



Appendix 14: Climate resilience strategy

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Purpose and Structure

Our Climate Resilience strategy describes how we plan to adapt to the impacts of climate change now and in the future. It describes a holistic systems-based framework, a key principle within our strategy to identify climate change adaptation risks and develop mitigating solutions.

We have described in detail the climate resilience risks identified, how we are responding to these in the short, medium, and long term through our RIIO-ED2 costed proposals supported by engagement with the Energy Networks Association (ENA) working group to deliver long term value for our customers and the environment. In addition, we have described our adaptation pathway and the customer benefit of our proposed mitigations.

This document has been set out against the following key areas:

- Executive summary
- Introduction to the sector specific challenges
- Our track record in delivering climate resilience programmes
- Our overall approach and framework
- Climate change hazards
- The risks and mitigations
- Our adaptation pathway and action plan

In recognition that our response to climate change is two-fold, we have developed this strategy in alignment with our Environmental Action Plan. This document focuses only on climate change adaptation (resilience to the impacts of climate change), whilst climate change mitigation such as our plans to decarbonise our operations are covered in Our Environmental Action Plan (Appendix16).

1 Executive Summary

The global challenge and the role we play

Globally, we face an increasing climate change challenge; greenhouse gas emissions are driving up temperatures, increasing the intensity of extreme weather events and changing our physical environment. These changes put the reliable supply of electricity to our customers at risk by reducing or disrupting network and operational performance. Impacts can already be seen today as the risk of flooding to our substations becomes a greater threat with increased rainfall during the winter months and extreme storm events during the summer. As a result, we need to protect our assets whilst enabling the transition to Net Zero to prevent the worsening of these climate change hazards. Given the uncertainty around future climatic changes, our approach needs to be flexible and collaborative to accommodate changing risks and customer and stakeholder priorities, today and into the future. To achieve this, we have developed our Climate Change Adaptation Strategy, built around gaining an improved understanding of both the risks and the opportunities by applying a whole system approach to climate change resilience within our business, see Figure 1 below:

Figure 1 – Our approach to climate change adaptation



Successful collaboration and stakeholder engagement

To develop our strategy, we have engaged with a variety of stakeholders both within and external to the business. Our continued engagement with the Energy Networks Association (ENA) has allowed us to collaboratively identify, assess, and prioritise the climate change hazards with other energy network operators in both electricity and gas. A report on these findings is submitted to the DEFRA¹ Adaptation Committee every five years. We also work with other industries such as water and telecoms to understand interdependencies and opportunities for collaboration to help mitigate against climate change risks.

Additionally, recognising the strong feeling amongst the public that climate change is now a global crisis, we used our core customer engagement programme to test our proposed response to the most significant climate change risk to our network - flooding. As a direct result of this engagement, we have chosen to accelerate our compliance, and indeed to go beyond the industry flooding standard, ETR138, offering enhanced protection to our customers supplied by at risk grid and primary substations.

¹ Department for Environment, Food & Rural Affairs

Delivering climate change resilience

We have improved our climate change adaptation strategy from RIIO-ED1 by including best practice from the National Infrastructure Commission approach to resilience published in 2020² and the UK Cabinet Office 4R's of resilience³.

Redundancy, Response & Recovery, Resistance and Reliability. The results of our whole system approach are summarised below:

1. Climate Change Hazards: we track and monitor climate change hazards as they become known through the latest modelling.

The climate change hazards have been determined from the latest UK Climate Projections (UKCP18) with the highest-level emissions scenario, Representative Concentration Pathway (RCP) 8.5. Of these hazards, eight have been prioritised through our work with the ENA as posing the greatest risk to our business in the future:

- | | |
|---|---|
| 1. <i>Extreme high temperatures</i> | 5. <i>Sea level rise</i> |
| 2. <i>Drought cycles</i> | 6. <i>Wetter conditions coincident with warmer temperatures and/or strong winds</i> |
| 3. <i>Prolonged/heavy rainfall</i> | 7. <i>Wildfire</i> |
| 4. <i>Intense short-duration rainfall</i> | 8. <i>Lightning</i> |

2. Identify Impacts on Our Business: We assess the priority climate change hazards across our business to determine risks.

In our latest assessment with the ENA working group and the Met Office, we have reviewed the eight climate change hazards mentioned above against our physical network systems and identified 15 priority asset-related risks (up one from our last review in 2014). The identified risks across our physical network systems are summarised below:

- AR1 Temperature: Overhead line conductors affected by temperature rise
- AR2 Drought: Overhead line structures affected by summer drought and consequent ground movement
- AR3 Wetter conditions: Overhead lines affected by interference from vegetation due to prolonged growing season
- AR4 Temperature: Underground cable systems affected by increase in ground temperature
- AR5 Drought: Underground cable systems affected by summer drought and consequential ground movement
- AR6 Temperature / Drought: Substation and network earthing systems adversely affected by summer heat and drought conditions
- AR7 Temperature: Transformers affected by temperature rise
- AR8 Temperature: Transformers affected by urban heat islands and coincident air conditioning demand leading to overloading in summer months
- AR9 Temperature: Switchgear affected by temperature rise
- AR10 Precipitation: Substations affected by river (fluvial) flooding due to increased winter rainfall
- AR11 Precipitation: Substations affected by pluvial (flash) flooding due to increased rainstorms in summer and winter
- AR12 Sea level: Substations affected by sea flooding due to increased rainstorms and/or tidal surges
- AR13 Precipitation: Substations affected by water flood wave from dam burst
- AR14 Lightning: Overhead lines and transformers affected by increasing lightning activity
- AR15 Wildfire (new risk): Overhead lines and underground cables affected by extreme heat and fire smoke damage

Additionally, prior to RIIO-ED2, we will assess the eight climate change hazards defined in Stage 1 across our operational and supply chain systems in line with our new systems-based approach to climate change resilience.

² Anticipate, React, Recover – Resilient infrastructure systems, National Infrastructure Commission, May 2020

³ Keeping the Country Running: Natural Hazards and Infrastructure, UK Cabinet Office, 2011

3. Assess the risks and identify current mitigations: review each risk against the common ENA risk scoring framework to assess resilience as we transition towards net-zero.

We updated the evaluation of our current and future resilience against these risks, using the ENA scoring framework, by considering the ability of our network to:

- Prevent the risk from materialising (*Resistance*)
- Mitigate the damage or loss from an event (*Reliability*)
- Provide continued service in the event of a disruption (*Redundancy*)
- Enable fast and effective response Prevent and recovery in the event of a disruption (*Response & Recovery*)

In addition, we have also considered how the changes we are making to our business to support the Net Zero energy transition would impact our resilience against these risks.

As a result, we found that our current network provided improved mitigation against the climate change risks when compared to our 2014 assessment. Many of our assets operate under capacity and we have standards in place to ensure they are operated safely, even in high temperatures. Our approach to increasing flood mitigation across our substations provides notable benefits against fluvial and pluvial flood risk. In addition, our innovation team are looking at ways to address the highest risk areas of our network including geospatial weather tracking and lightning impact modelling. Investment into becoming a Distribution System Operator (DSO) is providing further mitigation by increasing visibility of network capacity and load across all asset classes, data availability and allowing flexible network operation. For example, we are increasing the automation and remote monitoring capability across our low voltage network to provide a better understanding of the demand profiles. This will also help us monitor asset performance against temperature rises.

Regarding the energy transition, the increase in electricity demand from the adoption of low carbon technologies, such as electric vehicles, was identified as presenting additional risk to the network in the context of climate change as increased load on the network in combination with warmer temperatures puts additional strain across our asset base. However, our network investment plans, and strategy were found to be sufficient to mitigate this additional risk. We also identified opportunities through the energy transition which could improve resilience:

1. Distributed generation growth could reduce losses across the network by bringing supply closer to demand and limiting the number of customers impacted by a fault.
2. Adoption of electric vehicles has the potential to provide a temporary power source to customers in the event of a disruption.
3. Industry net zero commitments, such as the water sector commitment for 2030, drives the adoption of on-site energy sources which reduces reliance on distributed electricity, frees up network capacity and enables flexibility of operations.

These trends will continue to be monitored and assessed against climate change risks.

The table below provides an overview of the risks, scored using the ENA framework (see Table 7) taking account of the mitigation measures:

Table 1: UKCP18 Priority Climate Change Risk & Mitigations Summary

Risk	UKPN RIIO-ED1 View			UKPN Current View		
	2020	2050	2080	2021	2050	2100
AR1 Temperature: Overhead line conductors affected by temperature rise	Green	Light Orange	Light Orange	Green	Light Orange	Light Orange
AR2 Drought: Overhead line structures affected by Summer drought and consequent ground movement	Green	Light Orange	Light Orange	Green	Green	Green
AR3 Wetter conditions: Overhead lines affected by interference from vegetation due to prolonged growing season	Yellow	Yellow	Yellow	Yellow	Light Orange	Light Orange
AR4 Temperature: Underground cable systems affected by increase in ground temperature	Green	Light Orange	Light Orange	Green	Light Orange	Light Orange
AR5 Drought: Underground cable systems affected by Summer drought and consequential ground movement	Green	Light Orange	Light Orange	Green	Light Orange	Light Orange
AR6 Temperature / Drought: Substation and network earthing systems adversely affected by summer heat and drought conditions	Green	Light Orange	Light Orange	Green	Light Orange	Light Orange
AR7 Temperature: Transformers affected by temperature rise	Green	Light Orange	Light Orange	Green	Light Orange	Light Orange
AR8 Temperature: Transformers affected by urban heat islands and coincident air conditioning demand leading to overloading in summer months	Green	Light Orange	Light Orange	Green	Light Orange	Light Orange
AR9 Temperature: Switchgear affected by temperature rise	Green	Light Orange	Light Orange	Green	Light Orange	Light Orange
AR10 Precipitation: Substations affected by river (fluvial) flooding due to increased winter rainfall	Yellow	Yellow	Yellow	Yellow	Light Orange	Light Orange
AR11 Precipitation: Substations affected by pluvial (flash) flooding due to increased rainstorms in Summer and Winter	Yellow	Yellow	Yellow	Yellow	Yellow	Light Orange
AR12 Sea level: Substations affected by sea flooding due to increased rainstorms and/or tidal surges	Yellow	Yellow	Yellow	Yellow	Light Orange	Yellow
AR13 Precipitation: Substations affected by water flood wave from dam burst	Light Orange	Light Orange	Light Orange	Light Orange	Light Orange	Light Orange
AR14 Lightning: Overhead lines and transformers affected by increasing lightning activity	Green	Light Orange	Light Orange	Green	Light Orange	Light Orange
AR15 Wildfire (new risk): Overhead lines and underground cables affected by extreme heat and fire smoke damage	Grey	Grey	Grey	Green	Light Orange	Light Orange

4. Adaptation Pathways: we will create a flexible pathway and collaborate with others to continue delivering a network suitable for the future needs of our customers.

To gain greatest benefit from our investments, we need to be flexible and adapt our approach to the range of climate change scenarios presented in the UKCP18 projections. As such, our adaptation pathway (see Table 2) informs the type of action to be taken based on the level of risk identified. Higher level risks will require proactive intervention, either imminently or within the proceeding regulatory cycle, and lower-level risks will be monitored and mitigated where necessary as part of the internal governance structure we have established and our assets' natural replacement cycles.

5. Governance: we will build on established risk governance foundations within our business to monitor and report on climate risks in the longer term.

We are taking an integrated governance approach to managing our climate change risks through our established corporate risk management policies and procedures. Ahead of RIIO-ED2, we will review the eight climate change hazards with business directorate risk managers to assess them against our non-operational and supply chain systems using the relevant risk frameworks from each business area. High level risks will be incorporated into our corporate risk register to be monitored by our Risk and Assurance team. This approach allows us to manage climate change risks across the entirety of our business systems. This will benefit from the established reporting

we have in place through our Corporate and Business Risk Management Teams and ultimately into our Executive Management Team to provide increased visibility on climate change risks and our adaptation strategy going forward.

Table 2 Our Adaptation Pathways & Climate Change Actions

Risk Threshold	High Level Actions	Implementation Timeline
Start	Quarterly engagement with ENA Climate Change Working Group to review and assess climate change hazards. Identify and assess priority risks across the electricity and gas networks and score with respect to our network systems against current and future timelines. Develop joint mitigation options and review standards and legislation. Report on climate change risks to DEFRA Adaptation Committee.	
Minor	Continuous monitoring and tracking of risk as part of ENA Climate Change Working Group and within corporate risk framework.	Annually
Moderate	Implement detailed assessment of risk on network and analyse mitigation options to select most cost-effective option. Incorporate mitigation measure(s) within proceeding regulatory submission to deliver over the period. Aim to maintain or reduce risk level over subsequent time periods.	RIIO-ED2
Major		
Severe	Take immediate actions to mitigate and control risk through most cost-effective measures in the short-term and incorporate long-term mitigations as part of proceeding regulatory submission.	As needed

2 Introduction and Context

UK Power Networks manages the distribution of electricity from the National Grid to 8.4 million domestic and commercial customers located in London, the East and South East of England. This is done through our three licensed subsidiaries Eastern Power Networks plc (EPN), London Power Networks plc (LPN), and South Eastern Power Networks plc (SPN) which are responsible for managing these networks and delivering a safe, reliable, and efficient electricity supply to existing customers and timely, cost-effective connections to new customers. Our engagement programme reconfirmed that delivering a reliable supply is a base requirement for our customers, today and in the future and thus we need to understand and assess how the effects of climate change will affect our business operations. In this way, we can ensure that we take the necessary measures now to address future climate change hazards in a flexible and cost-effective manner.

The likely effects of climate change on our environment, as identified through the latest UK Climate Projections (UKCP18) by the Met Office and the Environment Agency, were released in November 2018. For the highest future greenhouse gas emissions scenarios, as modelled through Representative Concentration Pathways (RCP) 8.5, a best estimate increase in global mean surface temperature of 4.3°C by 2081-2100 was determined. This presents a variety of climate change hazards from hotter and drier summers, rainier winters, to more intense storm events and longer vegetation growth periods. These hazards can impact our network by limiting equipment capacity through reduced ability to dissipate heat, increasing faults through vegetation contact with overhead lines or greater risk of substation flooding from surface water runoff. There are also impacts on our business operations including limiting our ability to carry out scheduled construction work and mobilise staff to fault locations.

Given our ambition to be the most reliable and environmentally responsible DNO group, we see the challenge of tackling climate change as presenting both risks and opportunities in our ability to deliver on that ambition for our customers. As a result (alongside our work developing, managing, and delivering on Our Environmental Action Plan, see Appendix 16) we have been committed to monitoring and understanding climate change hazards and the risks they present to our business.

To address the challenges posed by climate change, we have set out a holistic strategy that considers all our business systems, both internal and external, to understand the associated climate adaptation challenges and opportunities. Our approach provides information around how we will continue to work with partners such as the Met Office, DNO groups and other sectors, including the wider energy sector, water, transport, and telecoms, to develop a comprehensive response.

In 2009, the primary climate change risk to the electricity network was considered to be flooding and was based on the UKCP09⁴ climate change model data. We have since established a flood risk mitigation programme, working with our partners to assess and mitigate the flood risk⁵ across our sites.

Building on our RIIO-ED1 work, our climate change risks have been revised in collaboration with the Energy Networks Association (ENA) working group. Using the latest UKCP18⁶ data, we identified eight priority climate change hazards which present themselves as 15 priority climate change risks across our network. We have then worked with our Asset Management and Planning teams to understand how our RIIO-ED2 investments provide mitigation and scored the risks against the ENA framework. The climate risks have been assessed against various timelines and a 'do-nothing' scenario to demonstrate the effect of our investments and long-term strategy into 2100. In addition, in line with our corporate risk governance, we will be taking a systems approach to assess how these risks impact our operational and supply chain processes ahead of the start of RIIO-ED2.

The result of these assessments will continue to inform our strategy to better understand our resilience to climate change hazards.

⁴ UK Climate Projections 2009

⁵ At risk is defined by the ENA engineering standard ETR 138

⁶ UK Climate Projections 2018

Through this strategy, we are committed to:

- Maintaining a robust governance framework for managing and identifying risks within our business to support decision making and promote transparency on climate risks in the longer term. We will continue to achieve this through our Corporate Risk Management process.
- Proactive management of the energy transition risks and opportunities to drive innovation and deliver value for our customers.
- Creating a flexible adaptation pathway and collaborating with the ENA to continue delivering a network suitable for the future needs of our customers.
- Improving our base resilience against the highest priority climate risks, this is a core aim of our adaptation pathway strategy.

Furthermore, we have included a RIIO-ED2 Business Plan commitment to establish an internal group of stakeholders within our business to own and monitor the climate change risks and actions identified as part of this strategy. This commitment is summarised below:

<u>Commitment CR1</u>			
We will establish a steering group with key internal stakeholders to own and monitor the risks identified as part of the Climate Change Adaption Strategy. The steering group will report to UK Power Network's executives and publicly report on actions taken to mitigate against identified risks throughout RIIO-ED2 using the Annual Environmental Report			
Resource and expenditure	Regulatory Treatment	Customer benefit	Stakeholders / customers said
No incremental increase in totex expenditure.	Included in baseline allowances.	By actively monitoring climate change risks, will we ensure we remain agile to emerging threats, deepen our understanding of the challenges climate change poses and ensure we continue to deliver the standard of services our customers expect today and in the future.	Climate change is seen as a global crisis with asset resilience being one of our customers' key priorities and providing a reliable service is seen as a base requirement now and in the future. See our Line of Sight and Engagement Summary documents for more detail. (See key insight AR1, AR2 and AR3 in our Line of Sight – Asset Resilience document).

3 Our track record in improving our network's resilience to climate change impacts

We have been assessing and reporting on the impact of climate change on our business for more than ten years, working alongside the ENA and other partners to assess the hazards, impact to our business, prioritise the risks and develop mitigating solutions. These assessments have been shared with DEFRA through the CCRA⁷ reporting mechanism and led to specific proposals published in our RIIO-ED1 business plan such as flood mitigation and tree cutting programmes. In addition, we have invested in our emergency response capability to improve our speed of restoring customers to supply and developed innovative approaches using artificial intelligence to improve our ability to predict and proactively respond in the case of an emergency. Additionally, our base resilience is established through the interconnectivity of our network and increased installation of automation technologies.

⁷ Climate Change Risk Assessment, <https://www.ukclimaterisk.org/>

Case Studies

1. Flood Mitigation Programme

Flooding of our substations and ground mounted transformers through accumulated rainfall, overflowing rivers or sea level rise can cause equipment damage and loss of power supply to our customers. Our flood mitigation programme was first published as part of our DPCR5 final proposals in 2009 in accordance with the first issue of the ETR138 recommendations, also published in 2009. Since then, we have reduced our customers at risk of flooding to comply with ETR138 recommendations from an average of 70% in 2011 to an average of 13% in 2020/21, representing 119 substations protected from fluvial, tidal, and surface water along with an improved understanding of flood risk across all three license areas. Furthermore, we are one of the only DNOs to have gone above the ETR138 requirements and considered the risk from burst water main flooding across our sites in LPN, due to customer density, and applied mitigation measures accordingly. Using updated models from the Environment Agency (EA) which shows a substantial increase in flood risk, we estimate a further 85 sites (grid and primary substations) will require flood mitigation works by the end of RIIO-ED2. We have integrated flood risk into business as usual by revising our technical design standards for substations to be more resilient against flooding, including measures such as raised switchgear installation. Further detail is available in our Flood Mitigation Programme Engineering Justification Paper⁸.

2. Improving our analytics and predictive capability to minimise risk and impact to our customers, today and in the future.

To improve our predictive capability, we have developed a Geospatial Analytics (GSA) tool using a power cut fault prediction model developed by the Met Office on our behalf. This allows us to identify a correlation between faults and accumulated rainfall, and we have developed separate predictive models for LV and HV faults, across EPN, LPN and SPN (with the exception of HV faults in LPN). This enables us to provide forecasts up to five days in advance for cumulative rainfall greater than 10mm of rain and the intelligence we have developed allows us to understand the correlation between this rainfall and the expected faults. For example, we now know that 15mm's of cumulative rainfall leads to a 100% increase in faults. This improves our resource planning capability by providing a probabilistic view of the storm impact and a quantified expected level of risk for each weather event enabling more effective planning. The GSA tool has been piloted with proven results (at 90% confidence levels) and we have developed this into a web-based digital application due to be rolled out during RIIO-ED2. Recently, we have improved our planning capability by using the GSA to create a tool which overlays EA data on our network maps for our planning team to use when designing new connections and substations.

Further to that, in the event of a lightning storm, we have developed a tool – 'Lightning'. Using weather data from the MeteoGroup, we are able to geographically map near real time data on lightning strikes to determine if lightning is the reason behind circuit-breakers opening and disconnecting our customers. Understanding this enables us to develop more effective resource allocation and allows circuit breaker reclosures to be achieved automatically in under three minutes. We are looking to incorporate this tool into Power On, our system for managing network utilisation, allowing us to use artificial intelligence to optimise our resource allocation and restore supply to our customers. This has been piloted in SPN and shown to improve overall network performance, reduce customer interruptions (CI) and customer minutes lost (CML) during lightning storms.

3. Effective Storm Response

In December 2013, the UK had its stormiest month since 1969 where maximum wind speed reached 142mph and rainfall levels were at 184.7mm, compared to averages around 120.2mm. This caused significant damage to our network through fallen trees, wind blowing debris on to overhead lines and flooding, which resulted in power cuts of greater than 3 minutes for a total of 331,931 of our customers. Although we were able to restore power to most customers impacted within 6 hours, our network was severely damaged and key business functions, such as our call centre, was overwhelmed. This event taught us many lessons and, as a result, we have since invested in

⁸ EJP-AS-016

increasing the resilience of our network and business. Some examples of this include improved tree cutting practices, replacement of power lines with covered electricity conductors to resist windborne debris, installation of flood defences and working alongside the Cabinet Office's Emergency Planning College (EPC) to enhance our resilience capabilities. Furthermore, due to customer feedback, we integrated a live power cut map on our website, enabled an online self-service fault reporting tool and improved our outage engagement with stakeholders including parish councils, local authorities and MPs. In Feb 2020, the UK experienced yet another large windstorm – Storm Ciara, with wind speeds of over 90 mph and rainfall of up to 177mm. Using our innovative forecasting tools (such as GSA) and through collaboration with the Met Office, we developed an effective emergency response plan, mobilising our team of engineers to identify and assess damages and restoring supply to our customers as quickly as possible. We assessed the outcomes from our response in three key areas:

1. **Customer Support:** efficient and proactive mobilisation of supply chain support, prioritising vulnerable customers and proactively reaching out to all 90,000 customers forecasted to lose supply in advance of the storms. Automated prioritisation of over 4,463 calls over the two days. Positive customer engagement, receiving 86% neutral or positive scores, increasing to 95% post event.
2. **Regulatory Customer Interruptions:** less than half the number of customer interruptions lasting more than 3 minutes (around 10,500 for Storm Ciara versus around c.22,600 in December 2013)
3. **Regulatory Customer Minutes Lost:** around 40% reduction in customer minutes lost (around 44,800 in Storm Ciara versus 69,000 in December 2013)

The improved performance is attributed to an increased focus on resilience through the following initiatives:

- **Automatic Power Restoration System (APRS):** automated switching to restore supplies on parts of the network (usually within 3 minutes), significant increase in APRS installation across the network between 2013 to 2020.
- **Quality of Service Initiatives:** Installation of fault passage indicators at substations and retrofitting of older circuit breakers so that they can be remote controlled. Installation of HV overhead line auto reclosers on parts of the network to reduce the impact of transient faults.
- **Storm preparedness plan:** implemented a storm preparedness plan and process which involves UKPN staff (in operational and non-operational roles) being placed on standby when weather forecasts indicate poor weather conditions are imminent, with specific roles assigned to each member of the team. This plan and process enabled us to respond and carry out repairs more quickly during Storm Ciara.

4. Tree Cutting: Light Detection and Ranging (LiDAR) programme implementation

To further improve our resilience, in RIIO-ED1 we were an early adopter of LiDAR technologies to our tree cutting strategy. This allowed us to better identify vegetation growth and cutting requirements to reduce risk across our overhead line network. As such, we carry out aerial surveys every two to three years to determine the level of risk posed by vegetation in or around the overhead line network. These surveys provide data on proximity of vegetation to the overhead lines, and the associated risk category, as well as the linear length of vegetation that needs to be cut. This approach has allowed us to perform targeted tree cutting to address areas of greatest risk and enables us to understand how tree cutting requirements are changing over time.

We are working to ensure compliance with ETR132 which details a risk-based approach to ensuring network resilience under adverse weather conditions. The UK Department of Trade and Industry's (DTI) Regulatory Impact Assessment⁹ of the 2006 amendment required that 20% of the 11kV and 33kV overhead line networks should meet the ETR132 standard by 2034. At the end of RIIO-ED1, it is predicted that we will have achieved at least pro-rata (over 11%) compliance with the ETR132 recommendations on a circuit and customer basis. We will increase our investment into tree cutting in RIIO-ED2 to address increased risk of vegetation growth due to climate change.

⁹ Engineering Inspectorate, DTI 7 June 2006, Full Regulatory Impact Assessment, Publication Reference URN 06/1295

4 Our Climate Resilience Framework

We have designed and adopted six key principles in developing this strategy:

1. Develop a holistic (or whole) systems approach to manage climate change risks, minimising the impact and enabling us to see the opportunities to drive efficiencies for our customers.
2. Build on our strong foundation of managing resilience and robust corporate risk governance.
3. Create a pathway for our adaptation strategy starting with improvements to our base asset health and a priority approach to climate change risks as certainty of impact increases.
4. Align our Climate Adaptation Strategy and Environmental Action Plan by ensuring that our climate change resilience activities, such as flood protection, limit our environmental impact, (i.e. by considering the integration of natural flood protection measures such as grass embankments as opposed to concrete walls).
5. Provide senior leadership with visibility to support decision making and promote transparency on our climate risk adaptation in the longer term.
6. Continuous engagement with our customers and stakeholders to test solutions and strategies being proposed.

This has led to the development of a holistic and integrated systems-based approach to addressing the challenge posed by climate change.

Figure 2: Our approach to climate change adaption



Through this strategy we consider three core Systems in our business:

- **Our Physical Network systems:** covering our network assets across our three license areas (EPN, LPN, SPN).
- **Our Operational systems:** this includes our operational and asset management directorates including its processes and systems along with enabling functions such as Facilities Management, Capital Programmes, Support Services, Procurement, HR, and Finance.
- **Supply Chain systems:** this includes our supply chain partners across our business.

Governance

We take an integrated governance approach to managing our Climate Adaptation risks through our established corporate risk management policies and procedures which are ultimately owned by our Executive Management Team (EMT) and the Corporate and Business Risk Management Teams.

In order to achieve this and better assess and monitor climate change risks on the network, we have realised the need to establish a permanent, collaborative, steering group within our business. As such, we are committing to establishing a climate change steering group to be reported on by our Risk and Assurance team which will comprise key stakeholders across the business (See commitment CR1). Membership will include representation from: Environment and Sustainability, Asset Management, Strategy and Regulations, Operations, Procurement, and Health & Safety to ensure that we have a comprehensive view of the climate change impacts across our business. This steering group will be responsible for owning the climate change adaptation pathways and associated Climate Change Action Plan along with report annually through the Annual Environmental Report.

Customer Benefit

Through our core engagement programme, we learnt the key priorities for our customers, and our climate change strategy has been designed with them in mind:

1. **Reliability is a base requirement for our customers** – this strategy helps to deliver network reliability and resilience by limiting the impact of climate change hazards.
2. **Our customers consider safety as a core responsibility for our business** - this strategy ensures the health and safety of our people and the public by assessing hazards against all areas of our business.
3. **Customers want us to ‘walk the walk’ when it comes to minimising our impact on the environment** – this strategy will further our environmental sustainability by minimising the need for capital investment and operating our network more effectively as a system.
4. **There is appetite to improve the reliability of service for our customers, particularly from short interruptions or those who are worst served** – this strategy works to improve the quality of service by looking to predict and prevent faults across our system before they occur.
5. **Customers’ disposable income is reduced due to the impact of the COVID-19 pandemic** – this strategy delivers value for money for customers by selecting the most cost-effective solutions through our engineering justification approach.
6. **Whilst transiting to net zero is recognised as being very important, there is some scepticism from our customers about its achievability and the impact on their lives** – this strategy helps to provide benefits to society by supporting net zero initiatives, helping reduce greenhouse gas emissions and climate change impact.

We have a longstanding record of engagement with our customers and stakeholders which we will continue throughout RIIO-ED2 and beyond, observations of which will be fed into this strategy as appropriate.

5 Climate Change Hazards

Hazards and Methodology

The latest UK Climate Projections (UKCP18), produced by the Met Office and the Environment Agency, were released in November 2018 which provided an updated view on the previous projections from 2009 (UKCP09). The comparison between the two models concluded that UKCP18 had an increased ability to define details within the climate projections when compared to UKCP09, but the main signals around climate change projections remained the same. The Met Office based their UK Climate Projection model (UKCP18) on various future greenhouse gas emissions scenarios, called Representative Concentration Pathways (RCPs), of which RCP8.5 represents the highest emission scenario into 2080-2100. Based on this modelling, we have been working with members of the ENA to assess the impact of these climate change projections on the electricity network. The RCP8.5 results were chosen by the ENA members as it represents the ‘worst case scenario’ with the highest greenhouse gas concentrations modelled as part of UKCP18, resulting in a best estimate increase in global mean surface temperature of 4.3°C by 2081-2100.

Through a series of workshops with the Met Office and other ENA members, we have identified and prioritised the weather and climate related hazards which need consideration both now and into the future. The detailed impact of these hazards on our networks and information as to the prevalence of the hazard in the current climate and the future RCP8.5 climate have been described as an output of this work¹⁰. The full list of prioritised climate change hazards include:

1. Extreme high temperatures
2. Heavy rainfall/drought cycles
3. Prolonged rainfall
4. Intense short-duration rainfall
5. Sea level rise
6. Wetter conditions coincident with warmer temperatures and/or strong winds
7. Wildfire
8. Lightning
9. Strong winds
10. Storm surge and high wave height
11. Snow and ice
12. Solar storms

Our work with the Met Office and ENA working group analysed all 12 hazards in further detail to better understand the impact they would have on our operating areas under RCP8.5. We found that increased frequency and durations of high temperature days, prolonged rainfall events, hourly rainfall extremes, sea-level rise, extreme sea level events, increased risk of wildfire and increased extreme daily weather cycle events are all expected over the 21st century. On the other hand, the frequency of snow and ice days are expected to decrease. Hazards for which there is not currently strong evidence for a change in frequency include strong wind events, high wave heights, wetter conditions coincident with warmer temperatures and/or strong winds, lightning and to some extent, daily variable temperature cycles.

Table 3: UKCP18 Climate Change Hazard Results across our License Areas¹¹

Hazard	Threshold(s) or Metric	Current Frequency/ Occurrence	2060-2100 Frequency/Occurrence
Temperature Increase	<ol style="list-style-type: none"> 1. Number of days/year > 28°C 2. Number of days/year > 35°C 	<ol style="list-style-type: none"> 1. 8-12 days/year 2. 0 days/year 	<ol style="list-style-type: none"> 1. >30 days/year 2. 3-4 days/year
Drought (soil drying & movement)	<ol style="list-style-type: none"> 1. 30 day minimum rainfall 2. 60 day minimum rainfall 	<ol style="list-style-type: none"> 1. 20 mm 2. 90 mm 	<ol style="list-style-type: none"> 1. 0 mm 2. 30 mm
Prolonged High Temperature Periods	3 consecutive days above 28 °C	0-8 days/year	30 days/year
Flooding (Fluvial)	<ol style="list-style-type: none"> 1. Number of months per year where rainfall event exceeds 90th percentile 2. Number of months per year where rainfall event exceeds 95th percentile 	<ol style="list-style-type: none"> 1. 1.2 months/year 2. 0.4 months/year 	<ol style="list-style-type: none"> 1. 1.2 months/year 2. 0.8 months/year

¹⁰ Energy Industry Specific Risk Assessment on Climate Change Impacts – Work Package 3 Report, Met Office, October 2020

¹¹ NA indicates that the measure is either absolute, and therefore not comparable, or that no conclusion was reached as part of the model

Flooding (Pluvial) / Heavy Rain	1. Change in winter 99th percentile mean daily rainfall 2. Change in summer 99th percentile mean daily rainfall	1. NA 2. NA	1. 20% - 30% 2. 0%
Flooding (sea breach)	Average sea level rise relative to 1981-2000 baseline	0.1m	0.8m
Strong Wind and Storm	1. % of days between 1990-2019 where winter wind gust > 55 mph 2. % of days between 1990-2019 where summer wind gust > 55 mph	1. 0 - 1 % 2. 0 – 1%	No clear signal in UKCP18 of change
Wetter & Warmer Conditions	Length of thermal growing season	252 days average (1961-1990)	282 days (2012), c.30 days increase in 20 years – observational, not explicitly modelled by UKCP18
Snow Sleet and Blizzard (incl. ice)	1. % change in winter mean snowfall compared to 1981-2000 2. % change in winter mean lying snow compared to 1981-2000	1. NA 2. NA	1. -100% 2. -100%
Lightning Days	Number of lightning days/year	NA	Not explicitly modelled by UKCP18, but reason to believe there will be an increase in lightning days in the future, especially in the warmer South East of England. ¹²
Wildfire	Number of wildfire events per year, MODIS (moderate resolution imaging Spectroradiometer) fire risk hotspots	UKPN currently has no fire risk hotspots in its operational area.	Not explicitly modelled by UKCP18, but evidence of increasing wildfire events in future climates ¹³ - particular risk of Moorland – with higher temperatures, drought conditions and increased wind.
Solar Storm	Strength of event	1 in 100 years	Not enough data available currently to model change in strength, considered high impact, low probability.
Diurnal Temperature Cycles	Average daily temperature difference between maximum and minimum temperature	7.5°C	Climate change projections are not very confident for this hazard, however there are indications of increases in summer diurnal temperature ranges. The southern UK is most affected by this hazard.

The table above indicates that changing temperature and rainfall are among the top climate change hazards which are likely to present a greater risk across our network in the future.

¹² In UKCP09, lightning was estimated using convective available potential energy, and future increases in number of lightning days were found (Boorman et al., 2010).

¹³ Jones, M. W., Smith, A., Betts, R., Canadell, J. G., Prentice, I. C., and Le Quéré, C, 2020. Climate change increases the risk of wildfires. Science Brief. Available at: <https://sciencebrief.org/briefs/wildfires>

With the Met Office and ENA working group, we have identified the following eight hazards as highest priority based on their impact to our networks and our ability to gain meaningful insight from the UKCP18 model:

Table 4: ENA Priority Climate Change Hazards 2020

Hazard	Threshold(s) or Metric
Temperature Increase/ Prolonged High Temperature Periods	Number of days/year > 28°C Number of days/year > 35°C 3 consecutive days above 28 °C
Drought (soil drying & movement)	30 day minimum rainfall 60 day minimum rainfall
Lightning	Number of lightning days/year
Wildfire	Number of wildfire events per year, MODIS (moderate resolution imaging Spectroradiometer) fire risk hotspots
Wetter & Warmer Conditions	Length of thermal growing season
Flooding (Fluvial)	Number of months per year where rainfall event exceeds 90th percentile
Flooding (Pluvial) / Heavy Rain	Change in winter 99th percentile mean daily rainfall
Flooding (sea breach)	Average sea level rise relative to 1981-2000 baseline

6 Identify Impacts on our Business

ENA Working Group Findings

The bespoke analysis undertaken by the Met Office for the ENA focused on the respective thresholds per hazard as indicated above and their impact on our network operating areas including the East, South East of England and London. As part of our work with the ENA, we have gone through three rounds of Adaptation Reporting Power (ARP) process to produce a climate risk assessment. This identified 15 key risks on the electrical distribution networks as a result of the eight priority climate change hazards. The resulting report¹⁴ has been prepared by the ENA Climate Change Adaptation Reporting Group (CCARG) of gas and electricity distribution and transmission network operators and provides the basis for the risks and mitigations identified as part of this strategy.

The third round of this reporting provides an update on the risks identified with consideration to the impact of the societal response to climate change as the UK transitions to net zero by 2050. The primary impact on our electricity network would be seen through increased electricity demand due to the prevalence of electrified heating and electric vehicles. However, it is noted that changing weather patterns could exacerbate demand from air conditioning as summer temperatures increase. The table below details the 15 priority risks as identified in the third round of ENA reporting in respect to top climate change hazards identified above.

Table 5: ENA 3rd Round DEFRA AR Reporting Risks

Priority Hazard Category	Risk No.	Impacted Asset Type	Risk	Considered in RIIO-ED1?
Temperature Increase & Prolonged High Temperatures	AR1	Overhead line conductors	<ul style="list-style-type: none"> Ground clearances compromised due to additional sag Capacity limitations due to inability of conductor to radiate heat 	✓
Drought (soil drying & movement)	AR2	Overhead line structures	<ul style="list-style-type: none"> Foundation instability due to ground shrinkage (especially with clayey soils) during summer drought 	✓

¹⁴ Adaptation to Climate Change Task Group 3rd Round Climate Change Adaptation Report, ENA, March 2021

Wetter & Warmer Conditions	AR3	Overhead lines	<ul style="list-style-type: none"> • Faults and physical damage due to increased vegetation growth from prolonged growing season 	✓
Temperature Increase & Prolonged High Temperatures	AR4	Underground cable systems	<ul style="list-style-type: none"> • Capacity limitations due to inability of conductor to radiate heat during drought and high temperatures 	✓
Drought (soil drying & movement)	AR5	Underground cable systems	<ul style="list-style-type: none"> • Cable joint failures due to ground movement through drying and shrinking during drought (especially with clayey soils) 	✓
Temperature Increase & Prolonged High Temperatures & Drought (soil drying & movement)	AR6	Substation and network earthing systems	<ul style="list-style-type: none"> • Earthing system failure due to decreased soil resistivity under drought conditions resulting in public safety issues 	✓
Temperature Increase & Prolonged High Temperatures	AR7	Transformers	<ul style="list-style-type: none"> • Life expectancy reduction and potential failure due to inability to radiate heat with higher ambient temperatures 	✓
Demand Increase due to climate change	AR8	Transformers	<ul style="list-style-type: none"> • Loss of supply caused by demand increase in urban environments due to localised heat build-up leading to increased air conditioning and ventilation usage 	✓
Temperature Increase & Prolonged High Temperatures	AR9	Switchgear	<ul style="list-style-type: none"> • Loss of supply or reduced operability due to exceedance of maximum operating temperature inside switch rooms 	✓
Flooding (Fluvial)	AR10	Substations	<ul style="list-style-type: none"> • Loss of supply and/or damage due to river (fluvial) flooding due to increased winter rainfall 	✓
Flooding (Pluvial) / Heavy Rain	AR11	Substations	<ul style="list-style-type: none"> • Loss of supply and/or damage due to flash (pluvial) flooding due to increased rainstorms in Summer 	✓
Flooding (sea breach)	AR12	Substations	<ul style="list-style-type: none"> • Loss of supply and/or damage due to sea flooding through increased rainstorms and/or tidal surges 	✓
Flooding (Pluvial) / Heavy Rain	AR13	Substations	<ul style="list-style-type: none"> • Loss of supply and/or damage due to water flood wave from dam burst 	✓

Lightning	AR14	Overhead lines and transformers	<ul style="list-style-type: none"> Faults and/or damage caused by increasing lightning strike frequency 	✓
Wildfire	AR15	Overhead lines, underground cables, operational telecoms	<ul style="list-style-type: none"> Loss of supply and/or damage due to wildfire from increased drought and high temperature conditions Loss of network control due to failure of telecommunication system 	✗

Interdependencies

Interconnections between different industry sectors is a major source of risk for the energy network, with failures from one sector potentially having the ability to cause impacts on others. Telecommunications and road transport are thought to be the most important sources of risk to the electricity sector. Telecommunications are already important for automated and remotely controlled equipment, and for communication with personnel in the field. Risk from telecommunications failure has the potential to increase in the future with greater reliance on smart systems (dependent on telecommunications). Road transport is often essential for restoration of supply and access to assets for routine maintenance. In terms of reliance on electricity, the water sector is one of the most critical industries. As water companies work to meet their Net Zero targets, many of them are starting to invest in on-site renewable energy sources to supply part or all their energy needs. Societal responses to climate change may also increase the risk on the road network from the electricity network, as electric vehicles become more commonplace.

We see collaboration as playing a vital role in both the energy transition and in developing our resilience to climate change, as such, we have agreed with our ENA partners to make the current ENA Climate Change Adaptation working group a permanent one and include engagement from Ofwat and DEFRA. The chair of this working group will also attend the ENA Resilience and Emergency Co-ordination Group (RECG) to provide increased visibility and collaboration going forward. We have also included an action as part of our Climate Change Action Plan for RIIO-ED2 to better understand the interdependencies of the climate change risks across other sectors and our customers, see action 4 in Section 8, Our Adaptation Pathway.

7 Assess the Risks and Identify Mitigations

Risk Assessment Approach

Except for wildfire, all the risks identified above were also considered in preparation for our RIIO-ED1 business plan and scored against the common ENA risk measurement framework. We have been managing these risks throughout the course of RIIO-ED1. As part of RIIO-ED2, we have incorporated industry best practice around resilience management by assessing our mitigations against the four R's of resilience:

- Redundancy:** measure of inherent substitutability
- Response & Recovery:** measure of capacity to mobilise resources in the event of a disruption
- Resistance:** ability of the system to prevent the risk from materialising
- Reliability:** ability of the system to operate even if the risk materialises

In order to update our view of the risk scores, we undertook the following steps:

- Reviewed our existing technical standards, inspection and maintenance policies and asset strategies against each risk based on the revised hazard to determine which aspects of the four R's of resilience are covered.
- Assessed gaps and reviewed our RIIO-ED2 business plan internally to ensure risks were mitigated to acceptable levels.
- Assessed our risk exposure to wildfire by gathering location information of our overhead lines with respect to areas at risk of wildfire including moorlands and forests.

4. We engaged with team members in various directorates including asset management, operations and planning to assess the residual risk on our network and score against the following revised timelines/scenarios:
 - *Current baseline (2021).*
 - *Baseline/Do Nothing 2050 (without implementing any of the RIIO-ED2 business plan so that only reactive action is taken – established to understand the full extent of the risk).*
 - *Improved 2050 (including measures from RIIO-ED2 business plan and beyond to 2050).*
 - *Targeted 2100 (where we would want to be in in 2100)*
5. Provided revised risk scores for each of the 15 risks against the ENA working group risk measurement framework, consistent with RIIO-ED1

In addition, taking our systems approach to risk management, we will assess the top eight climate change hazards against our operation and supply chain systems prior to RIIO-ED2 to better understand the overall risk across our business. We will work with business directorate risk leads to assess each hazard using the appropriate risk management frameworks.

The results of the detailed risk assessment will then be combined with the 15 Adaptation Reporting risks identified across our physical network and aggregated up within our corporate risk management framework to be tracked and monitored appropriately. Our corporate approach to risk management is designed around the following framework within the business:

- Proactively identify risks to its strategy, objectives, business developments and processes and implements internal controls to mitigate these.
- Explores the efficacy of those controls in mitigating the risks through internal audit and other monitoring mechanisms.
- Reactively monitors incidents, errors and breaches to identify control failures and determine areas for improvement.
- Develops contingency arrangements for business continuity and emergency incidents.

The responsibility for implementation of the risk management framework sits with UK Power Networks Executive Management Team (EMT) which is supported by the Corporate and Business Risk Management teams within each business Directorate. All identified risks are assessed by a business risk owner and escalated to the relevant Corporate or Business Risk Management team for authorisation to include on the risk register as appropriate.

Energy Transition Risks and Opportunities

Our risk assessment process takes the Energy Transition into consideration. We have a key role in the transition towards Net-Zero and our work facilitating “the pathway to a highly renewable electricity system is the best way to deliver low-cost low carbon electricity for the UK”¹⁵. Electricity demand and generation increase will need to be managed in a flexible way as the UK moves to achieve Net Zero by 2050. National Grid’s Future Energy Scenarios forecast the increase of electricity demand by up to 25% between now and 2038, with most new demand including low carbon technologies (LCTs) connected to low voltage networks.¹⁶ We have developed our own Distribution Future Energy Scenarios¹⁷ in collaboration with stakeholders including Local Authorities, Counties and Unitary Authorities and Local Enterprise Partnerships to identify the localised energy demand growth across our license areas which has helped shape our investment plan for RIIO-ED2. We will create a flexible pathway and collaborate with our partners to continue delivering a network suitable for the future needs of our customers.

However, whilst most of the challenge is focused on Climate Change Mitigation, there are risks and opportunities in transitioning that we need to manage, these include but are not limited to:

¹⁵ National Infrastructure Commission | Net Zero: Opportunities for the power sector, March 2020

¹⁶ Network Innovation Allowance Annual Summary, Progress and results from 2019/20, UKPN

¹⁷ Towards a net zero energy future, distribution future energy scenarios, UKPN 2021

- **Increasing demand in electricity:** As part of the drive towards net zero, an increase in the adoption of heat pumps and electric vehicles will result in a rise in electricity demand across the network. The addition of climate change results in the magnification of this demand where colder winters and hotter summers could put additional pressure across our network.
- **Increasing flexibility in operations:** Given the increasing instability and extremity of weather patterns, flexibility across the network will be evermore important to optimise network operations in order to prevent outages and meet demand.
- **Changing our business processes:** As we implement the role of a Distribution System Operator, we need to ensure our business processes and systems are integrated in a way which prioritises resilience against both changes in energy demand due to technology adoption and against unpredictable, less likely climate patterns which could strain the network.
- **Digitisation and data strategy:** To optimise our investment decision making and support our adaptation pathway strategy.

ENA 15 AR Risk Analysis Results

This section summarises the specific mitigations we have already established or are putting into place as part of our investment in RIIO-ED2 which will provide resilience against the ENA priority risks. The Engineering Justification Papers (summarised in Appendix 10: Non load overarching investment framework) provide detailed benefits and solutions around the programmes/projects as part of our RIIO-ED2 business plan. The mitigations have been considered against the 4Rs of resilience at a high level to provide indicative resilience levels.

Table 6 - RIIO-ED2 Asset Investment programmes aligned to Climate Change Risks

RIIO-ED2 Asset Investment programmes aligned to Climate Change Risks
LV UGB Programme
LV Switchgear programme
Distribution Switchgear
Distribution transformers
Primary Switchgear
Cut-Outs
Asset Protection Schemes
Grid and Primary Transformers
Grid and Primary Switchgear
LV cables
HV Cables
Poles
Towers
Fluid filled cables
EHV cable
Flood Mitigation

AR1 Temperature - Overhead line conductors affected by temperature rise

Example RIIO-ED2 Investment ¹⁸	Redundancy	Response & Recovery	Resistance	Reliability
Almost 4,000km of OHL conductor replacement at 132kV, 33kV, 6.6/11kV and LV) (Ref: V1)	✓	✓	✓	✓

Current and RIIO-ED2 overhead line (OHL) conductor design standards specify the upsizing of capacity to help meet future load demands and will help mitigate against higher temperatures impacting the sag and restricting the capacity. OHL conductors are being replaced in RIIO-ED2 as part of targeted performance improvement and load related drivers. Across the network, many of our OHLs include redundancy, especially across higher voltages due to the increasing connectivity of the network which results in customers being serviced by multiple OHL sources. LiDAR technologies are being utilised to measure OHL clearances at regular intervals to help determine whether increased sag during warmer temperatures might be an issue. In RIIO-ED2, there will be increased focus on automating/monitoring the LV network demand profiles which, combined with the geospatial weather prediction, will allow us to determine areas of risk prior to risk materialising. Recent field observation and analysis of faults and temperature data has revealed that there appears to be a link between heat waves and pole termination failure, however, the exact reasoning is not yet well understood. This will be investigated further in RIIO-ED2 and appropriate measures will be taken. In the event of an incident, our SCADA improvements will allow us to locate faults quickly utilising our emergency response team where necessary.

AR2 Temperature - Overhead line structures affected by summer drought and consequent ground movement

Example RIIO-ED2 Investment	Redundancy	Response & Recovery	Resistance	Reliability
Over 78,000 new poles and over 20 new towers installed. (Ref: V1)	✓		✓	✓

We are undertaking a large programme in RIIO-ED2 to replace HV/EHV wood poles to help increase the structural integrity of our OHL poles. We are also assessing the risk across our OHL network to marshlands. Currently, ground movement resulting in tilting of wooden poles is mainly due to wetter ground conditions, but poles are designed to be able to sustain a 20-degree tilt, as such, failures are very rare. The RIIO-ED2 programme includes the installation of pole supports to address those areas of decay and the use of pole saver technology will be considered for poles being installed in areas that are more susceptible to ground movement/flooding.

¹⁸ In reality, many different investments combine together to produce a rounded mitigation strategy, e.g. from replacement and upsizing of assets to general maintenance practices. The RIIO-ED2 investments highlighted against each risk are therefore not a complete picture and are provided to illustrate some of the key work programmes that contribute to mitigating these risks.

It is also worth noting that the volumes quoted indicate our best view at the time of submitting our RIIO-ED2 Business Plan. As per Ofgem's intention of creating a flexible regulatory framework, the exact volumes delivered will be responsive to differing intervention drivers at the time of investment such that customers are protected from unnecessary costs.

AR3 Temperature / precipitation - Overhead lines affected by interference from vegetation due to prolonged growing season

Example RIIO-ED2 Investment	Redundancy	Response & Recovery	Resistance	Reliability
£89.8m (tree cutting programme) (Ref: CV29)	✓	✓	✓	✓

We will continue to use LiDAR technology, working with our supply chain to assess vegetation growth requirements on a cyclical basis. The results will inform our cutting needs to ensure we deliver an optimised programme in RIIO-ED2 and beyond. The proposed RIIO-ED2 tree cutting programme has accounted for additional budget to account for faster growth of vegetation and increased tree cutting. The use of Met Office temperature models will also assist in identifying areas where increased tree growth might be problematic.

AR4 Temperature - Underground cable systems affected by increase in ground temperature

Example RIIO-ED2 Investment £m	Redundancy	Response & Recovery	Resistance	Reliability
Over 3000km LV Main, 3000km HV, 380km EHV and 150km 132kV new cable installed. (Ref: V1)	✓	✓	✓	✓

The LV, HV, EHV and 132kV asset replacement programmes due to load and non-load related reasons will help improve asset condition and increase capacity so that higher temperatures present less of a risk. We are installing increased ventilation across our substations and tunnels to accommodate for temperature rises. The risk becomes higher when multiple circuits are laid in the same trench. Design standards require new cables to be XLPE (plastic) and be installed at specific capacity bands which often exceed the peak demand requirements. The RIIO-ED2 plan is targeting the replacement of cables in poorest condition. Also, given that many HV, and some LV, cable circuits are automated, they can be restored more quickly when a fault occurs. Increased automation/ monitoring of LV cables is incorporated in the RIIO-ED2 business plan and, along with the installation of smart meters, will allow better understanding of the demand profile across the network and lead to improved operation. New technologies such as LV reclosers will be installed to help mitigate against transient faults and allow for quicker recovery as funded through the Interruptions Incentive scheme funding mechanism.

AR5 Temperature - Underground cable systems affected by summer drought and consequential ground movement

Example RIIO-ED2 Investment £m	Redundancy	Response & Recovery	Resistance	Reliability
Over 185km of fluid filled cable removed from the network (Ref: V1)	✓		✓	✓

Fluid filled cables (FFC) are at greatest risk of failure due to ground temperature changes/ground movement and their susceptibility to leaks. We are continuing to target those in poor health condition as part of our asset replacement programme in RIIO-ED2, mitigating against the growing risk of leakage, particularly during warmer summers. Additionally, we are part of the ENA FFC working group and are looking into an innovation programme

to identify the link between soil type and leaks, along with the types of joints most affected which will allow us to better target replacement activities. We are starting to roll out the installation of active pressure control units (originally an innovation project¹⁹) across our network of FFCs to reduce the leakage rate. There is also an ongoing innovation project²⁰ looking at self-healing cables which prevents small leaks from becoming fast leaks – this is currently in final trials and will proceed to validation then roll-out if deemed successful.

AR6 Temperature - Substation and network earthing systems adversely affected by summer heat and drought conditions

Example RIIO-ED2 Investment £m	Redundancy	Response & Recovery	Resistance	Reliability
Investment covered as part routine inspection of earthing systems.	✓		✓	✓

We are enhancing inspection of earthing systems on a cyclical basis to help identify whether there are any changes to soil resistivity that need to be taken into account. Current design standards incorporate a factor of safety which mitigates against some level of soil drying. Earthing failures have not been an issue in the recent hot summer spells. Most new substations installed include ventilation to help dissipate heat during warmer days. Substations /tunnels are designed with heating/ventilation in mind and will include air conditioning depending on situation. Tunnel inspections are undertaken once a year, with a temperature recording taken. Newer cables in tunnels have continuous temperature monitoring devices installed (DTS) to help measure effects. Larger transformers, which generate more heat, are typically installed outdoors. Most new grid substations have ventilation and a yearly inspection takes temperature measurement at substations to monitor trends.

AR7 Temperature -Transformers affected by temperature rise

Example RIIO-ED2 Investment £m	Redundancy	Response & Recovery	Resistance	Reliability
Over 21,000 HV, 100 EHV and 55 132kV new transformers installed (Ref: V1)	✓	✓	✓	✓

Distribution, grid and primary transformer replacement programmes taking place due to load/non-load reasons will increase capacity of transformers allowing them to operate at higher temperatures. Furthermore, most transformers only operate at about 50% capacity, so heat is less likely to be a risk in the short term. The network in LPN has greater redundancy built in which reduces risk of service interruptions. Increased monitoring equipment on the network allows transformers to run hotter as condition/performance can be closely monitored, combined with visual inspection, maintenance, and improved data collection in RIIO-ED2, this risk will be better understood. UKPN specifies transformers according to the Eco Design Directive Legislation²¹ which indicates the use of low-loss transformers. Furthermore, RIIO-ED2 transformer replacements will consider the use of natural/synthetic ester oils where heat risk is higher as these are more resistant to higher temperatures.

¹⁹ NIA Reference: NIA_UKPN0012

²⁰ NIA Reference: NIA_UKPN0030

AR8 Temperature -Transformers affected by urban heat islands and coincident air conditioning demand

Example RIIO-ED2 Investment £m	Redundancy	Response & Recovery	Resistance	Reliability
Over 21,000 HV, 100 EHV and 55 132kV new transformers installed (Ref: V1)	✓	✓	✓	✓

Growth in air conditioning system installation is being considered in our DFES models. Therefore, transformers will be specified to take on the loads accordingly. New transformers installed will support the cyclical rating during both summer and winter so that they can be operated variably according to demand and ambient temperatures. Increased remote monitoring/operation enabled by SCADA will improve response/recovery to redistribute load within the system should it be required, and the use of demand side response will be deployed to manage peak load if appropriate.

AR9 Temperature - Switchgear affected by temperature rise

Example RIIO-ED2 Investment £m	Redundancy	Response & Recovery	Resistance	Reliability
Over 13,000 HV, 360 EHV and 130 132kV new circuit breakers installed (Ref: V1)	✓	✓	✓	✓

Our switchgear replacement programme for RIIO-ED2 will improve switchgear capacity and condition to create more resilience in the network. However, based on temperatures in London of up to 42°C in 2100, our existing switchgear spec of 40°C ambient temperature may need to be reconsidered or temperature control measures added.

AR10, AR11, AR12, AR13 Precipitation - Substations affected by flooding due to: nearby watercourses, heavy rain, sea level rise and/or dam bursting as a result of increased winter rainfall

Example RIIO-ED2 Investment £m	Redundancy	Response & Recovery	Resistance	Reliability
£17.1m (flood mitigation schemes total) (Ref: CV16)		✓	✓	✓

Our RIIO-ED2 flood mitigation programme includes an increase in investment towards protecting our substations from flooding where all grid and primary substations will be compliant and indeed going beyond the industry planning standard ETR138 by the end of RIIO-ED2. Furthermore, we have robust emergency response procedures to mitigate against additional risk. We will continue to review our assessment as new models are developed and deliver appropriate mitigation as required.

AR14 Lightning - Overhead lines and transformers affected by increasing lightning activity

Example RIIO-ED2 Investment £m	Redundancy	Response & Recovery	Resistance	Reliability
Investment against this risk is covered via the appropriate specification of individual assets and their associated replacement cost.	✓	✓	✓	✓

We will continue to specify the use of cable connections instead of bushings for grid/primary transformers to allow for better protection against lightning. The adoption of GIS switchgear will minimise the need for outdoor busbar arrangements, thus reducing risk of lightning damage. Furthermore, all PM switchgear, conductors and transformers have standalone surge protectors which protect against lightning and voltage can be increased/decreased accordingly.

AR15 Wildfire - Overhead lines and underground cables affected by extreme heat and fire smoke damage

Example RIIO-ED2 Investment £m	Redundancy	Response & Recovery	Resistance	Reliability
N/A	✓	✓	✓	✓

We are looking into the risk across our OHL network from wildfires by determining the length of OHL crossing forests and moorland. Based on the results of this assessment, we will assess the level of mitigations necessary and collaborate with our partners in the ENA working group to devise solutions for future mitigations as required.

Additional Risk Mitigations

In addition, we have general mitigations which provide further resilience against all risks:

- 1 Our implementation of the DSO along with our operational IT expenditure of in RIIO-ED2 e.g. through increased LV monitoring and control of the network through automation will support in the monitoring and speedy recovery of service in the event of a fault.
- 2 Our strategic spares policy enables rapid asset replacement in the event of a fault, reducing the need to procure equipment from suppliers, allowing us to restore supplies faster.
- 3 Our standards team regularly review our technical standards against new climate change hazards to make amendments as required.
- 4 Higher voltage asset classes are designed to operate with a factor of safety (e.g. N-1) which provides redundancy and helps to mitigate against loss of supply to customers.
- 5 We comply with P2/7 security of supply standards which requires assets with greater capacity to have redundancy built into the system.
- 6 In RIIO-ED2, our load related expenditure will be delivered through reinforcement schemes to allow the network to carry greater capacity, accommodating the transition to Net Zero, and be operated in a more integrated manner to minimise the impact of increased demand. Furthermore, increased distributed generation will mitigate against any fault affecting large portions of the network and minimise losses as generation moves closer to demand.
- 7 We undertake regular fault assessments to determine trends and correlations against other parameters including storm events, wind speed, and temperature. We will continue to improve these assessments as we collect further data and improve our data quality.

- 8 Demand side response will be utilised to help manage peak loads where the network capacity is limited. This may be demand reduction, demand movement or autonomous network management that is increasingly expected to be part of the normal network planning and operational planning processes.
- 9 Our investment in the inspection and maintenance of our assets will ensure they're operating effectively and support their performance.
- 10 Our innovation programme will continue to unlock new solutions, with many helping to improve network performance and resilience.

Climate Change Risk Scoring

We held internal workshops with subject matter experts to take each risk and applying the above mitigations we scored each risk in turn using the ENA risk scoring matrix:

Table 7: ENA Risk Measures Scoring System

		Likelihood				
		Very Unlikely	Unlikely	Possible	Likely	Almost Certain
Impact	Extreme	5 / moderate	10 / major	15 / major	20 / severe	25 / severe
	Significant	4 / moderate	8 / moderate	12 / major	16 / major	20 / severe
	Moderate	3 / minor	6 / moderate	9 / moderate	12 / major	15 / major
	Minor	2 / minor	4 / moderate	6 / moderate	8 / moderate	10 / major
	Limited	1 / minor	2 / minor	3 / minor	4 / moderate	5 / moderate

Table 8 Impact Rating Definition

Impact Rating	Definition
Extreme	Regional area affected with people off supply for a month or more OR asset de-rating exceeds ability to reinforce network leading to rota disconnections on peak demand.
Significant	County or city area affected with people off supply for a week or more OR asset de-rating requires a significant re-prioritisation of network reinforcement and deferment of new connection activities.
Moderate	Large town or conurbation off supply for up to a week OR significant increase in cost of network strengthening
Minor	Small town off supply for a 24 hour period OR significant increase in cost of network maintenance requirements.
Limited	Limited impact - can be managed within "business as usual" processes.

Table 9 Likelihood Rating Definition

Likelihood Rating	Definition
Almost certain	The risk in the process of materialising and may already be under active management as an event
Likely	Past events have not been fully resolved, effective mitigations not yet identified, control weakness are known and are being managed.
Possible	Past events satisfactorily resolved, mitigations are in place or are on track to be in place, control improvements are under active management
Unlikely	Events are rare, required mitigations in place, controls are effective
Very Unlikely	No known event or if known extremely rare, extreme industry-wide scenarios

Through consultation with members of our team, we were able to establish a revised view of the scores in comparison with the start of RIIO-ED1. The results of this assessment are provided below:

Table 10 ENA Priority Risks Scores

Risk	UKPN RIIO-ED1 View			UKPN Current View			
	2020	2050	2080	Present Baseline 2021	Baseline 2050 (Do Nothing)	Improved 2050 (based on RIIO-ED2+ plans)	Targeted improvement 2100 (ED2++)
AR1 Temperature - Overhead line conductors affected by temperature rise	3	6	9	3	12	6	6
AR2 Temperature - Overhead line structures affected by Summer drought and consequent ground movement	2	4	4	2	9	3	3
AR3 Temperature / precipitation - Overhead lines affected by interference from vegetation due to prolonged growing season	10	10	10	12	20	8	8
AR4 Temperature - Underground cable systems affected by increase in ground temperature	3	6	9	3	12	6	6
AR5 Temperature - Underground cable systems affected by Summer drought and consequential ground movement	2	4	4	2	12	4	4
AR6 Temperature - Substation and network earthing systems adversely affected by summer heat and drought conditions	3	6	6	2	12	4	6
AR7 Temperature - Transformers affected by temperature rise	3	6	6	2	12	4	6
AR8 Temperature - Transformers affected by urban heat islands and coincident air conditioning demand	3	6	9	2	12	4	6
AR9 Temperature - Switchgear affected by temperature rise	3	6	6	2	12	4	4
AR10 Precipitation - Substations affected by river (fluvial) flooding due to increased winter rainfall	16	16	16	12	20	8	8
AR11 Precipitation - Substations affected by pluvial (flash) flooding due to increased rainstorms in Summer and Winter	12	12	12	12	25	10	8
AR12 Precipitation - Substations affected by sea flooding due to increased rainstorms and/or tidal surges	15	15	15	12	16	9	12
AR13 Precipitation - Substations affected by water flood wave from dam burst	5	5	5	5	5	5	5
AR14 Lightning - Overhead lines and transformers affected by increasing lightning activity	3	6	6	3	12	4	4
AR15 Wildfire - Overhead lines and underground cables affected by extreme heat and fire smoke damage	NA	NA	NA	2	12	4	4

It can be seen that we have made progress against our RIIO-ED1 position through the resilience improvements that are either currently in place or will be put into place during RIIO-ED2. The main areas of residual risk include vegetation growth and flooding which will have an increased focus in RIIO-ED2 as investment towards both areas increases. The results of this risk assessment and scoring were used to define our adaptation pathway to continue to provide future resilience against climate change hazards.

8 Our Adaptation Pathway

Our adaptation pathway utilises the level of risk determined as scored above, 'Minor', 'Moderate – Major' and 'Severe', to determine the steps within the climate change action plan to be implemented in response. In order to further provide our customers with quality service, we will continue to monitor and evaluate climate change risks as part of the UK Power Networks Risks, Control and Compliance Framework. The risk reviews include updates on the status of the risk, including any changes to the context of the risk, and progress in implementing agreed action plans. As new climate change data becomes available this will be reviewed by the risk owner and used to develop the response to the risk.

Furthermore, we will continue to work in a co-ordinated approach with our energy sector partners and dependent external industry stakeholders to manage the residual risk. In particular, where changing standards for new plant may be appropriate based on detailed analysis of the incremental cost weighed against the impact of accepting the risk of climate change. We have reviewed our Climate Change Action Plan and adapted it for RIIO-ED2 to better track, monitor and improve our approach to climate change adaptation in RIIO-ED2 and beyond.

The below table highlights the identified risks at each threshold and the corresponding actions we are putting in place.

Table 11 Adaptation Pathways & Climate Change Action Plan

Risk Threshold	Risk Present View 2021	High Level Actions	Actions from RIIO-ED2 Climate Change Adaptation Plan	Timeline
Start		Continuous engagement with ENA Climate Change Working Group to review and assess climate change hazards against our business systems as and when new models become available. Identify priority risks across the business and score with respect to our network systems against time-based scenarios.		
Minor	AR1 AR2 AR4 AR5 AR6 AR7 AR8 AR9 AR14 AR15	Continuous monitoring and tracking of risk as part of ENA Climate Change Working Group and within corporate risk framework.	1. Advocate for the continuation of the current ENA Climate Change Resilience working group with expansion to include stakeholders external to the energy sector such as telecoms, water and local authorities.	2021
			2. Establish a UKPN Climate Change Resilience Steering group consisting of stakeholders from key business directorates to own the climate change strategy going forward with oversight from the UKPN Risk and Assurance team.	2021-2022
			3. Identify opportunities for further data collection and work with our DSO team to integrate this into our asset data systems.	Annually
			4. Analyse and assess our interdependencies against other sectors and customers to better understand our climate change resilience.	2021-2022
Moderate	AR3 AR10 AR11 AR12 AR13	Implement detailed assessment of risk within network and analyse mitigation options to select most cost-effective option. Incorporate mitigation measure(s) within	5. Quantify risk(s) at an asset voltage class level within the license areas to identify risk 'hot spots' and take targeted action to mitigate. 6. Assess risk(s) across our supply chain to better understand exposure and collaborate	2021 - 2023

Major		proceeding regulatory submission to deliver over the period. Aim to maintain or reduce risk level over subsequent time periods.	to address risks through increased innovative and resilient solutions.	
Severe	No risks currently rated as Severe	Take immediate actions to mitigate and control risk through appropriate measures in the short-term and incorporate long-term mitigations as part of proceeding regulatory submission.	7. Work with UKPN Climate Change Steering Group to assess detailed risk impacts and immediate mitigation options to undertake a cost benefit analysis towards developing the most appropriate mitigation measure.	As needed

The actions as part of our Climate Change Action Plan are detailed below.

1. Advocate for the continuation of the current ENA Climate Change Resilience working group with expansion to include stakeholders external to the energy sector such as telecoms, water and local authorities.

Together with other electricity DNOs and Ofgem, we have agreed the need to extend the Terms of Reference of our existing ENA working group looking at Defra's Climate Change Adaptation Reporting (CCAR) to include the climate resilience points identified in the Sector Specific Methodology Decision (SSMD) and Business Plan Guidance (BPG). These would include sector-wide thinking around how to approach the climate change challenges, sharing of best practice, and development of industry standards to increase resilience. The group would also be expanded to include non-energy sector members including, but not limited to, parties from the water, telecoms and highways industries, academics, and wider experts in the field. UKPN will also support the Department for Business, Energy & Industrial Strategy (BEIS) project for Climate Services. The overall aim of this provision is to ensure that BEIS policies and priorities are informed by up-to-date policy-relevant evidence & scientific advice, where this is required to inform decisions. This includes being transparent about our Net Zero transition efforts, climate change action plans and engagement with the ENA working group to ensure the climate change risks for the energy network are well established and communicated.

2. Establish a UKPN Climate Change Resilience Steering group consisting of stakeholders from key business directorates to own the climate change strategy going forward with oversight from the UKPN Risk and Assurance team.

In order to better assess and monitor climate change risks on the network, we have realised the need to establish a permanent, collaborative, steering group within our business. As such, we are committing to establishing a climate change steering group to be reported on by our Risk and Assurance team which will comprise of key stakeholders across the business including: Environment and Sustainability, Asset Management, Strategy and Regulations, Operations, Procurement, and Health & Safety to ensure that we have a comprehensive view of the climate change impacts across our business. This steering group will be responsible for owning the climate change adaptation pathways and associated Climate Change Action Plan. They will work with various parts of the business, including the DSO and network innovation, to better quantify the risks and support preparation towards future reporting for the Task Force for Climate-related Financial Disclosures (TCFD). In 2019 a UK government paper called for listed companies and large asset owners to align disclosures with the TCFD recommendations by 2022. UKPN's shareholders fall into this category and will therefore need to comply with the recommendations which include disclosing how companies are addressing climate change risks through their organisational metrics and targets, risk management processes, strategy, and governance. The group will also report annually through the Annual Environmental Report. The full Terms of Reference for the group will be developed and agreed with leadership prior to the start of RIIO-ED2.

3. Identify opportunities for further data collection and work with our DSO team to integrate this into our asset data systems.

The established UKPN Climate Change Steering Group will also be responsible for working closely with our DSO team to better understand how the data being collected across our network could be utilised to support climate change risk monitoring and understanding. As part of RIIO-ED2, we are increasing investment into the automation and remote monitoring of our network. This data and technology will also enable us to better understand the interactions between the climate and our assets to help develop solutions that will improve resilience. One example includes better understanding the relationship between the ambient temperature and that within our substations to be able to proactively react when ambient temperatures reach certain thresholds.

4. Analyse and assess our interdependencies against other sectors to better understand our climate change resilience.

We are aware that resilience is interdependent and that our customers can be impacted through failures in power generation, transmission, gas or telecoms networks. In addition, other sectors like water and rail are dependent on our network to maintain their customer service. As such, it's crucial for us to work with these parties, and others, to fully understand and map out our interdependencies and assess the impacts of climate change on the system as a whole. As part of RIIO-ED2, we will work within our ENA working group to better understand these interdependencies as a sector and utilise our existing stakeholder relationships to assess the impact on our network as a whole.

5. Quantify risk(s) at an asset voltage class level within the license areas to identify risk 'hot spots' and take targeted action to mitigate.

For those priority risks which we have identified to be 'moderate' or 'major' level of risk through the ENA climate change risk framework, our UKPN Climate Change Steering Group will be taking actions to better understand the risks across our network, such as:

- a) Developing the current systems approach and resilience framework to enable a more detailed and quantified analysis of climate change risks within our business, aligned to the TCFD²² recommended governance.
- b) Assessing risks at license area level based on asset class, risk exposure, and impact through data analysis including asset health, customers served and load profiles.
- c) Quantifying risks exposure across the scenario timelines to establish climate change risk profile and look to integrate climate change risk into long term monetised risk assessments to inform future asset management strategies.
- d) Developing mitigations to address risk 'hot spots' in order to improve base level resilience across the network.
- e) Work with academic and research institutions, for example our existing relationship with the Electric Power Research Institute (EPRI), where appropriate to take advantage of the latest findings.

These steps will be further developed in RIIO-ED2 with the aim of providing a quantified, consistent, and comprehensive view of the priority risks across our network. Following this, the steering group will collaborate to develop mitigation options which will be taken through a cost/benefit assessment process and incorporated into either the current regulatory period, if appropriate, or within the business plan for RIIO-ED3. The modification of technical standards will also be considered as part of the mitigation options where applicable.

²² Task Force on Climate-Related Financial Disclosures

6. Assess risk(s) across our supply chain to better understand exposure and collaborate to address risks through increased innovative and resilient solutions.

Our supplier relationship managers will be part of our Climate Change Steering group and, through this, we will actively work together to understand the risks climate change poses for their businesses and where mitigation measures need to be taken. We will consider all 12 climate hazards as a starting point to ensure we are comprehensive and narrow down the priority risks using the same ENA risk scoring framework for consistency. Subsequently, we will work together to identify and assess mitigation measures which need to be developed to improve resilience.

7. Work with UKPN Climate Change Steering Group to assess detailed risk impacts and immediate mitigation options to undertake a cost benefit analysis towards developing the most appropriate mitigation measure.

Where we have identified climate change risk to pose a 'severe' risk to our business according to the ENA risk assessment framework, we will take more immediate action to mitigate in the short term. This would involve the following steps:

- a. Escalate risk and cost benefit analysis to senior leadership for funding approval and engage with supply chain for delivery.
- b. Implement mitigation measure(s) to lower risk to acceptable level.
- c. Incorporate long-term mitigation measures as necessary within proceeding regulatory period.

Currently, we don't have any risks assessed at this level, however, through regular review of risks, it may be determined that some local 'hotspots' within the broader 'moderate' and 'major' risks need to be addressed according to this process.