UKPN Climate Change Adaptation Report

16 December 2021

UK Power Networks
Delivering your electricity

Contents

1. Introduction

UK Power Networks started to identify climate change impact on our networks and initiated monitoring and mitigation actions due to the Climate Change Act (2008). We took part in climate change adaptation reporting as requested by the Department for Environment Food and Rural Affairs (Defra). In the first two rounds of reporting, UK Power Networks collaborated with the Energy Networks Association (ENA) working group members to identify the key climate risks to our network and establish a systematic assessment methodology to monitor and update the climate risks.

In November 2018, the Met Office and the Environment Agency released the latest climate change forecast through UK Climate Projections (UKCP18). This product simulates different greenhouse gas emissions scenarios and their impact on the future environment. For the highest emission scenario, as modelled through Representative Concentration Pathways (RCP) 8.5, the global mean surface temperature is estimated to increase 4.3°C by 2081-2100. This scenario is likely to result in a variety of climate change hazards from hotter and drier summers, rainier winters, to more intense storm events and prolonged vegetation growth periods.

The energy network is vulnerable to these hazards, for example:

- Limited equipment capacity due to reduced ability to dissipate heat in hotter summers
- Increased overhead line faults from overgrown trees touching live conductors
- Greater substation flooding risk, especially from surface water runoff
- Impact on scheduled maintenance or improvement work as well as emergency call-out to fault location due to adverse environment

UK Power Networks sees the challenge of future climate change as presenting both risk and opportunity to deliver on our ambitions as a respected corporate citizen and the most environmentally responsible DNO group for our customers. In this third round of climate change adaptation reporting, we have updated our understanding of future climate change and reviewed the existing mitigation measures to identify the gap. As this task is carried out at the time we are planning for the Electricity Distribution price control 2023-2028 (RIIO-ED2), we have integrated climate change adaptation into our RIIO-ED2 strategy to operate a more climate-resilient network for our customers.

This document summarises the findings and mitigation measures as stated in our Climate Resilience Strategy report [1] available on our website. This document mainly focuses on how we have actioned to mitigate and adapt to future climate risks. To find out how we help to reduce greenhouse emissions and take care of the wilder environment, please refer to our Environmental Action Plan (EAP). [2]

[1] Appendix 14 Climate resilience strategy, available at: https://ed2.ukpowernetworks.co.uk/additional-information/

[2] Appendix 16 Environmental Action Plan, available at: https://ed2.ukpowernetworks.co.uk/additional-information/

2. Organisation Overview

UK Power Networks owns and maintains the electricity distribution network across our three licensed areas: Eastern Power Networks plc (EPN), London Power Networks plc (LPN), and South Eastern Power Networks plc (SPN). We are responsible for keeping the lights on across 29,250 square kilometres, serving over 8.3 million domestic and business customers in London, the East and South East of England. We care to provide our services safely and sustainably. To achieve this, we:

- Put safety and reliability as the priority for our electricity networks, and minimise customer interruption.
- Continuously improving our existing services and actively shaping new ones to meet our customers' evolving demands.
- Reduce the environment impact of our operations and enable transition to Net Zero carbon emissions.
- Ensure we remain legitimate and responsible in the eyes of our customers.
- Support our customers in vulnerable circumstances and care for their specific needs.

In answering the challenges identified in UKCP18, UK Power Networks works closely with the energy transmission and distribution operators through Energy Networks Association (ENA). We participate and contribute to the ENA Adaptation to Climate Change Task Group to review climate change risks and their potential impacts on energy networks.

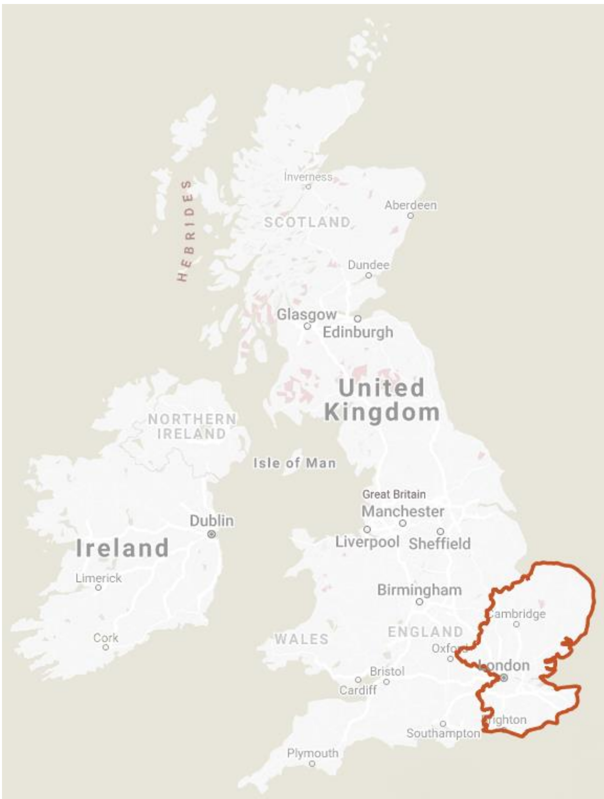

Figure 1: UKPN Operating Area

3. Case Studies

Since its first report on climate change adaptation, UK Power Networks has been assessing and developing its knowledge on the climate risks, hazards and impact to the business over ten years. We have taken various approaches and innovative solutions to minimise these impacts and ensure we provide a reliable energy supply to our customers even in adverse environmental conditions.

The following are some of our climate resilience case studies that we summarised and shared with Defra through the ENA Climate Change Adaptation group reporting mechanism.

4.1 Flood Mitigation Programme

Flooding has been identified as one of the top climate risks in the first two rounds of climate change adaptation reporting. Accumulated rainfall, overflowing rivers, sea level rise, reservoir breach and water main burst can lead to severe water ingress to critical electrical assets and ground-mounted transformers, causing equipment damage and loss of power supply to our customers.

We initiated our flood mitigation programme in 2009 in accordance with the first issue of *Engineering Technical Report 138 (ETR138): Resilience to Flooding of Grid and Primary Substations* recommendations published in the same year. Since then, we have continuously improved our understanding of substation flood risk across all three license areas along with the development and updates of the Environment Agency (EA) flood models. Mitigation solutions such as water-resistant bunding and flood gates are delivered at our existing substations. 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.

In 2020, UK Power Networks conducted a gap analysis of its mitigation progress against the latest EA flood models and UKCP18 climate change updates. We have seen a substantial increase in flood risk to our substations, particularly in the London area. This, together with the findings of the third round climate change adaptation studies, shaped our future flood mitigation programme and strategies as shown in 6.4 Action: Adaptation Pathway.

In addition to the proactive mitigation approach, UK Power Networks has stored a 1km long temporary flood barrier ready to deploy as a reactive measure in the event of an emergency,

As of today, UK Power Networks has protected over 2.8 million customer connections from flood risk, reduced our customers at risk of flooding from an average of 70% in 2011 to an average of 13% in 2021.

4.2 Improved Analytics and predictive Tools

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 tool allows us to identify a correlation between faults at different voltage levels and accumulated rainfall across EPN, LPN and SPN. The further understanding of the correlation between faults and rainfall enables us to provide forecasts up to five days in advance for cumulative rainfall greater than 10mm of rain and effectively prepare for the expected faults increase.

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 in the next pricing control period RIIO-ED2. Recently, we have improved our planning capability by using the GSA to create a tool that overlays EA data on our network maps for our planning team to use when designing new connections and substations.

In the event of a lightning storm, we have developed a tool – 'Lightning' using weather data from MeteoGroup. This tool enables us 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. We can therefore better allocate our resource and achieve circuit breaker reclosures automatically in under three minutes. We are looking to incorporate this tool into PowerOn, our system for managing network utilisation, and use artificial intelligence to optimise our resource allocation as well as 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.

4.3 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 onto 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.

We have learned several lessons from this event and, ever since, invested in 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.

In February 2020, the UK experienced another large windstorm – Storm Ciara, with wind speeds of over 90 mph and rainfall of up to 177mm. Through collaboration with the Met Office, we used the GSA analytic tool and 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:

I. **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.
II. **Regulatory Customer Interruptions:** less than half of the number of customer interruptions lasting more than 3 minutes (around10,500 for Storm Ciara versus around c.22,600 in December 2013)
III. **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 Supply 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 our 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.

4.4 Tree Cutting: LiDAR programme implementation

We were an early adopter of LiDAR technologies to our tree cutting strategy. 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 *Engineering Technical Report 132(ETR132) - Improving resilience of overhead networks under abnormal weather conditions using a risk based methodology*, 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 Assessment of the 2006 amendment required that 20% of the 11kV and 33kV overhead line networks should meet the ETR132 standard by 2034. We expect to achieve at least pro-rata (over 11%) compliance with the ETR132 recommendations on a circuit and customer basis by the end of RIIO-ED1, and increase our investment into tree cutting in RIIO-ED2 to address the increased risk of vegetation growth due to climate change.

4. Understanding Climate Change

5.1 UKCP18 Update

The latest UK Climate Projections (UKCP18), produced by the Met Office and the Environment Agency, provided an updated view on the previous projections from 2009 (UKCP09). The signal and trend around future climate change remain the same in UKCP18, yet this latest model provides fine details on each climate factor. We are prepared to see these following trends:

Increased Risk:

- Increased frequency and durations of high temperature days
- Prolonged rainfall events and hourly rainfall extremes
- Increased risk from sea-level rise and extreme sea level events
- Increased risk of wildfire
- Increased extreme daily weather events

Decreased Risk:

- Reduced frequency of snow and ice days

Currently no strong evidence of risk change:

- Strong wind events
- High wave height
- Wetter conditions coincident with warmer temperatures and/or strong winds
- Lightning
- Daily variable temperature cycles

Based on this modelling, we collaborated with members of the ENA and the Met Office to prioritise key climate hazards on electricity networks under different Representative Concentration Pathways (RCP) for greenhouse emissions. RCP8.5 has been selected as it represents the worst-case scenario, resulting in a best-estimated 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 prioritised the weather and climate-related hazards that can have an adverse impact on the energy network and identified the following eight hazards, as shown in Table 1. For the complete analysis of each hazard, please refer to Appendix A.

Table 1 ENA 3rd Round DEFRA AR Reporting Risks

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

5.2 ENA Working Group Findings

UK Power Networks has gone through the first two rounds of the ENA Adaptation Reporting Power (APR) mechanism to establish a climate risk assessment methodology to translate climate hazard into quantified network risk on our assets and network.

The third round of this reporting provides an opportunity to review and update on these risks with consideration of the impact of the societal response to climate change as the UK transitions to net zero by 2050. We are expecting increased electricity demand due to the prevalence of electrified heating and electric vehicles, as well as the new challenge of exacerbating demands in summer from air conditioning due to temperature increase.

The table below details the 15 priority risks as identified in the third round of ENA reporting in respect to the top climate change hazards identified above:

Table 2 ENA 3rd Round DEFRA AR Reporting Risks

Priority Hazard Category	Risk No.	Impacted Asset Type	Risk	Considered in ARP2?
Temperature Increase & Prolonged High Temperatures	AR1	Overhead line conductors	• 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	• Foundation instability due to ground shrinkage (especially with clayey soils) during summer drought	✔
Wetter & Warmer Conditions	AR3	Overhead lines	• Faults and physical damage due to increased vegetation growth from prolonged growing season	✔
Temperature Increase & Prolonged High Temperatures	AR4	Underground cable systems	• Capacity limitations due to inability of conductor to radiate heat during drought and high temperatures	✔
Drought (soil drying & movement)	AR5	Underground cable systems	• 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	• Earthing system failure due to decreased soil resistivity under drought conditions resulting in public safety issues	✔
Temperature Increase & Prolonged High Temperatures	AR7	Transformers	• Life expectancy reduction and potential failure due to inability to radiate heat with higher ambient temperatures	✔
Demand Increase due to climate change	AR8	Transformers	• 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	• Loss of supply or reduced operability due to exceedance of maximum operating temperature inside switch rooms	✔
Flooding (Fluvial)	AR10	Substations	• Loss of supply and/or damage due to river (fluvial) flooding due to increased winter rainfall	✔
Flooding (Pluvial) / Heavy Rain	AR11	Substations	• Loss of supply and/or damage due to flash (pluvial) flooding due to increased rain storms in Summer	✔
Flooding (sea breach)	AR12	Substations	• Loss of supply and/or damage due to sea flooding through increased rain storms and/or tidal surges	✔
Flooding (Pluvial) / Heavy Rain	AR13	Substations	• Loss of supply and/or damage due to water flood wave from dam burst	✔
Lightning	AR14	Overhead lines and transformers	• Faults and/or damage caused by increasing lightning strike frequency	✔
Wildfire	AR15	Overhead lines, underground cables, operational telecoms	• 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	✘

5. Network Risk and Resilience

6.1 Risk Assessment Approach

With the exception of the newly identified AR15 wildfire, UK Power Networks has been managing and mitigating the other 14 risks since the last round of reporting. We take this opportunity to incorporate industry best practices and review our future climate resilience readiness by assessing our mitigations against the four Rs 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

We have taken consideration of climate adaptation into our business strategy for RIIO-ED2. Each residual risk is assessed 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)

6.2 ENA 15 AR Risk Analysis Results

AR1 Temperature - Overhead line conductors affected by temperature rise

Future Mitigation	Redundancy	Response & Recovery	Resistance	Reliability
Ongoing OHL conductor replacement at 132kV, 33kV, 6.6/11kV and LV	✔	✔	✔	✔

Current 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. 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.

UK Power Networks will 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 reason 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

Future Mitigation	Redundancy	Response & Recovery	Resistance	Reliability
Replace exiting poles and tower, and adopting pole supports and pole saver technology	✔		✔	✔

We are undertaking a large programme to replace HV/EHV wood poles to help increase the structural integrity of our OHL poles currently and in RIIO-ED2. 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 future mitigation 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.

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

Future Mitigation	Redundancy	Response & Recovery	Resistance	Reliability
Increased investment in tree cutting using LiDAR due to expected faster vegetation growth	✔	✔	✔	✔

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, accounting for faster growth of vegetation in RIIO-ED2 and beyond. 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

Future Mitigation	Redundancy	Response & Recovery	Resistance	Reliability
New LV Main, HV, EHV and 132kV cable installed	✔	✔	✔	✔

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. We are 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 future development 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

Future Mitigation	Redundancy	Response & Recovery	Resistance	Reliability
Risk-based fluid filled cable removal	✔		✔	✔

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 the programme in RIIO-ED2, replacing these FFC to mitigate against the increasing 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 project[3]) across our network of FFCs to reduce the leakage rate. There is also an ongoing innovation project[4] looking at self-healing cables

[3] NIA Reference: NIA_UKPN0012
[4] NIA Reference: NIA_UKPN0030

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

Future Mitigation	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

Future Mitigation	Redundancy	Response & Recovery	Resistance	Reliability
New HV, EHV and 132kV transformers installation	✔	✔	✔	✔

Distribution, grid and primary transformer replacement programmes taking place due to load/non-load reasons can 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 London 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. UK Power Networks specifies transformers according to the Eco Design Directive Legislation[5], which indicates the use of low-loss transformers.

Furthermore, the future transformer replacements will consider the use of natural/synthetic ester oils where heat risk is higher as these are more resistant to higher temperatures.

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

Future Mitigation	Redundancy	Response & Recovery	Resistance	Reliability
New HV, EHV and 132kV transformers installation	✔	✔	✔	✔

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

Future Mitigation	Redundancy	Response & Recovery	Resistance	Reliability
New HV, EHV and 132kV circuit breakers installation	✔	✔	✔	✔

Our switchgear replacement programme 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 specification 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

Future Mitigation	Redundancy	Response & Recovery	Resistance	Reliability
Increased investment in flood risk assessments and mitigation delivery.		✔	✔	✔

Our 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

Future Mitigation	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 Gas Insulated Switchgear will minimise the need for outdoor busbar arrangements, thus reducing risk of lightning damage. Furthermore, all pole-mounted 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

Future Mitigation	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.

6.3 Climate Risk Scoring

We apply the following ENA risk-scoring matrix (Table A) to rate each of the risk and corresponding mitigations plans.

Table 3: 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

We therefore established a revised view of the scores in comparison with the rating in APR2. The results of this assessment are demonstrated in Table 4.

It can be seen that we have already made progress against our ARP2 position through the resilience improvements that are currently in place or will be put into place during RIIO-ED2 and ongoing years. The main areas of residual risk include vegetation growth and flooding which will have an increased focus in RIIO-ED2 as we intend to increase investment in both areas. The results of this risk assessment and scoring were used to define our adaptation pathway to continue to provide future resilience against climate change risks.

Table 4 UKPN Priority Risks Scores

Risk	UKPN APR2 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

6.4 Action: 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 provide our customers with enhanced quality of 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.

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 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. We have submitted our RIIO-ED2 proposal based on these actions to Ofgem. The final investment plan will be available in 2022/23.

Table 5 Adaptation Pathways & Climate Change Action Plan

Risk Threshold	Risk Present View 2021	High Level Actions	Actions from 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 proceeding regulatory submission to deliver over the period. Aim to maintain or reduce risk level over subsequent time periods.	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 to address risks through increased innovative and resilient solutions.	2021 - 2023
Major				
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

6. Opportunities and Barriers

7.1 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 impact 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 have seen increased collaboration within the industry and across sectors. We view this 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 are looking to 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 distribution networks 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. UK Power Networks 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.

7.2 UKPN Climate Change Resilience Steering group

We have already implemented climate change resilience via internal design standards, business plans and routine operation and maintenance. However, in order to better assess and monitor climate change risks on the network, we have decided to establish a permanent, collaborative, steering group within our business.

As such, we are committing to establishing a climate change steering group which will comprise of key stakeholders across the business to ensure that we have a comprehensive view of the climate change impacts. 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 teams, 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. Our 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 Action Plan reporting. The full Terms of Reference for the group will be developed and agreed with the leadership team in 2023.

7.2 Innovation

UK Power Networks, as one of the most innovative network operators, will continuously research for innovative mitigation solutions and smarter products to further reduce climate change impact on our operation. We have seen success in our underground cable programme, and have confidence to keep our momentum into RIIO-ED2.

We will also identify opportunities for further data collection and work with the DSO team to integrate climate change data into our asset data systems. The established UKPN Climate Change Steering Group will also be responsible for working closely with the DSO 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 the RIIO-ED2 proposal, we are increasing investment in 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.

7. Appendix

Appendix A – Full Climate Hazard Analysis

Hazard	Threshold(s) or Metric	Current Frequency/ Occurrence	2060-2100 Frequency/Occurrence
Temperature Increase	1. Number of days/year > 28°C 2. Number of days/year > 35°C	1. 8-12 days/year 2. 0 days/year	1. >30 days/year 2. 3-4 days/year
Drought (soil drying & movement)	1. 30 day minimum rainfall 2. 60 day minimum rainfall	1. 20 mm 2. 90 mm	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)	1. Number of months per year where rainfall event exceeds 90th percentile 2. Number of months per year where rainfall event exceeds 90th percentile	1. 1.2 months/year 2. 0.4 months/year	1. 1.2 months/year 2. 0.8 months/year
Flooding (Pluvial) / Heavy Rain	1. Change in winter 99th percentile mean daily rainfall 2. Change in winter 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	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.
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 - 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.