefits as well as capacity benefit for connection of more LCT. This is demonstrated in our asset resilience programmes delivering future capacity for decarbonisation. This also allows customers unconstrained access to low carbon energy markets with associated value for customers.

A shift to lower loss transformers, including the use of amorphous core transformer technology, also helps.

In line with CCC recommendations, we will target the replacement of the worst leaking SF_6 gas filled equipment rather than full scale early life replacement of this equipment.

We will also use alternative insulating mediums to SF_6, which will be evaluated on a project by project basis as new innovative equipment is brought to market by manufacturers.

Our network is vulnerable to the impacts of climate change and we will continue to deliver our programmes for flood defences and vegetation management to mitigate these risks

We are working to understand a broad range of climate change risks, as per our adaptation strategy, out of which we prioritise flooding and vegetation management.

Since 2007 we have been implementing a programme of flood defences at our major substation sites across our network in line with this being a top stakeholder priority. By 2023 we will have delivered flood mitigation works at 211 at risk sites, ensuring that all of our major substations are compliant with ETR 138.

We are ahead of other DNOs in both volumes delivered and investment levels in the 2015-23 period. All works associated with fluvial, pluvial and coastal flooding at major sites considered at risk and all at risk sites with more than 10,000 customers will have been addressed by 2023.

Our flood defences have been constructed in line with Met Office and Environment Agency (EA) climate change forecasts. The level of defence at each site includes allowances for the forecast over the lifetime of the substation.

As all at risk sites are now compliant with ETR 138, we will build further resilience through our asset replacement and reinforcement programmes. We will look to relocate assets away from flood plains where appropriate, increase the network interconnection and add automation at exposed sites.

We will work with other agencies on more localised flood defence measures in order to contribute to and enhance the broader regional adaptation plans.

We will expand our climate change adaption vegetation management to use innovative LiDAR technology to help manage the risks of ash die-back and accelerated growing patterns. This will enable us to better target the programme, making more efficient use of our resources to ensure that we get the maximum benefit.

Elsewhere we will take the opportunity to improve resilience further through consideration of climate change projections for the lifespan of our assets during our asset replacement and reinforcement schemes to increase the resilience of overhead line circuits to severe weather including wind, rain, and lightning.

We will seek to incrementally improve resilience to widespread network interruptions and disturbances

Investment in resilience measures for low probability high consequence events can be viewed as optional in nature. However, these types of events do occur and, in an evolving electricity system, there is the potential for them to occur more frequently.

These investments provide incremental outputs compared to 2015-23.

We will require a replacement of our emergency voice communication system due to removal of existing Airwave service.

In addition, we will create additional resilience in operational telecommunications system including use of portable microware links that can be deployed during an emergency event.

Following learning from the August 2019 event, we will proactively target the replacement and re-specification of low frequency demand disconnection. This will improve system resilience and allow greater granularity in the disconnection of customers during a low frequency event.

TECHNICAL PANEL ASSURANCE

We have set up an independent technical panel of experts to provide scrutiny and quality assurance of the analysis that underpins our investment plan

The objective of the panel is to act as a critical friend and provide a level of impartial scrutiny and quality assurance of the analysis carried out by Northern Powergrid as part of 2023-28 business planning activity. This includes, but is not limited to, the choice and application of modelling methodologies employed, the inputs to that analysis and the outputs and conclusions of that analysis.

The panel have tested how robust and fit for purpose the investment planning process is, ensuring that our plan is suitably balanced in terms of risk between company and consumer and in terms of the needs of current and future customers.

To enable this objective the panel has had the freedom to question us on any part of the operational cost base, but with a particular focus on condition/performance based replacement/refurbishment, reliability, resilience, environmental, innovation, and network utilisation.

The panel has been examining and discussing the EJPs that support the business plan. They have been on the journey with us from the initial development of the investment strategy and engineering analysis into the finalised documents being presented as part of the plan.

The scope of the panel was a cross-cutting review ensuring that the net zero predictions are core to our investment decisions regardless of the initial driver to intervene (e.g. condition, performance, safety etc.). The panel has tested the assumptions on use of customer flexibility, smart grid solutions, conventional solutions and smart grid enablers used to deliver a 'net zero ready' network for the least possible cost.

The panel has also assessed the innovation strategy and digitalisation plan, as being important enablers of the net zero transition.

The panel was formed from independent, diverse, and technically expert members drawing on individuals from across both industry and academia. The key route for accessing the relevant technical expertise required was to use Supergen Energy Networks Hub and Innovate UK's Catapult Networks. These organisations bring together the vibrant and diverse energy networks community (industrial and academic) to gain a deeper understanding of the interactions and inter-dependencies of energy networks. This permitted recruitment targets at four principal technical disciplines; digital, climatology, whole systems, and electrical engineering.

The panel is chaired by our non-executive board director Professor Phil Taylor and is made up of five other members whose areas of expertise span multiple technical disciplines.

The panel was established in June 2020 and members met with us on at least a monthly basis from then until plan submission. Activity will continue after submission of the draft business plan and the panel will use specialist engineering consultants to provide further scrutiny of individual investment proposals before final submission.

The panel's role in supporting and assuring business plan development has enabled them to provide opinion, alongside this plan submission, on the extent to which the plan is:

- ambitious: demonstrates a clear vision of the organisational goals with evidence of an aspiration to stretch the boundaries in areas;
- robust: analysis is accurate and conclusions well justified;
- resilient: suitable consideration of the impact of uncertainty has been sufficiently given;

- safe: suitable consideration of public and operational safety and legal compliance has been made;
- forward-looking: decisions are made with future customers and utilisation in mind;
- innovative: evidence exists of the adoption of innovative solutions in business as usual; and
- progressive: there is a progressive approach to continual improvement in both techniques and technologies.

The panel has published a letter to our board setting out its independent opinion on the 2023-28 business plan (for the draft submission see the technical panel report) and by 19 November 2021 (for the final submission) that contains:

- its collective opinion on the technical aspects of the 2023-28 business plan;
- the coverage of its opinion, based on the work programme of items that have been reviewed;
- the methods undertaken to form its views; and
- a record of the key challenges made during the course of the work programme, the actions they have taken to address comments, and any changes made as a result.

Appendix 1: asset plan optioneering for non-load related investment

Six primary options or scenarios (table 1) were considered during the development of the non-load related element of our investment plan, the costs shown here exclude the impact of real price effects.

Scenario		2023-28 cost p.a. (£m)		
		Total	Variance to 2015-23	
2015-23 reference case		£152.8m	£0.0m	0%
Scenario 1	Minimum cost solutions to maintain compliance with legal obligations	£117.5m	-£35.3m	-23%
Scenario 2	Mitigate the most significant asset risks with targeted capacity increases	£168.6m	£15.8m	10%
Scenario 3	Target investments that maintain stable asset risk profiles	£205.0m	£52.2m	34%
Scenario 4	Target investments that deliver net zero capacity benefits as well as maintain stable asset risk profiles	£200.5m	£47.7m	31%
Scenario 5	Accelerated programme of asset replacement to deliver net zero capacity benefits early	£233.0m	£80.2m	53%
Scenario 6	Deliver all initiatives across all plan output areas	£304.5m	£151.7m	99%

Table 1: Scenarios for non-load related investment

- Scenario one: minimum cost – sets the bottom end of the range and represents the minimum cost solutions to maintain compliance with our legal obligations as a five year commitment (i.e. investment constrained to these levels for 2023-28 only).

- Scenario two: highest risk initiatives only – through a set of investment initiatives targeted at our highest risks, we assembled a suite of priority investment initiatives that we could manage within an overall envelope expenditure broadly equivalent the 2015-23 expenditure of £152.8m p.a. (after the application of synergies). Risks would increase in some areas, however, a reasonable proportion of the investments we make would deliver capacity benefit that we expect to be required over the planning period to 2050.

- Scenario three: stable risk – offered a very specific set of investment initiatives targeted at the core asset risks on our network. The investments were characterised by shorter-term investment solutions with relatively smaller amounts of investment in longer-term network solutions compared to other scenarios.

- Scenario four: targeted investments – offered a longer-term approach to managing the risks that have been identified whilst targeting upgrades of the network where they are most needed.

- Scenario five: accelerated net zero investments – offered a programme of asset replacement that maximises the capacity benefit and future functionality.

- Scenario six: all initiatives – showed the upper end of the optioneering range and quantified the costs required to deliver a step change in network resilience whilst maintaining our asset resilience across all asset classes delivering all current ambitions in our customer outcome sections.

Costs split by capacity assumption

The levels of synergy between decarbonisation and asset resilience were assessed by comparing the candidates for asset replacement against the assets in network areas that are forecast to have capacity constraints in the 2023-28 period and beyond. This was done initially using our planning scenario as per the decarbonisation section of the plan.[5] The result of this process and assessment is presented in table 2 and figure 5.

- Green costs represent those assets that require replacement for both capacity and condition drivers during 2023-28.
- Amber costs represent those assets that require condition-based replacement in 2023-28 and would also have a capacity constrained in the period 2029-39 based on our best view forecast.
- Yellow costs represent those assets that require condition-based replacement in 2023-28 and would also have a capacity constrained in the period 2040-50 based on our best view forecast.
- Grey costs represent those assets that require condition-based replacement in 2023-28, that may in the future become capacity constrained but there is uncertainty as to where and when this may occur. There is option value in this incremental capacity for this uncertainty, in addition to benefits from reduced losses in that network component over the short to medium-term.
- Red costs represent those assets that require condition-based replacement in 2023-28 from which no decarbonisation benefit can be reasonably obtained.

Depending on the decarbonisation pathway that we follow these capacity requirements may occur sooner and even potentially in the 2023-28 period depending on the aggressiveness of the electrification pathway or localised clustering effects.

5. See also annex A4.1 'scenarios and investment planning'

Scenario	Total cost split by capacity assumption £m (% of total cost)					2023-28 cost p.a. (£m) 2020-21 prices				
		Delivers capacity benefit				excl. Decarb synergy		incl. Decarb synergy		
	No capacity benefit	2023-28	2029-2039	2040-2050	Option value	Total	Variance to 2015-23	Decarb cost synergy (% of decarb plan)	Total	Variance to 2015-23
2015-23 Reference case	£107.0m	£3.1m	£4.6m	£7.6m	£30.6m	£152.8m	£0.0m	-£6.8m	£128.8m	-£6.8m
	70%	2%	3%	5%	20%		0%	-10%		-5%
1 – Minimum cost	£69.8m	£4.7m	£12.3m	£9.8m	£20.8m	£117.5m	-£35.3m	-£4.7m	£112.8m	-£40.0m
	59%	4%	10%	8%	18%		-23%	-5%		-26%
2 – Highest risk initiatives only	£101.5m	£8.6m	£17.3m	£12.6m	£28.6m	£168.6m	£15.8m	-£8.6m	£160.0m	£7.2m
	60%	5%	10%	7%	17%		10%	-10%		5%
3 – Stable risk	£115.2m	£9.5m	£22.1m	£17.6m	£40.6m	£205.0m	£52.2m	-£9.5m	£195.5m	£43m
	56%	5%	11%	9%	20%		34%	-11%		28%
4 – Targeted investments	£87.3m	£24.8m	£24.9m	£24.0m	£39.4m	£200.5m	£47.7m	-£24.8m	£175.7m	£22.9m
	44%	12%	12%	12%	20%		31%	-28%		15%
5 – Net zero early	£93.8m	£31.1m	£30.3m	£28.6m	£49.2m	£233.0m	£80.2m	-£31.1m	£201.9m	£49.1m
	31%	10%	10%	9%	16%		53%	-35%		32%
6 – All initiatives	£140.1m	£32.8m	£38.0m	£28.2m	£65.4m	£304.5m	£151.7m	-£32.8m	£271.7m	£118.9m
	46%	11%	12%	9%	21%		99%	-36%		78%

Recommended

Table 2: 2023-28 high-level scenarios considered showing decarbonisation capacity synergies

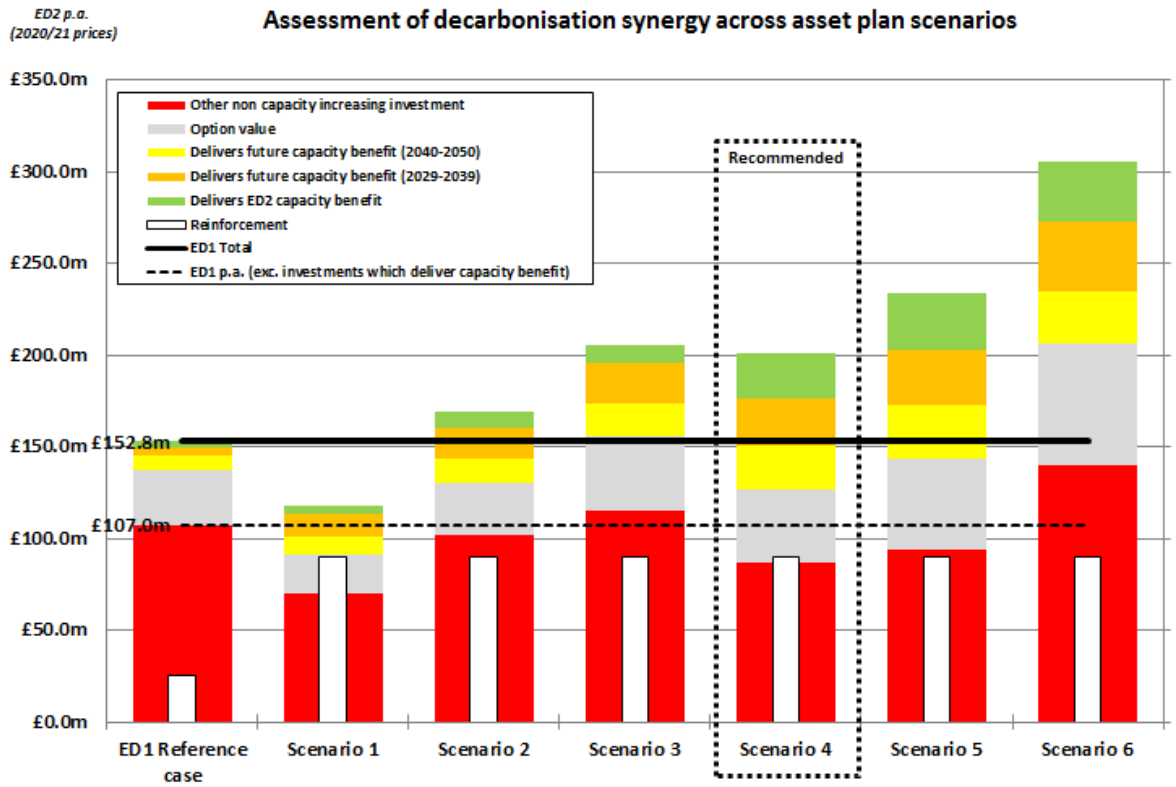

Figure 5: assessment of decarbonisation synergy across asset plan scenarios

Output Measures – Ofgem NARMs assessment

The distribution network is characterised by the significant investment throughout the late 1950s to the 1970s in infrastructure that was installed originally to provide typical assets lives of around 60 years, particularly in relation to substation plant and overhead lines.

This began to manifest itself as a risk during 2010-15 as high populations of assets were degrading into the highest risk bands at similar times.

Our modelling shows that we continue to be on an upward trajectory with increasing numbers of assets degrading into the highest risk bands throughout the 2023-28 period. This is illustrated in the risk projections in figure 6 and figure 7 below:

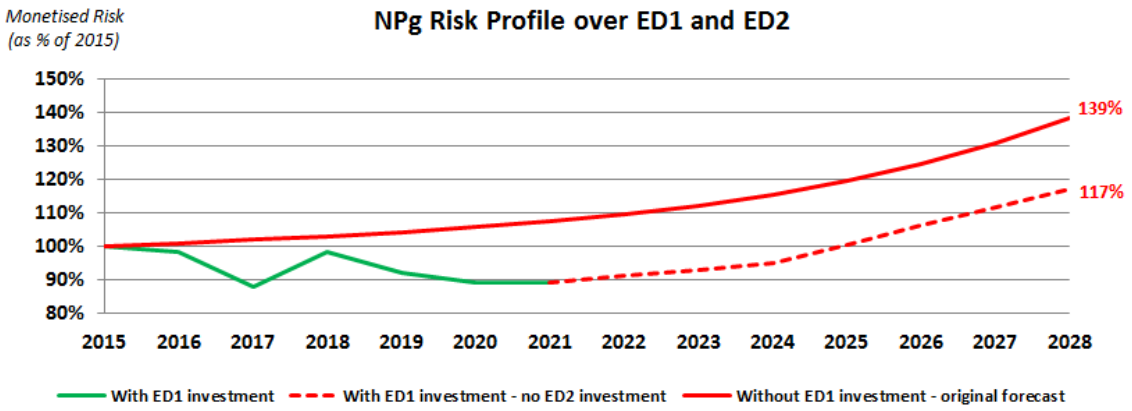

Figure 6: Risk profile over 2015-23 and 2023-28 periods

Our forecasts at the start of the 2015-23 period indicated an increase in overall network risk of 39% over the period 2015-2028.

Although our risk profiles have been relatively volatile during 2015-23 as a consequence of emerging risks on our network, we are on track to reduce our risk profile by approximately seven per cent by the end of the period by:

- prioritising investment in our highest risk assets, for example LV poles in residential areas, fluid filled cables near water courses and legacy LV boards;
- prioritising investment in our worst condition assets by targeting assets with the highest probability of failure as a consequence of observed or measured condition data, or performance data;
- increasing the use of asset refurbishment to ensure we could address a wider range of assets, albeit delivering shorter-term benefits than traditional asset replacement solutions; and
- establishing other enhanced risk mitigation measures such as more frequent and/or comprehensive asset inspections.

Allowing for our 2015-23 investment programmes to conclude, and without further investment in the 2023-28 period, we project risk will increase by 17 per cent by 2028, relative to 2015.

This consequential increase in asset lives across most asset categories has resulted in approximately 20 per cent of the network exceeding what has traditionally been accepted as their ‘normal expected life’.

As an example, Figure 7 shows the age and health index (HI) profile for LV and HV wood poles.

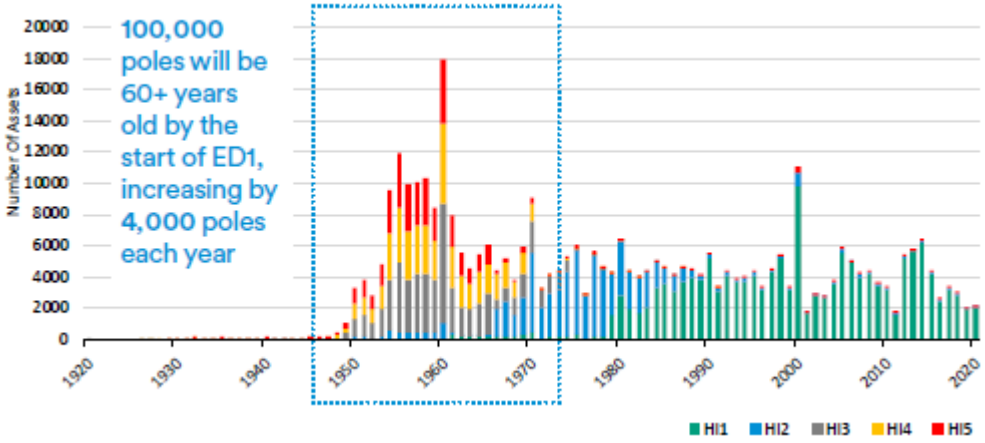

Figure 7: Age and health index profile for LV and HV wood poles

In order to address the particular risks in each underlying plan area (e.g. cables) we have developed a range of investment initiatives including repair on failure, enhanced monitoring, mid-life refurbishment and full asset replacement, as appropriate to the asset under consideration. When combined these solutions form the overall asset plan scenarios discussed at the start of this appendix.

Based on the different characteristics of each scenario, the longer-term risk projections demonstrate the quite different outputs that we would expect from each scenario (figure 8).

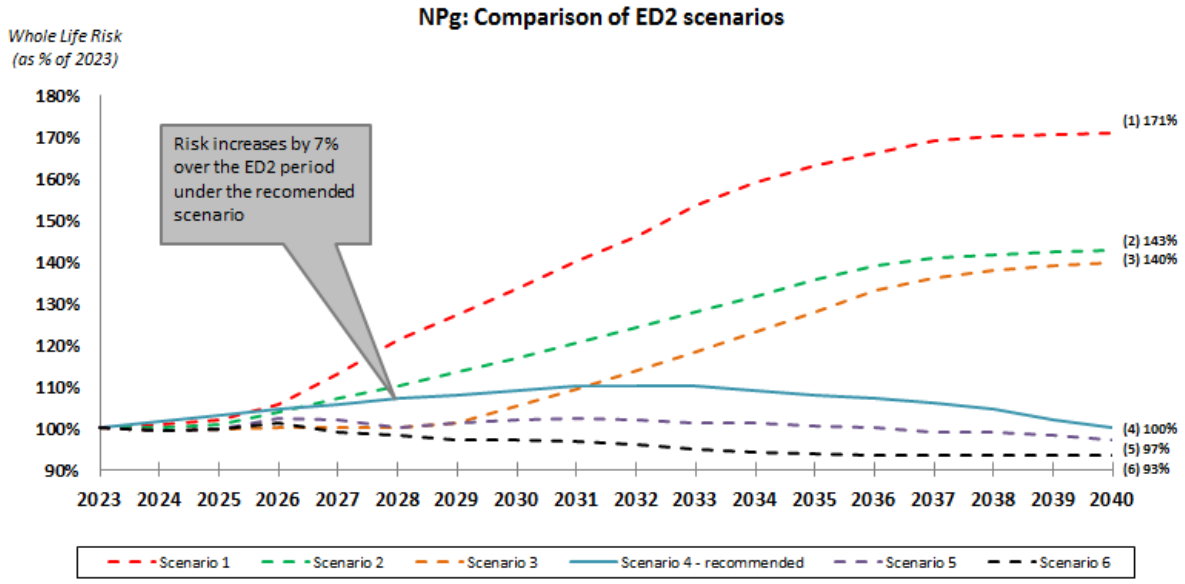

Figure 8: Comparison of whole life risk over time until 2040

Scenarios one and two are characterised as leading to increases in risk in both the short and longer term.

Scenario three has a very specific risk objective which is to manage risk to as low as practicable level within the 2023-28 period and is delivered through a mixture of targeted asset replacement and refurbishment schemes with limited investment in longer-term asset resilience or general network upgrade solutions.

Scenarios four, five and six offer a longer-term approach to managing the risks that have been identified whilst targeting upgrades of the network where they are most needed. The scenarios can be largely discriminated by the different risk

profiles in the shorter-term period (2023-28 and 2028-33) which is largely proportionate to the amount of overall investment incurred under each as figure 9 illustrates.

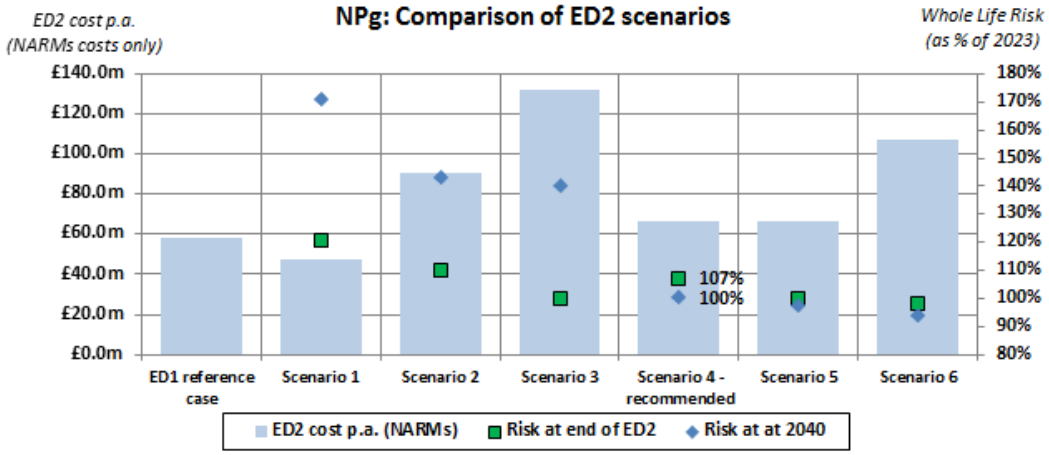

Figure 9: Comparison of whole life risk and costs at 2028 and 2040

Scenario four (our recommended scenario) offers a measured increase in short term risk (+ seven per cent over the 2023-28 period) to allow investments to be prioritised in activities that contribute to both asset risk and decarbonisation over the longer-term.

At the more granular plan level, our optioneering optimises our investment programmes across areas with quite different risk profiles in terms of absolute levels of risk, our projections for how this will change over the period, and available to us as summarised in table 3.

Asset group	Whole life risk at the start of 2013-28 in £s	Whole life risk as a % of asset group at the start of 2023-28			Cost of NARMs interventions	EJP reference
		End of 2023-28 (without intervention)	2023-28 Risk movement delivered through NARM interventions	End of 2023-28 (with intervention)		
Wood poles	£1,603m	130%	(28%)	102%	£114m	**EJP-4.1a, 4.1b 4.2**
Tower lines	£107m	128%	(21%)	108%	£16m	**EJP-4.3**
EHV and 132kV cables	£399m	128%	(15%)	112%	£33m	**EJP-1.3**
Distribution substations – plant	£237m	136%	(31%)	106%	£76m	**EJP-1.6, 2.1**
Major substations – plant	£767m	135%	(20%)	116%	£93m	**EJP-3.1a, 3.1b**
Total	**£3,114m**	**131%**	**(24%)**	**107%**	**£332m**	

Table 3: Scenario 4 broken down by asset area

Wood poles represent our most significant area of risk in absolute terms (over 51 per cent of total network risk) and we forecast an increase of 30 per cent during the 2023-28 period. Much of our population was installed during the peak investment period of the 1950s to 1970s which we expect to degrade to the point that intervention is required during the next period. We have identified opportunities to optimise our investment programmes across all overhead line work activity such that overall risk in this area is maintained to levels equivalent to our 2023 position.

We will continue to manage our tower population through mid-life refurbishments to ensure that these assets do not degrade beyond the point that refurbishment becomes uneconomic. Half of the tower line conductor population will move beyond the normal expected asset life which results in the forecast increase in this area of eight per cent. This is our early indicator that the population is reaching end of life and we will be increasing replacement of tower line conductors in the period (relative to 2015-23) ahead of a more substantial programme of replacement in 2028-33 and beyond. Risk will be further mitigated through intrusive assessments such as conductor sampling during the 2023-28 period.

We are forecasting a 12 per cent increase in risk within our EHV and 132kV cables asset group during the next period. Our 2023-28 proposals will see a large reduction in investment in the replacement of fluid-filled cable with investment priorities judged to be higher in other areas. The 12 per cent risk increase is mitigated by the use of PFT to better manage fluid loss, managing the key risk impact and allowing an overall cost reduction in this area compared with 2015-23.

We are also forecasting an increase in risk associated with distribution substations. Similar to wood poles, a high proportion of the asset base was installed in the 1950s to 1970s and will exceed its normal life expectancy during the 2023-28 period. High volumes of plant assets will therefore degrade into the highest risk bands (HI4-5) during 2023-28. In our optioneering (which considers risks within and across asset groups) we considered the investment required to manage risk to the 2015-23 levels by targeting individual assets for replacement. However, given the projected uptake in the connection of LCTs, demand on the distribution network is likely to increase significantly over the next and future periods. This will increase the emphasis on carrying out work that delivers network improvements as well as managing the underlying asset risk. Therefore, we are targeting investment in full substation replacements where network utilisation is forecast to be the greatest at the expense of a moderate increase over the 2023-28 period.

We are proposing to manage a moderate risk increase of 16 per cent for the plant at our major substation sites such that we can prioritise investment in assets where network utilisation is highest and the need for reinforcement more certain across decarbonisation pathways. The risk profile is characterised by a significantly higher number of assets in the HI4 band for which we have additional mitigation in place by way of targeted mid-life refurbishments and enhanced monitoring. The overall population of our highest risk assets (HI5 assets) will be managed to 2015-23 levels through targeted replacements.