Adapting to Climate Change

Fourth Round Report

December 2024

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Executive Summary

At Northern Powergrid we have experienced the effects of climate change and the severe weather it can bring. We recognise that a secure and resilient electricity supply is becoming increasingly more important to our customers and we are committed to continuing to adapt to meet the needs of our customers.

In 2011, we published our first Climate Change Adaptation Report. This document is the fourth iteration of this original and sets out updates to our approach to ensuring a resilient network and organisation. It should be read in conjunction with our third-round report[1], which provides greater detail on our risks and adaptation plans. The Northern Powergrid Adaptation Pathway is shown below and forms the basis of this report.

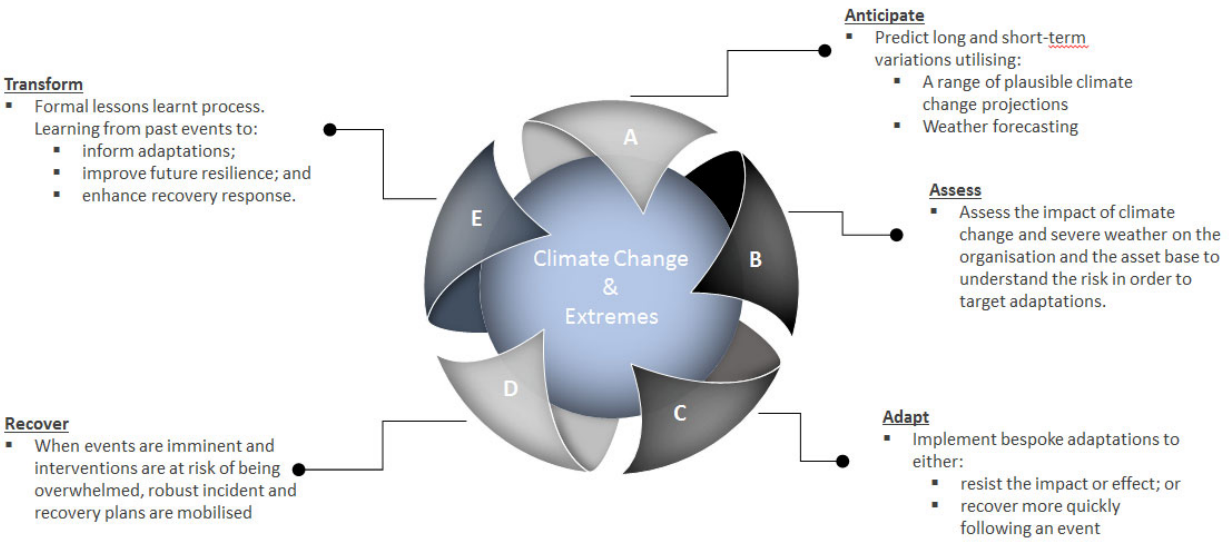

Figure 1 - Northern Powergrid Adaptation Framework

- In ARP1 (2011) we established the response as a collaborative project amongst electricity network operators and identified key risks to network assets and operation posed by climate change impacts.
- In ARP2 (2015) we built on our understanding of the risks and updated DEFRA on industry mitigation measures being put into place on the networks. We developed the consistent reporting methodology from ARP1 and provided further evidence of actions taken in response to key climate risks.
- In ARP3 (2021) we provided an update on existing risks, mitigation measures and programmes and identified new risks being realised in order to provide a fuller picture of the potential for climate change impacts to affect networks. Our ARP3 report was published on a similar timeline to our RIIO-ED2 climate resilience strategy[2].
- In ARP4 (2024) we aim to update on the progress made with the implementation of our action plans.

[1] https://www.northernpowergrid.com/sites/default/files/assets/6578.pdf
[2] https://ed2plan.northernpowergrid.com/sites/default/files/document-library/Climate_resilience_strategy.pdf

Introduction

Business Overview

Northern Powergrid is responsible for delivering electricity to over 8 million customers across 3.9 million businesses and homes. We operate through our subsidiary companies Northern Powergrid (Northeast) Ltd in the North East and North Yorkshire and Northern Powergrid (Yorkshire) plc in South, East and West Yorkshire and northern Lincolnshire.

The Northern Powergrid network consists of more than 63,000 substations and some 60,000 miles of overhead power lines and underground cables spanning 9,650 square miles.

Figure 2 - Northern Powergrid's Area

As a distribution network operator (DNO), our aim is to efficiently deliver a top-class service where the lights stay on, the network remains healthy and our customers enjoy outstanding, ever-improving levels of personal service. The future presents an opportunity to power our region with sustainable, long-term investments that unleash the potential of innovation, digitalisation and our people to:

- Lead the drive towards decarbonisation
- Operate a highly reliable and resilient network
- Delight our customers with outstanding service
- Provide remarkable value for money
- Ensure world-class levels of safety and security
- Be a force for good throughout our region and beyond.

Electricity Networks Overview

In the UK, generation is a competitive market. Energy supply companies buy electricity in bulk from generation companies and pay transmission and distribution companies to transport electricity through their networks to homes and businesses. Transmission and distribution companies are responsible for providing a reliable supply of electricity to their connected customers across the UK in an efficient manner whilst delivering excellent standards of customer service.

These are regulated businesses, operate under licences issued by Ofgem and are subject to a common regulatory framework. They are also subject to common statutory requirements including The Electricity Act and Electricity Safety Quality and Continuity Regulations (ESQCRs) which are overseen by Department for Energy Security and Net Zero (DESNZ) and the Health and Safety Executive (HSE).

This basis of a common background, asset standards and regulatory processes means that UK Electricity DNOs have very high commonality when approaching the assessment of climate change impacts on their networks. The level of climate change will vary across the UK but the assessment of impact per unit of change, such as degrees Celsius, can be established using common methodology. As a consequence of these common drivers, UK Electricity DNOs have worked together through the Energy Networks Association (ENA) for many years across a wide range of activity including:

- Establishing UK network owner input to the content, development and modification of national and international standards.
- Establishing common equipment specifications and design standards, across the full spectrum of network assets, to reduce procurement costs and ensure availability of product.
- Providing a unified input to UK Government and Regulators (Ofgem, HSE etc) on development of regulations, processes, reporting etc.
- Collaborating on research and development, including impacts of climate change and work on asset designs/ratings.

Allowed revenues for the industry are currently set by Ofgem with individual network operators and these periodic reviews govern all expenditure, including resilience against natural hazards and emergency planning. This provides common oversight and accountability to Ofgem and the DESNZ. Any costs associated with adaptation to climate change are subject to regulatory scrutiny.

System Overview

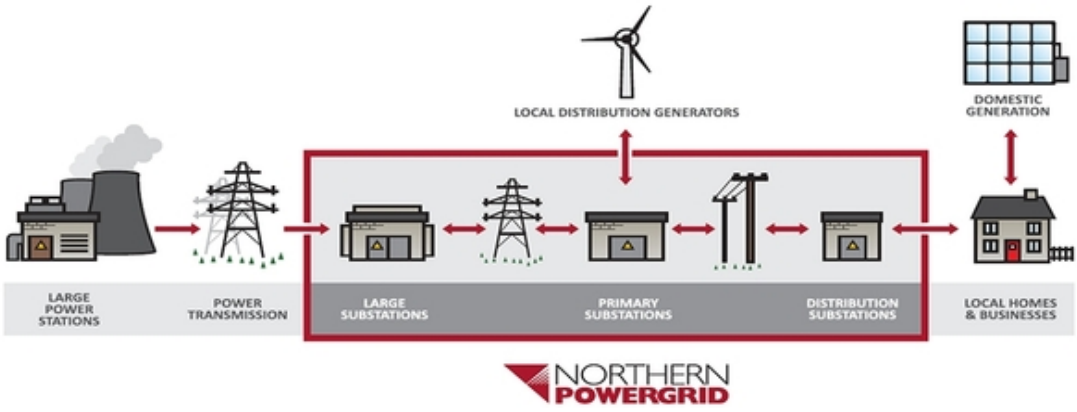

Figure 3 - Typical Electricity Supply Chain

Electrical power is transported from generating plants to customers over networks managed by transmission and distribution companies. The transmission system operates at typically 400,000 volts (400kV) or 275kV and the distribution system, as operated by Northern Powergrid, uses voltages from 132kV to the normal household voltage of 230V.

The system comprises a mixture of overhead lines and underground cables. In addition, there are sites; called substations, where voltage transformation takes place and switching and control equipment are located.

The transmission system is owned and operated by National Grid and the interface between them and the Northern Powergrid distribution systems takes place within grid supply or super grid substations at 132kV.

Decarbonisation and reaching net zero is expected to drive a significant increase in the electrification of existing energy vectors, with electricity demand projected to double out to 2050. This decarbonisation via electrification further increases the reliance on the network to be resilient to the environment it operates in and the effects that climate change will bring.

Risk Assessment

Climate Change Data

ARP3 utilised the Met Office UK Climate Projection (UKCP18) tool[3] for projections towards the end of the 21st century. In 2020, on behalf of its members, ENA commissioned the Met Office to undertake a review of the UKCP18 data and provide an RCP 8.5 worst case scenario in order to understand the changes in potential impact to energy infrastructure assets from climate change. The report from this research has been used to assess the current risks to the energy network, and to guide future mitigation or management actions. ARP4 does not offer any new climate change data but does retain the research carried out for ARP3. The Met Office data provided in ARP3 has been reviewed and examined for ARP4.

Future Risk Scoring

Future Risk Scoring for 2050 and 2100 have been utilised to establish grounds for future risk mitigation, however, future climate projections are speculative and reduce in accuracy the further in the future the prediction is made. All scoring for 2050 and 2100 are expected to be subject to unforeseeable variables and are thus accompanied by a confidence rating. Confidence ratings are provided for each future risk score to flag uncertainty in the data based on the confidence that the score will be accurate by 2050 and 2100. 2050-70 projections in current climate data have reasonable confidence, however beyond 2070, confidence decreases significantly.

[3] https://ukclimateprojections-ui.metoffice.gov.uk/ui/home

Although the risks to the network are assessed at a detailed level by Northern Powergrid, we have provided a view of the highest priority risks to the operation of the network. A more detailed discussion on these risks can be found in Appendix 1 and further discussion of risks to our business operation can be found in Appendix 2.

LIKELIHOOD OF OCCURRENCE					
Almost Certain					
Likely		AR3			
Possible		AR2, AR5, AR6, AR7, AR14	AR1, AR4, AR8, AR10, AR16		
Unlikely		AR9	AR11, AR15	AR12	
Highly Unlikely					AR13
IMPACT	Minimal	Minor	Moderate	Major	Catastrophic

Table 1 - Key Asset Risks

Likelihood of occurrence		Impact	
Almost Certain	The risk is in the process of materialising and may already be under active management as an event	Catastrophic	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
Likely	Past events have not been fully resolved, effective mitigations not yet identified, control weakness are known and are being managed	Major	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
Possible	Past events satisfactorily resolved, mitigations are in place or are on track to be in place, control improvements are under active management	Moderate	Large town or conurbation off supply for up to a week OR significant increase in cost of network strengthening
Unlikely	Events are rare, required mitigations in place, controls are effective	Minor	Small town off supply for a 24 hour period OR significant increase in cost of network maintenance requirements.
Highly Unlikely	No know event or if known extremely rare, extreme industry-wide scenarios	Minimal	Limited impact – can be managed within “business as usual” processes.

Table 2- Definitions of Likelihood and Impact

Risk Code	Impact		Climate Variable	Current Likelihood	Risk Status				Risk Considerations
	Asset / Network Effect	Current Rating			Current	2050's	2100's (2°C)	2100's (4°C)	
AR1	Overhead line conductors affected by temperature rise.	Moderate	Temperature	Possible	Low	Low	Low	Low	Localised increase in pole heights and age related replacement maintains line clearances. No significant changes in UKCP18 predictions over UKCP09.
AR2	Overhead line structures affected by Summer drought & consequent ground movement	Minor	Temperature	Possible	Low	Low	Low	Low	Emerging risk. Impact dependent on geology and topology.
AR3	Overhead lines affected by interference from vegetation due to prolonged growing season	Minor	Temperature / Precipitation	Likely	Low	Low	Low	Low	Increase in growth offset by increase in cutting at each visit or increased cutting frequency.
AR4	Underground cable systems affected by increase in ground temperature,	Moderate	Temperature	Possible	Low	Low	Low	Low	Limited data on impact on cable ratings.
AR5	Underground cable systems affected by Summer drought & consequential ground movement	Minor	Temperature	Possible	Low	Low	Low	Low	Emerging risk. Impact dependent on geology and topology.
AR6	Substation & network earthing systems adversely affected by Summer drought conditions	Minor	Temperature	Possible	Low	Low	Low	Low	Limited test data available. Anecdotally Grid and Primary substations are buried deep enough to only experience minor impact in performance.
AR7	Transformers affected by temperature rise	Minor	Temperature	Possible	Low	Low	Low	Low	Temperature rise accommodated in design
AR8	Transformers affected by urban heat islands & coincident air conditioning demand	Moderate	Temperature	Possible	Low	Low	Low	Low	Managed through load planning although extended high load may reduce the life expectancy of the transformer.
AR9	Switchgear affected by temperature rise	Minor	Temperature	Unlikely	Low	Low	Low	Low	Temperature rise accommodated in design
AR10	Grid & Primary Substations affected by river flooding due to increased winter rainfall	Moderate	Precipitation	Possible	Low	Low	Low	Medium	While risk of flooding has increased, the asset protection measures employed have offset & reduced the risk.
AR11	Grid and Primary Substations affected by pluvial (flash) flooding due to increased rain storms in Summer and Winter	Moderate	Precipitation	Unlikely	Low	Low	Low	Medium	While risk of flooding has increased the asset protection measures employed have offset and reduced the risk.
AR12	Grid & Primary Substations affected by sea flooding due to increased rain storms and/or tidal surges	Significant	Precipitation	Unlikely	Low	Low	Low	Low	While risk of flooding has increased the asset protection measures employed have offset and reduced the risk.
AR13	Grid & Primary Substations affected by water flood wave from dam burst	Extreme	Precipitation	Highly Unlikely	Low	Low	Low	Low	Considered unviable to protect against.
AR14	Overhead lines & transformers affected by increasing lightning activity	Minor	Lightning	Possible	Low	Low	Low	Low	Existing mitigation measures adequate.
AR15	Overhead lines & underground cables affected by extreme heat and fire smoke damage	Moderate	Wildfire	Unlikely	Low	Low	Low	Low	Based on Saddleworth Moor incidents.
AR16	Overhead lines affected by strong winds	Moderate	Wind	Possible	Low	Low	Low	Low	Events are rare but impact has the potential to be quite severe.

Table 3 - Considerations for Key Asset Risks

Action Plans and Implementation

Resilient Infrastructure

The climate resilience process currently followed by Northern Powergrid closely aligns to the framework set out by the National Infrastructure Commission (NIC) in its report "Anticipate, React, Recover" from May 2020. In their 2024 report, "Developing resilience standards in UK infrastructure" the NIC further develop their framework for resilience. These developments will be considered in the next iteration of the Northern Powergrid resilience framework and will inform the next round of adaptation reporting.

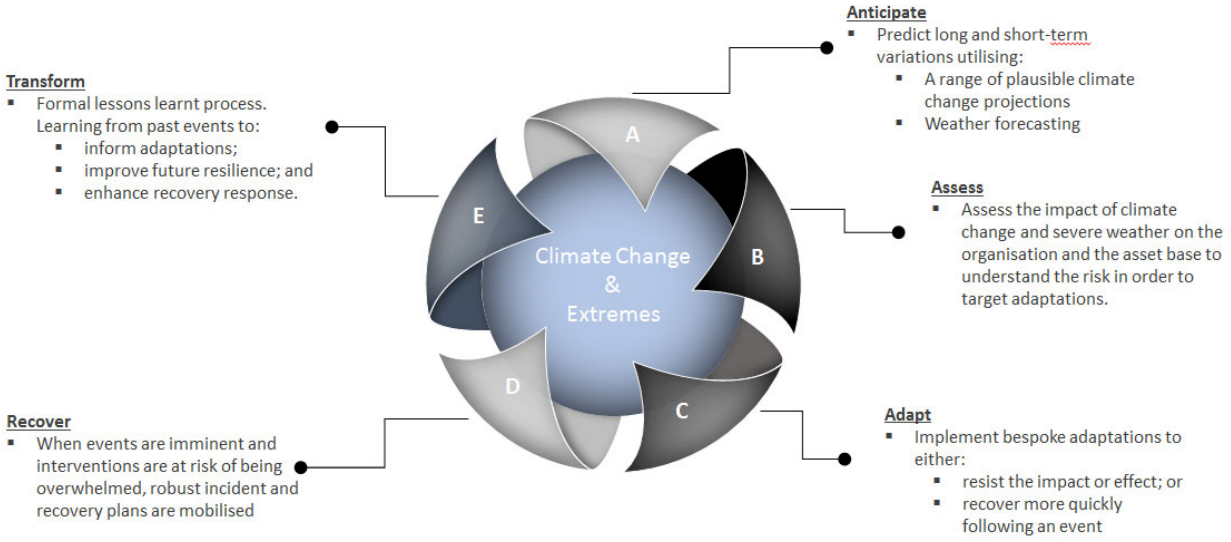

Figure 4 - Northern Powergrid Adaptation Framework

Anticipate: We have utilised the UKCP18 Climate Change Projections produced by the Met Office to ensure that we are using the latest and most robust scientific data on climate change. Each climate condition that could potentially affect our network has been considered and the projections to the end of the century examined across a number of plausible climate scenarios. The climate conditions considered to be of most concern to Northern Powergrid relate to flooding and rainfall levels and increases in temperature

Assess: In order to fully prepare for the changes highlighted during the Anticipate phase, we have considered the impact of the projected changes on both our network and organisation as well as the potential interdependencies with other infrastructure organisations. The risks of most concern include flooding and vegetation management although there are potential impacts on network performance from temperature rises and other extreme events.

Adapt: Following on from the risk assessment, we have considered how best to adapt to the challenges. This may be through resisting through preventative measures such as flood defences or responding to incidents by making changes to our network, such as increased automation, to allow us to restore supplies in a more timely manner following an incident occurring.

Recover: We also recognise that in some cases, interventions may be overwhelmed and we have ensured that we have robust incident and recovery plans in place to help us quickly restore the network to the expected levels of service. These plans have been implemented multiple times and are subject to continual review to ensure that they continue to provide the best possible service for our customer.

Transform: The final stage of our adaptation pathway ensures that we continue to transform our organisation to enhance the resilience of our network. This is achieved by considering lessons learnt from network incidents alongside continually reviewing best practise to allow our adaptations and organisation to evolve.

We continue to invest in innovation and research and to build emerging technologies and practices into our organisation to allow us to continue to provide the service that our customers expect from us.

Storm Improvement Plans

Climate change risks are captured within the National Risk Register (2023)[4], feeding into Local Resilience Forum (LRF) risk registers and into Northern Powergrid's emergency planning risk register. The Northern Powergrid suite of major incident documentation has been reviewed in 2024 to take into consideration changes to regulations and risk.

In 2021 the United Kingdom was hit by Storm Arwen. This brought widespread disruption to the UK Electricity Networks and resulted in significant numbers of customers off supply for prolonged periods. In February 2022 Ofgem produced an interim report which highlighted several recommendations which Distribution Network Operators were to implement. To deliver these recommendations Northern Powergrid developed the executive driven 'Storm Response Improvement Programme'. The Storm Response Improvement Programme has been successful in implementing a host of industry defined and internally defined improvements.

These include, but aren't limited to:

- Increased the number of staff trained to use our fault management system
- Increase in overhead line resource capacity to support with operational response
- Improvements to the website, including overall capacity and information
- Increased call handling capacity and stability via internal resource
- Investment in batteries as temporary power solutions for vulnerable customers

Storm Arwen Re-opener

Northern Powergrid was one of the most severely impacted DNOs during storm Arwen, resulting in significant damage to the network with up to 280,000 customers experiencing power cuts. In response to the event the Department for Business, Energy and Industrial Strategy (BEIS) commissioned the "Energy Emergencies Executive Committee Storm Arwen Review" (E3C review); the review made recommendations for DNOs to enhance network resilience and improve customer support during adverse weather events.

Northern Powergrid has addressed the E3C recommendations via proposals made in our Storm Arwen re-opener submission to Ofgem. The submission requests for funding to enhance network resilience and improve restoration time in areas of the network identified as least resilient to adverse weather. The proposals also include a variety of measures to improve customer support through provision of additional customer support vehicles, welfare packs and generator units. All proposals have integrated feedback from engagement with a wide range of key stakeholders including telecommunication companies, water utilities and local councils.

We submitted our response to the Ofgem consultation earlier this year and a final determination on our proposals was made in December 2024. We are now evaluating the determination and beginning to implementing the accepted proposal[5]. A summary of our submission is available here for reference[6].

Wildfire Plans

Northern Powergrid recognise the threat that wildfire poses to our network and the risk that our network poses to its environment. It is important that we work to understand this issue in full and as such we have committed to produce a full risk management statement (RMS) on this issue.

For a wildfire to occur, there needs to be an ignition source alongside a specific climate (hot, dry, windy). The RMS will consider the likely ignition sources from our assets as well as establishing a risk level due to the current climate using the Fire Severity Index (FSI). Mitigation measures will be discussed and where applicable, recommendations to change current practices made.

The likelihood of a wildfire in the Northern Powergrid license area is believed to be low however, this risk is expected to rise as the climate becomes more volatile.

[4] https://assets.publishing.service.gov.uk/media/64ca1dfe19f5622669f3c1b1/2023_NATIONAL_RISK_REGISTER_NRR.pdf
[5] https://www.ofgem.gov.uk/decision/final-determinations-riio-2-re-opener-applications-2024-electricity-transmission-electricity-distribution-and-gas-distribution
[6] https://www.northernpowergrid.com/sites/default/files/2024-04/Storm%20Arwen%20Reopener%20-%20Core%20document%2030-01-2024.pdf

Pole Mounted transformers

Following evidence of increased saline corrosion and hence reduced asset life in Pole Mounted Transformers (PMTs) located near the coast, analysis has been carried out to corroborate this. Sites within 1km of the coast have been identified as at risk initially. We are reviewing our equipment specifications to provide PMTs with increased corrosion protection for use at coastal sites and we have updated our policies so that new and replacement PMTs within 1km of the coast utilise the new high corrosion resistant PMT designs.

Extreme Heat

In July 2022 observed temperatures in the Yorkshire region exceeded 30°C for three consecutive days with highs of 39.7°C experienced. This caused issues on our network and fault numbers were found to be at a level comparable to winter storms experienced earlier in 2022.

Increasing ambient temperatures and extreme heat events were considered as part of the detailed risk assessment on climate resilience carried out in 2010 and were reviewed in 2021 following the release of UKCP18. Heat was considered to be a longer term issue for the network, with current adaptations and network specifications assessed as adequate for the short to medium term based on the projections.

Following the events of 2022, a detailed analysis of the incident combined with the meteorological conditions and future projections was carried out. This has led us to review the risk assessment of extreme heat and it is now considered a medium term risk. Consideration of a number of bespoke adaptations – both synergies with our ongoing asset replacement programmes and pro-active programmes of work – is now underway. This will be carried out alongside a review of our standards and specifications to ensure that they are adequate for the lifetime of the asset.

LiDAR

A contract has now been let to allow an initial full network flight to be carried out. This will then be revisited at three yearly intervals where a percentage of the network at risk from vegetation will be flown (potentially 30-40% of the network). Following completion of this initial flight, data will allow a growing picture of the state of the network. This data will then drive our vegetation management programmes as well as identifying any clearance infringements for resolution.

Climate Resilience Reporting and Metrics

Northern Powergrid has submitted reports under all four rounds of the Adaptation Reporting Power, as laid out in the Climate Change Act 2008. As part of our RIIO-ED2 submission we presented our Climate Resilience Strategy to Ofgem for their approval and we report on our climate change adaptation plans in our Annual Reports[7] as required under the Companies Act 2006. In addition, we report annually to Ofgem on our progress against a number of resilience related metrics including compliance with ETR138 for flood defences and ETR132 for vegetation management.

Ofgem has set out the ambition to deliver a “climate resilience metric” (CRM) for implementation at the start of ED3[8] stating “We will work with DNOs and other interested stakeholders to develop a wider resilience metric over RIIO-ED2, ready for implementation in RIIO-ED3”. It was originally proposed that this metric would cover activities such as flood resilience, tree cutting and climate resilience. Northern Powergrid is participating in discussions to facilitate this metric and the outcomes of these discussions will help to steer our climate resilience strategy for the ED3 period.

Interdependencies

Infrastructure

Interdependencies between sectors were considered as part of the third round reporting process. One of the potential interdependencies within the energy sector is the knock-on effect on gas network operations from increased electricity demand. Increasing temperatures will lead to increased use of air-conditioning systems in both commercial and domestic environments, particularly in urban areas. This in turn will lead to an increase electricity demand which is often supported by gas fired generation resulting in a drawdown of gas reserves which could impact domestic supplies as pressures are reduced to meet generation demand.

[7] https://www.northernpowergrid.com/sites/default/files/assets/Yorkshire Reg Accs 23-24 Final - 31.07.24.pdf; https://www.northernpowergrid.com/sites/default/files/assets/Northeast Reg Accs 23-24 Final - 31.07.24.pdf
[8] RIIO-ED2 Sector Specific Methodology Decision | Ofgem

The electricity networks are also aware that other infrastructure operators and society in general are reliant on having a reliable and resilient supply. DNO's and NGET continue to work to ensure that the UK electricity network remains one of the most reliable networks in the world and climate change is one of the impacts considered when developing and reinforcing those networks.

The critical infrastructure network (telecommunications, water, road, rail and air transport, ports and energy) is highly linked, with impacts on one sector affecting all others. The energy sector itself is a critical supplier to all other infrastructure. With systems becoming smarter the sectors are even more tightly linked with telecommunications becoming to a greater degree a central component of all other sectors.

Additional to these interdependencies, the COVID-19 pandemic highlighted the interconnected nature of risk outside of infrastructure, with energy demand affected by changes in usage and maintenance and disrupted office work. However, for some personnel the situation has reduced the reliance on the transport sector.

A number of key hazards were highlighted for each sector, alongside the knock-on impacts for energy. These, along with Met Office insights from work across the sectors, are summarised in Table 4 - Hazards by sector:

Sector	Key Hazards	
Gas	– flooding – high temperature – wind – lightning – erosion	– ground contamination from flooding – ground movement – sea level rise – vegetation growth
Telecommunications	– strong winds – flooding – snow and ice	– high temperatures (causing line sagging) – lightning – solar storm
Water	– Flooding – Erosion	– ground movement – drought
Road and rail	– extreme high temperatures (tarmac melting/rails buckling) – flooding – strong winds – sea-level rise	– storm surge – longer growing seasons – snow and ice – solar storm (rail sector)
Aviation, especially offshore helicopters	– strong winds – extreme high temperatures (reducing 'lift') – high wave heights	– lightning – in-air conditions, such as in-flight icing and turbulence.
Ports	– sea-level rise – strong winds	– high wave heights – storm surge

Table 4 - Hazards by sector

It is also worth considering the supply chain to the energy sector (e.g. the system of organisations providing system components. This is not a sector with key national infrastructure, but essential for the resilience of the energy network. This network could be reliant on hazards on a global level. These hazards have not yet been investigated.

The interdependencies between sectors have been further explored through examination of a simplified value chain for energy (Figure 5 - value chain for energy) – each element of the value chain is reliant on different interconnections with other sectors. If parts of the value chain are disrupted this can impact the network itself. This visual map and the responses from ENA members have been used to highlight how impacts on other sectors affect the energy sector itself

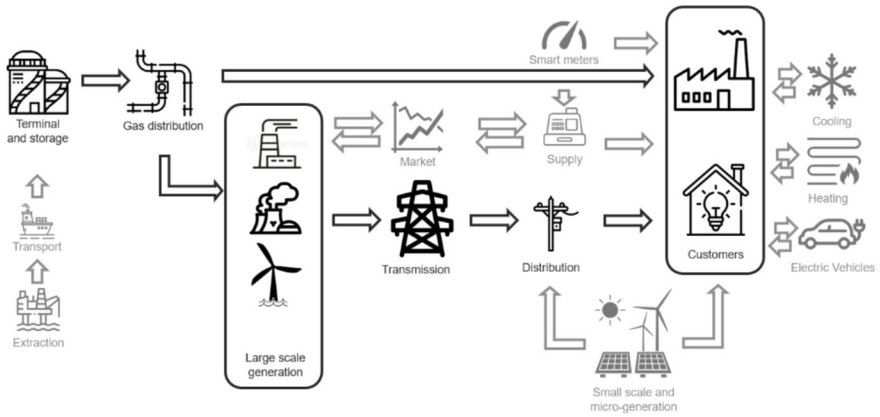

Figure 5 - value chain for energy

This is summarised in Table 5 - summary of value chain. Here telecommunications are highlighted as potentially the most critical sector affecting all parts of the value chain though the impact on maintenance and the reliance on remote operation of some equipment. This is followed by road, which is critical in terms of access to infrastructure and office space. Additionally, in the future road transport could represent a key consumer of electricity and so affect the resilience of current infrastructure. The water sector can impact underground electrical assets through flooding and is also a key consumer of electricity. Whereas aviation and ports are mostly only relevant to the extraction and transportation of gas. The table also highlights the importance of supply chain across the value chain for energy – delays in supply of key components have the potential to disrupt all aspects of the energy value chain.

Value Chain	Telecoms	Water	Road	Rail	Aviation	Ports	Supply Chain
Extraction / transport of gas	X				X	X	X
Storage	X		X				X
Gas Distribution & Transmission	X		X				X
Large Scale Generation	X		X				X
Market	X						
Electricity Transmission	X		X				X
Electricity Distribution	X	X	X				X
Small scale & micro-generation							X
Consumers	X	X	(X)	X			X

Table 5 - summary of value chain

Stakeholder Engagement

Cross Utility Forums

The Cross Utility Forum, hosted by Northern Powergrid, happens three times a year and brings together peers to discuss shared issues. At the July 2024 session the group focused on the changing climate and the impacts on the UK's infrastructure systems. Northern Gas Networks, Northern Powergrid, Yorkshire Water and Cadent all shared an outline of their principal climate risks, challenges to resilience and adaptation, their general approach to resilience and an outline of their strategic response to identified climate hazards. An opportunity for questions and a discussion session then followed.

A number of areas where interdependencies across the attendees exist were identified and participants agreed a collaborative approach would add value. It was acknowledged that there needs to be more whole system modelling and it is proposed to set up a workstream with a data lead from each organisation to look to overlay data. Initiatives put forward included the sharing of information and data such as the provision of heat maps based on fault data, locations of importance to other infrastructure providers and an enhancement of the winter preparedness material provided over winter 2023.

Attendees agreed that there is a strong need for a regional focus on adaptation as national work doesn't always suit regional differences and there is an appetite for further discussion and collaboration. It is intended that these sessions focussing on the resilience of infrastructure for the North will continue.

Local Resilience Forums (LRFs)

Climate change risks are captured within the National Risk Register (2023), feeding into Local Resilience Forum (LRF) risk registers and into Northern Powergrid's emergency planning risk register. Risks within the national risk register have been looked at through the lens of chronic and acute risks, and thus climate change has been an underpinning factor to many risks, such as, extreme weather, from flooding to drought.

Through the identification of risks, Northern Powergrid works with LRF's to strengthen incident preparedness, response and recovery phases to support communities across the North-East and Yorkshire. Northern Powergrid are a Category Two responder under the Civil Contingencies Act 2004 (CCA), this requires the organisation to share information and cooperate with other partner agencies. This includes working with other Category Two responders to understand interdependencies during incident response. There is a Category Two group across the North-East, Yorkshire and Humber that supports this collaboration and increased understanding.

CS-Now interactions

Climate services for a Net Zero resilient world (CS-NOW) is a research programme funded by the UK Government. Northern Powergrid has been called upon to provide information, evidence and expertise for a number of research projects running under this umbrella. We will continue to support this project and will utilise the outcomes in our future climate change adaptation work.

Newcastle Projects

Northern Powergrid has expressed its support for a number of projects proposed by Newcastle University to further understand the effect of wind on the energy networks. Unfortunately, to this point, funding has not been successfully secured. We remain in close contact with the university and will support further projects as the evolve.

Climate READi

The Electric Power Research Institute (EPRI) is undertaking Climate READI, a multi-year project with the aim of strengthening the power sector's collective approach to managing climate risk to the power system. The project will culminate in the provision of a Common Framework which will provide a comprehensive, consistent and collaborative approach to physical climate risk assessment.

The project is being undertaken across three workstreams:

- Physical climate data and guidance which will assess a shared view on climate risk assessment data needs;
- Energy system and asset vulnerability assessment which will provide a common approach to risk mitigation thresholds on the impact to energy grid assets and the integrated power system; and
- Resilience / Adaptation planning and prioritization which will work towards a set of adaptation strategies for specific climate impacts while maintaining a reliable, resilient and affordable power system for consumers.

Northern Powergrid are participating in this project as a subsidiary of Berkshire Hathaway. We continue to assess the outputs as they are published and participate wherever possible and will look to utilise the learning from this project to understand the wider impacts of the risks to our distribution network and to provide additional tools to assist in our adaptation planning.

ENA Working Groups

The Energy Networks Association (ENA) represents the owners and operators of licenses for the transmission and/or distribution of energy in the UK and Ireland. The goals of the ENA are to promote UK and Ireland energy networks, ensuring the networks are the safest, most reliable, most efficient and sustainable in the world and they influence decision makers on issues that are important.

In 2009, the UK and Ireland electricity transmission and distribution network operators came together through ENA to write an industry wide adaptation report in response to the first round of adaptation reporting under the Climate Change Act 2008. This working group has continued meeting to discuss an industry wide approach to adaptation and to share knowledge. Prior to the third round of reporting in 2021, the group was expanded to include the gas network operators so that a coherent energy sector response to the challenges of adaptation could be considered and presented.

Following the RIIO-ED2 settlement, the remit of the working group was reviewed to align with the requirement to work with Ofgem to create climate resilience metrics for implementation by 2028. The group continues to meet regularly to consider the industry approach to adaptation and to work alongside Ofgem to agree a meaningful approach to monitoring adaptation progress in the future.

Northern Powergrid has worked with this group since its formation and is committed to continue to do so.

Decarbonisation

As we progress towards Net Zero we expect to see more intermittent energy generation sources connected to the distribution system, more flexible customer demand for power – with the amount of customer flexibility driving how much additional capacity we need. Our approach to this is to monitor, manage and reinforce. Our smart grid enablers programme is transforming our ability to monitor, control and communicate with our network through the upgrade and replacement of equipment, and complements our adaptation plans. We can utilise the intelligence provided to operate an active local network using real-time data to automatically reconfigure or adjust settings and release capacity when it is needed due to either Net Zero driven additional loading, or a reduction in available network capacity through changing climate conditions, such as extended periods of extreme heat.

Reinforcement allows us to build additional capacity into the network where there is most certainty for future growth by reinforcing our physical assets through replacing or upgrading cables, switchgear, and substations. In preparations for Net Zero we are upsizing assets where we are already intervening to repair or replace as part of our core asset renewal plans. This complements adaptation plans, which require that our core asset renewal plans provide synergistic benefits through not only the uprating of assets as required by Net Zero but also through the introduction of enhanced resilience, as the additional capacity released will not only support the move to Net Zero but also allow headroom within the network to support the changes required to accommodate climate change. This is facilitated using modern standards of build, particularly with respect to overhead lines, where the enhancement of storm resilience is key.

As we move to Net Zero and an increased reliance on the electricity network, traditional assumptions must be challenged to ensure they are still fit for purpose and consumer behaviours and the impact of an increased dependency on electricity need to be understood. Traditionally we have experienced higher loadings in winter and lower loadings in summer, however this will be challenged.

The thermal rating is the ability of much of our equipment to carry power and is related to the both the load and local ambient temperatures. The overhead line network is one of the areas most impacted by this relationship. The rating of overhead lines are currently designed to use a probabilistic approach which takes the pragmatic view that exceeding the overhead line conductor design temperature, for a very small period of time, is an acceptable risk. The probability of the design temperature of an overhead line being exceeded is based on the probability of different weather conditions coinciding with different circuit loadings. Clearance to ground and objects depends on several factors, which impact final conductor temperature as they all impact the resultant conductor expansion and change in sag of the conductors. These factors are:

- The conductor material used to construct the overhead line.
- The assumed ambient temperature of the air (dependent upon the time of the year).
- The cooling effects from any wind present.
- The heating effects from any solar radiation together with the emissivity of the conductor material.
- The conductor heating caused by the passage of current through the conductors.

Conductors in the UK have historically been designed to operate at a maximum likely temperature of 50°C which assumes the impact of higher ambient temperatures in summer months is offset by the traditionally lower network loadings in the same period. However, these assumptions must be challenged to ensure they are still fit for purpose.

A balance is needed where delivering Net Zero creates short-term opportunities, potentially at the expense of long-term benefits. In general, enabling Net Zero creates opportunities to deliver synergistic benefits to the resilience of the network with few conflicts. The optimised use of flexibility to defer network reinforcement, which complements our adaptation plans through the release of capacity, but conflicts with these plans in that it may lead to deferral of some asset replacement and hence deferral of the opportunity to improve network resilience.

Appendix 1: Risk Assessment (Asset Risks)

Temperature

Risk Code	Risk	Description	ARP3 Risk Score	ARP4 Risk Score	2050's		2100			Mitigation Progress
					Risk	Confidence Rating	Risk (2°C)	Risk (4°C)	Confidence Rating	
AR1	Overhead line conductors affected by temperature rise.	Despite the thermal expansion of conductors being considered when being designed to account for sag, lines exposed to frequent and prolonged extreme temperatures by UK standards may cause the sag to exceed current overhead line design parameters. This could increase the number of incidents where conductor clearance limits are compromised. Increasing temperatures also impact on the capacity of the conductors. Conductors are designed to operate at their maximum efficiency up to a maximum core temperature, and as air temperature increases it becomes difficult for the heat from the conductor to radiate. As the core temperature increases so does resistance within the conductor reducing its ability to carry current, thus reducing its capacity.	9	9	12	Medium	12	12	Low	Northern Powergrid carries out annual reviews of network loading to ensure that there is adequate headroom on the network. A number of innovation projects have examined overhead line ratings and standards have been amended to reflect these findings. Following the July 2022 heatwave, a detailed analysis of the effect of heat on the network was carried out within Northern Powergrid and a number of recommendations made including the requirement to review and challenge the current temperature and loading assumptions included within internal overhead line specifications. Wherever possible new and re-conductored lines are now designed to a rated temperature of 75°C (historically this has been 55°C) to allow for additional capacity on the network and/or increasing ambient temperature.
AR2	Overhead line structures affected by Summer drought & consequent ground movement	Rising temperatures can dry the ground, causing ground shrinkage. This applies movement to structures built on top of it, leading to instability of the foundations. Overhead line foundations are vulnerable to this process.	6	6	6	Medium	6	6	Low	Overhead line construction standards take into account different ground types and accommodate these to ensure ongoing stability. Northern Powergrid has a policy for the inspection and maintenance of overhead systems. As part of this inspection regime we monitor pole lean, amongst other conditions, and defects are rectified if identified.
AR4	Underground cable systems affected by increase in ground temperature,	Cables are designed to operate at their maximum efficiency up to a maximum core temperature. But as the ground temperature increases significantly it becomes difficult for the heat from the conductor to radiate; as the core temperature increases so does resistance within the conductor reducing its ability to carry current and thus reducing its capacity.	9	9	9	Medium	9	9	Low	Underground cable standards take into account different ground types and accommodate these to ensure cables are adequately rated for their environment. Synergies with decarbonisation allow for the uprating of cables which will offset the capacity reduction anticipated from climate change
AR5	Underground cable systems affected by Summer drought & consequential ground movement	Ground movement caused by drying and shrinkage will exert tensile forces on cables. Whilst cables have an inherent tensile strength, joints in the network are more vulnerable and can fail by being pulled apart. Extreme wet-dry and freeze-thaw ground movements will create a similar impact.	6	6	6	Medium	6	6	Low	Underground cable standards take into account different ground types and accommodate these to ensure cables are adequately rated for their environment. Following anecdotal evidence of additional failures of cable joints due to ground movement, specifications have been reviewed to introduce more stringent test conditions for joints to ensure these failures are avoided.
AR6	Substation & network earthing systems adversely affected by Summer drought conditions	Drought seasons deprive soil of moisture thereby increasing soil resistivity, thus reducing the effectiveness of electricity passing through the earthing system. Where earthing design parameters are exceeded, system and public safety issues can arise with reduced touch potential distances or failure to fully dissipate fault currents, leaving live and exposed metal components in and outside the site boundary.	6	6	8	Medium	8	8	Low	Earthing standards take into account different ground types and accommodate these to ensure earthing systems are adequately rated for their environment. Earthing systems are subject to ad-hoc surveys to ensure they remain fit for purpose.
AR7	Transformers affected by temperature rise	Transformers are designed to operate within specified temperature parameters. However, as air temperature increases, it becomes more difficult to expel the heat created by the transformation process, consequently transformers can begin to overheat reducing capacity and life expectancy and, in extreme cases, causing catastrophic failure of the unit.	6	6	9	Medium	9	12	Low	Northern Powergrid carries out annual reviews of network loading to ensure that there is adequate headroom on the network. Where headroom is deemed to be insufficient, we look to upsize assets to increase capacity. The installation of larger transformers results in reduced losses and greater resilience. Following the July 2022 heatwave, a detailed analysis of the effect of heat on the network was carried out within Northern Powergrid and a number of recommendations made including further work to consider providing some form of sun protection in specific conditions. Transformer specifications take into account operating conditions, including ambient temperature. The impact of heat is most significant in secondary substations.
AR8	Transformers affected by urban heat islands & coincident air conditioning demand	As a result of increased air conditioning and ventilation use to cope with rising temperatures, some network operators are seeing little difference between Summer and Winter customer electricity demand when previously Winter was significantly more demanding. Increased demand can overload transformers, causing tripping and supply loss.	9	9	12	Medium	12	12	Low	
AR9	Switchgear affected by temperature rise	Switchgear is designed to international standards however, there are recorded days where switch room ambient temperatures have exceeded the switchgears operational maximum as a result of prolonged periods of hot weather. In such cases, switchgear may reduce in capacity, or in extreme cases, cause improper operation or loss of supply, thereby damaging the network. Increased temperature can also raise the potential for faults or maloperation.	4	4	6	Medium	6	8	Low	Switchgear is designed with maximum ambient air temperatures of 40°C maximum continuous and 35°C for a 24 hour period. Where the ambient air temperature cannot be controlled or monitored switchgear will have to be de-rated to ensure specified temperature ratings are not exceeded. DNO policies reflect the need for ventilation, air conditioning and dehumidification based on building specifications.

Precipitation

Risk Code	Risk	Description	ARP3 Risk Score	ARP4 Risk Score	2050's		2100			Mitigation Progress
					Risk	Confidence Rating	Risk (2°C)	Risk (4°C)	Confidence Rating	
AR10	Grid & Primary Substations affected by river flooding due to increased winter rainfall		9	9	12	High	16	16	Medium	Northern Powergrid utilises ETR138 - Electricity Substation Resilience to flooding to shape our flood mitigation policy. All sites have been assessed against this standard and a programme of works began in DPCR5 to ensure compliance with this standard across all sites and 271 sites were identified as at risk. As of now all but three sites have been addressed with adequate defences in place. Northern Powergrid's code of practice for flood mitigation at operational premises ensures that when assets are being replaced or new sites constructed, the flood risk is assessed at the design stage and any risks mitigated as appropriate. Northern Powergrid's policy for the management of major incidents due to widespread flooding details the flood risk warnings that are monitored and the response that will be employed following the receipt of a warning. The Environment Agency flood maps are reviewed as appropriate and compliance with ETR138 is revisited to ensure no additional sites are at risk and that current flood mitigation measures are sufficient. There are currently limited future projections available. The next release should include some additional indication of future projections however these have not yet been assessed, hence the uncertainty in future projections. There is uncertainty for our Yorkshire licence area due to the flood risk presented by the Humber Estuary. Work is ongoing through the Environment Agency on the Humber 2100+ project which is looking at how to mitigate these risks. The outcome of this project could impact on our flood mitigation requirements, hence there is long term uncertainty around this risk, in particular sea flooding and tidal surges.
AR11	Grid and Primary Substations affected by pluvial (flash) flooding due to increased rain storms in Summer and Winter		6	6	9	High	16	16	Medium	
AR12	Grid & Primary Substations affected by sea flooding due to increased rain storms and/or tidal surges	Flood water, regardless from its source, can physically damage plant and equipment. Additionally, water ingress can cause faulting within assets and the network, leading to extensive loss of supply. Consequential repair or replacement of assets is costly and time-consuming. Network operators will often choose to switch out plant and equipment in order to avoid water ingress, causing a fault and uncontrolled shut down.	8	8	12	High	16	16	Medium	
AR13	Grid & Primary Substations affected by water flood wave from dam burst	Where substations are located far enough away from dams the impact of water inundation from a dam burst is no different from "standard" pluvial, fluvial, or tidal flooding and flooding impacts can be considered similar. Where substations are close enough to dams to be impacted by the full force of a breach, the damage to a substation would be substantial. Plant and equipment would not only be impacted by water ingress but are likely to be physically damaged or washed away. It would not be possible to re-establish supply without fully reconstructing and recommissioning the site.	5	5	5	High	5	5	High	Northern Powergrid's internal policy for the Management of Major Incidents due to Widespread Flooding contains information on flood risk warnings which would be received with relation to failure of man made reservoirs alongside the appropriate response to flood warnings. Because of the difficulty in identifying and protecting against flood risks in the form of reservoir failure, canal bank bursts and water pipe bursts it is expected that mitigating action will normally focus on effective recovery plans to ensure that services can be restored as quickly as possible rather than physical protection.

Other

Risk Code	Risk	Description	ARP3 Risk Score	ARP4 Risk Score	2050's		2100			Mitigation Progress
					Risk	Confidence Rating	Risk (2°C)	Risk (4°C)	Confidence Rating	
AR3	Overhead lines affected by interference from vegetation due to prolonged growing season	Increasing temperature and precipitation encourages increased vegetation growth. Accelerated growth in trees increases the occurrence of physical damage to overhead lines where trees adjacent to these structures impact them.	8	8	8	Medium	15	15	Low	Northern Powergrid's internal policy for the Management and control of vegetation near overhead lines lays out the clear requirements for vegetation management on our network. This is periodically reviewed to ensure that the policy is fit for purpose. Our code of practice on clearances sets out the required clearances to vegetation in both climbable and non-climbable situations. This code of practice implements the Northern Powergrid view of ENA-TS 43-8. Enhanced resilience requirements are laid out in ETR 132 - Improving resilience of overhead networks under abnormal weather conditions using a risk-based methodology, and Northern Powergrid has adopted the standards laid out within this recommendation. Our RIIO ED2 plans included requests for appropriate funding to meet our obligations under both standards. Our vegetation management programme is informed by a number of sources of inspection data including high speed helicopter patrols, foot patrols and in ED2 LiDAR inspections to enable us to move to more efficient programmes of work.
AR14	Overhead lines & transformers affected by increasing lightning activity	Increased storm frequency can lead to an increased lightning strike frequency. Where lightning strikes exposed substation plant or, more likely, overhead line assets, the resulting surge will cause circuits to trip under fault condition. In extreme cases, strikes will lead to physical damage to the assets or a loss of generation, leading to other network protection systems operating and leading to loss of supply.	6	6	6	Medium	6	6	Low	Northern Powergrid has long had a code of practice for the application of lightning protection. This covers in detail the equipment that is included on our network to prevent faults due to lightning. Northern Powergrid's network is compliant with this code of practice and it has proven effective. There are currently no projections which call into question the validity of this code of practice. Our code of practice for the management of a major incident details the trigger levels associated lightning which would lead to us implementing our major incident management plans and the appropriate responses for dealing with the incidents
AR15	Overhead lines & underground cables affected by extreme heat and fire smoke damage	Despite being a result of increased temperatures and reduced precipitation, wildfires pose a significant risk to overhead line structures and conductors where they are located in susceptible areas (e.g., open heathland). Operational telecommunication systems can also be threatened from this scenario, potentially disabling control of the network and risking loss of supply.	6	6	6	Medium	6	6	Low	Northern Powergrid is currently working to solidify its wildfire mitigation plans through the creation of a Risk Management Statement. In addition, standard preservative treatment of poles will help to prevent fires damaging our equipment and routine vegetation management programs assist in mitigating the risks of wildfire. We are considering moving from oil insulated equipment to equipment that utilises synthetic ester in places at risk of wildfire to help reduce the risk of fires.
AR16	Overhead lines affected by strong winds	Increases in the frequency and intensity of wind storms are likely to occur. This will result in addition failures of older construction, less resilient overhead lines or overhead lines located in susceptible areas. Longer duration storms will present challenges to restoration due to prolonged high winds restricting the ability to work at heights to repair storm damage.	9	9	9	Low / Medium	9	9	Low	Northern Powergrid has an extensive programme of condition based overhead line replacement. This programme has ramped up significantly from 2023 and will continue to do so. This allows us to replace older construction lines with modern, more resilient lines. In addition, we have submitted a re-opener to Ofgem to request additional funding to allow us to carry out works on our most at-risk overhead line construction types and locations which will embed further resilience. Our ongoing programmes of automation will also enhance the resilience of our overhead line network through improved restoration times when faults do occur. Our vegetation management programme helps to minimise the effects of strong winds and the resulting tree damage on our network.

Appendix 2: Risk Assessment (Business Operation Risks)

Risk Code	Risk	Description	ARP3 Risk Score	ARP4 Risk Score	2050's	2100		Mitigation Progress
					Risk	Risk (2°C)	Risk (4°C)	
BO1	Lack of climate change management procedure.	The requirements for climate change management need to be specified to ensure the necessary procedures and actions are integrated into the organisation's environmental management system. This leads to a greater understanding of the potential impact of climate change and improves the overall environmental culture within the business.	8	6	6	6	6	Northern Powergrid is required to include climate related financial disclosures under the Companies Act 2006. This information is included in our Annual Report and includes details on how Climate Change Risk Management forms part of our business as usual processes. Climate Change Adaptation risks are fully integrated into our Asset Risk Management processes and treated the same as any other risk. Details of the process and how it is incorporated into our corporate risk management processes are included within our code of practice for our Asset Serviceability Review and risk management. Liaison with our internal Safety, Environment and Emergency Planning team ensures visibility across other relevant areas.
BO2	Lack of specific policies and procedures governing risk assessment process on climate change	A robust climate risk assessment process is required for all major network investment decisions. Climate change needs to be considered at the planning stage prior to the installation of new/replacement gas and electricity infrastructure. This will result in a greater level of asset data and information and increased asset integrity.	8	6	6	6	6	
BO3	Wildlife impacts	The effects of climate change could lead to impacts on wildlife due to changes in environments, habitats, and behaviours. This could lead to restricted access to assets from changed nesting habits, prolonged nesting seasons, changes to species migration, subsidence from digging etc.	9	9	9	9	9	Internal codes of practice detail our approach to the protection of plants, animals and conservation areas. These are reviewed at regular intervals to ensure that the guidance remains current.
BO4	Supply chain impacts	Business Continuity Management (BCM) plans could be affected due to severe travel difficulties resulting from extreme weather events. This can result in reduced capability and support from supply chain businesses and impact on the continued operation and maintenance of the networks. The adoption of new technology and equipment will assist in the ability of the workforce to work remotely and continue to manage network assets.	6	6	6	6	6	The policies and codes of practice detailed against BO4 are complemented by a policy for the management of strategic spares which is reviewed at regular intervals. This policy ensures that any critical spares are held in sufficient quantity to ensure the continued operation of the network. In addition to this, reciprocal agreements with other companies allow additional access to sources of spares in an emergency situation.
BO5	Precipitation - BCM plans affected due to severe travel difficulties resulting from extreme weather events	Business Continuity Management plans could be affected due to extreme weather events. There may be an impact on organisational capability and staff resources and the continued operation and maintenance of the networks. The recent COVID pandemic has tested the current arrangements and systems in place which have proved to be effective The adoption of new technology and equipment will also assist in the ability of the workforce to work remotely and continue to manage network assets.	4	4	4	4	4	Northern Powergrid has a comprehensive suite of business continuity codes of practice and Major Incident Management Plans alongside a number of other policies and codes of practice including a pandemic plan. These are reviewed at regular intervals to ensure plans remain current. These plans have been implemented many times and following each implementation a lessons learnt process is followed to ensure any improvements or inadequacies are highlighted and corrected or implemented.