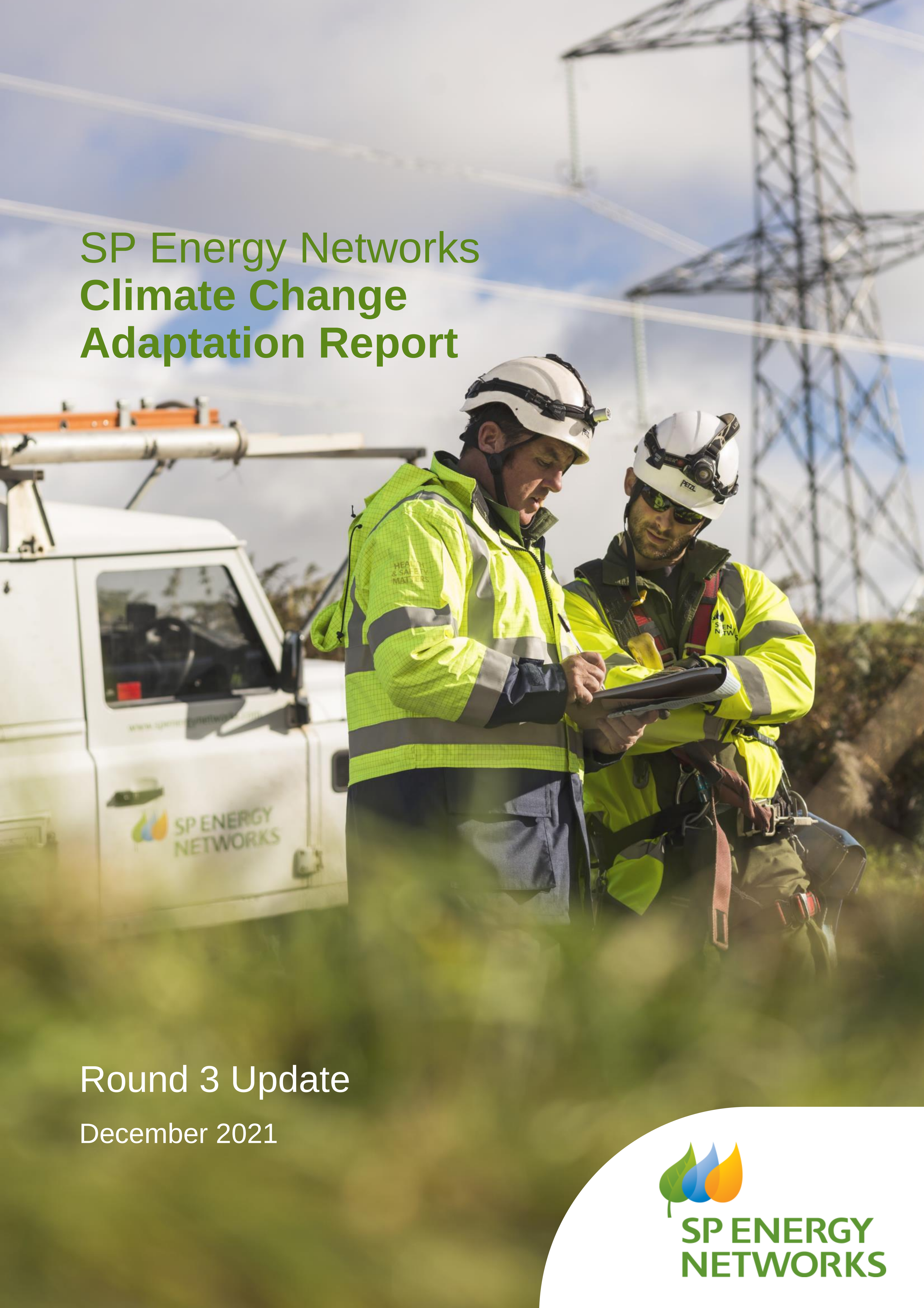
SP Energy Networks

Climate Change Adaptation Report



Round 3 Update

December 2021

SP ENERGY
NETWORKS

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1. Executive Summary

The UK Climate Change Act (2008) gave the Secretary of State for the Department for Environment, Food, Agriculture and Rural Affairs (DEFRA) the power to require companies to report on their preparedness for climate change, under the Adaptation Reporting Power (ARP). The Adaptation Reporting Power was first exercised in 2010, when the Secretary of State required companies responsible for infrastructure and other essential services, including power distribution and transmission companies, to report on their preparedness to adapt to the impacts of climate change.

SP Energy Networks (SPEN), published our first-round response under the ARP in 2011[1], and our second in 2015[2]. In light of a further invitation from the Secretary of State in December 2018, this report captures our third-round update to DEFRA, including an assessment of:

- The current and future predicted effects of climate change on our organisation - this includes how we have identified and assessed the risks to our network & business from climate change.
- Our proposals for adapting to climate change - this includes how we have identified the resulting optimal actions & mitigation plan to the threats from climate change

As the provider of a critical national infrastructure, we have an obligation to ensure the electricity we distribute to our customers is safe, reliable, efficient, and environmentally sustainable. This report sets out how we have assessed the threats to our infrastructure from climate change, and the future mitigating actions we may need take in response to these threats. However, as an electricity network operator serving over 3.5m GB customers, we also have a critical role in enabling the UK's journey to Net Zero, and in limiting the effects of Climate Change.

In November 2021, the UN Climate Change Conference COP26 was hosted in our home city of Glasgow. The COP26 President, Rt Hon Alok Sharma MP, stated "…*we have kept 1.5 degrees alive*" however, the global pledges will only limit warming to 1.8 degrees above the pre-industrial average if fully implemented[3].

We are enabling our customers to lead the global Net Zero transition by facilitating our communities to connect up to 1.8m electric vehicles, 1.1m heat pumps and up to an additional 7.5GW of distributed generation (around 90% of which is derived from renewable and storage solutions) by the end of this decade. More details on our plans to invest in our networks to enable this transition can be found in our RIIO-2 plans[4].

Our Climate Risk Assessment

We assessed the risks from climate change to our network[5] and to our business[6] using global best practice. We did this across four key climate change projection variables (temperature, precipitation, sea level rise, and wind speed/storminess) over three time periods (2030s, 2050s, and 2100s) and two Representative Concentration Pathways (RCP) projection scenarios[7] (RCP6.0 and RCP8.5). The information for which was sourced from the United Kingdom Climate Projections 2018 (UKCP18) data[8].

This approach allowed us to identify new risks within our third-round update, such as the impact of increased air conditioning electrical loading in summer periods. This could lead to overloads of system assets or low-hanging conductors for equipment which is typically has a lower electrical rating in summer periods (AR1). We have also built on past work, such as our 2015 Climate Change Adaptation Report[9] and the Energy Network Association (ENA) 2021 3rd round climate change adaptation report and Addendum[10].

This has been further validated through external stakeholder engagement and workshops held with internal colleagues.

[1] http://archive.defra.gov.uk/environment/climate/documents/adapt-reports/04distribute-trans/sp-energy-networks.pdf
[2] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/479266/clim-adrep-sp-energy-networks-2015.pdf
[3] https://ukcop26.org/cop26-keeps-1-5c-alive-and-finalises-paris-agreement/
[4] https://www.spenergynetworks.co.uk/pages/riio_2.aspx
[5] Network risks are primarily direct risks to network infrastructure (e.g. substation flooding).
[6] Business risks are primarily risks to business operation (e.g. delayed (non-)operational tasks due to heatwaves).
[7] Climate change projection scenarios have been established based on two Representative Concentration Pathways (RCP).
[8] https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index
[9] SP Energy Networks. (2015). Climate Change Adaptation Report, Round 2 Update. [Accessed 3rd May 2021]. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/479266/clim-adrep-sp-energy-networks-2015.pdf
[10] Included in full within Annex A of this report.

In order to determine the significance of each risks to our network and to our business, we considered the relative likelihood and impact for each risk for both RCP6.0 and RCP8.5 projection scenarios, categorising each risk into 'Very High, 'High, 'Medium' or 'Low' risk. Examples of 'Very High' or 'High' risks identified include:

Increased Temperature: Overhead line conductors affected by temperature rise and increased cooling demand, reducing rating and ground clearance (AR1)

Fluvial and Pluvial Flooding: Substations affected by river flooding due to increased winter rainfall, with loss or inability to function leading to reduced security of supply. (AR10)

Summer Drought: dry-out of soil surrounding underground cables will lead to increased thermal resistivity, reduced heat transfer, and a reduced current (load) carrying capacity (AR16)

Hurricanes & High Winds: Overhead line structures affected by wind speeds not accommodated for in design.

For each risk, we identified their adaptation tipping points (i.e. when will network or business functions will be compromised, and so when we need to implement our adaptation strategy).

Our Climate Adaptation Pathways

There may be several different solutions to any one risk. Each solution may have different costs, be suitable for different thresholds and be applicable at different points in time. In order to allow future decision makers flexibility, a global best-practice *adaptation pathways* approach has been adopted, providing solution pathways which help identify the best sequence of actions for different assets. For example, to mitigate the impact of higher temperatures on substations, we should adopt passive cooling solutions early; however, we may ultimately need to use forced-cooling or nature-based solutions such as vegetation to provide shade.

Adaptation pathway diagrams have been developed to demonstrate the route we should adopt for identified hazards and associated risks to adapt our network and business operations. These can be seen in section 8.

Our Contribution to Cross-Sector Work

A reliable and resilient electric power supply is a key enabler of the decarbonisation and adaptation efforts of other sectors which will require a significant amount of electrification, in order to meet the legally binding Net Zero carbon emission targets of UK Governments.

Therefore, it is important to understand the interdependencies between the electric power sector and other critical infrastructure sectors such as water, oil and gas, telecommunications, and transportation. Like other Distribution Network Operators (DNOs) and the Transmission Network Operators (TNOs), we will continue to work to ensure that the UK electricity network remains one of the most reliable networks in the world and that climate change is one of the impacts considered when developing and reinforcing those networks.

Ongoing Monitoring and Evaluation

As part of our approach, we will establish a framework for Monitoring and Evaluation (M&E) to ensure that the key climate risks are regularly reviewed, and current adaptation approaches are sufficient to mitigate potential impacts. We have outlined a number of roles for internal appointment within our business, including a 'Resilience Coordinator', and 'Resilience Champions' to be responsible for implementing the M&E process.

Why we need to act and the importance of the Adaptation Reporting Power

Net Zero is a period of wider societal change. Over coming decades electricity networks will be a key enabler of our customers low carbon transition and will also stimulate the national Green Recovery.

Network utilisation is forecast to be stressed beyond the original design capacity of the network. Complexity of network operation is increasing significantly as we rely on flexibility, Distribution System Operator (DSO) constraint management and innovation for real-time advanced network management. The criticality of our assets is rising as customers transition to Net Zero and connect greater numbers of electric vehicles and heat pumps. Meanwhile, all of this is set against the background of the climate emergency and increased external threats from rising sea-levels, rising temperatures, changing precipitation and unpredictable severe weather.

Our commitment to assessing, managing, and mitigating the effects of climate change is essential to the asset management of our critical national infrastructure. This report, produced under DEFRAs ARP, helps to ensure that providers of essential services and national infrastructure have embedded climate resilience into the management and operation of their equipment and businesses.

2. Introduction and background to report

SP Energy Networks (SPEN) is the group within Scottish Power (SP) which incorporates three licence holders: SP Transmission plc; SP Distribution plc; and SP Manweb plc. This Adaptation Report has been prepared for all of the operations within SP Energy Networks and hence jointly responds to the Directions received by the three separate licence holders regarding reporting under the Adaptation Reporting Power (ARP). Consideration has been given throughout the assessment to the differences between each part of the overall business.

The following key sources are used as the basis of this report:

The Energy Networks Association (ENA) "3rd Round Climate Change Adaption Report and Addendum (Sept 2021)" industry wide response to the 3rd Adaptation reporting round.

- The ENA is the industry body for UK "wires and pipes" companies which carry electricity and gas to UK homes and businesses.
- The ENA and its member companies (including SP Energy Networks) have contributed to all rounds of climate change adaption reporting as follows:
    - In the first-round adaption report, the response was established as a collaborative project amongst electricity network operators and identified key risks to network assets and operation posed by climate change impacts.
    - In the second-round adaption report, we collectively built on our understanding of the risks and updated the Department for Environmental, Food and Rural Affairs (DEFRA) on industry mitigation measures being put into place on the networks. A consistent reporting methodology was developed, and further evidence was provided of actions taken in response to key climate risks,
    - In the third-round adaption report, the aim was to provide an update on existing risks, mitigation measures and programmes, and also look to identify any new risks materialising. This third-round report also consolidated Gas and Electricity network reports to provide an Energy Industry response.
    - SP Energy Networks has been involved throughout the development of these industry-wide responses and hence the third-round report has been taken as a suitable baseline for this report, with detail added in addition to the ENA baseline regarding the specific characteristics and circumstances of SPEN, and our future Climate Change Resilience Strategy as we look ahead to RIIO-2 and beyond;
    - This report has been provided in Appendix A in full for ease of reference.

The SP Energy Networks "Climate Change Adaptation report – Round 2 Update" (June 2015)[11].

- This report articulates the progress made following the previous round 1 update, with identification of the key risks to our network and proposed actions.

The SP Energy Networks "Climate Resilience Strategy" for RIIO-ED2 Business Plan (Issue 2, December 2021)[12].

- As part of the development of our RIIO-ED2 business plan, we have developed a Climate Resilience Strategy. This strategy built upon all the previous work above, with the additional introduction of "Adaption Pathways" that allow evaluation of both the changing situation with regards to climate change and the identification and timing of new actions that must be taken.

The United Kingdom Climate Projections 2009 (UKCP09)[13] for the UK underpinned the assessment of risks under the first round Climate Change Adaptation report and continued to underpin them in the second report. The third-round reports have been updated using United Kingdom Climate Projections 2018 (UKCP18).

[11] https://www.gov.uk/government/publications/climate-adaptation-reporting-second-round-sp-energy-networks
[12] https://www.spenergynetworks.co.uk/userfiles/file/Annex%204A.7%20-%20Climate%20Resilience%20Strategy.pdf
[13] https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index

2.1 Information on our organisation

SP Energy Networks constructs, maintains and repairs the electrical equipment and network assets that transport electricity to around 3.5 million homes and business in the south and central belt of Scotland, and north Berwickshire, Cheshire, Merseyside and North Wales (see Figure 1). The assets, transmission and distribution licenses are owned by three wholly owned subsidiaries:

- SP Transmission plc (SPT);
- SP Distribution plc (SPD); and
- SP Manweb plc (SPM).

These are illustrated in Figure 1.

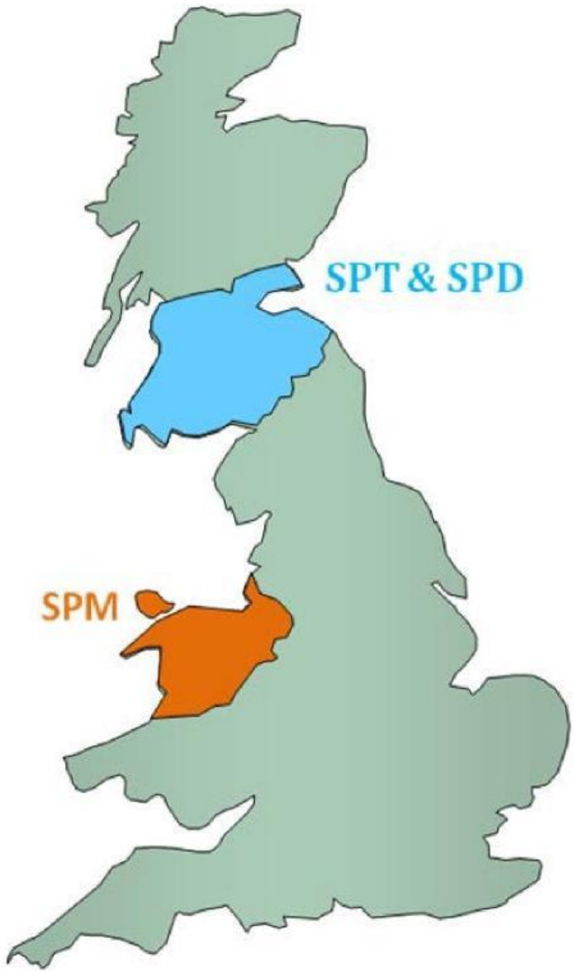


Figure 1 SP Energy Networks Transmission and Distribution Licences

SP Energy Networks operate in a regulated environment where their regulator, Ofgem, sets targets typically covering a five-year period (the 8-year RIIO-ED1 period being the recent exception). SP Energy Networks undertakes the statutory obligations and day-to-day management of the three individual networks with the aim of delivering regulatory targets and implementing an investment strategy to upgrade and reinforce the network. This Adaptation Report is for all of the network assets of Scottish Power.

SP Energy Networks is responsible for restoring supply as quickly as possible should a fault occur on the network, providing new connections to the network and maintaining the performance and safe condition of the network. Key drivers for the business are:

- The health & safety of SP Energy Networks employees, contractors, and the public;
- Maintaining security of supply;
- Improving customer service;
- Delivering capital investment to modernise the network and connect new customers; and

- Delivery of the Energy Policy.

Climate change therefore has the potential to impact on a number of the drivers for the business and hence climate risks are recognised as being relevant to the design, construction, operation, and maintenance of networks.

SPM, SPT and SPD are regulated businesses and operate under licences issued by Ofgem. They are subject to a common regulatory framework set by Ofgem and the statutory requirements set by the Electricity Act and Electricity Safety Quality and Continuity Regulations (ESQCR) which are overseen by the Department of Energy and Climate Change (DECC) and the Health and Safety Executive (HSE). As a consequence of these common drivers, UK electricity network operators have worked together for many years across a wide range of activity including:

- Establishment of common equipment specifications and design standards, across the full spectrum of network assets, to reduce procurement costs and ensure availability of product;
- Establishing UK network owner input to the content, development, and modification to national and international standards - British Standards (BS), European Standards (EN), International Electrotechnical Commission (IEC) etc.;
- Providing a unified input to UK government, regulators (Ofgem, Health and Safety Executive (HSE), etc.) on development of regulations, processes, reporting, etc.; and
- Collaboration on research and development (including impacts of climate change) and work on asset designs/ ratings.

This basis of a common industry background, asset standards and regulatory processes means that UK electricity network operators have very similar requirements when approaching the assessment of climate change impacts on their networks. This has meant that the ENA has been able to produce a core assessment for all of the UK transmission and distribution companies.

The ENA's Electricity Networks Climate Change Adaptation Report Round 1 also included a description of electrical networks, levels of service, standards (both international and national) and emergency planning. Similarly, the previously published National Grid Electricity Transmission plc report contained descriptions of the transmission network and assets within it such as overhead line, cables, and transformers. As was the case within the Round 2 report, these descriptions are not replicated here as they are standard across the industry.

2.2 Background and obligation to report

The UK Climate Change Act 2008 set the UK target to reduce greenhouse gas emissions by at least 100% by 2050[14], from a 1990 baseline. The Act also gave the Secretary of State the power to require companies to report on their preparedness for climate change, under the Adaptation Reporting Power.

The Adaptation Reporting Power was first exercised in 2010, when the Secretary of State required a number of companies responsible for infrastructure and other essential services, including distribution and transmission companies and others in the power sector, to report on their preparedness to adapt to impacts of climate change.

Following on from the first and second Adaptation Reporting Power call, in December 2018 the Secretary of State invited companies which had submitted reports under the first and second rounds to submit an update on their levels of preparedness for climate change[15]. Primarily this is to cover the following:

- The current and future predicted effects of climate change on our organisation
- Our proposals for adapting to climate change

The ENA has again coordinated an industry-wide response on behalf of all its members, and SP Energy Networks have been involved throughout the development of this industry-wide response. This report has been provided in full in Appendix A for ease of reference.

SP Energy Networks has also developed its own response to the Secretary of State's call to report, which is contained in this "Climate Change Adaption: Round 3 Update" report.

[14] Updated from 80% in June 2019: https://www.legislation.gov.uk/ukpga/2008/27/contents
[15] https://www.gov.uk/government/publications/climate-change-adaptation-reporting-third-round#history

3. Updates to climate change predictions

The most recent headline statement from the Intergovernmental Panel on Climate Change (IPCC) states that "There is a high confidence that global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate"[16].

The UN Climate Change Conference UK 2021, COP26, was held in Glasgow, UK, in November 2021. This concluded on Saturday 13th November with every party – representing almost 200 countries – agreeing the Glasgow Climate Pact. This global agreement will accelerate action on climate this decade[17].

The COP26 President, Rt Hon Alok Sharma MP, stated at the end of the conference that "…we have kept 1.5 degrees alive" however the global pledges made at Glasgow will only limit warming to 1.8 degrees above the pre-industrial average if fully implemented[18].

There are a number of policies from international to local scale outlining targets to limit climate change. The Paris Agreement on Climate Change (2016)[19] unites many of the world's nations under a single agreement on tackling climate change. The UK is a signatory and has pledged actions to help mitigate climate change. The Paris Agreement's central aim is to keep a global temperature rise well below 2 degrees Celsius (above pre-industrial levels) and to limit the temperature increase even further to 1.5 degrees Celsius. A range of actions are proposed to support this aim.

Climate Adaptation is also included in the United Nations' Sustainable Development Goals (UN SDGs), and the United Kingdom wishes to demonstrate leadership in the delivery of these goals. As a result, the Greening Government Commitments[20] state that: "Climate resilience planning and mitigation shall be incorporated at all business levels. Strategic climate impact risk mitigation shall be embedded in strategic programmes and plans including estate rationalisation and disposal. Where climate risks are identified, appropriate adaptation actions shall be undertaken".

These statements highlight the importance of not only working towards Net Zero, but also ensuring the network is resilient to these future changes in temperature, and the resulting effect on climate.

One of the most recent and highest impacting storm events to hit the UK in recent decades, Storm Arwen, highlights the impact that such weather events can have on UK electricity customers. Storm Arwen occurred between 26th and 27th November 2021 and nationally, this storm caused electricity disruption to almost 1 million customers. While 83% of disrupted customers had their power restored within 24 hours, a small but significant proportion experienced a disruption of up to 11 days (note although some GB customers were affected for this long it was not on SPEN networks)[21]. As a result, Ofgem and BEIS have launched independent reviews into the impact of Storm Arwen, due to report in early 2022. SPEN have also launched internal and external reviews into the impact and performance of its network during this event. The impact of this storm on our network remains the subject of ongoing review, and will inform future updates to our climate resilience strategy using the approaches described later in this report.

3.1 UK Climate Projections

The headline result from the latest independent Met Office UKCP18 climate change projections can be summarised as follows[22]:

- "a greater chance of warmer, wetter winters and hotter, drier summers"

The main impacts on gas and electricity networks from these latest projections remain unchanged from the previous projections:

[16] International Panel on Climate Change (IPCC). n.d. Headline Statements [online] [26 March 2021]. Available at: https://www.ipcc.ch/sr15/resources/headline-statements/#:~:text=Sea%20level%20will%20continue%20to,depend%20on%20future%20emission%20pathways.&text=There%20are%20limits%20to%20adaptation,associated%20losses%20(medium%20confidence)
[17] https://ukcop26.org/the-conference/cop26-outcomes/
[18] https://ukcop26.org/cop26-keeps-1-5c-alive-and-finalises-paris-agreement/
[19] United Nations Framework Convention on Climate Change (UNFCC). (2015). The Paris Agreement. Available at: https://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf
[20] UK Gov. (2018). Policy Paper – Greening Government Commitments 2016 – 2020 [online]. [26 March 2021] Available from: https://www.gov.uk/government/publications/greening-government-commitments-2016-to-2020
[21] https://www.gov.uk/government/publications/storm-arwen-electricity-distribution-disruption-review
[22] https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index

- Temperature – predicted increase
- Precipitation—predicted increase in winter rainfall and summer droughts.
- Sea level rise—predicted increase.
- Storm surge—predicted increase.
- Increasing wet – dry cycles.
- Increasing windstorm frequency (particularly when following high intensity precipitation).
- Significant cold spells – predicted decrease but more severe.
- Wildfire.

3.2 Climate Change Research

In considering adaptation to climate change, electricity and gas network companies use the Met Office UK Climate Projection (UKCP18) tool, and take into account projections to the end of this century as much of the network infrastructure generally has an operational life expectancy of 30-80 years.

In spring/summer 2020, on behalf of its members, the ENA commissioned the Met Office[23] to undertake a review of the UKCP18 data and existing studies 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 networks, and to guide future mitigation or management actions. In addition, other tools, for example the Landmark flood mapping tool, have been used by Energy Industry organisations in research and risk assessments independent to the ENA Met Office research.

Because of the diversity of the hazards it was decided to prioritise those which pose the highest risk to energy network assets, and the assessment process was accordingly graded to provide an appropriate focus.

A full climate assessment was produced for the highest priority hazards:

- Prolonged rainfall leading to flooding
- Extreme high temperatures
- Heavy rainfall/drought cycles
- Since there is currently no strong signal within the climate projections for a change to future storm intensity, the risk of strong winds was assessed in the current climate only.

For the remaining lower priority hazards, a qualitative approach was undertaken:

- Sea level rise
- Warm and wetter conditions, followed by heavy rainfall and/or wind
- Storm surge and wave height
- Warmer and wetter conditions – longer growing/nesting seasons
- Snow and ice
- Wildfire
- Lightning
- Solar storm
- Diurnal temperature cycles

3.3 Met Office Report Outputs

The final version of the commissioned report was provided by the Met Office in November 2020.

Many of the hazards identified by ENA members are projected to increase due to future climate change: increased frequency of high temperature days, prolonged rainfall events, hourly rainfall extremes, sea-level rise, extreme sea level events, increased risk of wildfire and increased extreme diurnal cycle events are all expected over the 21st century. On the other hand, the frequency of snow and ice days are expected to

[23] https://www.metoffice.gov.uk/

decrease. Hazards for which there is not currently strong evidence for a change in frequency include strong wind events, high wave heights, wetter conditions coincident with warmer temperatures and/or strong winds, lightning and to some extent, diurnal temperature cycles. Solar storms are not affected by increased greenhouse gases, so a study of historic occurrence of this hazard was presented.

The societal response to climate change has also been considered in the context of hazards to the energy network. Impacts of the weather hazards on the energy network are likely to come in the form of an altered dependency between weather and both supply and demand. Increases to the prevalence of electrified heating and electric vehicles in turn increases the reliance on the electricity network by our consumers. This increases the impact of hazards on our electricity network.

Interconnections between different industry sectors is a major source of risk for the energy network, with failures from one sector frequently causing impacts. Telecommunications and road transport are thought to be the most important sources of risk. 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 and emergency restoration. Societal responses to climate change may also increase the risk on the road network from the electricity network, as electric vehicles become more commonplace.

4. Summary of Climate Change projections

This section looks at the most likely and worst-case possibilities for what the future climate may be. UKCP18 data has been used to gather climate change projections for the UK, in addition to the recent Energy Network Association (ENA) Commissioned Met Office review of UKCP18 data in relation to energy infrastructure assets[24].

This work includes the analysis of projections for weather extremes and prolonged periods of adverse weather, forming the basis for the climate risk assessment. The baseline climate has been used to determine the impact climate risks currently have on SP Energy Networks, and how the climate change projections present the likelihood of climate risks in the future. UKCP18 data is used to inform the findings of the “Committee on Climate Change (CCC) - Progress in preparing for climate” report[25] and the National Infrastructure Commission report on resilient infrastructure systems[26].

The climate change projections have been established for the following future time periods: 2030s, 2050s and 2100s. For each time-period, two scenarios, based on two Representative Concentration Pathways (RCP), RCP6.0[27] and RCP8.5, were used to provide projections of how the climate may change in the future. The best estimate of global average temperature rise by 2100 for RCP8.5 is 4.3ºC (3.2-5.4ºC) and for RCP6.0 is 2.8ºC (2.0-3.7ºC).[28] Comparing more than one RCP is the approach being taken by the UK Climate Change Risk Assessment (CCRA)[29]. RCP8.5 is the most likely scenario at present, and the highest RCP[30].

Climate variables have been extracted for the whole of the UK, in alignment with our 2015 Risk Assessment (with the exception of sea level data which were selected from specific tide gauges close to SP Energy Networks regions). The temperature and precipitation variables are taken from the UKCP18 25km land probabilistic projections, whilst the wind speed projections are taken from global 60km-resolution models. In this report, the baseline period of 1981 – 2010 is used for assessing the projected future climate change anomalies. However, due to data availability, it should be noted that the sea level rise projections used in this analysis are relative to a 1981 – 2000 baseline. This section gives consideration to observed climate change,

[24] See Appendix A for more details

[25]Committee on Climate Change. (2019). Progress in preparing for climate change – 2019 Progress Report to Parliament. [Viewed 09.04.2021]. Available from: https://www.theccc.org.uk/wp-content/uploads/2019/07/CCC-2019-Progress-in-preparing-for-climate-change.pdf

[26] National Infrastructure Commission. (2020). Resilient infrastructure systems. [Accessed 09.04.2021]. Available at: Anticipate-React-Recover-28-May-2020.pdf (nic.org.uk)

[27] Note that for the wind speed and sea level rise projections, RCP4.5 was used as a substitute for RCP6.0 due to UKCP18 data availability limitations.

[28] RCPs specify concentrations of GHG against total radiative forcing targets by 2100. Met Office, 2021, UKCP18 Guidance: Representative Concentration Pathways [online]. Met Office. [viewed 22 March 2021]. Available from: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-guidance---representative-concentration-pathways.pdf

[29] https://www.theccc.org.uk/uk-climate-change-risk-assessment-2017/

[30] Note this analysis was completed prior to COP26 and therefore any impact of the Glasgow Climate Pact has not been taken into account.

observed extreme weather events and the current situation with respect to drought, severe weather and flooding and management of vegetation growth.

4.1 Observed Climate Change

According to the latest State of the UK climate report (2019),[31] the UK's has experienced headline changes presented below. It is assumed that these changes will continue in a similar trajectory into the future:

- The most recent decade (2009–2018) has been on average 0.3ºC warmer than the 1981–2010 average and 0.9ºC warmer than 1961–1990; moreover, all the top ten warmest years for the UK, in the series from 1884, have occurred since 2002;
- The UK seasonal mean temperature for summer increased by 6% from the 1961 – 1990 average of 13.8ºC to 14.6ºC in the 2010 - 2019 period (Figure 2);
- The most recent decade (2009–2018) has been on average 1% wetter than 1981–2010 and 5% wetter than 1961–1990 for the UK overall (values provided in Table 1).
- Mean sea-level around the UK has risen by approximately 1.4 mm/year from the start of the 20th century, which equates to approximately a 17 cm increase when corrected for land movement, and;
- There are as yet no compelling trends in storminess, as determined by maximum gust speeds, from the UK wind network over the last four decades.

Table 1: Average annual rainfall values (mm) across the UK and England, Scotland, and Wales.

Area	1961 – 1990 average	1981 – 2010 average	2010 – 2019 average
UK	1100	1150	1158
England	827	853	864
Scotland	1470	1562	1570
Wales	1402	1459	1430

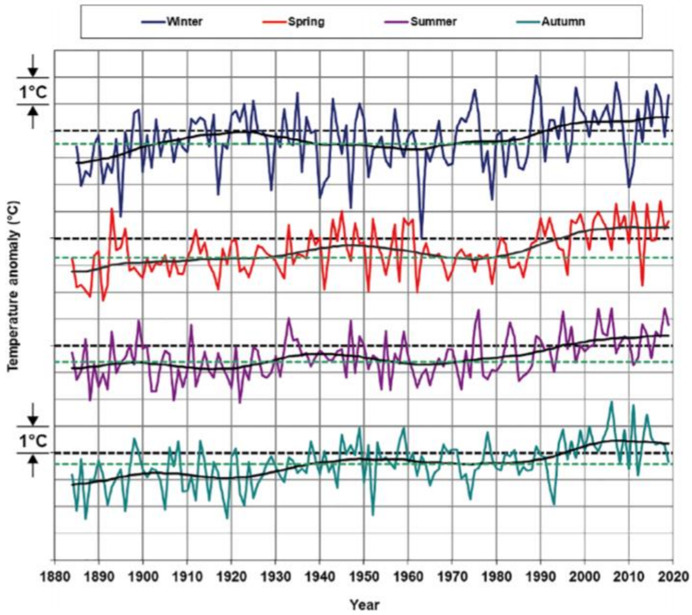


Figure 2: Seasonal T_{mean} (ºC) for the UK, 1884–2019, expressed as anomalies relative to the 1981–2010 average. The hatched black line is the 1981– 2010 long-term average. The lower hatched green line is the 1961–1990 long-term average. Light grey gridlines represent anomalies of ±1ºC.

[31] *Met Office, 2021, State of the UK climate [online]. Met Office. [viewed 22 March 2019]. Available from: https://www.metoffice.gov.uk/research/climate/maps-and-data/about/state-of-climate*

4.1.1 *Observed Weather Events*

As with national trends, areas to which we operate have been experiencing changes to annual temperatures and precipitation since the 1980s, as well as severe extreme weather events that has resulted in disruptions to water supply, energy supply, travel delays and human health impacts.

The impacts of Storm Christoph are outlined in the example below, with other significant weather events that have occurred and impacted SP Energy Networks' operations since 2000 outlined within Table 2.

Understanding how we have been impacted in the past by climate risks forms the impact rating given to climate hazards in the climate change risk assessment.

Storm Christoph: 19 – 22 January 2021

<100mm of rain

Flooding in North East England and North Wales, impacting and inundating substations – as seen with the secondary substation pictures to the right.

Power restored to 13,045 customers, 99% of which occurred within 12 hours.

Source: @SPEnergyNetworks

Type	Date	Description	Impacts
Storms (N.B. Only recent notable events are listed)	21 October - 2 November 2020	Storm Aiden: • 61 mph winds in Scotland, 60mph winds in Wales	13,002 customers across SPD and SPM impacted, all of which were restored within 12 hours.
	25 - 26 August 2020	Storm Francis: • 76mph wind speeds	14,605 customers impacted, 97% of which were restored within 12 hours.
	15 - 16 February 2020	Storm Dennis • 67 mph wind speed in Scotland and 91mph in Wales.	16,519 SPD and 9,227 SPM customers impacted over, 100% of which were restored within 12 hours.
	13 – 14 January 2020	Storm Brendan • 68 mph wind speed in Scotland, 74 mph wind speed in Wales	7,942 customers across both SPD and SPM, 100% of which were restored within 12 hours.
	26 – 27 November 2021	Storm Arwen • 98 mph wind speed recorded	One of the most damaging storms in 60 years, 1-in-30-year event with and impact assessment ongoing.
	7 - 8 December	Storm Barra • Max 85 mph wind speed recorded	Statistics and impact assessment ongoing, all customers restored within 12 hours.
Drought	2010 - 2012	Much of central, eastern, and southern England and Wales experienced a prolonged period of below average rainfall from 2010 to early 2012	Low reservoir levels: hosepipe bans across north-west England affecting six million consumers; widespread agricultural and environmental issues

[32] SP Energy Networks. (2021). Exceptional Events Register

Type	Date	Description	Impacts
Heatwave	July 2006	Sustained warmth and prolonged sunshine resulted in the month of July 2006 being the warmest single month on record over much of the UK[33]. For example, in the first four days of the month maximum temperatures exceeded 28 °C widely across England and Wales, weather that was to recur on many days later in the month.	Disruptions to water and energy supply; Travel delays and disruptions (for example, heat damage to tarmac road surfaces and speed restrictions on railways due to the risk of buckling); Health impacts from heat stress; Strain on health and fire services; Numerous grass/heath/forest fires; Increased tourism
	August 2003	A 10-day UK-wide heatwave, with a record maximum of 38°C.	Health impacts and fatalities from heat; Low river flows and lake levels; High incidence of forest fires; Reduced water supplies; Fatality of livestock and crop failure; Travel delays and disruptions
Flooding	February 2020	UK-wide flooding brought about by intense rainfall of up to 180mm in a single 18-hour period from Storm Ciara and Storm Dennis, alongside 85mph winds.	Travel delays and disruption Flooding of properties and agricultural land Over the 69-hour duration of the storm, 19,688 customers were affected (92% restored within 3 hours, 100% within 25 hours) across North Wales.

The most recent major event at the time of producing this report, Storm Arwen, occurred 26 – 27 November 2021. Nationally, this storm caused electricity disruption to almost 1 million customers. While 83% of disrupted customers had their power restored within 24 hours, a small but significant proportion experienced a disruption of up to 11 days (note although some GB customers were affected for this long it was not on SPEN networks)[34]. As a result, Ofgem and BEIS have launched independent reviews into the impact of Storm Arwen, due to report in early 2022. The impact of this storm on our network is still the subject of ongoing review, if necessary it will inform future updates to our climate resilience strategy.

4.2 Climate Projections

This section summarises the projected climate changes for temperature, precipitation, sea level rise and wind using UKCP18 data for the 2030s, 2050s and 2100s time periods.

4.2.1 Temperature

Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C. There is a high confidence that global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate.[35]

Headline trends

- There is an expected increase of temperature across all seasons with disproportionate increases in extreme high summer temperatures, leading to increased cooling demand and higher likelihood of SP Energy Networks' assets overheating.

Projected climatic parameters for UK temperature change are presented in Table 3. This presents two scenarios based on RCP6.0 and RCP8.5, for the 30-year averages around the 2030s, 2050s, and 2080s time slices. By the 2080s time period, for the RCP8.5 scenario, 50% of climate model results showed warming of up

[33] Met Office. (2012). Record breaking heat and sunshine - July 2006. [viewed 12th April 2021]. Available from: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/weather/learn-about/uk-past-events/interesting/2006/record-breaking-heat-and-sunshine---july-2006---met-office.pdf

[34] https://www.gov.uk/government/publications/storm-arwen-electricity-distribution-disruption-review

[35] *IPCC, 2018. Special Report: Global Warming of 1.5°C Summary for Policymakers [online]. IPCC. [viewed 19 March 2021]. Available from: https://www.ipcc.ch/sr15/chapter/spm/*

to 4.32ºC to the mean summer air temperature, 3.03ºC to the mean winter temperature, 3.59ºC to the maximum summer temperature and 3.01ºC to the minimum winter temperature.

Table 3: Projected UK temperature change for three climatic variables under RCP6.0 and RCP8.5 for three time slices, relative to a 1981 – 2010 baseline (10-90% range of models shown in parentheses).

Temperature variable	Climate Hazard	2020 - 2049 (2030s)		2040 - 2069 (2050s)		2070 - 2099 (2080s)	
		RCP 6.0	RCP 8.5	RCP 6.0	RCP 8.5	RCP 6.0	RCP 8.5
Change in mean annual air temperature anomaly at 1.5m (ºC)	Temperature Increase	+0.77 (0.29 to 1.28)	+1.02 (0.47 to 1.63)	+1.17 (0.49 to 1.90)	+1.77 (0.90 to 2.73)	+2.41 (1.27 to 3.63)	+3.45 (1.99 to 5.07)
Change in mean summer air temperature anomaly at 1.5m (ºC)	Heat waves Wildfires	+0.90 (0.18 to 1.64)	+1.20 (0.42 to 2.03)	+1.41 (0.43 to 2.49)	+2.13 (0.91 to 3.42)	+3.05 (1.43 to 4.83)	+4.32 (2.16 to 5.53)
Change in mean winter air temperature anomaly at 1.5m (ºC)	Ice and snow	+0.70 (0.03 to 1.41)	+0.94 (0.17 to 1.76)	+1.07 (0.19 to 2.01)	+1.63 (0.48 to 2.88)	+2.06 (0.67 to 3.53)	+3.03 (1.17 to 5.01)
Change in maximum summer air temperature anomaly at 1.5m (ºC)	Heat waves Wildfires	+0.83 (0.30 to 1.40)	+1.09 (0.48 to 1.75)	+1.23 (0.48 to 2.04)	+1.86 (0.89 to 2.90)	+2.50 (1.27 to 3.85)	+3.59 (1.98 to 5.35)
Change in minimum winter air temperature anomaly at 1.5m (ºC)	Ice and snow	+0.65 (0.19 to 1.19)	+0.90 (0.11 to 1.83)	+1.06 (0.37 to 1.84)	+1.63 (0.41 to 3.10)	+2.29 (1.05 to 3.63)	+3.01 (1.04 to 5.41)

UKCP18 data showed that the UK will experience warmer wetter winters and hotter drier summers on average[36]. Colder than average winters and summers will still occur but will become less likely the further we go into the 21st century. Additionally, the Intergovernmental Panel on Climate Change (IPCC) noted that cold episodes were projected to decrease significantly in a future warmer climate. However, it has also been suggested that the decrease in sea ice caused by the mean warming could induce, although not systematically, more frequent cold winter extremes over northern continents. Therefore, it is important to still be prepared for extreme cold temperatures and snow in the future as they are likely to occur, even if less frequently.[37]

[36] Met Office, UK extreme events – Cold [viewed 12 April 2021]. Available from: https://www.metoffice.gov.uk/research/climate/understanding-climate/uk-extreme-events_cold
[37] *IPCC (2012) Changes in Climate Extremes and their Impacts on the Natural Physical Environment. Available from: https://www.ipcc.ch/site/assets/uploads/2018/03/SREX-Chap3_FINAL-1.pdf*

4.2.2 Precipitation

Projected climatic parameters for UK precipitation change are presented in Table 4. This presents two scenarios based on RCP6.0 and RCP8.5.

Headline trends

- Winter precipitation projected to increase, increasing the risk of flooding at substations
- Extreme hourly rainfall projected to increase in winter
- Decrease in summer precipitation increasing the likelihood of drought, increasing risks of earth and ground movement on SP Energy Networks' assets

For the 2080s time slice (for example, the 30-year average over 2070-2099) for the RCP8.5 scenario, 50% of climate model results showed an annual increase of 3.6% in rainfall, a 15.7% increase in winter rainfall and a 26.8% decrease in summer rainfall.

Under RCP6.0, 50% of climate model results showed an annual increase of 1.6% in rainfall, a 10.5% increase in winter rainfall and a 19.7% decrease in summer rainfall.

Table 4: Projected UK precipitation change under RCP6.0 and RCP8.5 for the Project timeframes, relative to a 1981 – 2010 baseline (10-90% range of models shown in parentheses).

Precipitation variable	Climate Hazard	2020 - 2049 (2030s)		2040 - 2069 (2050s)		2070 - 2099 (2080s)	
		RCP 6.0	RCP 8.5	RCP 6.0	RCP 8.5	RCP 6.0	RCP 8.5
Change in mean annual precipitation rate anomaly (%)	Flooding	1.45 (-1.42 to +4.51)	2.04 (-1.21 to +5.30)	1.07 (-2.79 to +4.89)	2.17 (-2.37 to +6.97)	1.59 (-3.70 to +6.91)	3.60 (-3.15 to +10.47)
Change in mean winter precipitation rate anomaly (%)	Flooding	2.06 (-4.55 to +9.93)	3.99 (-3.99 to +12.12)	4.50 (-4.25 to +13.91)	7.61 (-2.94 to +19.84)	10.49 (-2.98 to +24.73)	15.65 (-1.56 to +35.90)
Change in mean summer precipitation rate anomaly (%)	Drought	-5.51 (-16.29 to 4.95)	-7.08 (-18.59 to 3.85)	-11.88 (-24.99 to 1.05)	-15.90 (-31.23 to -1.15)	-19.71 (-36.41 to -3.85)	-26.76 (-48.95 to -6.01)

4.2.3 Sea Level Rise

The projected increases in mean sea level anomaly by 2100 relative to 1981 – 2000 are shown in Table 5 and Figure 4. Under RCP8.5 (red in Figure 4), sea level rise projections from UKCP18 models by the end of the century range from 0.3-0.9m in Scotland and 0.4-1m in North Wales and Merseyside. For the lower emissions scenario RCP4.5[38] (blue in Figure 4), projections range from 0.2-0.6m in Scotland and 0.3-0.7m in North Wales and Merseyside.

Headline trends

- Sea level will continue to rise up-to and beyond the end of the 21st century, with projections up to 1 m by 2100 under a high emissions scenario
- Extreme sea levels will increase due to the rise in mean sea level, increasing the risk of coastal flooding and erosion to our coastal assets

[38] RCP4.5 is a scenario that requires significant mitigation and global reductions in greenhouse gas concentrations. It is used here for sea level rise rather than RCP6.0 due to the availability of data on the UKCP18 Interface.

Extreme sea levels will increase due to the rise in mean sea level, affecting the likelihood of coastal flooding and coastal erosion. There is potential for changes in the severity of future storm surge events, but it is unknown from the model results whether the frequency and severity of storm surge events will increase.[39]

Table 5: Time-mean sea level anomaly (m) with 5-95% range of models shown in parentheses.

Region	2030		2050		2100	
	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
SPD						
West Scotland (Portpatrick gauge)	0.08 (0.04 - 0.13)	0.09 (0.05 - 0.14)	0.15 (0.08 - 0.25)	0.19 (0.11 - 0.29)	0.35 (0.17 - 0.64)	0.57 (0.32 - 0.94)
East Scotland (Leith gauge)	0.07 (0.03 - 0.12)	0.08 (0.04 - 0.13)	0.14 (0.07 - 0.23)	0.18 (0.09 - 0.28)	0.33 (0.15 - 0.61)	0.54 (0.30 - 0.90)
SPM						
North Wales & Merseyside (Hilbre Island gauge)[40]	0.11 (0.07 - 0.16)	0.12 (0.08 - 0.17)	0.20 (0.13 - 0.30)	0.24 (0.16 - 0.35)	0.45 (0.27 - 0.74)	0.68 (0.43 - 1.04)

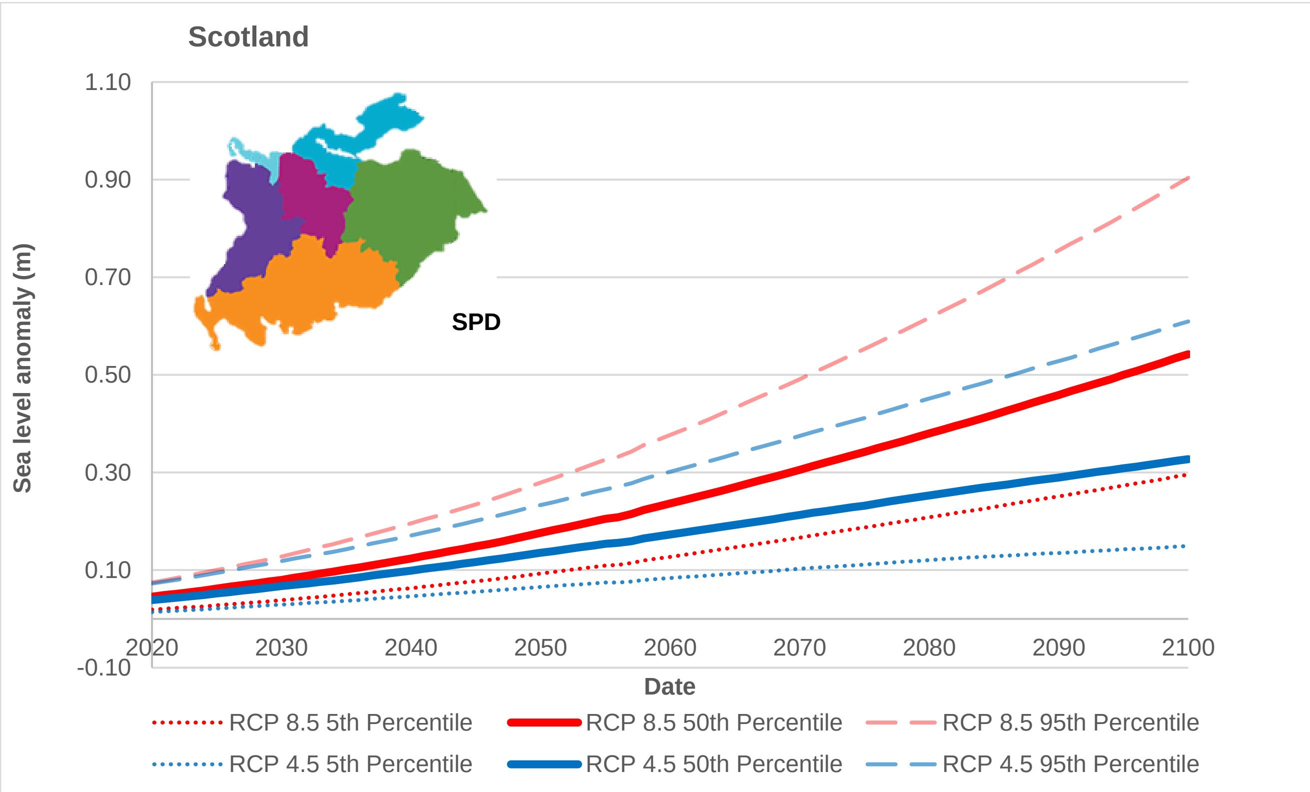


Figure 3: 21st century mean sea level rise anomaly (m) for SPD within SP Energy Networks under RCP4.6 and RCP8.5 relative to 1981-2000.

[39] *Met Office, 2021. UKCP18 Factsheet: Sea level rise and storm surge [online]. Met Office. [viewed 25 March 2021]. Available from: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-fact-sheet-sea-level-rise-and-storm-surge.pdf*

[40] Due to very similar levels at North Wales and Merseyside gauges, one location has been used to represent the North Wales & Merseyside area.

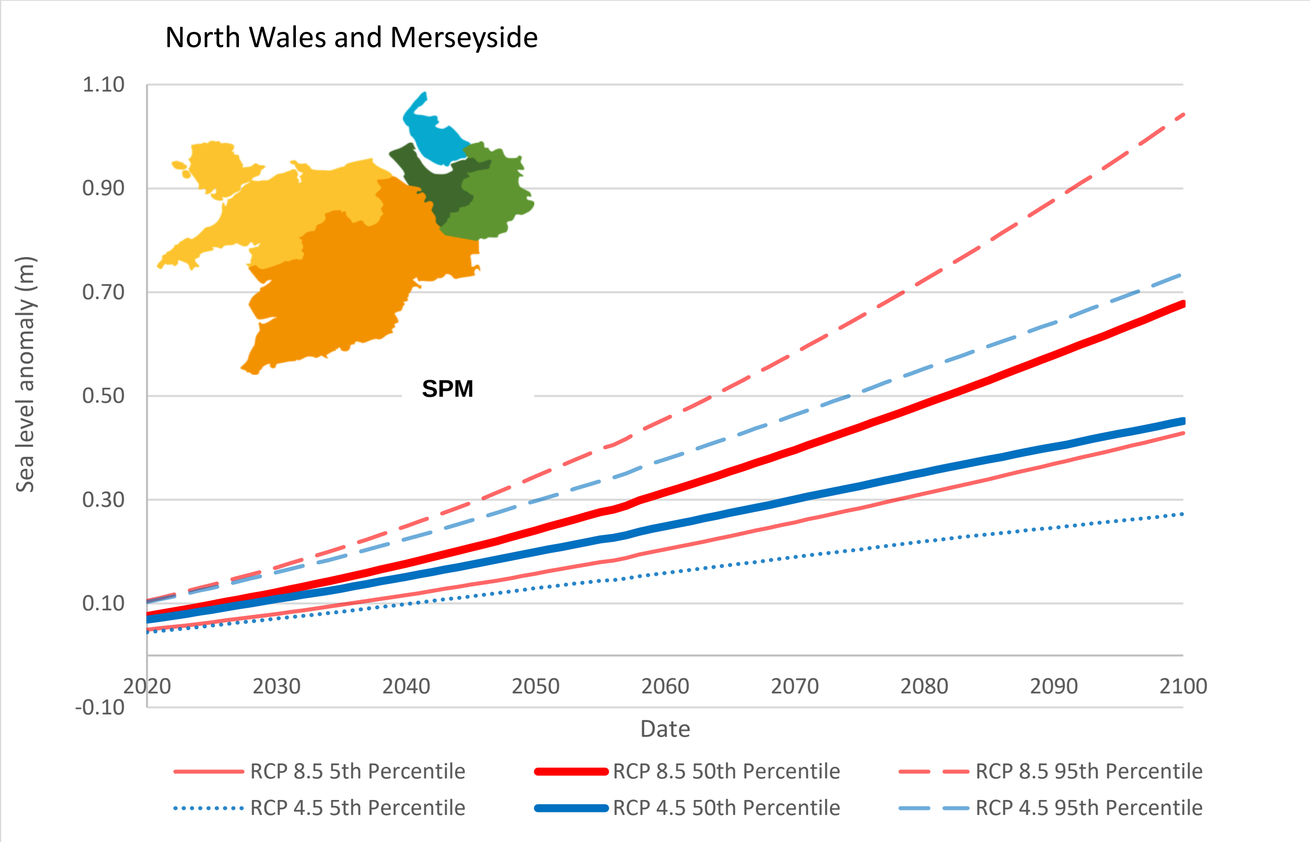


Figure 4: 21st century mean sea level rise anomaly (m) for SPM within SP Energy Networks under RCP4.6 and RCP8.5 relative to 1981-2000.

4.2.4 Wind / Storminess

UKCP18 projections show an increase in near surface wind speeds over the UK for the second half of the 21st century for the winter season, with some climate models in the Met Office PPE-15 (Figure 5) ensemble displaying large peaks in some years. However, the increase in wind speeds is modest compared to interannual variability.

Headline trends

- Interannual and decadal variability of windstorms
- An increase in near surface wind speeds over the UK for the second half of the 21st century for the winter months, increasing the risk of damage to SP Energy Networks' overhead lines
- There is currently no strong signal within the climate projections for a change to future storm intensity
- Poleward shift of storm tracks, increasing storm activity in higher latitudes (GB), could lead to more frequent storms – of uncertain intensity compared to historical storms.

In terms of storminess and lightning, there is currently limited data about the response of these hazards to climate change, so it is not possible to provide projections of change in frequency and severity. Since there is currently no strong signal within the climate projections for a change to future storm intensity, these risks have been assessed as per the current climate, for example the out-of-season storm that impacted the SP Energy Networks in August 2020. It is recognised that prevailing wind direction is a potential hazard for SP Energy Networks, but, like storminess, there is a lack of climate model trends for this variable. However, on a global scale, the IPCC suggests that in a warmer climate there could be a poleward shift of storm tracks, increasing storm activity in higher latitudes, typically associated with increased ocean temperatures[41].

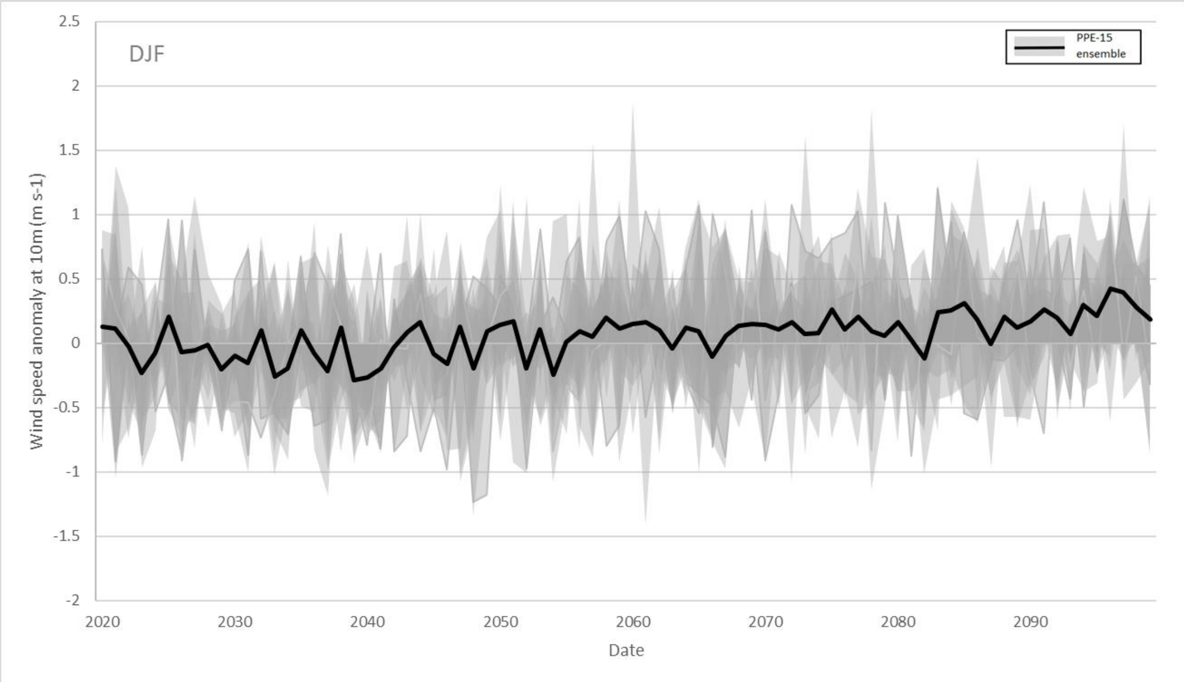


Figure 5: Winter wind speed anomaly at 10m (m s-1) for the UK under RCP8.5 in comparison to the 1981-2010 baseline, from 15 simulations of the Met Office Hadley Centre model (PPE-15).

5. Progress since 2nd round reporting

As a business, we have been focusing on managing key climate risks since the publication of our Adaptation Reports in 2011 and 2015. As a result, we have carried out several adaptive actions across key function areas across the network.

As an example, we have a focus on improving resilience to flooding. We have produced Engineering Justification Papers (EJPs) for Flood Resilience as part of both the RIIO-T2 business plan submission in December 2019, and the RIIO-ED2 business plan submission in December 2021. These EJPs detail our proposed programmes of flood mitigation works across the three licence areas of SP Energy Networks, aiming to ensure compliance with ETR 138[42].

The papers outline the strategy for flood mitigation within the RIIO-2 periods that SPEN will undertake to reduce the risk of the network from coastal, fluvial, and pluvial flooding, in response to following key risks identified:

- AR10 – Substations affected by fluvial (river) flooding due to increased winter rainfall, with loss of inability to function leading to reduced security of supply.
- AR11 – Substations affected by pluvial (surface water) flooding due to severe rainfall, with loss of ability to function leading to reduced security of supply.
- AR12 – There is a risk that due to extreme sea flooding a substation may be lost or unable to function leading to reduced system security of supply. A number of sites may be at risk from sea level rise/coastal erosion.

Impact of flooding on our ground located assets can have significant impact on our networks leading to loss of supply no matter the source of flooding. The necessary repair or replacement of flood damaged assets is costly and time consuming, potentially extending periods of loss of supply beyond the initial flood event.

[41] *IPCC. (2018). Global Climate Projections, Chapter 10. [Online]. [Viewed 31/03/2021]* *https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg1-chapter10-1.pdf*
[42] ENA Engineering Technical Report (ETR) 138 “Resilience to Flooding of Grid and Primary Substations”

This strategy will ensure compliance with the requirement within ETR 138 "Resilience to Flooding of Grid and Primary Substations" to protect substations against a 1:1000 and 1:100-year flood events (refer to Table 6), based on voltage and customer numbers, and provide network security from the effects of flooding, with investment being taken between 2021-2028.

5.1 ETR 138 – Resilience to Flooding of Grid and Primary Substations

ETR 138 was first issued in October 2009 and has had a further two iterations in 2016 & 2018. Issue 2 of the document saw the inclusion of pluvial (surface water) flooding, taking account of improved availability of data from the Environment Agencies. Further to this there was updated guidance on flood risk from reservoir dam failures and canal bank bursts, in line with new data being made available from Environmental Agencies and waterway agencies.

Substation Type	Flood Resilience Level
Grid Substations	Protection against the level of flooding that may occur within a 1:1,000-year flood contour for fluvial, pluvial and coastal flooding.
Primary Substations (33kV) (>10,000 unrecoverable connections)	Protection against the level of flooding that may occur within a 1:1,000-year flood contour for fluvial, pluvial and coastal flooding.
Primary Substations (33kV) (<10,000 unrecoverable connections)	Protection against the level of flooding that may occur within a 1:100 year fluvial and pluvial flood contour (1:200 in Scotland) and within the 1:200 contour for coastal flooding throughout GB
Secondary Substations	Not normally protected but may require protection in certain circumstances

Table 6: ETR 138 Flood Resilience Levels

Following flooding events in 2015 which resulted in some large substations being affected within the UK, the government undertook a review for flood resilience of critical infrastructure. The review recommendations called for the development for longer term plans for permanently improving the resilience of service provision to sites supplying significant local communities. This recommendation was the driver for Issue 3 (2018) of ETR 138 to include increased resilience for sites with greater than 10,000 unrecoverable customers/connections. Table 6 summaries the resilience levels as set out in Issue 3 of ETR 138.

Within SP Energy Networks we have incorporated the ETR 138 recommendations into our 'Substation Flood Resilience Policy' SUB-01-018. This policy document applies to substations at all voltages within SP Energy Networks and sets out the standards for flood resilience work at existing substations on the network, as well as defining resilience levels to be incorporated into new substations.

Although secondary substations do not have a defined requirement to be protected against a specific flood return level, in instances where flooding is resulting in repeat loss of supply, action shall be taken to protect or move the asset. In accordance with SUB-01-018, new secondary substation installations shall be checked against the 1:200 (SPD) and 1:100/200 (SPM) flood maps and the plinth constructed above the flood level where reasonably practicable to do so. (This approach has been endorsed by our recent stakeholder engagement on which activity is prioritised).

5.2 Updated risk assessments

The ENA 3rd Round Climate Change Adaption Report, March 2021 (Appendix A), has provided a collaborative update on existing risks, mitigation measures and programmes to provide an overall view of the potential for climate change impacts to affect energy networks. As previously mentioned, the report was prepared by a task group of gas and electricity distribution and transmission network operator members of the ENA and is intended to provide a response to climate change adaption on behalf of the Energy Industry. The ENA report is provided in full in Appendix A for reference and has been used as the foundation for the work presented within this report.

The three highest rated risks identified in the 2nd round report: AR10, AR11 and AR12, were all rated as "major". The consolidated view of the industry was to reduce these to a "moderate" rating for the 3rd round report, as a result of the flood mitigation work previously completed across the industry as described above.

This carries the caveat that it represents a consolidated view of the risks from climate change, and that there may be differences between networks arising from specific function and regional location.

Following the updates to ETR 138, SP Energy Networks consider risk of flooding as the highest risk climate change variable affecting our network in the short term, as we have ground-based assets that currently do not have the required flood mitigation in place to meet the requirements detailed in Table 6. Recognising the importance of implementing a more detailed strategy to mitigate the wider impacts of climate change in addition to flooding, SP Energy Networks has produced our own risk assessment and mitigation strategy, and this is presented within the following sections.

6. Risk Assessment Summary

This section identifies the key climate risks and determines the adaptation tipping points of our network and business functions. The risk matrix shown below developed in line with the Energy Network Association (ENA) 3rd Round Climate Change Adaptation report[43] identifies accepted risk levels, asset and function performance threshold levels, and minimum performance requirements.

Table 7: Scoring matrix used to determine the significance of risks for SP Energy Networks

Relative Impact						
	Extreme	5	10	15	20	25
	Significant	4	8	12	16	20
	Moderate	3	6	9	12	15
	Minor	2	4	6	8	10
	Limited	1	2	3	4	5
		Very Unlikely	Unlikely	Possible	Expected	Almost Certain
		Relative Likelihood				

The below (Table 8) outlines the definitions associated with the relative impact and likelihood classifications of risks. The impact relates to the scale of the area affected by the hazard and the likelihood is based on how frequent the event causing the risk occurs and is likely to occur in the future based on climate projections.

Table 8: Impact and Likelihood classification definitions

Relative impact	
Extreme	Regional area affected with people off supply for a month or more/OR asset de-rating exceeds ability to reinforce network leading to rota disconnections on peak demand.
Significant	County or city area affected with people off supply for a week or more OR asset de-rating requires a significant re-prioritisation of network reinforcement and deferment of new connection activities
Moderate	Large town or conurbation off supply for up to a week OR significant increase in cost of network strengthening.
Minor	Small town off supply for a 24-hour period OR significant increase in cost of network maintenance requirements.
Limited	Limited impact - can be managed within “business as usual” processes
Relative Likelihood	
Very Unlikely	No known event or if known extremely rare, extreme industry-wide scenarios
Unlikely	Events are rare, required mitigations in place, controls are effective
Possible	Past events satisfactorily resolved, mitigations are in place or are on track to be in place, control improvements are under active management
Expected	Past events have not been fully resolved, effective mitigations not yet identified, control weakness are known and are being managed.

[43] ENA’s Electricity Networks Climate Change Task Group, 3rd Round Climate Change Adaptation Report, March 2021 – See Appendix A

Almost Certain	The risk in the process of materialising and may already be under active management as an event

The risk assessment is built on the understanding and identification of the tipping point of functions in the power system. This is the point when the function of different parts of the power system is no longer viable in relation to the projected climate parameters, such as temperature thresholds and flood capacity, and so adaptation actions are therefore required. The Adaptation Sub-Committee of the Committee on Climate Change Evidence Report[44] identifies and assesses 56 individual climate change risks and opportunities for the UK.

The impact score has been highlighted in each risk table as it is assumed that the impact would remain constant while the likelihood changes in relation to climate projections. Climate hazards associated with each risk are also included in the table and relate to at least one of the climate variables presented in Section 4: temperature; precipitation; sea level rise; and wind/storminess. The risks presented in this report have been subject to review internally within SP Energy Networks through workshops[45]. The risks have been separated into function categories as follows:

Network Risks

- Overhead lines, poles & towers
- Underground cables
- Transformers
- Substation Sites
- Vegetation management
- Network Loading

Business Risks

- Emergency Response and planning
- Routine business and maintenance
- Customer Service

Table 9 presents the meaning behind the risk ID given to all the risks identified, some of the IDs are legacy ones given in the SP Energy Networks 2015 CCRA[46], the rest have been created in this assessment.

Table 9: Key for risk ID and source of ID

ID	Name, Source	ID	Name, Source
AR	Risk originally identified by the ENA first report, SP Energy Networks CCRA 2015	GN	Generation/Network Loading, RIIO-ED2 Climate Resilience Working Group 2021
NG	Risk originally identified by National Grid Electricity Transmission plc report, SP Energy Networks CCRA 2015	ER	Emergency Response, RIIO-ED2 Climate Resilience Working Group 2021
SP	Risks specific to SP Energy Networks identified, SP Energy Networks CCRA 2015	RB	Routine Business, RIIO-ED2 Climate Resilience Working Group 2021
VM	Vegetation Management, AECOM 2021	CS	Customer Service, RIIO-ED2 Climate Resilience Working Group 2021

The remainder of this section is presented in two parts:

[44] Committee on Climate Change. (2017). UK Climate Change Risk Assessment Evidence Report. [Online]. [Accessed on 17/03/2021]. Available from: theccc.org.uk/tackling-climate-change/preparing-for-climate-change/uk-climate-change-risk-assessment-2017/

[45] Risks with the source 'CRS Workshop 1' were derived from the workshop held on the 24th March 2021 to discuss and confirm the climate risks and tipping points identified for the RIIO-ED2 Climate Resilience Strategy

[46] SP Energy Networks. (2015). Climate Change Adaptation Report, Round 2 Update. [Accessed 3rd May 2021]. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/479266/clim-adrep-sp-energy-networks-2015.pdf

- Section 6.1 – Key Network Risks relating to assets and infrastructure, as set out above.
- Section 6.2 – Key Business Risks relating to people, processes and systems required to operate effectively and safely, and meeting our customers' expectations, as set out above.

6.1 Key Network Risks

The following outlines the key network risks posed to SP Energy Networks and the change in risk scores over time for the two Representative Concentration Pathways (RCP) scenarios.

6.1.1 Overhead Lines, Poles and Towers

Overhead lines (OHL), poles and towers are a key element of our infrastructure, consisting of 606,600 poles and towers and 40,000 km of OHL (as per 2020 figures). Risks associated include the direct risk temperature poses to the capability of the asset to operate, and the risk posed by many climate variables on the structural integrity of the asset, in some cases increasing the deterioration.

Table 10: Climate risks posed to overhead lines, cable bridges & towers

				Risk score					
Source	Risk ID	Climate Hazard: Risk	Impact Score	RCP6.0			RCP8.5		
				2030	2050	2100	2030	2050	2100
SP Energy Networks CCRA 2015	AR1	Increased Temperature: Overhead line conductors affected by temperature rise and increased cooling demand, reducing rating and ground clearance.	3	High 9	High 9	High 12	High 9	High 12	High 15
SP Energy Networks CCRA 2015	AR2	Summer Drought: Overhead line structures affected by summer drought and consequent ground movement.	2	Med 4	Med 6	Med 6	Med 4	Med 6	Med 8
SP Energy Networks CCRA 2015	AR3	Prolonged growing season: Overhead lines affected by interference from vegetation	3	High 15	High 15	High 15	High 15	High 15	High 15
SP Energy Networks CCRA 2015	NG3	Increased River Erosion from Increased Precipitation: If foundations are exposed, weakened or soil stability is reduced lines may fail.	3	High 9	High 9	High 12	High 9	High 12	High 15
UK CCRA 2017	AR15	Hurricanes & High Winds: Overhead line structures affected by wind speeds not accommodated for in design.	3	High 9	High 9	High 12	High 9	High 12	High 15
SP Energy Networks CCRA 2015	AR14	Increased Lightning activity: Overhead lines affected by increased lightning activity.	2	Med 6	Med 6	Med 8	Med 6	Med 8	Med 10
SP Energy Networks CCRA 2015	NG1	Sea Level Rise: A number of sites may be at risk from sea level rise. Sites may become non-operational due to sea inundation potentially leading to a loss of system resilience or a loss of supply.[47]	3				Med 3	High 6	High 9
SP Energy Networks	NG2	Coastal Erosion: A number of sites may be at risk from coastal erosion. (Due to the slow nature of erosion any site that	3				Med 3	High 6	High 9

[47] Sea level rise projections aren't available for RCP6.0

Source	Risk ID	Climate Hazard: Risk	Impact Score	Risk score RCP6.0 2030	RCP6.0 2050	RCP6.0 2100	RCP8.5 2030	RCP8.5 2050	RCP8.5 2100
CCRA 2015		is identified at risk will be either protected or relocated prior to any system impacts, however mitigation costs may be significant.)							

6.1.2 Underground cables

The risks posed to underground assets can cause moderate to extreme impacts due to the size of the network affected, and access issues related to resolving underground faults. We have around 65,000 km of underground cable assets. Although temperature change experienced underground is not as extreme as the ambient air temperature changes, fluctuations in temperature can cause significant impacts to underground assets.

In recent years, a peak in faults in underground cable joints was experienced associated with high ambient temperatures and a combination of day to night cooling inducting faults in otherwise reliable assets. Ground movement can also pose a detrimental risk to underground assets.

Table 11: Climate risks posed to underground line, tunnels, and cable routes

Source	Risk ID	Source	Risk ID	Risk score Source 2030	Source 2050	Source 2100	Risk ID 2030	Risk ID 2050	Risk ID 2100
SP Energy Networks CCRA 2015	AR4	Increased Temperature: Underground cable systems affected by the increase in ground temperature, reducing cable current (load) carrying capacity/ratings.	3	High 9	High 9	High 9	High 9	High 9	High 9
SP Energy Networks CCRA 2015	AR5	Summer Drought: Underground cable systems affected by summer drought and consequent ground movement, leading to mechanical damage/failure.	4	High 8	V High 12	V High 12	High 8	V High 12	V High 16
ED2 Workshop	AR16	Summer Drought: dry-out of the soil surrounding UG cables. This will lead to an increased thermal resistivity, reduced heat transfer from cable to surrounding soil/backfill, and a reduced current (load) carrying capacity	4	High 8	V High 12	V High 12	High 8	V High 12	V High 16
SP Energy Networks CCRA 2015	NG4	Sea Level Rise: A very small number of sites are potentially at increased risk if the level of current protection is not maintained or improved. (Due to the slow nature of sea level rise any cable identified at risk will either be protected or relocated prior to any system impacts; however, mitigation costs may be significant)[48].	3				Med 3	High 6	High 9

6.1.3 Transformers

Transformers are posed with direct risks of temperature change on the functioning of transformers, combined with the increased energy demand associated with temperature changes, such as increased cooling and heating requirements, which can result in overloading the transformers. Lightning is also an ever-constant risk; however, our network assets have lightning protection built in where currently required.

[48] Sea level rise projections aren't available for RCP6.0

Table 12: Climate risks posed to transformers

Source	Risk ID	Climate Hazard: Risk	Impact Score	Risk score					
				RCP6.0			RCP8.5		
				2030	2050	2100	2030	2050	2100
SP Energy Networks CCRA 2015	AR7	Increase Temperature: Transformers affected by temperature rise, reducing rating. Increasing the operation of cooling fans and pumps fitted for transformers, increasing auxiliary losses	2	Med 6	Med 6	Med 8	Med 6	Med 8	Med 10
SP Energy Networks CCRA 2015	AR8	Increase Temperature: Transformers affected by urban heat islands and coincident air conditioning demand leading to overloading in summer months.	3	High 9	High 9	High 12	High 9	High 12	High 15
SP Energy Networks CCRA 2015	AR14	Lightning: Transformers affected by increased lightning activity.	2	Med 6	Med 6	Med 8	Med 6	Med 8	Med 10

6.1.4 Substation Sites (Including transformers, switchgear & earthing)

The highest risk posed to our 30,000 substation sites is associated with flooding: fluvial, pluvial, and coastal. The voltage and size of the substation determines the flood return period that it is built to be resilient to.

Grid and primary substations feeding 10,000-30,000 customers are protected against 1:1000 flood levels, those primary substations that have less than 10,000 recoverable customers are protected against 1:100/1:200 level, and secondary substations are retrospectively protected against flooding where regularly at risk or with vulnerable customers.[49] The real-world return periods of those flood levels are likely to decrease with climate change in the future, increasing the frequency of more severe flooding.

Table 13: Climate risks posed to substation sites

Source	Risk ID	Climate Hazard: Risk	Impact Score	Risk score					
				RCP6.0			RCP8.5		
				2030	2050	2100	2030	2050	2100
SP Energy Networks CCRA 2015	AR6	Summer Drought: Substation and network earthing systems adversely affected by summer drought conditions reducing the effectiveness of earthing systems.	2	Med 6	Med 6	Med 6	Med 6	Med 6	Med 8
SP Energy Networks CCRA 2015	AR9	Increased Temperatures: Switchgear affected by temperature rise, reducing rating.	2	Med 6	Med 6	Med 8	Med 6	Med 8	Med 10
SP Energy Networks CCRA 2015	AR10	Fluvial and Pluvial Flooding: Substations affected by river flooding due to increased winter rainfall, with loss or inability to function leading to reduced security of supply.	4	V High 16	V High 16	V High 16	V High 16	V High 16	V High 20
SP Energy Networks CCRA 2015	AR11	Fluvial and Pluvial Flooding: Substations affected by flash flooding due to severe rainfall, with loss or inability to function leading to reduced security of supply.	4	V High 12	V High 12	V High 16	V High 12	V High 16	V High 20
SP Energy Networks CCRA 2015	AR12	Sea level and storm surge: there is a risk that due to extreme sea flooding a substation may be lost or unable to function leading to reduced system	5				V High 15	V High 20	V High 25

[49] SUB-01-018 SP Energy Networks Flood Resilience Policy, Issue No.2

Source	Risk ID	Climate Hazard: Risk	Impact Score	Risk score RCP6.0 2030	2050	2100	RCP8.5 2030	2050	2100
		security of supply. A number of sites may be at risk from sea level rise/coastal erosion.[50]							
SP Energy Networks CCRA 2015	AR13	Increased Precipitation: Substations affected by water flood from dam burst.	5	Med 1	Med 1	High 2	Med 1	High 2	High 2
UK CCRA 2017	AR17	Summer Drought: Surface infrastructure foundations affected by summer drought and consequent ground movement, leading to mechanical damage.	4	High 8	V High 12	V High 12	High 8	V High 12	V High 16

6.1.5 Vegetation Management

There are legislative obligations under the Electricity Safety, Quality and Continuity Regulations (ESQCR) associated with Overhead line conductor clearance including from vegetation. There are two elements to the risks associated with vegetation.

1. Increased precipitation and temperatures can prolong the growing season of vegetation, increasing the maintenance requirements.
2. Climate hazards i.e. floods, can also directly damage vegetation, moving vegetation within the clearance zones resulting in network faults.

These can depend upon vegetation density and species type. Although isolated events of vegetation induced risks have a low impact on our network, these can result in a cumulatively higher impact to network resilience.

Table 14: Climate risks posed to vegetation management

Source	Risk ID	Climate Hazard: Risk	Impact Score	Risk score RCP6.0 2030	2050	2100	RCP8.5 2030	2050	2100
Adapted from other DNO CRS	VM1	Fluvial and Pluvial Flooding: Flooding events undermine tree roots, leading to additional faults due to falling trees.	3	High 6	High 6	High 9	High 6	High 9	High 12
Adapted from other DNO CRS	VM2	Coastal Flooding: Flooding events undermine tree roots, leading to additional faults due to falling trees.[51]	2				Med 4	Med 6	Med 8
CRS Workshop 1	VM3	Drought events affect tree structure and stability	1	Low 3	Low 3	Low 4	Low 3	Low 4	Low 4
Adapted from other DNO CRS	VM4	Ice and snow accumulation occur on trees leading to additional faults due to falling debris	2	Med 4	Med 4	Med 6	Med 4	Med 6	Med 6
ENA 2021	VM5	Hurricane and high winds: Increased frequency of events may weaken trees leading to additional wind damage causing faults	2	Med 6	Med 6	Med 8	Med 6	Med 8	Med 10
CRS Workshop 1	VM6	Prolonged Growing Season: Increase in precipitation lead to an extended growing season and hence additional encroachment of vegetation.	2	Med 10	Med 10	Med 10	Med 10	Med 10	Med 10

[50] Sea level rise projections aren't available for RCP6.0
[51] Sea level rise projections aren't available for RCP6.0

				Risk score					
				RCP6.0			RCP8.5		
Source	Risk ID	Climate Hazard: Risk	Impact Score	2030	2050	2100	2030	2050	2100
ENA 2021	VM7	Prolonged Growing Season: High raised temperatures leading to increased growth rates and the need for enhanced vegetation clearance and tree cutting schedules	2	Med 10	Med 10	Med 10	Med 10	Med 10	Med 10
Adapted from other DNO CRS	VM8	Lightning: Increased lightning storms leading to increased number tree lightning strikes.	2	Med 6	Med 6	Med 8	Med 6	Med 8	Med 10
Adapted from other DNO CRS	VM9	Drought: Change in water content of soil leads to changes in natural habitats of different species.	1	Low 3	Low 3	Low 4	Low 3	Low 4	Low 4
UK CCRA 2017	VM10	Pests, pathogens, and invasive species: Changes in weather conditions can allow pests, pathogens, and invasive species to appear in the UK, damaging trees leading to additional faults due to falling trees, for example, ash dieback.	2	Med 6	Med 6	Med 8	Med 6	Med 8	Med 8
UK CCRA 2017	VM11	Wildfire: Higher temperatures during summertime can create the conditions for wildfires that can affect trees and electrical infrastructure near them	3	Med 3	Med 3	High 6	Med 3	High 6	High 9

6.1.6 Telecoms & Control Infrastructure

Infrastructure used to manage communications around the network are primarily at risk of flooding. A flood event can cause the entire site or equipment to become non-operational.

Table 15: Climate risks posed to control infrastructure

				Risk score					
				RCP6.0			RCP8.5		
Source	Risk ID	Climate Hazard: Risk	Impact Score	2030	2050	2100	2030	2050	2100
SP Energy Networks CCRA 2015	SP3	Fluvial, pluvial and sea flooding: Flooding impacts upon communication and control infrastructure. Whilst control centres are thought not to be at risk from flood, a site may become non-operational due to flooding potentially leading to a loss of system resilience or a loss of supply. Communications are also reliant upon third parties (Information communication technologies, ICT) who may also be impacted by an event.	3	High 9	High 9	High 12	High 9	High 12	High 15

6.2 Key Business Risks

These sections outline the business risks posed to how we operate associated with climate change.

6.2.1 Emergency Response and Planning

An increased frequency and severity of extreme events associated with climate change projections can increase the number of faults experienced and therefore the requirement for emergency response. How emergency events change in the future may require changes to be made to the planning and ultimately the capacity of the emergency response mechanisms we currently have in place.

Table 16: Climate risks posed to emergency response and planning

Source	Risk ID	Climate Hazard: Risk	Impact Score	Risk score					
				RCP6.0			RCP8.5		
				2030	2050	2100	2030	2050	2100
ENA 2021	ER1	Ice: An increased frequency of events leads to an increased number of major incidents.	3	High 6	High 6	High 9	High 6	High 9	High 9
ENA 2021	ER2	Snow: heavy snowfalls leading to excessive loading on buildings, and secondary risks from icing of equipment and road, leading to access issues in emergencies.	3	High 9	High 9	High 6	High 9	High 6	High 6
ENA 2021	ER3	Hurricane & High Winds: Increased frequency and severity of extreme events causes additional faults leading to a strain on resources.	3	High 9	High 9	High 12	High 9	High 12	High 15
AECOM	ER4	Snow and Ice: Increased heating demand causing additional loadings placed on network, leading to additional faults.	3	High 6	High 6	High 9	High 6	High 9	High 9
ENA 2021	ER5	Increased number of lightning strikes lead to additional faults.	2	Med 6	Med 6	Med 8	Med 6	Med 8	Med 10
CRS Workshop 1	ER6	Increased Temperature: Increased cooling demand, causing additional loadings placed on network, leading to additional faults.	3	High 6	High 9	High 12	High 9	High 12	High 15
Adapted from other DNO CRS	ER7	Heat Wave: High staff absence due to sickness leading to a reduced internal workforce	2	Med 4	Med 4	Med 6	Med 4	Med 6	Med 8
UK CCRA 2017	ER8	Slope and embankment failures causes additional faults and hampers staff movements leading to slow response times.	4	High 8	High 8	High 8	High 8	High 8	High 8

6.2.2 Routine Business

An increased number of faults across the network associated with climate change may reduce the capacity of the organisation to carry out routine business activities, such as maintenance, restoration, repairs, and capital investment. The risks are primarily associated with resources being diverted to attend to extreme events and the accessibility of the network either to carry out routine maintenance or respond and repair faults. Extreme events associated with multiple climate variables can impede access, such as flooding affecting access to faults on the network, and severe cold spells affecting the ability of our staff to travel around the network.

Table 17: Climate risks posed routine business

Source	Risk ID	Climate Hazard: Risk	Impact Score	Risk score RCP6.0 2030	RCP6.0 2050	RCP6.0 2100	RCP8.5 2030	RCP8.5 2050	RCP8.5 2100
ENA 2021	RB1	Fluvial and Pluvial: Increased number of substations at risk of flooding, leading to diversion of resources away from routine business	3	High 9	High 9	High 12	High 9	High 12	High 15
ENA 2021	RB2	Coastal Flooding: Increased number of substations at risk of flooding, leading to diversion of resources away from routine business[52]	3				High 9	High 12	High 15
Adapted from other DNO CRS	RB3	Ice: Routine business suffers as a result of additional faults on the network.	2	Med 4	Med 4	Med 6	Med 4	Med 6	Med 6
ENA 2021	RB4	Heavy Snow: heavy snowfalls leading to excessive loading on buildings, and secondary risks from icing of equipment and road, leading to access issues and disruption to operational activities	2	Med 4	Med 4	Med 6	Med 4	Med 6	Med 6
Adapted from other DNO CRS	RB5	Hurricane & High Winds: Certain activities postponed due to safety concerns.	2	Med 6	Med 6	Med 8	Med 6	Med 8	Med 10
Adapted from other DNO CRS	RB6	Heat Wave: Certain operational & non-operational activities postponed/delayed due to unsuitability of PPE for temperature conditions.	2	Med 4	Med 4	Med 6	Med 4	Med 6	Med 6
CRS Workshop 1	RB7	Fluvial and Pluvial: Risks to staff travelling to work from flooding of transport network. And Limiting ability to get to site to repair faults.	2	Med 6	Med 6	Med 8	Med 6	Med 8	Med 10
CRS Workshop 1	RB8	Cold Spells: Risks to staff travelling to work from cold spells and increase snow and ice on the transport network	2	Med 4	Med 4	Med 6	Med 4	Med 6	Med 6
SP Energy Networks CCRA 2015	SP1	Increased Temperatures: Maintenance programme may be impacted as increased temperatures may increase loads during summer reducing opportunity for planned outages and network reinforcement to enable maintenance. Temperature increases could thus lead to a possible reduction in the flexibility of the network (because of the change in load balance through the year).	3	High 9	High 9	High 12	High 9	High 12	High 15
SP Energy Networks CCRA 2015	SP2	Extreme Events: During extreme events teams may have limited safe access to isolate and repair faults. This could result in loss of supply to customers for a greater period of time.	2	Med 6	Med 6	Med 8	Med 6	Med 8	Med 10

6.2.3 Customer Service

Meeting customer service satisfaction requirements is a key priority of our organisation. Ofgem regulates the compliance of customer service requirements by stipulating the maximum response times of unplanned interruptions, appreciating that the frequency of certain climatic hazards can be unpredictable, but there should be adequate mitigation measures in place. Climate change shows an increase in severity and frequency of climate hazards which could slow down response times by impeding network access and affecting the health and safety of our staff and customers. The UK Net Zero carbon emissions by 2050 goal will likely increase

[52] Sea level rise projections aren't available for RCP6.0

electrical demand through increases in electrification of transportation, however at least the same levels of customer service will be needed.

Table 18: Climate risks posed to customer service

				Risk score					
Source	Risk ID	Climate Variable: Risk	Impact Score	RCP6.0			RCP8.5		
				2030	2050	2100	2030	2050	2100
UK CCRA 2017	CS1	Fluvial & Pluvial Flooding: Increased number of substations at risk of flooding. Fault restoration times extended due to floodwaters.	3	High 9	High 9	High 12	High 9	High 12	High 15
Adapted from other DNO CRS	CS2	Fluvial & Pluvial Flooding: Certain types of work prevented due to safety issues caused by office buildings flooding.	2	Med 6	Med 6	Med 8	Med 6	Med 8	Med 10
UK CCRA 2017	CS3	Coastal Flooding: Increased number of substations at risk of flooding. Fault restoration times extended due to floodwaters. [53]	4				V High 12	V High 16	V High 20
Adapted from other DNO CRS	CS4	All Climate Hazards: Slow response times and increased fault durations due to large number of network faults and problematic access and travel.	2	Med 6	Med 6	Med 8	Med 6	Med 8	Med 10
Adapted from other DNO CRS	CS5	Heavy Snow: Slow response times and increased fault durations due to large number of network faults and problematic access and travel.	2	Med 4	Med 4	Med 6	Med 4	Med 6	Med 6
Adapted from other DNO CRS	CS6	Hurricanes & High Winds: Slow response times and increased fault durations due to a large number of network faults.	2	Med 6	Med 6	Med 8	Med 6	Med 8	Med 10
Adapted from other DNO CRS	CS7	Heat Wave: Risks to staff travelling to work from high temperatures on public transport	2	Med 4	Med 4	Med 6	Med 4	Med 6	Med 8
CRS Workshop 1	CS8	Heat Wave: Vulnerable customers need additional prioritisation.	3	High 6	High 9	High 12	High 9	High 12	High 15
Adapted from other DNO CRS	CS9	Cold Spells: Vulnerable customers need additional prioritisation.	3	High 9	High 9	High 6	High 9	High 6	High 6
UK CCRA 2017	CS10	Slope and Embankment Failures: Slow response times and increased fault durations due to large number of network faults and problematic access and travel.	3	High 6	High 6	High 6	High 6	High 6	High 6
UK CCRA 2017	CS11	Drought: Risks to public water supplies from drought and low river flows affecting workers in offices	2	Med 4	Med 6	Med 6	Med 4	Med 6	Med 8
UK CCRA 2017	CS12	Vector-borne Pathogens: High staff absence due to sickness leading to a reduced internal workforce.	3	High 9	High 9	High 9	High 9	High 9	High 9
UK CCRA 2017	CS13	Coastal Flooding: Certain types of work prevented due to safety issues caused by office buildings flooding. [54]	4				V High 12	V High 16	V High 20

[53] Sea level rise projections aren't available for RCP6.0
[54] Sea level rise projections aren't available for RCP6.0

7. Adaptation Tipping Points

Our strategy for climate resilience has been developed using the climate adaptation pathways approach[55] [56]. While this work was undertaken to develop our Climate Resilience Strategy (CRS) as part of our RIIO-ED2 business plan submission[57], the overarching strategy will be applied to the whole of SPEN, including SPT.

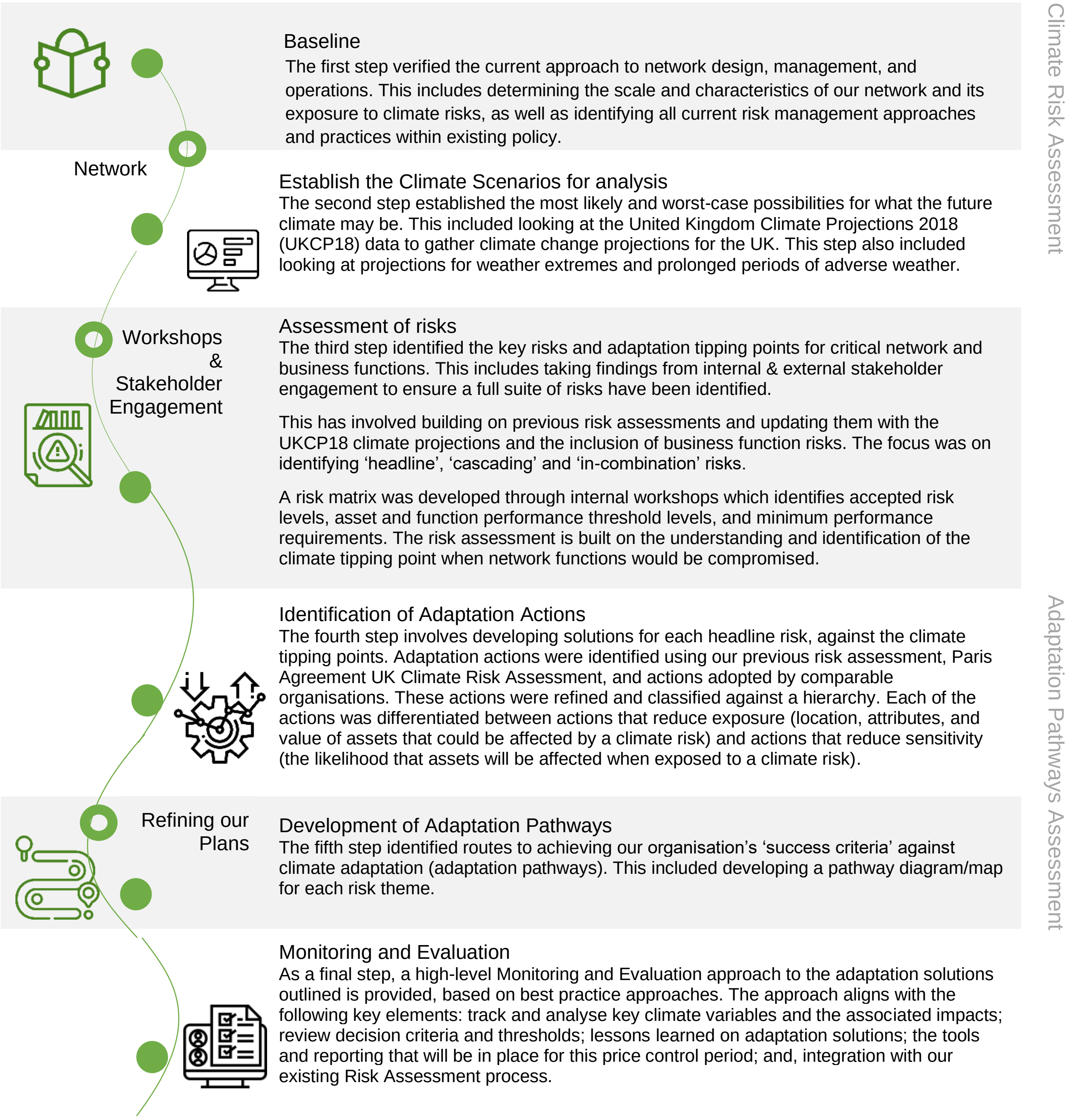


Figure 6: SP Energy Networks Climate Resilience Strategy Approach

The assessment is split into two stages; the Climate Risk Assessment, and the Adaptation Pathways Assessment, each of which has a set of series of steps and associated actions. The method taken is illustrated in Figure 6.

[55] IEEE Power & Energy Society (2020). Technical Report – Resilience Framework, Methods, and Metrics for Electricity Sector. PES-TR83. The Institute of Electrical and Electronic Engineers. Inc.
[56] Haasnoot, M, et al., (2014). Dynamic adaptive policy pathways; A method for crafting robust decisions for a deeply uncertain world. Global Environmental Change 23. 485-298. Elsevier.
[57] https://www.spenergynetworks.co.uk/pages/our_riio_ed2_business_plan.aspx

7.1 Industry Engagement

Throughout the development of this strategy, a comprehensive and bespoke programme of engagement was undertaken with various SP Energy Networks colleagues, alongside understanding, and leveraging from the information gathered by engagement activities completed by both the Energy Network Association (ENA) and internal colleagues for other similar and interconnected strategies.

This included:

i. Completing a total of six, 1-hour peer to peer, semi-structured interviews, alongside hosting two virtual workshops with internal colleagues. Participants included but were not limited to; sustainability specialists; asset managers; control room managers and engineers.

   The first workshop was one and a half hours in length and was held in March 2021 to discuss and confirm the climate risks and tipping points identified. The second workshop was held in April 2021, to finalise the tipping point evaluation and begin discussing potential adaptation solutions that could build on existing approaches to reduce future risks.

ii. Understanding and incorporating ENA stakeholder engagement output from the Adaptation to Climate Change Task Group, 3rd Round Climate Change Adaptation Report.

iii. Understanding and incorporating the outputs from recently completed engagement activities with around 14,000 customers and external stakeholders between November 2020 and November 2021, including topics on our:

   - Strategy for Biodiversity and Natural Capital Enhancement,
   - Strategy for Business Carbon Reduction, and;
   - Strategy for Sustainable Resource use.

An adaptation tipping point is reached when the magnitude of climate change is such that the current adaptation solution is no longer effective.

Three types of tipping points have been derived across two pre-defined categories - Stable State; where the formal objective / performance threshold of a solution (standards / laws) is exceeded, and Mechanism; where accessibility, temporal or economic thresholds are surpassed[58].

Developed in order to better reflect the scope of the network and business risks, the three tipping points types as outlined within Table 19, echo both the qualitative and quantitative nature of the climate variables and the suite of assets / operational activity within the scope of SP Energy Networks.

Table 19: Adaptation Tipping Points

Type	Description	Example	Category
i. **Climate Variable / Design Threshold**	Applied where the climatic variable considered has a direct impact on the asset itself. Applied to high risks where possible.	Ambient air temperature that informs the maximum or minimum conductor temperature is exceeded.	Stable State
ii. **Response Led**	Where climate variable/design threshold is not applicable, this is led by available data on SP Energy Networks activity and current approaches	An observed increase in time and cost spent on current vegetation management practices.	Mechanism
iii. **Outcome Led**	Informed by associated impact of an event occurring (apply only to low risks where possible)	Heightened number of customer complaints and an increase in the duration of disruption from climatic events.	Mechanism

[58] Kees C H van Ginkel et al (2020). Environ. Res. Lett. 15 023001. Available at: https://iopscience.iop.org/article/10.1088/1748-9326/ab6395/pdf

8. Adaptation Solutions and Pathways

The following section presents the proposed adaptation solutions[59] which are organised into adaptation pathways[60] for each of the climate hazards. The solutions address the climate risks identified in Section 4 accounting for tipping points and climate change projection scenarios, with a view of building in climate resilience.

The solutions identified originate from several sources, including the 2015 Risk Assessment, interviews with key internal colleagues, and documentation from the Energy Network Association (ENA). They were updated or adjusted against the Risk Assessment carried out for the CRS and supplemented with findings from workshops.

Two styles of pathways diagrams have been developed (traditional pathways diagram and flow diagram) based upon the type of tipping point data available. Both follow a decision matrix format, and example diagrams are shown in Figure 7.

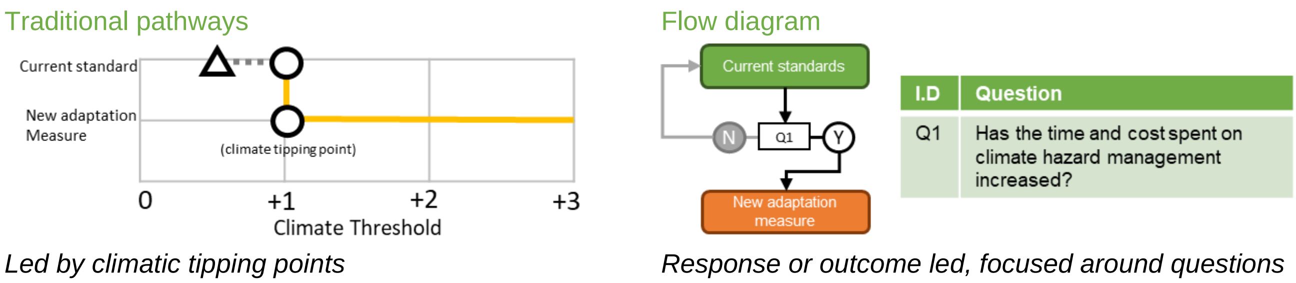


Figure 7: Examples of traditional and flow diagram pathways

We have assigned the following style of diagram and assessment for each hazard based on which approach was better suited to the hazard identified, and the availability of corresponding decision points:

- **High temperatures**; traditional pathways
- **Low temperatures**; flow diagram
- **Flooding**; flow diagram
- **Growing Season**; flow diagram
- **Droughts**; flow diagram
- **Storms & High Winds**; flow diagram
- **Other risk**; no pathways

The adaptation pathways approach enables moving between of adaptation solutions over time as new information and conditions emerge[61].

The solutions in the pathways are arranged by their ease of implementation, which relates to the level of work and resources required to deploy the solution, ranging from our current practices to changes in standards and design. Section 10 presents the proposed monitoring and evaluation approach to implement the climate adaptation pathways and are regularly reviewed.

8.1 High Temperatures

The expected increase in annual, minimum, and maximum air temperatures across all seasons poses a number of risks, including reduced ratings of transformers, switchgear and cables, and additional faults on our network caused by increased loadings from high cooling demand.

Figure 8 presents different pathways of adaptation actions that we would apply to reduce the sensitivity or the exposure of our assets.

- Pathways have been established for two climate scenarios, RCP6.0 and RCP8.5, to illustrate when changes in the UK's maximum summer average temperature would be met under different possible

[59] **Definition:** Actions to adapt to climate change
[60] **Definition:** Routes to achieve climate resilience
[61] Vandever,J., Bonham-Carter, C., Kapoor, A. (2021). Navigating Uncertain Futures with the Climate Adaptation Pathways Approach. Available at: https://naep.memberclicks.net/assets/newsletter/Newsletter2021/NAEP%20Winter%202021%20Article%20Navigating%20Uncertain%20Futures.pdf

futures. The associated time periods for each of the expected changes in temperature are displayed along the x-axis of the diagram.

- All pathways begin in the middle of the diagram with the current policies (shown in yellow text).
- Actions reducing sensitivity are displayed above the current policy, and actions that reduce exposure are displayed below.
- The circles represent the maximum summer average temperatures that are assumed to trigger a change to new adaptation actions. For example, it is assumed that reaching the maximum summer average temperature of 20ºC will trigger us to incorporate comprehensive changes in our network, especially accelerating its efforts to update legacy assets.
- The triangles show which maximum summer average temperatures are assumed to trigger a decision point to incorporate the corresponding new adaptation action.
- It is common that after a decision is made there is a lead time until the decision can be implemented, represented in the diagram by a dotted line between the triangles and circles. As an example, it is assumed that the maximum temperature reaching around 21ºC will trigger the decision to adopt new transformer technologies, but it is assumed that this action will only be implemented once the maximum temperature reaches around 22ºC.
- In this diagram, the only action that has a tipping point (that is, when the action stops being effective) is keeping legacy assets built to old specifications. Its tipping point has a question mark as it is uncertain when all of these assets will be changed. The rest of actions are assumed to reach their tipping points at higher temperatures than the ones plotted in the diagram. That is why their pathways end in arrows.
- Finally, the pathways are colour coded according to the network functions that each action affects.

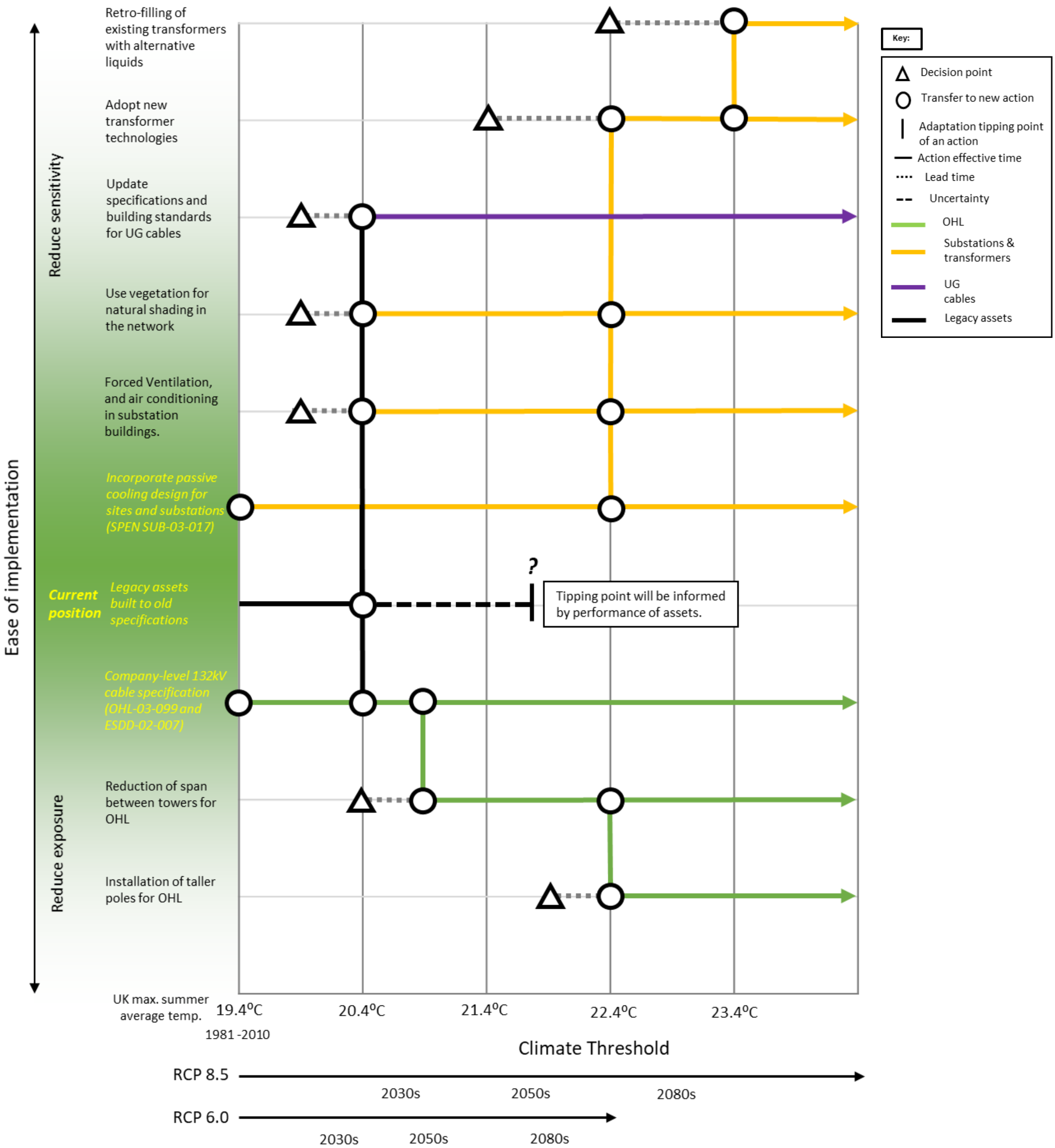
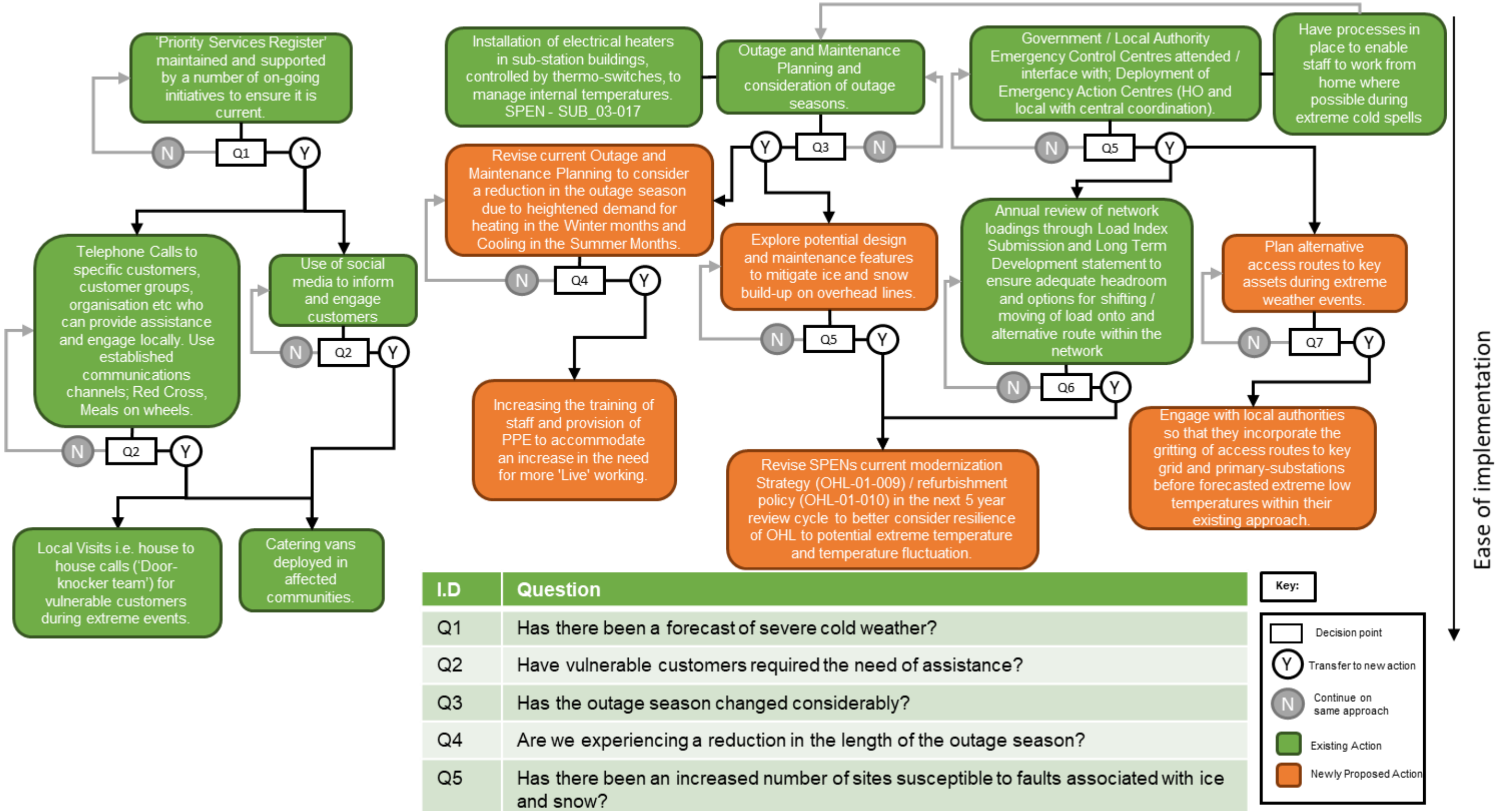


Figure 8: Traditional adaptation pathways diagram for dealing with high temperatures

8.2 Low Temperatures

As discussed in Section 4.2.1, it is likely that colder temperatures will become less frequent, however extreme events will still occur and it is important to plan for them. Prolonged cold spells may lead to additional network faults due to additional loadings caused by increased heating demand. Also, heavy snow events and snow build up may cause travel disruptions for staff, and large numbers of additional network faults may lead to slow response times and cause routine business to suffer. Figure 9 below outlines the adaptation solutions for low temperatures.

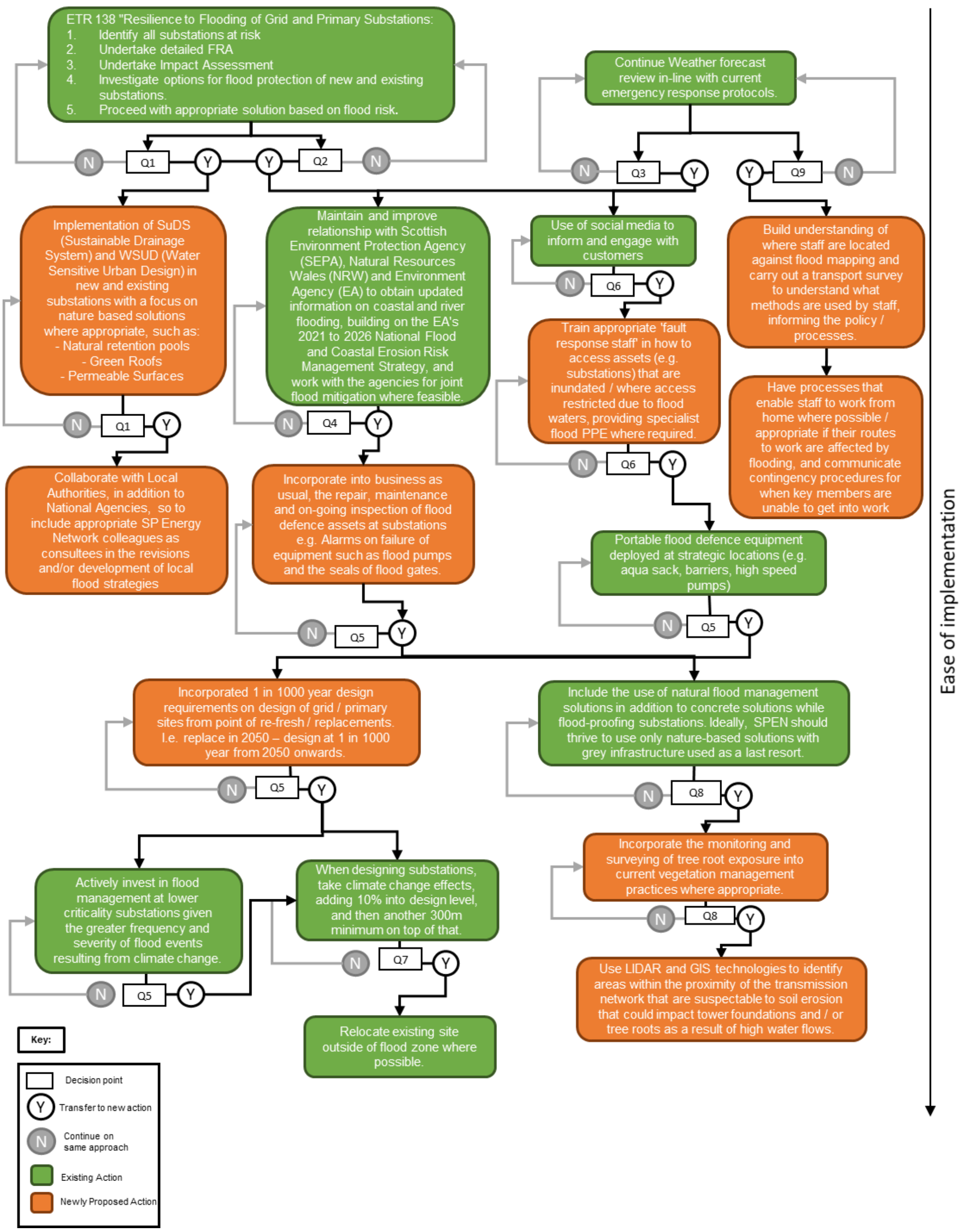


I.D	Question
Q1	Has there been a forecast of severe cold weather?
Q2	Have vulnerable customers required the need of assistance?
Q3	Has the outage season changed considerably?
Q4	Are we experiencing a reduction in the length of the outage season?
Q5	Has there been an increased number of sites susceptible to faults associated with ice and snow?
Q6	Have alternative routes within the network for shifting / moving of load been exhausted or not found?
Q7	Have we observed that main and alternative access routes to key assets during extreme weather events are frequently not free of snow or ice?

Figure 9: Flow diagram for climate adaptation pathways approach for dealing with low temperatures

8.3 Flooding

Climate change projections show increases in extreme winter precipitation in the future. This increases the risk of fluvial and pluvial flooding affecting our network, extending fault restoration times, and diverting resources away from routine business operations. Other risks from flooding include transport disruptions for staff travelling to work and falling trees due to tree roots being undermined. Figure 10 below outlines the adaptation solutions for these flooding risks.

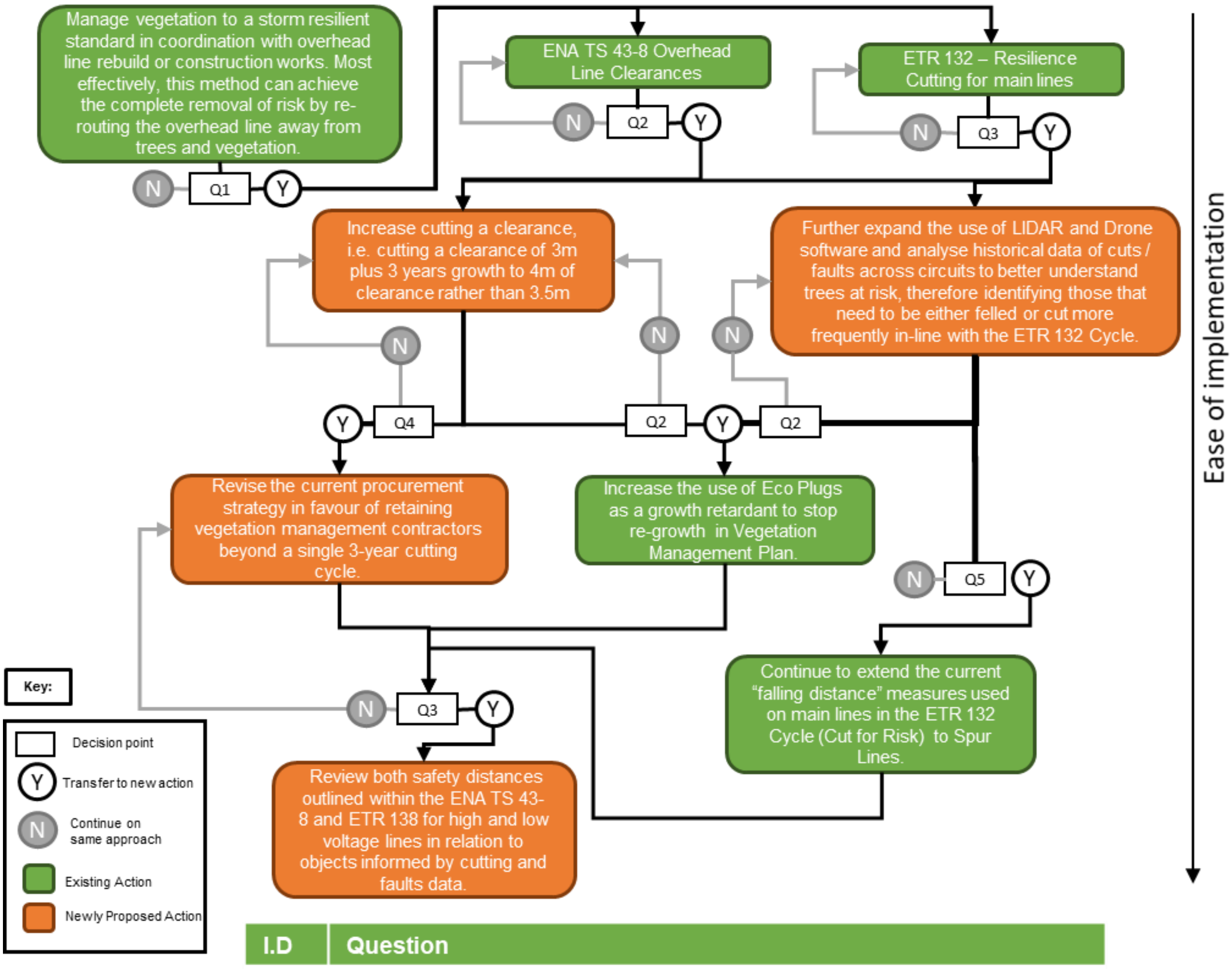


I.D	Question
Q1	Have we experienced an increase in surface flood events?
Q2	Have we experienced an increased frequency and severity of flood events?
Q3	Has a flood warning been issued?
Q4	Have we experienced any failures of flood defences?
Q5	Are the flood defences no longer effective in mitigating the identified impact?
Q6	Was there a heightened number of faults with unacceptable outage timeframes?
Q7	Are the flood defences no longer effective in protecting grid and primary substations
Q8	Has there been an increased amount of falling trees during a flood event?
Q9	Have we experienced any flood events that affected the ability of staff getting into work?

Figure 10: Flow diagram for climate adaptation pathways approach for dealing with flooding

8.4 Growing Season

As previously discussed in this report, a prolonged growing season due to higher temperatures associated with climate change may create risks for SP Energy Networks. Risks include the interference and encroachment of vegetation, affecting overhead lines. Figure 11 below outlines the adaptation solutions for risks from a prolonged growing season.

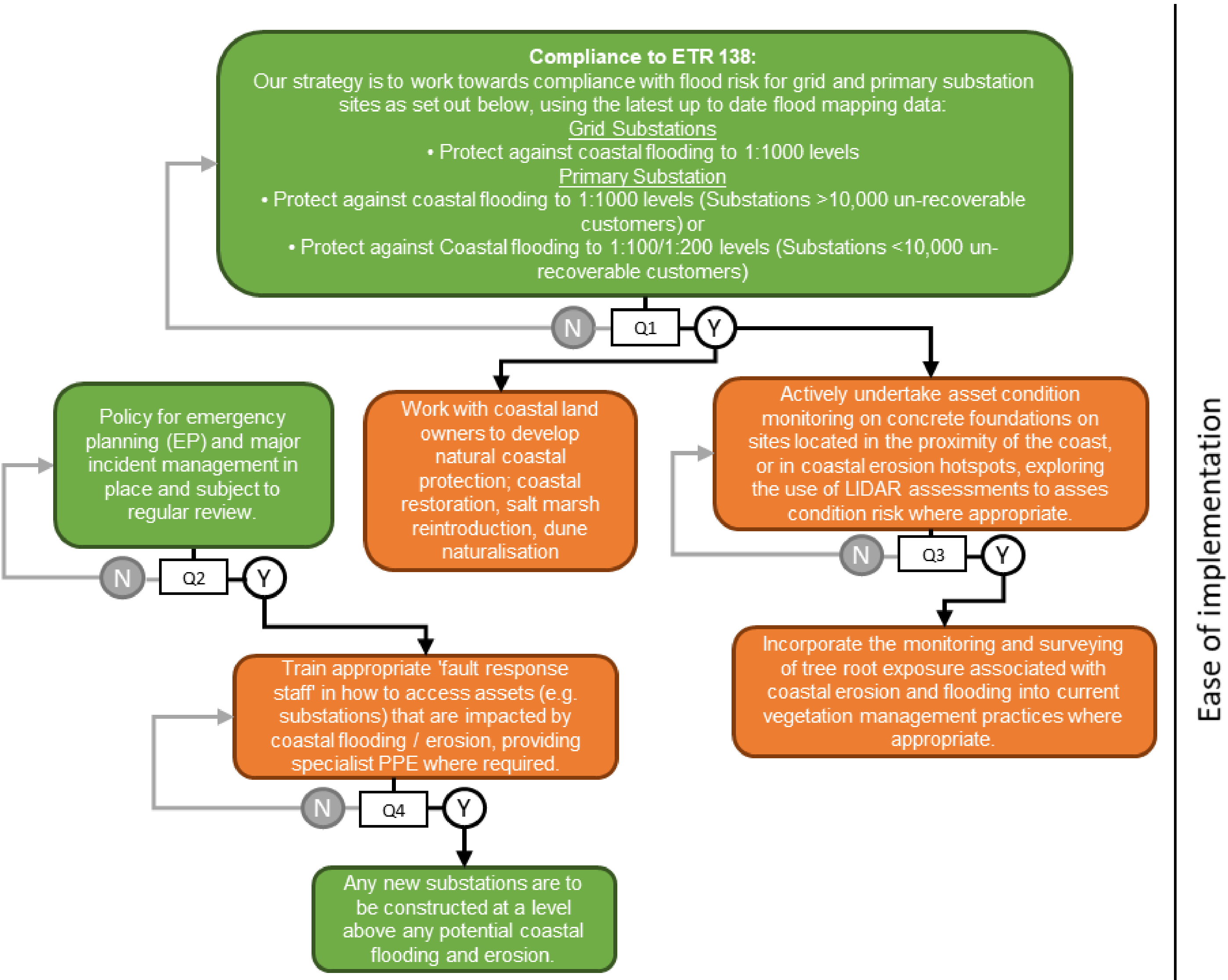


I.D	Question
Q1	Is vegetation encroaching on newly built lines, and therefore required maintenance?
Q2	Are we experiencing faster vegetation growth, and are we therefore needing to cut more frequently and extensively?
Q3	Is the data demonstrating more frequent tree fall related faults on OHL?
Q4	Is it costing more time and money for our contactors to undertake cutting cycles?
Q5	Are Spur lines experiencing a greater number of tree fall related faults?

Figure 11: Flow diagram for climate adaptation pathways approach for dealing with increased vegetation growing season

8.5 Sea Level Rise

Projected mean sea level rise of up to 1 m by the end of the century may impact a number of our sites and cause them to be non-operable due to inundation or erosion. The increased frequency and severity of extreme tidal surge events also has the potential to affect the ability of a substation to function, leading to reduced system security of supply. Figure 12 below outlines the adaptation solutions for sea level rise.



I.D	Question
Q1	Have we experienced an increased rate of coastal erosion?
Q2	Was there a heightened number of faults with unacceptable outage timeframes?
Q3	Has there been an increased amount of falling trees during a coastal flood event?
Q4	Are sea levels exceeding the current coastal defences?

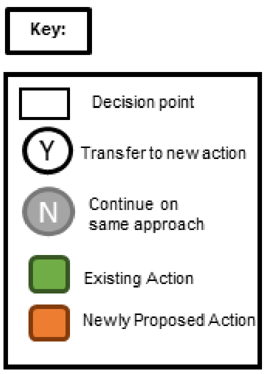
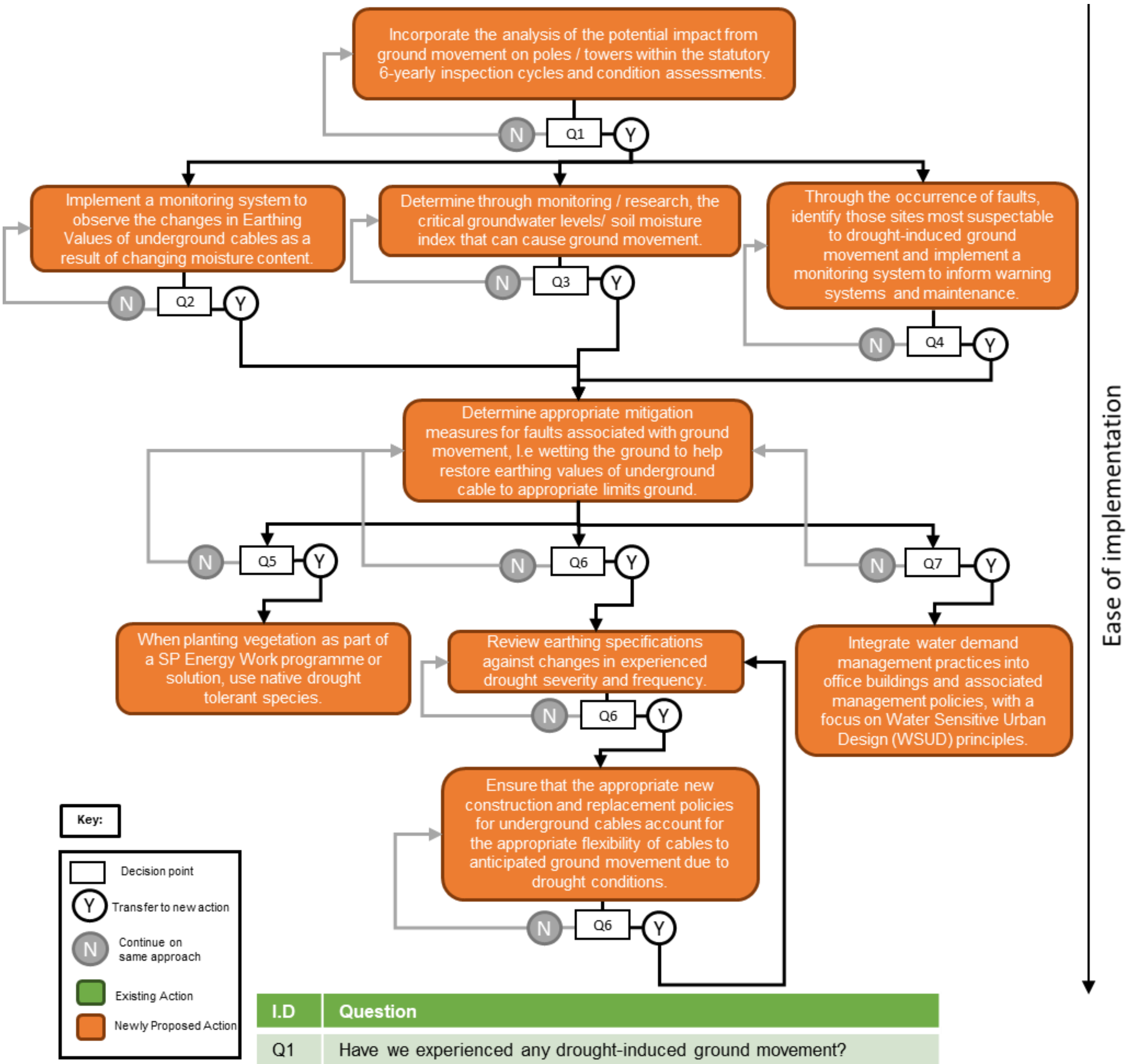


Figure 12: Flow diagram for climate adaptation pathways approach for dealing with sea level rise

8.6 Drought

Climate change projections show a decrease in summer precipitation, increasing the likelihood of drought and the risks of earth and ground movement on our assets. Currently, we have no specific drought mitigation strategy and so all the adaptation actions are classed as new. Figure 13 below outlines the adaptation solutions for drought.

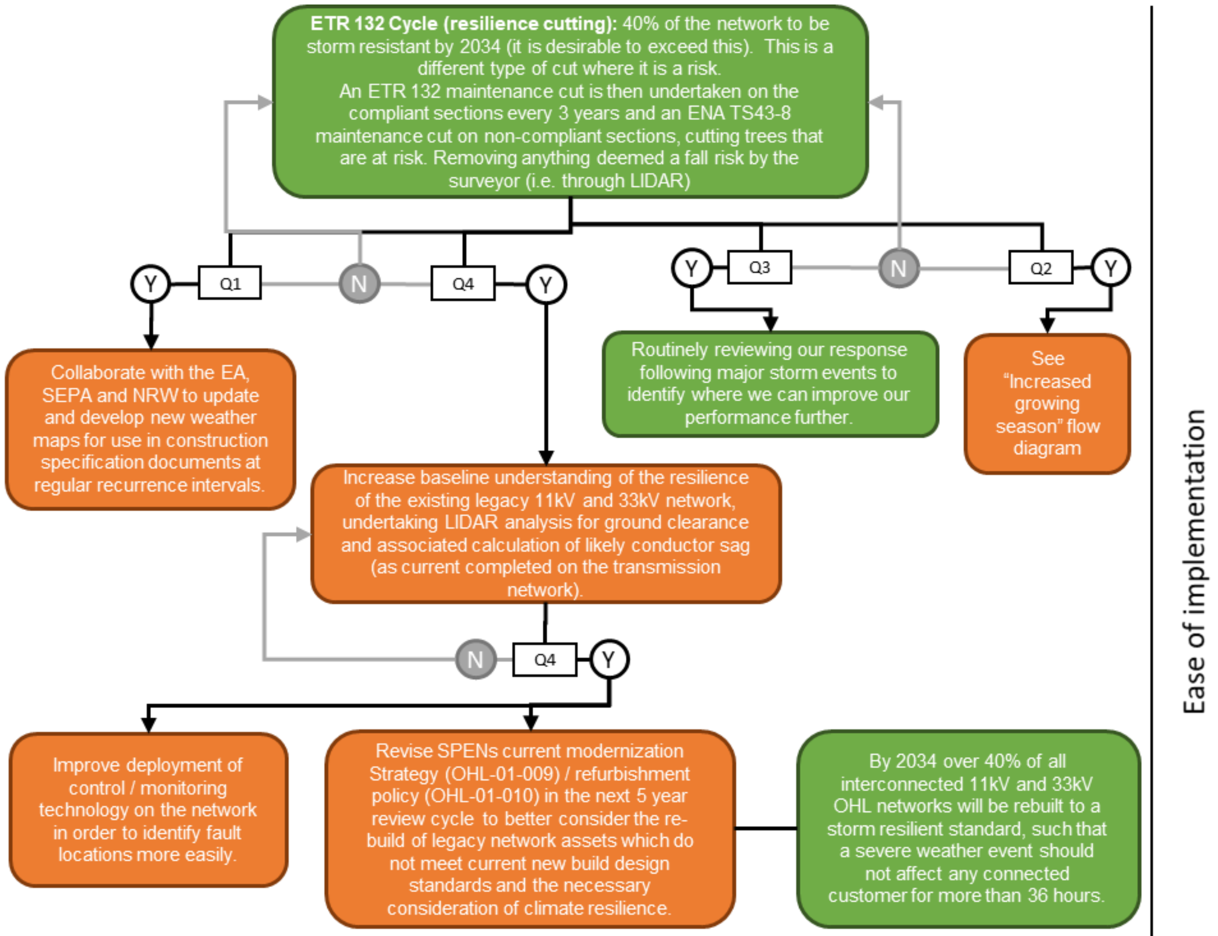


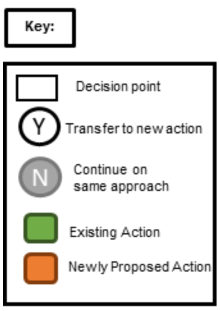
I.D	Question
Q1	Have we experienced any drought-induced ground movement?
Q2	Has there been a significant change in moisture content, resulting in underground cable faults?
Q3	Have critical groundwater levels been met, causing ground movement?
Q4	Has there been an increased number of sites susceptible to faults associated with drought?
Q5	Have we noticed a decrease in biodiversity?
Q6	Have we experienced an increased amount of drought events, and an increased number of faults as a result?
Q7	Have we experienced any water shortages?

Figure 13: Flow diagram for climate adaptation pathways approach for dealing with drought

8.7 High Winds and Storms

UKCP18 projections show an increase in near surface wind speeds over the UK for the second half of the 21st century during the winter season, with some climate models displaying large peaks in some years. Although there is interannual and decadal variance of windstorms and uncertainty in future storm intensities, it is still vital to be prepared for such events. Risks to SP Energy Networks include large numbers of network faults, leading to slow response times, strain on resources and the postponement of work due to safety concerns. Figure 14 below outlines the adaptation solutions for storms and high winds.





I.D	Question
Q1	Are we experiencing storm events that do not correlate with the existing weather maps?
Q2	Are we experiencing a greater number of faults due to tree-falls during storm / high wind events?
Q3	Was there a heightened number of faults with unacceptable outage timeframes?
Q4	Are we experiencing an increased number of faults on the existing legacy 33KV network?

Figure 14: Flow diagram for climate adaptation pathways approach for dealing with storms and high winds

8.8 Other Risks

Finally, there are a number of other climate-related risks and hazards which are not included in the categories above. These are lightning, pests and pathogens, wildfires, and embankment failures. As these risks are not in line with a specific climate variable and the solutions are not inter-linked through common response or outcome led tipping points, neither a pathway nor flow diagram has been produced. Solutions have been categorised according to their adaptation type, depending on the stage in the process that they fall under (planning, design, standards/specifications, monitoring, or engagement), and whether they reduce exposure or sensitivity. Any solutions which are Nature-Based Solutions[62] are highlighted. Table 20 defines these categories.

Table 20: Definition of categorisation of adaptation solutions

Term	Definition
Reduce Exposure	Changing the location, attributes, and value of assets that could be affected by a climate risk
Reduce Sensitivity	Reducing the likelihood that assets will be affected when exposed to a climate risk
Adaptation Type	Planning: Determining the level of risk, and developing plans to set out the approach to deal with the climate risk Monitoring: Assessing how the risk changes over time, and any external factors such as load patterns Standards/Specifications: Specific requirements Design: Structural changes Engagement: Communication approach with key stakeholders
Nature-Based Solution	Any solutions using natural approaches have been indicated with this symbol: 

For each adaptation solution, it's alignment with the SP Energy Networks sustainable business strategy and six sustainability drivers has been indicated in the solutions table using the icons displayed in Figure 15.

Figure 15: SP Energy Networks Sustainable Business Strategy Sustainability Drivers

Proposed solutions for other risks are presented below in Table 21.

[62] Nature-Based Solutions are defined by the IUCN as "actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits". https://www.iucn.org/commissions/commission-ecosystem-management/our-work/nature-based-solutions

Table 21: Adaptation solutions for lightning, all risks, pandemics, slope instability and wildfires

Adaptation solution	Risk ID	Sustainability Driver
Lightning Design: By 2034 over 40% of all interconnected 11kV and 33kV OHL networks will be rebuilt to a storm resilient standard, such that a severe weather event should not affect any connected customer for more than 36 hours.	AR14a	
Lightning Design: Improved lightning protection including earthing and, surge arresters on plant, and other equipment and automated procedures will be considered if lightning strike frequency increases.	AR14b	
Lightning Design: Introducing increasing numbers of reclosers and remotely operated switchgear, which allow electrical faults to be isolated and the network reconfigured remotely	SP2	
Lightning Monitoring: Routinely reviewing our response following major storm events to identify where we can improve our performance further.	ER5	
All Risks Engagement: Use of social media to inform and engage customers.	CS4	
Pandemics Planning: Pandemic strategy; Have processes in place to enable staff to work from home where possible.	CS12	
Slope Failures Monitoring: Monitor weather for seasonal prolonged wet and drying periods which increase the likelihood of slope failures.	ER8 CS9	
Slope Failures Design: Identify locations that are susceptible to slope failure and work with appropriate stakeholders and landowners to implement mitigating solutions, for example, planting trees with strong root structures to stabilise the slope.	ER8 CS10	
Pest Monitoring: Incorporate the detection of invasive species into existing vegetation management approaches and work with relevant stakeholders to inform and also develop options for mitigating against the invasive species.	VM0	
Wildfire Planning: Use LIDAR and GIS technologies, working with appropriate stakeholders (such as Forestry Commission, EA, NRW) to identify and map areas at greater risk to wildfires to help inform appropriate management activities.	VM1	
Wildfire Monitoring: Incorporate the removal of dry vegetation litter/fuel build up during periods of high temperatures into current Vegetation Management practices/cutting cycles.	VM1	

9. Future Activity

One of the challenges with ensuring our network is resilient to climate change is the uncertainty in the climate change predictions. Applying the adaption pathways approach to our operational activities allows us to monitor our existing activity against different climate change scenarios and find the balance between building resilience and over-investment. The adaption pathways highlight tipping points, which are reached when the magnitude of climate change is such that the current adaption solution is no longer effective, and the course of action must be changed.

The areas identified with the highest Climate Hazard Risk (Section 6) have been evaluated against the future pathways process (Sections 7 and 8) and the future tipping points established in each case. The outcome of this analysis has determined the actions we must now take to ensure that we build a network that is resilient to future climate change, and the trigger points for future actions are identified. This analysis is presented in Table 22.

Table 22 Applying the adaption pathways approach to our network

			Risk score			
			RCP6.0	RCP8.5		
Risk ID	Climate Hazard: Risk	Impact Score	2030	2030	Tipping Point Analysis	Resulting Action
AR5	Summer Drought: Underground cable systems affected by summer drought and consequent ground movement, leading to mechanical damage/failure.	4	High 8	High 8	Tipping point is at Q1: have we experienced any drought induced ground movement?	Incorporate the analysis of the potential impact from ground movement on poles / towers within the statutory 6-yearly inspection cycles and condition assessment.
AR16	Summer Drought: dry-out of the soil surrounding UG cables. This will lead to an increased thermal resistivity, reduced heat transfer from cable to surrounding soil/backfill, and a reduced current (load) carrying capacity	4	High 8	High 8	Tipping point is at Q1: have we experienced any drought induced ground movement?	Incorporate the analysis of the potential impact from ground movement on poles / towers within the statutory 6-yearly inspection cycles and condition assessment.
AR10	Fluvial and Pluvial Flooding: Substations affected by river flooding due to increased winter rainfall, with loss or inability to function leading to reduced security of supply.	4	V High 16	V High 16	Tipping point is at Q5: when existing flood mitigation measures stop being effective.	ETR 138 - Resilience to Flooding of Grid and Primary Substations: Identify all substations at risk, undertake detailed FRA and impact assessment; investigate options and proceed with appropriate solution.
AR11	Fluvial and Pluvial Flooding: Substations affected by flash flooding due to severe rainfall, with loss or inability to function leading to reduced security of supply.	4	V High 12	V High 12	Tipping point is at Q5: when existing flood mitigation measures stop being effective.	ETR 138 - Resilience to Flooding of Grid and Primary Substations: Identify all substations at risk, undertake detailed FRA and impact assessment; investigate options and proceed with appropriate solution.

AR12	Sea level and storm surge: there is a risk that due to extreme sea flooding a substation may be lost or unable to function leading to reduced system security of supply. A number of sites may be at risk from sea level rise/coastal erosion.[1]	5		V High 15	Tipping point is at Q1: have we experienced an increased rate of coastal erosion?	Strategy is to work towards compliance with ETR138: protect against flooding to 1:1000 levels for Grid substations and Primary substations >10k un-recoverable customers, or 1:100/1:200 levels for substations <10k unrecoverable customers
AR17	Summer Drought: Surface infrastructure foundations affected by summer drought and consequent ground movement, leading to mechanical damage.	4	High 8	High 8	Tipping point is at Q1: have we experienced any drought induced ground movement?	Incorporate the analysis of the potential impact from ground movement on poles / towers within the statutory 6-yearly inspection cycles and condition assessment.
CS3	Coastal Flooding: Increased number of substations at risk of flooding. Fault restoration times extended due to floodwaters. [1]	4		V High 12	Tipping point is at Q1: have we experienced an increased rate of coastal erosion?	Strategy is to work towards compliance with ETR138: protect against flooding to 1:1000 levels for Grid substations and Primary substations >10k un-recoverable customers, or 1:100/1:200 levels for substations <10k unrecoverable customers
CS13	Coastal Flooding: Certain types of work prevented due to safety issues caused by office buildings flooding. [1]	4		V High 12	Tipping point is at Q1: have we experienced an increased rate of coastal erosion?	Strategy is to work towards compliance with ETR138: protect against flooding to 1:1000 levels for Grid substations and Primary substations >10k un-recoverable customers, or 1:100/1:200 levels for substations <10k unrecoverable customers

A more detailed description of these actions is provided in the following sub-sections. Note the investment referenced from our RIIO-ED2 business plan submission is still subject to Ofgem determination. Further detailed information on all of the proposed investment can be found within the Engineering Justification Papers submitted as part of our RIIO-T2 and RIIO-ED2 business plan submissions, and the Environmental Action Plans (EAPs) for each.

9.1 Flood Mitigation

Within the RIIO-T2 period we will invest £5.5m in flood mitigation. This work was proposed following surveys on 26 substation sites that identified 10 substations (seven 132kV substations, three 275kV substations) where flood mitigation was deemed necessary following the updates to ETR 138.

Within the RIIO-ED2 period we are proposing to invest £9.65m (£5.30m in SPD and £4.34m in SPM) in flood mitigation at our substation's locations. This includes the undertaking of 328 detailed flood risk assessments at sites identified as being at risk based on the latest flood mapping by the environment agencies and forecast flood mitigation works will be required at 105 of these locations.

Our flood mitigation works contribute to mitigating the following risks identified within this document:

- **AR10 - Fluvial and Pluvial Flooding:** Substations affected by river flooding due to increased winter rainfall, with loss or inability to function leading to reduced security of supply.

- **AR11 - Fluvial and Pluvial Flooding:** Substations affected by flash flooding due to severe rainfall, with loss or inability to function leading to reduced security of supply.
- **AR12 - Sea level and storm surge:** there is a risk that due to extreme sea flooding a substation may be lost or unable to function leading to reduced system security of supply. A number of sites may be at risk from sea level rise/coastal erosion.

9.2 Overhead Line Storm Resilience

Within RIIO-ED2 we are undertaking an extensive programme of OHL modernisation (£208m) which includes a 171km of EHV and 1,117km of HV OHL re-build in accordance with latest storm resilient standards. The overhead line re-build programme shall be in compliance with ETR132 Specification (storm resilience vegetation management). The overall programme shall provide benefits in mitigating the below risks identified within this strategy.

AR3 - Prolonged growing season: Overhead lines affected by interference from vegetation

AR15 - Hurricanes & High Winds: Overhead line structures affected by wind speeds not accommodated for in design.

9.3 Vegetation Management

Within RIIO-ED2 we shall continue to deliver our Tree Cutting Programme (CV29) which has a forecast expenditure of £82.02m (£23.82m in SPD and £58.20m in SPM) over the 5-year period. Within RIIO-ED2 our tree-cutting expenditure has increased slightly to maintain our RIIO-ED1 cyclic-cutting programme in-light of our latest framework costs and the increased growth rates identified in VM6 and VM7.

By continuing this programme of vegetation management and adapting to changes in growth rates as they occur within our cyclic programmes of cutting, we shall provide benefit in mitigating the below risks identified within this strategy.

- **VM1 Fluvial and Pluvial Flooding:** Flooding events undermine tree roots, leading to additional faults due to falling trees. This has been described as a high-risk factor.
- **VM2 Coastal Flooding:** Flooding events undermine tree roots, leading to additional faults due to falling trees. This has been described as a medium-risk factor.
- **VM3 Drought**: Events affect tree structure and stability. This has been described as a low-risk factor.
- **VM4 Ice and Snow:** Accumulation occurs on trees leading to additional faults due to falling debris. This has been described as a medium-risk factor.
- **VM5 Hurricane and High Winds:** Increased frequency of events may weaken trees leading to additional wind damage causing faults. This has been described as a medium-risk factor.
- **VM6 Prolonged Growing Season:** Increase in precipitation lead to an extended growing season and hence additional encroachment of vegetation. This has been described as a medium-risk factor.
- **VM7 Prolonged Growing Season:** High raised temperatures leading to increased growth rates and the need for enhanced vegetation clearance and tree cutting schedules. This has been described as a medium-risk factor.
- **VM8 Lightening:** Increased lightning storms leading to increased number tree lightning strikes. This has been described as a medium-risk factor.
- **VM9 Brought:** Change in water content of soil leads to changes in natural habitats of different species. This has been described as a low-risk factor.
- **VM10 Pests, Pathogens, and Invasive Species:** Changes in weather conditions can allow pests, pathogens, and invasive species to appear in the UK, damaging trees leading to additional faults due to falling trees, for example, ash dieback (see Section 6.4.3 of this Annex). This has been described as a medium-risk factor.
- **VM11 Wildfire:** Higher temperatures during summertime can create the conditions for wildfires that can affect trees and electrical infrastructure near them. This has been described as a high to medium risk factor.

10. Monitoring and Evaluation

This section outlines the framework for Monitoring and Evaluation (M&E) that we will put into place to ensure that the pathways outlined as part of our Climate Resilience Strategy are appropriately implemented.

M&E is a fundamental pillar of the adaptation pathways approach, the processes of which work together to assess the performance of an intervention over time. Effective M&E is an essential part of our CRS and can inform best use of resources, increase understanding of changing risks, and inform decision making and investment.

Monitoring refers to the on-going analysis of the progress of actions as they are being implemented to ensure they are proceeding as planned.

Evaluation is the periodic assessment of the results of monitored resilience actions.

10.1 Roles and Responsibilities

The following roles and associated responsibilities have been identified for internal allocation/appointment within SP Energy Networks as part of the M&E framework, beginning formally prior to RIIO-ED2.

Resilience Coordinator: The Resilience Coordinator, to be appointed internally, will hold the following role:

- To oversee the implementation of the appropriate pathways and application of the M&E approach,
- Help identify Resilience Champions (see below) who will advocate for resilient outcomes in each of the Function categories,
- Collaborate with Resilience champions to ensure proper progress in monitoring and evaluation is completed,
- Coordinate the production of the appropriate reporting requirements; and,
- Communicate with the internal Business Assurance Team to incorporate climate risks into our current Enterprise Risk Management Framework.

Resilience Champions: For each function category identified within the CRS, an internal Resilience Champion will be identified. These individuals would be responsible for monitoring and implementing the M&E process for their function category. Reporting to the Resilience Coordinator, Resilience Champions will determine appropriate stakeholders within the business for data collection and will be responsible for compiling and developing the appropriate reporting content for their function category.

It is expected that Resilience Champions across function categories work collaboratively, especially on cross-cutting pathways, to help ensure efforts to make us more resilient are not 'siloed' within one function category.

10.2 M & E Framework

The diagram in Figure 16 highlights the key elements of the M&E framework to be adopted as part of the adaptation pathways methodology utilised within the CRS.

This framework ensures that the key climate risks identified are regularly reviewed, alongside assessing whether the current adaptation approach being implemented are sufficient to mitigate against the potential impact of future climate risks. If the adaptation approach is currently sufficient, then it should be maintained and monitored on a regular basis. If the approach is not sufficient, then it should be reviewed based on the tipping points and potential future impact of the climate risks.

This monitoring is a continuous process that will be carried out at regular intervals or strategic points in time. The M&E framework for the CRS will be conducted in-line with Ofgem's 5-year price control review period, with reporting updates provided prior to the next price control submission.

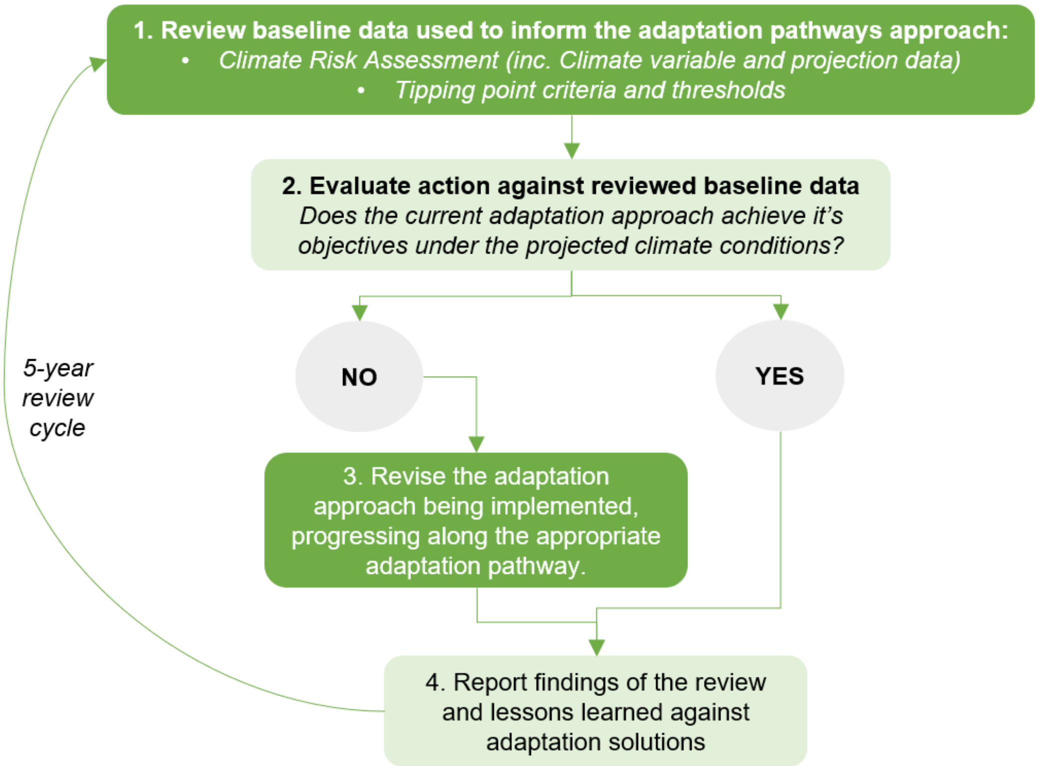


Figure 16: Key monitoring and evaluation steps for SP Energy Networks to maintain climate resilience

1. Monitor and Review Baseline data: Climate Risk Assessment and Tipping Point Criteria/Thresholds.

In order to effectively assess whether the current adaptation approach adopted is enough to mitigate against the impacts of climate change, key climate variables and their associated impacts against the network and business functions should be tracked and analysed to help inform associated consequence ratings applied in the risk assessment. This data will also be evaluated against decision criteria and thresholds used to inform the tipping points within the adaptation pathways approach.

Concurrently, the climate change projection data should be periodically reviewed in the light of any new scientific findings, such as updated Met Office UK Climate Projections or environment agencies (SEPA/EA/NRW) flood risk data.

This review will help inform any required changes to likelihood rating applied to the climate risk assessment, alongside the decision thresholds used by the tipping points. Using a Design Threshold/Climate Variable tipping point perspective example, if the projected maximum temperature values are more severe or climate thresholds are to be reached sooner than originally expected, the adaptation solutions pathway will be revisited, moving to the next solution option in the pathway where necessary.

From a response-led tipping point perspective, if seasonal variability is more severe than expected and therefore growing seasons are extended and this has an impact on the number of observed faults or an increase in the cost/time spent on cutting cycles, then the pathway will be revised. This approach will also help inform current uncertainties within the climate model community, an example being the projections for wind and storminess.

Additionally, the review of the baseline data should also incorporate the latest available information and best practice on climate resilience from our associated stakeholders, such as the Energy Network Association (ENA) Adaptation to Climate Change Task Group. This should also include a review of the risk matrix criteria and definitions applied to ensure they are up to date in light of any new information.

2. Evaluate Actions Against Reviewed Baseline Data.

This stage involves identifying whether each implemented action is having the desired results and impacts, including the evaluation of positive and negative, intended, and unintended long-term effects of the adaptation solutions. This will be undertaken as part of a 'lessons learned' analysis, which is necessary to facilitate learning about what is and what is not working in terms of the adaptation solutions. The review of action performance therefore needs to also identify areas of good practice and areas for improvement. Determining what adjustments need to be made is required in order to maximise the potential for positive impact. Examples of questions to ask include:

- Has there been sufficient flexibility in the adaptation approach to allow alternative courses of action to be pursued?
- Have there been any financial benefits from implementing adaptation actions, for example, cost-benefit analysis, fewer working days lost, more efficient operations?

During this evaluation of the actions, consideration should also be given to whether any observed extreme climate events have had undesired impacts on our network or business operations, or have come close to causing undesired impacts, and review whether operational plans were sufficient.

3. Revise if the adaptation approach being implemented is progressing along the appropriate adaptation pathway.

Based on the review of the baseline information data and the evaluation of the actions, the adaptation pathway should be revised to ensure that an appropriate solution is being implemented that effectively mitigates against future impacts.

4. Reporting

In-line with the 5-yearly price control periods, a report will be produced and presented regarding the CRS which will include a summary of:

- Change in baseline data: Climate Risk Assessment and Tipping Points,
- Action implementation status and any issues encountered including lessons learned,
- Recommendations for revisions to any actions and progression along pathways, and;
- Potential new actions for consideration.

10.3 Integration with existing SP Energy Networks Risk Assessment

We currently apply an Enterprise Risk Management Framework, the purpose of which is to assist in the achievement of both short and long terms goals of the company. The process of which is outlined within the document “BUPR-03-011 Issue No.2[63]”.

It is important to ensure that the key climate risks identified within our CRS are integrated and monitored within this risk management framework. Each month, we are required to produce a Key Risk Register (KRR) which is submitted to the SP Energy Networks Holding Board, Iberdrola and the SP Risk Team.[64] In order to produce the monthly KRR, each SP Energy Networks License Area is required to produce an individual KRR and submit it to the Business Assurance for review and consideration.

The individual business unit reports are additionally utilised to populate and update the Asset Risk Register. A draft KRR for the month is tabled at the Executive Performance Meeting for debate, after which it is finalised. It is then submitted to our Holding Board for discussion.

Where possible, Resilience Co-ordinator(s) will communicate with the internal Business Assurance Team and representatives of the areas within SP Energy Networks that the risk reporting covers.

[63] SP Energy Networks (2014). Guidelines on Risk Reporting – BPR-04-011. SP Energy Networks.

11. Summary

The UK Climate Change Act 2008 has set the UK target to reduce greenhouse gas emissions by at least 100% by 2050, from a 1990 baseline. The Act also gave the Secretary of State the power to require companies to report on their preparedness for climate change, under the Adaptation Reporting Power.

The most major recent storm event to hit the UK, Storm Arwen, highlights the impact that such weather events can have on UK electricity customers. Storm Arwen occurred between 26th and 27th November 2021 and nationally, this storm caused electricity disruption to almost 1 million customers. While 83% of disrupted customers had their power restored within 24 hours, a small but significant proportion experienced a disruption of up to 11 days (note although some GB customers were affected for this long it was not on SPEN networks).

The Adaptation Reporting Power was first exercised in 2010, when the Secretary of State required a number of companies responsible for infrastructure and other essential services, including distribution and transmission companies and others in the power sector, to report on their preparedness to adapt to impacts of climate change.

Following on from the first and second Adaptation Reporting Power call, in December 2018 the Secretary of State invited companies which had submitted reports under the first and second rounds to submit an update on their levels of preparedness for climate change. The primarily focus of this report is to cover the following:

- The current and future predicted effects of climate change on our organisation
- Our proposals for adapting to climate change

Our previous 2nd round climate adaption report, published in 2015, highlighted the following actions for SP Energy Networks to mitigate the impact of climate change:

- At a high level, SP Energy Networks will continue to include climate change impacts and concerns in the high-level decisions regarding e.g. new assets, infrastructure, and planning;
- On the ground, SP Energy Networks will continue to implement flood resilience measures as indicated by available flooding data, which will be updated as further data becomes available; and
- SP Energy Networks will review adaptation actions in future when new information or evidence becomes available.

This 3rd round report demonstrates how we have fulfilled and built upon the above actions as follows:

- As a business, we have been focusing on managing key climate risks since the publication of our previous report in 2015. Improving resilience to flooding has been provided as a detailed example, with the recommendations from ETR 138 incorporated into our 'Substation Flood Resilience Policy' SUB-01-018, which applies to substations at all voltages within SP Energy Networks for both existing and new substation installations (Section 5).
- The updates to ETR 138 (both 2016 and 2018 iterations) have been considered in detail and formed the basis for our flood mitigation work elements of both our RIIO-T2 and RIIO-ED2 business plan submissions (Section 5).
- We have updated our risk assessment to identify key climate risks to our network and developed adaption pathways for key climate risks (Sections 6, 7 and 8). This process has identified the actions we must take, based on the most up to date climate projections, to ensure our network remains resilient to climate change impacts. This includes specific short to medium term actions for the highest risks identified: summer drought; fluvial and pluvial flooding; sea level and storm surge; and coastal flooding (Section 9).

In addition, we have outlined our plans to implement a robust Monitoring and Evaluation framework to ensure that key climate risks are regularly reviewed, alongside assessing whether the current adaption approach that is being implemented is sufficient to mitigate against the potential impact of future climate risks. This work has formed the foundation of our Climate Resilience Strategy submitted as part of our RIIO-ED2 business plan submission[65] and will be used to steer future climate adaption investment on our network, ensuring the right investment at the right time, to maintain both a high level of service and value for money for our customers.

[65] https://www.spenergynetworks.co.uk/pages/our_riio_ed2_business_plan.aspx

12. Appendix A: ENA 3rd Round Report

Adaptation to Climate Change Task Group

Gas & Electricity Transmission and Distribution Network Companies

3rd Round Climate Change Adaptation Report

March 2021

1. Introduction

Method of producing the report and background information

Energy Networks Association (ENA) is the trade association for the energy networks. Our members own and operate the wires and pipes which carry electricity and gas into your community, supporting our economy. This assessment report has been developed in response to the requirements placed on reporting authorities by the Climate Change Act under the 3rd Round of Adaptation Reporting.

ENA and its member companies have contributed to all rounds of climate change adaptation reporting.

- In ARP1 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. The key messages for the gas network businesses similarly revolved around the resilience of the gas networks and any climate vulnerabilities.
- In ARP2 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 we aim to provide an update on existing risks, mitigation measures and programmes, but will also look to identify new risks being realised in order to provide a fuller picture of the potential for climate change impacts to affect networks. More importantly this ARP3 report aims to consolidate Gas and Electricity network reports to provide an Energy Industry response.

This report has been prepared by a task group of gas and electricity distribution and transmission network operator members of ENA, and is intended to provide a response to climate change adaptation on behalf of the Energy Industry. This report continues the progress made since the second round of reporting and should be read in conjunction with the 2nd Round Reports.

It is intended that companies can use this report as the basis for their individual reports which will also include company specific information. This report intentionally provides information at an industry level as details of how risk is specifically managed within member companies will be dealt with within their individual reports.

Transmission and distribution companies in Great Britain are regulated businesses and operate under licences issued by the Office of Gas and Electricity Markets (Ofgem), and are also subject to common statutory requirements which are overseen by the Department for Business, Energy and Industrial Strategy (BEIS), the Health and Safety Executive (HSE), the Environment Agency (EA), the Scottish Environment Protection Agency (SEPA), and Natural Resources Wales (NRW). Allowed revenues for the industry are currently set by Ofgem in periodic price reviews and therefore any costs associated with adaptation to climate change need to be agreed with Ofgem.

Transmission and distribution companies are responsible for transporting gas and electrical power from generating plants to customers over their networks. Overall levels of supply security are agreed with Ofgem and these standards specify the requirements for the availability of alternative supplies at various levels of customer load. Although these standards allow for the loss of multiple electrical circuits, they do not provide for certain low probability events including multiple failures or the total failure of the network. Particular attention must therefore be given to key sites when considering network resilience.

Whilst every effort is made to ensure network resilience, companies have well developed business continuity and emergency plans to ensure an effective response to a range of events that can affect both transmission and distribution networks. Under the terms of the Civil Contingencies Act, network operators are Category Two responders and work closely with other utilities, the emergency services and local authorities. They are also active participants in the BEIS Energy Emergencies Executive Committee (E3C).

Headline climate change impacts

The main impacts on gas and electricity networks from the latest independent Met Office UKCP18 climate change projections remain:

- Temperature—predicted increase.
- Precipitation—predicted increase in winter rainfall and summer droughts.
- Sea level rise—predicted increase.
- Storm surge—predicted increase.
- Increasing wet – dry cycles.
- Increasing windstorm frequency (particularly when following high intensity precipitation).
- Significant cold spells – predicted decrease but more severe.
- Wildfire.

2. Climate Change Research

In considering adaptation to climate change, electricity and gas network companies use the Met Office UK Climate Projection (UKCP18) tool, and take into account projections to the end of this century as much of the network infrastructure generally has an operational life expectancy of 30-80 years.

In spring/summer 2020, on behalf of its members, ENA commissioned the Met Office to undertake a review of the UKCP18 data and existing studies 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. In addition, other tools, for example the Landmark flood mapping tool, have been used by Energy Industry organisations in research and risk assessment independent to the ENA Met Office research.

Because of the diversity of the hazards it was decided to prioritise those which pose the highest risk to energy network assets, and the assessment process was accordingly graded to provide an appropriate focus.

- A full climate assessment was produced for the highest priority hazards.
    - Prolonged rainfall leading to flooding

- Extreme high temperatures
- Heavy rainfall/drought cycles

- Since there is currently no strong signal within the climate projections for a change to future storm intensity, the risk of strong winds was assessed in the current climate only.
- For the remaining lower priority hazards, a qualitative approach was undertaken:
    - Sea level rise
    - Warm and wetter conditions, followed by heavy rainfall and/or wind
    - Storm surge and wave height
    - Warmer and wetter conditions – longer growing/nesting seasons
    - Snow and ice
    - Wildfire
    - Lightning
    - Solar storm
    - Diurnal temperature cycles

3. Met Office Report Outputs

The final version of the commissioned report was provided by the Met Office in November 2020.

Many of the hazards identified by ENA members are projected to increase due to future climate change: increased frequency of high temperature days, prolonged rainfall events, hourly rainfall extremes, sea-level rise, extreme sea level events, increased risk of wildfire and increased extreme diurnal cycle events are all expected over the 21st century. On the other hand, the frequency of snow and ice days are expected to decrease. Hazards for which there is not currently strong evidence for a change in frequency include strong wind events, high wave heights, wetter conditions coincident with warmer temperatures and/or strong winds, lightning and to some extent, diurnal temperature cycles. Solar storms are not affected by increased greenhouse gases, so a study of historic occurrence of this hazard has been presented.

The societal response to climate change has also been considered in the context of hazards to the energy network. Impacts of the weather hazards on the energy network are likely to come in the form of an altered dependency between weather and both supply and demand. Increases to the prevalence of electrified heating and electric vehicles increases the reliance on the electricity network by consumers. This increases the impact of hazards on the electricity network.

Interconnections between different industry sectors is a major source of risk for the energy network, with failures from one sector frequently causing impacts. Telecommunications and road transport are thought to be the most important sources of risk. 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 and emergency restoration. Societal responses to climate change may also increase the risk on the road network *from* the electricity network, as electric vehicles become more commonplace.

4. Climate Change Adaptation Risks

This section details the Adaptation Risks referenced in the first and second round reports and highlighted in the third-round reporting template. The climate variables and their impact on the transmission and distribution networks have been identified. The mitigation measures being undertaken by networks are outlined in Section 5.

4.1 Electricity Network Risks

AR1 Temperature - Overhead line conductors affected by temperature rise

Thermal expansion of conductors in Summer is a common consideration for all overhead lines, and supporting structures are designed to account for sag to ensure the minimum ground to conductor clearances are maintained.

Where these lines are exposed to temperatures considered extreme by UK standards, and where the frequency and duration of these events increases, it is possible that sag will exceed the current overhead line design parameters. This could lead to an increasing number of incidents where conductor clearance limits are compromised.

Increasing temperatures also impact on the capacity of the conductors and of the network as a consequence. 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.

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

Increasing temperatures will, without precipitation, lead to drying of the ground causing it to shrink. Any structures built on this ground will be subject to movement which, as well as being amplified by the height of the structure, can lead to instability of the foundations. Overhead line structures are more vulnerable to this movement, but it can also impact on ground mounted structures such as transformer bases and switch house foundations.

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

Increases in both temperature and precipitation will lead to increased vegetation growth. This impacts on overhead lines as increased growth of branches of trees growing adjacent to the overhead lines can impact on minimum clearances leading to faults and physical damage.

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

As with overhead lines, increasing temperatures impact on the capacity of cables and of the network as a consequence. Cables are designed to operate at their maximum efficiency up to a maximum core temperature, and as the ground 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 and thus reducing its capacity.

AR5 Temperature - Underground cable systems affected by Summer drought and 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 effectively pulled apart. Extreme wet-dry and freeze-thaw ground movements will have a similar impact.

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

As moisture in the soil reduces the soil resistivity increases reducing the effectiveness of 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 current, leaving exposed metal components inside and outside the site boundary live.

AR7 Temperature - Transformers affected by temperature rise

As with cables and overhead conductors, transformers are designed to operate within particular temperature parameters. 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.

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

Localised build-up of heat, particularly in city environments, will lead to increased demand from air-conditioning and ventilation unit operation; some network operators are now seeing very little difference between Summer and Winter demand where traditionally Summer was always the season of reduced electricity usage. Increased demand can overload transformers causing tripping and loss of supply.

AR9 Temperature - Switchgear affected by temperature rise

Increasing temperature impacts all plant and equipment and increases will impact on switchgear by reducing its capacity, or in extreme cases lead to the switchgear tripping resulting in loss of supply or operating incorrectly and damaging the network. Prolonged periods of hot weather will increase the temperature inside switch rooms above the maximum optimum operating parameter for the switchgear increasing the potential for faults or mal-operation.

Although, as with overhead lines, switchgear is designed to international standards, there are recorded days where switch room ambient temperatures have exceeded the operational maximum of the switchgear.

AR10 Precipitation - Substations affected by river (fluvial) flooding due to increased winter rainfall

AR11 Precipitation - Substations affected by pluvial (flash) flooding due to increased rain storms in Summer and Winter

AR12 Precipitation - Substations affected by sea flooding due to increased rain storms and/or tidal surges

Regardless of the source the impact of flooding on ground located assets is the same. Plant and equipment are physically damaged by flood water, but water ingress will also cause faulting within the assets and the network leading to extensive loss of supply. Consequential repair or replacement of assets is costly and time-consuming extending restoration of supply to local areas. Network operators will often choose to switch out plant and equipment in order to avoid water ingress causing a fault and uncontrolled shut down.

AR13 Precipitation - 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 even washed away by the force of water. Where a substation site has been impacted by the full force of a dam breach, it would not be possible to re-establish supply without fully reconstructing and recommissioning the site.

AR 14 Overhead lines and 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.

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

This risk has been added for the third-round reporting following the Saddleworth Moor wildfires in 2018. Although a consequential risk of increased temperatures and reduced precipitation, wildfire poses a significant risk to overhead line structures and conductors where they are located in susceptible areas such as open heathland.

Operational telecommunication systems should also be considered at risk from this scenario, and without operational telecoms it is impossible to control the network and loss of supply could occur following an unrectified fault.

4.2 Gas Network Risks

ARG4 Precipitation - Flood risk of above ground assets (governors and pressure reducing equipment)

There is a risk of physical damage to assets located in flood plains (fluvial) or to other assets from extreme and extended rainfall (pluvial) with ancillary instrumentation and communication equipment being the most vulnerable, although governors and pressure reducing equipment are resilient and capable of operating when submerged in water. This will be exacerbated if flood defences are ineffective and/or plant relocation is not possible.

ARG5 Precipitation- Flood risk of above ground assets (governors and pressure reducing equipment) from catastrophic dam failure

Extreme precipitation can lead to dam overload and failure. Where assets 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 assets are close enough to dams to be impacted by the full force of a breach, the damage would be substantial. Plant and equipment would not only be impacted by water ingress, but are likely to be physically damaged or washed away by the force of water.

ARG6 Temperature - Above ground assets affected by raised temperatures

Gas network assets are manufactured to international standards and designed to operate within particular temperature parameters. Increasing temperature impacts all plant and equipment and increases could affect rating and asset performance. However, gas equipment is inherently resilient and designed to operate at high temperatures in excess of any expected average increase and there should be minimal impact on the gas network controls.

ARG7 Wind - Damage to above ground assets from storm events

Assets are subject to damage from extreme weather events including storms and high winds. Any increase in the frequency and severity of these events will mean a higher risk of infrastructure damage and failure and an impact on support services. Again, communication equipment will be the most vulnerable assets.

ARG8 Temperature - Extreme weather impacts from lightning

Increased storm frequency can lead to an increased lightning strike frequency. Where lightning strikes exposed assets, this could cause physical damage and failure. This may lead to operational failure, loss of telecommunications equipment, and a fire risk to gas venting stacks.

ARG9 Precipitation - Asset impact from snow/ice falls and accumulation

The risk to above ground assets is expected to gradually decrease due to less frequent snow events. However, a risk remains of physical damage from excessive snow or ice falls, for example increased loading on building roofs.

ARG10 Precipitation - Risk to underground pipelines from river erosion

Pipelines can be exposed and are then susceptible to physical damage from external impact or from being unsupported, with the main risk being the scouring and erosion of pipeline coatings. More frequent flooding and increased river and watercourse flows will increase this level of risk.

ARG11 Precipitation - Ground contamination and transport of materials from flooding of contaminated sites

Flooding of contaminated sites will lead to faster and greater transportation of materials in ground water, especially for sites located within flood plains. This will lead to increased inspection and remediation costs to mitigate any damage. There is also a risk of resulting regulatory and enforcement action.

AR12 Temperature - Ground movement due to drought conditions and dry ground

Ground movement caused by drying and shrinkage will exert tensile forces on underground assets, especially to more vulnerable joints and connections, with cast iron mains presenting the highest risk. This could lead to mechanical damage and the potential fracture of pipelines leading to a serious risk of gas release or explosion. Any loss of ground cover above pipes could also increase the risk of third-party strikes.

ARG13 Temperature & precipitation - Vulnerability of critical IT systems managed by third parties from extreme weather events

This represents an interdependency with other service suppliers and there is a risk of the loss of critical IT systems and functionality, especially if there is insufficient flood protection or cooling of third-party data centres and/or these cannot be relocated. Any loss of capacity could lead to the need for manual intervention and reduced network control.

ARG14 Wildfire - Asset damage if no wildfire risk assessment or remediation measures

Wildfire is a consequential risk of increased temperatures and reduced precipitation and, whilst difficult to forecast, pose a significant risk to above ground assets where they are located in susceptible areas. These include open heathland, grassland or forested areas and may be in remote locations. The risk of underground pipeline damage is increased in the absence of vegetation clearance within 3m of site boundaries. There is an interdependent risk from any impact on other utility assets such as electricity lines and substations and telecommunication lines.

ARG15 Temperature & precipitation - Vegetation growth

Increases in both temperature and precipitation will lead to increased vegetation growth. Above ground assets will be impacted by any increased growth of trees adjacent to operational equipment. This will lead to increased levels of maintenance and reduced access issues. Similar issues may be encountered with the accelerated growth of plants or invasive species. Any change in the numbers or seasons of nesting birds and protected species will need to be registered on habitat surveys and could potentially restrict work activities.

ARG 20 Sea level rise - Tidal Flooding of above ground assets

Regardless of the source the impact of flooding on above ground assets is the same. There is a risk of physical damage to assets, although governors and pressure reducing equipment are resilient and capable of operating when submerged in water. This will be exacerbated if flood defences are ineffective and/or plant relocation is not possible.

ARG 21 Sea level rise - Saline contamination and increased corrosion rate of above and below ground assets from sea water

There is a risk of gradual chemical damage to pipelines from increased tidal flooding, which will affect asset integrity and could lead to water ingress and gas release. Ingress of saline groundwater may also impact the buoyancy of pipes and cause structural issues.

ARG 22 Precipitation - Ground water flooding of below ground assets leading to water ingress to pipes

Despite the inherent resilience of pipelines, more frequent and prolonged flooding will increase the risk of physical damage and the likelihood of water ingress leading to operational and supply issues.

Management Risks

Management risks have been identified where there is a potential that company corporate policy, procedure and strategy may not be adequate to realise and address climate change hazards, or where the risk is not directly attributable to the damage or reduced operation of an asset.

ARG1 All - 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.

ARG2 All - 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.

ARG3 All - Risk and action owners not identified at senior leadership team level

Asset climate risks need to be afforded the same status as other risks to assets including security, safety, and other environmental impacts. Accountability is then required at senior management level and responsibilities included within existing business risk processes.

ARG16 All - 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.

ARG17 All - 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.

ARG18 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 l 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.

ARG19 All - Knock on effect on GDN operations from variable electricity supply due to impact on DNOs

One of the potential interdependencies within the sector is the knock-on effect on gas network operations from a variable electricity supply. Any initial climate impact on the electricity networks, as set out in the electricity network risks, may result in electricity supply interruptions leading to an impact on asset operations and gas supplies to customers.

5. Risk Mitigation and Management

Electricity Networks

AR1, AR2, AR4, AR5, AR6, AR7, AR8

While the likelihood of global temperature rise is accepted, the impacts on UK distribution and transmission network operators have not yet begun to be realised. Because of this, networks do not currently see any drivers to invest ahead of need to offset risks. Network and asset performance will continue to be monitored and developed and will be modified once climate change impacts begin to have a direct and longer-term effect.

Where low ground to conductor clearance has been identified, and air temperature sagging is considered to be a contributing or additional factor, some DNO companies have installed taller poles during pole replacement programmes in order to counteract the loss of clearance through thermal sagging.

It should be noted that all DNOs use cables and overhead conductors designed and manufactured to international standards, and consequently these assets are designed to operate safely in much greater maximum and minimum temperature ranges than those found in the UK.

AR3

Currently DNOs treat vegetation growth as a business-as-usual activity and manage it as part of their ongoing overhead line maintenance and clearance programmes. No information from overhead line patrols has indicated a requirement for an enhanced or more frequent tree cutting programme.

ENA document ETR132, “Improving resilience of overhead networks under abnormal weather conditions using a risk-based methodology”, provides industry guidance on the management of vegetation below and to the side of overhead line routes. This document is reviewed on a regular basis and would incorporate a suggestion of increased frequency of tree cutting and vegetation management if the BaU programmes were not managing to maintain minimum clearances or in the light of increasing storm frequency.

AR9

Many DNO switch rooms and plant enclosures are designed to maximise the use of natural ventilation to keep internal temperatures within plant and equipment operating within their optimum parameters. Where heat build-up is perceived to be an issue forced ventilation is used and, in extreme cases or where the path to an external air inlet is problematic, air conditioning is considered.

AR10, 11 & 12

Throughout the DPCR5, RIIO ED1 and T1 price control periods, network operators have undertaken an extensive flood protection programme to provide physical protection and network reconfiguration to minimise disruption from localised flood events. Dependent on the outcome of the next regulatory settlement, the flood protection programmes will continue into RIIO ED2 and T2 to accommodate recommendations raised in the 2016 Government National Flood Risk Review. New substation development and substation reinforcement schemes will continue to reference guidance from the ENA ETR 138 document, “Resilience to flooding of grid and primary substations”.

AR13

It is understood that dams are now designed to a 1:10,000 risk of failure, far exceeding the 1:1000 design risk utilised for assessing and developing flood protection measures for substations with more than 10,000 connected customers. While DNOs will try and avoid constructing a new substation within the breach zone of a dam, there is currently no programme to relocate existing substations.

AR14

Storm and lightning frequency are not expected to increase, and technical controls and tripping are currently employed to earth lightning strikes and protect network equipment. More earthing, surge arresters on plant, and other equipment and automated procedures will be considered if strike frequency increases.

AR15

The impact of increasingly dry and warm Summers on the frequency of wildfires has yet to be established. Once established the frequency would need to be ratified against a potential increase of risk to overhead line and operational telecommunications assets.

DNOs acknowledge the possibility of this emerging wildfire risk and are maintaining a watching brief on events and event frequency.

Gas Networks

ARG4 Precipitation - Flood risk of above ground assets (governors and pressure reducing equipment)

Above ground assets, such as Pressure Reducing Stations (PRS) and buildings, will be subject to risk of flooding, particularly those located within flood plains. Company risk assessment processes and the use of available tools, such as Environment Agency Flood Maps, will assist in the development of asset registers and determine vulnerabilities. Assets can be protected by the use of physical flood barriers and there may be opportunities to install more resilient equipment on replacement. Companies should also work with environmental regulators and agencies to establish catchment area flood mitigation practices.

Asset replacement programmes should include consideration of current and future expected climate change, and in some cases the risk assessment could incorporate flood modelling prior to design and installation. There may be limited opportunity to relocate assets and so robust emergency response plans and equipment should be in place, such as the use of breathers on pipes and procedures for shutting off the network in extreme circumstances.

ARG5 Precipitation - Flood risk of above ground assets (governors and pressure reducing equipment) from catastrophic dam failure

Existing flood protection practices and equipment will form the basis of risk management controls for flooding from dam failure. Dam locations and assets in proximity to dams should be identified, and the potential impact on the business and customers assessed in the event of catastrophic failure. There will be limited opportunities to relocate new or replacement assets outside of the flood risk area, and so emergency incident plans will need to consider the likelihood of asset loss and appropriate response procedures.

ARG6 Temperature - Above ground assets affected by raised temperatures

Gas network assets are manufactured to international standards and are designed to operate at significantly elevated temperatures to those experienced in the UK, including any expected average increase over the course of the century. There could be some minor impact on performance in the event of extended, elevated temperatures during heatwaves, but the most vulnerable assets are considered to be IT equipment and instrumentation which may need to be housed or supported by cooling (air conditioning) to avoid any overheating. The performance of all assets is monitored and maintained as part of routine asset management practices.

ARG7 Wind - Damage to above ground assets from storm events

Gas network assets are mainly located underground, and above ground equipment is designed and constructed to be resilient to storms, although a level of risk remains from extreme weather events. Larger transmission assets will be less vulnerable than local or regional distribution equipment, but the latter represent a lower level of business and customer supply risk. Electrical and instrumentation control equipment are the most vulnerable assets, and may need to be protected or housed if located in exposed areas.

Offices and buildings are subject to wind damage or damage from trees so effective vegetation management practices and building maintenance procedures assist in reducing any risk.

ARG8 Temperature - Extreme weather impacts from lightning

The risk from lightning strikes is currently assumed to remain at the same low level of risk, and the Met Office report forecasts no notable change in frequency or intensity. Any impact on operational activity is addressed through risk assessment of buildings and assets, and existing earthing arrangements are deemed sufficient to manage any impact from lightning. The risk assessment should also address any likelihood of gas ignition.

ARG9 Precipitation - Asset impact from snow/ice falls and accumulation

The risk from snow and ice falls is forecast to decrease over time as average temperatures correspondingly increase. The possibility remains for localised, extreme events with heavy snowfalls leading to excessive loading on buildings, and secondary risks from icing of equipment and roads.

Both can lead to access issues and disruption to operational activities. Building integrity and the risk to assets (control equipment, water pipes) will need to be determined, and there may be a need to insulate equipment and revise operational procedures.

ARG10 Precipitation - Risk to underground pipelines from river erosion

Assets that cross or are located near river courses are vulnerable to the effects of river erosion, and a register of such assets should be maintained to assess the level of risk. Similarly, any subsidence or increased frequency in flooding should be recorded to establish whether this risk has increased. The main concerns are the exposure of buried pipes from ground erosion, and the impact and damage to pipes from flood water and any debris contained within it.

It is unlikely that new or replacement pipelines can be relocated away from areas of flood risk and is likely to be cost prohibitive, but this may be an option or it may be possible to utilise directional drilling techniques and change the depth of pipes underneath waterways. Ongoing maintenance and proactive checks of pipeline condition are other mitigation practices in place, and this provides early warning of any increase in the risk of exposure.

ARG11 Precipitation - Ground contamination and transport of materials from flooding of contaminated sites

Contaminated land sites have been identified and recorded within site risk registers. This has led to proactive programmes of remediation, which is steadily reducing the level of business risk exposure. Site surveys and sampling provides a good understanding of the contaminants present, and determines the appropriate remediation processes to employ to remove any hazardous material.

Short term impacts from flooding presents less of a risk than long term leaching of contaminants from sites with elevated groundwater levels, but both risks are being reduced through the robust, established decontamination programmes in place.

ARG12 Temperature - Ground movement due to drought conditions and dry ground

Any ground movement or subsidence presents a risk of damage or fracture to gas pipes including joints and connections. This risk is higher for older, less ductile iron gas mains pipes. The risk is gradually being reduced through the established industry gas mains replacement programme and the introduction of less vulnerable polyethylene pipe. Other proactive mitigation includes pipeline walking surveys, and the monitoring and recording of instances of ground subsidence/movement to determine any vulnerable areas or increased frequency of events.

ARG13 Temperature & precipitation - Vulnerability of critical IT systems managed by third parties from extreme weather events

IT equipment and electrical instrumentation have been identified as assets that are vulnerable to extreme weather events, such as prolonged elevated temperatures. Such equipment may need to be housed in temperature monitored buildings and cooled by air conditioning equipment to avoid overheating. Such housing may need flood protection barriers and systems in place if located in flood plains or vulnerable areas. If the equipment is owned and managed by third parties on behalf of the network businesses then this represents a reduced level of control, and suitable service provision agreements should be in place.

ARG14 Wildfire Asset damage if no wildfire risk assessment or remediation measures

This is an emerging issue, but currently represents a low risk to the gas networks as pipeline depths should normally be sufficient to prevent any impact from wildfires. As heat rises any such events would pose more of a risk to electricity and telecommunications assets, although this does represent an interdependency risk to gas network operations.

Vegetation management and clearance practices should be reviewed in any sensitive areas, such as peat land, where above ground assets are located. Other mitigation is provided through emergency and fire response procedures.

ARG15 Temperature & precipitation - Vegetation growth

Increased growth rates and growing seasons arising from raised temperatures and precipitation levels may lead to the need for enhanced vegetation clearance and tree cutting schedules to maintain separation from assets/buildings. This will be ascertained by monitoring vegetation growth rates and any spread of fast-growing invasive species. Existing controls include habitat surveys and environmental risk assessments for new installations/projects. Any protected trees, species or wildlife should be identified and recorded within this process.

ARG 20 Sea level rise - Tidal Flooding of above ground assets

This represents a lower overall risk than pluvial and fluvial flooding, but any events are likely to be more significant, extreme events. Registers of the type and location of vulnerable above ground assets (such as Pressure Reducing Stations) should be maintained and risk assessed to determine whether additional protection measures are required; these could include flood barriers, emergency response equipment etc. This assessment should consider the risk from both current and future climate impacts.

A number of sources of supporting information on coastal erosion and flood risk are available for use, including shoreline management plans and guidance from DEFRA and environmental regulatory bodies (EA, SEPA, NRW, NIEA). These can be referenced for both existing sites and any new asset investment plans.

ARG 21 Sea level rise - Saline contamination and increased corrosion rate of above and below ground assets from sea water

Above and below ground assets located in coastal flood plains carry a low risk associated with saline contamination and increased rates of corrosion. Asset registers will assist in routine monitoring and inspection programmes, and these could also record any differences in risk levels from the resistance of different pipeline construction materials. Monitoring of the cathodic protection coatings help ensure the continued integrity of gas pipes is maintained, or indicate whether repair or earlier replacement is needed.

ARG 22 Precipitation - Ground water flooding of below ground assets leading to water ingress to pipes

There is a risk of water ingress into low pressure gas pipelines, and this risk could increase in line with more severe and higher rates of flooding. Water ingress can also result from burst and struck water mains. Historic water ingress events will provide a benchmark to monitor any increase in the level of risk, but this is being reduced by the ongoing gas mains replacement programme and the removal of other, older assets, and the installation of polyethylene pipes. Improved operational practices and response procedures will also reduce any impact on gas supplies to customers from such events.

Management Risks

Management risks have been identified where there is a potential that company corporate policy, procedure and strategy may not be adequate to realise and address climate change hazards, or where the risk is not directly attributable to the damage or reduced operation of an asset.

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 and considered for all major network investment decisions.

Asset climate risks need to be afforded the same status as other risks to assets including security, safety, and other environmental impacts. Accountability is then required at senior management level and responsibilities included within existing business risk processes.

Supply chains could be affected due to travel difficulties resulting from extreme weather events. This can result in an impact on the continued operation and maintenance of the networks and on emergency response during and after a significant event. Business Continuity Management plans must therefore consider and address the impact of climate change.

6. Risk Assessment

As part of the ARP and ARP2 responses the risks AR1-14 were assessed and quantified in the Risk Matrix as set out in **Figure 1** below.

In order to provide comparison, the assessment has been repeated for ARP3 in **Figure 2** for Electricity, and a new Risk Matrix has been developed for the Gas networks**, Figure 3**. Both are based on industry progression in mitigating or managing climate change impacts, utilising the information and predictions set out in the Met Office Report provided for the Energy Industry in November 2020.

Risk Code (Score)	Climate Variable	Impact	ARP3 Risk Considerations
AR1 (9)	Temperature	Overhead line conductors affected by temperature rise	Localised increase in pole heights and age-related replacement maintains line clearances. No significant changes in UKCP18 predictions over UKCP09
AR2 (6)	Temperature	Overhead line structures affected by Summer drought and consequent ground movement	Emerging risk. Impact dependent on geology and topology
AR3 (8)	Temperature / precipitation	Overhead lines affected by interference from vegetation due to prolonged growing season	Increase in growth offset by increase in cutting at each visit.
AR4 (9)	Temperature	Underground cable systems affected by increase in ground temperature	Limited data on impact on cable ratings
AR5 (6)	Temperature	Underground cable systems affected by Summer drought and consequential ground movement	Emerging risk. Impact dependent on geology and topology
AR6 (6)	Temperature	Substation and network earthing systems adversely affected by Summer drought conditions	Limited test data available, but anecdotally Grid and Primary substations are buried deep enough to only experience minor impact in performance.
AR7 (6)	Temperature	Transformers affected by temperature rise	Temperature rise accommodated in design
AR8 (9)	Temperature	Transformers affected by urban heat islands and coincident air conditioning demand	Managed through load planning although extended high load my reduce the life expectancy of the transformer.
AR9 (4)	Temperature	Switchgear affected by temperature rise	Temperature rise accommodated in design
AR10 (9)	Precipitation	Grid and Primary Substations affected by river flooding due to increased winter rainfall	While risk of flooding has increased the asset protection measures employed have offset and reduced the risk.

Risk Code (Score)	Climate Variable	Impact	ARP3 Risk Considerations
AR11 (6)	Precipitation	Grid and Primary Substations affected by pluvial (flash) flooding due to increased rainstorms in Summer and Winter	While risk of flooding has increased the asset protection measures employed have offset and reduced the risk.
AR12 (8)	Precipitation	Grid and Primary Substations affected by sea flooding due to increased rainstorms and/or tidal surges	While risk of flooding has increased the asset protection measures employed have offset and reduced the risk.
AR13 (5)	Precipitation	Grid and Primary Substations affected by water flood wave from dam burst	Considered unviable to protect against.
AR14 (6)	Lightning	Overhead lines and transformers affected by increasing lightning activity	Existing mitigation measures adequate.
AR15 (6)	Wildfire	Overhead lines and underground cables affected by extreme heat and fire smoke damage	Based on Saddleworth Moor incidents and increased frequency of California wildfires

Risk Code (Score)	Climate Variable	Impact	ARP3 Risk Considerations
ARG1 (8)	All	Lack of climate change management procedure	Climate risks are considered alongside other business risks and incorporated within company business plans and asset management policies.
ARG2 (8)	All	Lack of specific policies and procedures governing risk assessment process on climate change	Adaptation issues integrated within environmental management system to provide the necessary governance of long-term risks.
ARG3 (9)	All	Risk and action owners not identified at senior leadership team level	Leadership and accountability ensure that Adaptation Action Plans are monitored and reviewed, and corrective actions taken.
ARG4 (9)	Precipitation	Flood risk of above ground assets (governors and pressure reducing equipment)	Above ground assets are less resilient than gas pipes and may need flood protection barriers and emergency response plans to be in place
ARG5 (4)	Precipitation	Flood risk of above ground assets (governors and pressure reducing equipment) from catastrophic dam failure	Vulnerable assets identified, but flood protection systems will be insufficient to prevent loss.
ARG6 (8)	Temperature	Above ground assets affected by raised temperatures	Gas assets inherently resilient to temperature changes, but IT equipment and instrumentation may need additional protection.

Risk Code (Score)	Climate Variable	Impact	ARP3 Risk Considerations
ARG7 (6)	Wind	Damage to above ground assets from storm events	Risk of damage to buildings and control equipment from extreme weather remains, but this represents a low business and customer supply risk.
ARG8 (3)	Temperature	Extreme weather impacts from lightning	Risk to remain at low level, and existing risk assessment and earthing arrangements deemed sufficient.
ARG9 (6)	Precipitation	Asset impact from snow/ice falls and accumulation	Despite a general increase in overall temperatures, there will be an ongoing need to manage extreme snow/ice events and any impact on buildings and roads/access.
ARG10 (12)	Precipitation	Risk to underground pipelines from river erosion	Increased levels of flooding will result in more incidents of pipeline exposure and asset damage.
ARG11 (6)	Precipitation	Ground contamination and transport of materials from flooding of contaminated sites	Flooding will exacerbate leaching of materials from contaminated land, but short and long-term risks managed by established monitoring and remediation programmes.
ARG12 (6)	Temperature	Ground movement due to drought conditions and dry ground	The gas mains replacement programme and growth in PE pipe installation are reducing risks from ground movement arising from drought conditions.
ARG13 (8)	Temperature & precipitation	Vulnerability of critical IT systems managed by third parties from extreme weather events	IT and electrical instrumentation equipment are the most vulnerable to extreme weather

Risk Code (Score)	Climate Variable	Impact	ARP3 Risk Considerations
			events, but are critical to management of the networks requiring protection from flooding and increased temperatures.
ARG14 (6)	Wildfire	Asset damage if no wildfire risk assessment or remediation measures	Emerging but low risk to gas networks; potential interdependency risk from wildfire impacts on electricity and telecommunications assets.
ARG15 (4)	Temperature & precipitation	Vegetation growth	Any increased vegetation growth can be managed through enhanced clearance and tree cutting schedules, and environmental assessments for new installations.
ARG16 (3)	All	Wildlife impacts	Any change in wildlife activity may result in access issues, but are managed by ecological surveys as required.
ARG17 (6)	All	Supply chain impacts	Risk to supply chain provision for both equipment and services in the event of extreme weather events, addressed within Business Continuity Plans.
ARG18 (4)	Precipitation	BCM plans affected due to severe travel difficulties resulting from extreme weather events	Extreme weather events and flooding may affect travel and operational activities, but current systems have proved to be effective. Suitable technology and equipment will support self-sufficiency and remote working.

Risk Code (Score)	Climate Variable	Impact	ARP3 Risk Considerations
ARG19 (6)	All	Knock-on effect on GDN operations from variable electricity supply due to impact on DNOs	Increasing risk from the dependency on electricity supplies for gas network operation; for example, the risk of substation flooding, but this is mitigated by asset protection measures.
ARG20 (9)	Sea level rise	Tidal Flooding of above ground assets	Flood risk to above ground assets; vulnerable areas to be identified and additional flood protection and emergency response equipment employed.
ARG21 (4)	Sea level rise	Saline contamination	Low risk of corrosion in coastal flood plain areas; vulnerable assets are identified, and pipeline cathodic protection monitored, or assets repaired/replaced.
ARG22 (8)	Precipitation	Ground water flooding of below ground assets leading to water ingress to pipes	Increased flooding increases the risk of water ingress, but mitigated by the gas mains replacement programme and the installation of PE pipe and improved operational practices

ARP Risk Matrix (Electricity)

The following risk explanations and matrices have been developed as a means of measuring climate adaptation risk based on the definition and assessment of both the level of impact and likelihood of the identified risks being realised.

The ARP3 Risk matrix shows a general reduction in risk over ARP2 when considering the measures and mitigation put in place over the DPCR5 and ED1 regulatory periods to manage the risk.

Horizons: 2025, 2050, 2080		Impact				
		Limited	Minor	Moderate	Significant	Extreme
Likelihood	Almost Certain	5 / moderate	10 / major	15 / major	20 / severe	25 / severe
	Likely	4 / moderate	8 / moderate	12 / major	16 / major	20 / severe
	Possible	3 / minor	6 / moderate	9 / moderate	12 / major	15 / major
	Unlikely	2 / minor	4 / moderate	6 / moderate	8 / moderate	10 / major
	Very Unlikely	1 / minor	2 / minor	3 / minor	4 / moderate	5 / moderate

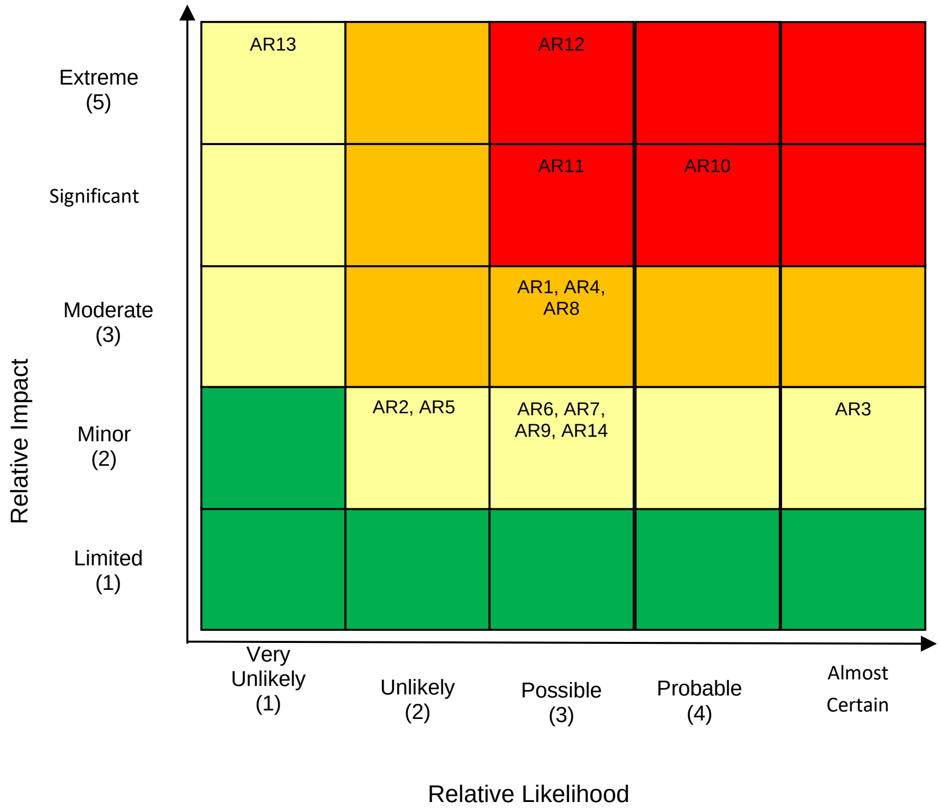
Impact

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

Likelihood

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

ARP2 Risk Matrix (Electricity)



High = major up-rating

Low = minor up-rating

Medium = minor up-rating

Negligible = updated specification of new assets

Figure 1

ARP3 Risk Matrix (Electricity)

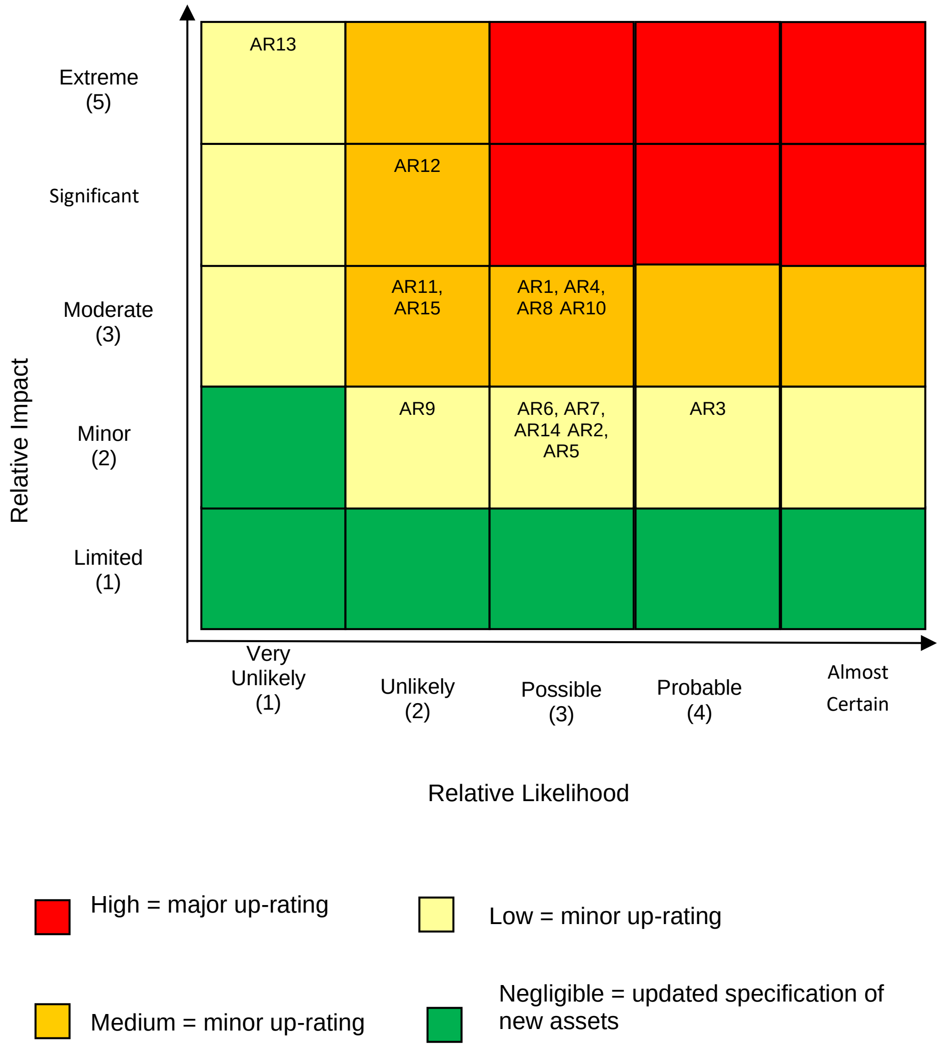


Figure 2

Please note, the above matrix is the consolidated view of the risks from climate change to the gas distribution and transmission networks. There may be minor differences between networks arising from their specific function and regional location, and the individual network reports should be referred to for individual network risk scoring and accompanying narrative.

ARP3 Risk Matrix (Gas)

ARP3 is the first time Gas networks have collectively assessed their risks, so no previous industry risk matrices are available.

Companies have developed a means of measuring climate adaptation risk based on the definition and assessment of both the level of impact and likelihood of the identified risks being realised. These are then scored to provide a comparative rating which can be used for future benchmarking of progress.

Measurement of risk

Horizons: 2025, 2050, 2080		Impact				
		Limited (1)	Minor (2)	Moderate (3)	Significant (4)	Extreme (5)
Likelihood	Almost Certain (5)	5 / moderate	10 / major	15 / major	20 / severe	25 / severe
	Likely (4)	4 / moderate	8 / moderate	12 / major	16 / major	20 / severe
	Possible (3)	3 / minor	6 / moderate	9 / moderate	12 / major	15 / major
	Unlikely (2)	2 / minor	4 / moderate	6 / moderate	8 / moderate	10 / major
	Very Unlikely (1)	1 / minor	2 / minor	3 / minor	4 / moderate	5 / moderate

<u>Impact</u>

Rating	Definition
Extreme/Catastrophic	Regional area affected with people off supply or significant asset failure which exceeds ability for network intervention or reinforcement. Financial: Cost dependent on GT/GDN impact (>£50M, typically >£20M) Safety: Multiple fatality/HSE Enforcement Notice Reputation: External impact on international stakeholders, company accused of poor practice or negligence, direct blame to company leading to extensive media coverage, significant business and company value impact, loss of licence Environment: Reportable incident, serious and lasting environmental damage or loss (>10 years recovery), enforcement action and fine certain Asset/Security of Supply: Total loss of asset, major conurbation and high customer numbers off supply for lengthy period of time

	(major conurbation off supply >24 hours), national transmission system disruption
Significant/Major	County or city area affected with people off supply or significant asset failure which requires significant network intervention or reinforcement. Financial: Cost dependent on GT/GDN impact (≤ £50M, typically £10-20M) Safety: Fatality/Life changing injury/HSE Enforcement Notice Reputation: External impact on national stakeholders, extensive media coverage, business and company value impact, repeated regulatory intervention, potential loss of licence Environment: Reportable incident, significant environmental damage or loss (5-10-year recovery), enforcement action expected Asset/Security of Supply: Significant asset damage or failure, geographical area off supply, major outage on distribution networks
Moderate	Significant increase in costs of response and network strengthening Financial: Cost dependent on GT/GDN impact (≤ £30M, typically £1-10M) Safety: Major injury e.g. RIDDOR reportable Reputation: External impact on stakeholders, adverse media coverage, negative customer impact, regulatory intervention, minor company value impact Environment: Reportable environmental incident resulting from breach of consent or permit, medium damage and loss to environment (up to 5 years recovery), potential enforcement action/letter of concern Asset/Security of Supply: Asset damage of failure, significant numbers of tariff customers off supply for considerable time
Minor	Cost of network maintenance requirements and impact on business now of concern Financial: Cost dependent on GT/GDN impact (≤ £10M, typically £500K - £1M) Safety: Lost time injury/HSE Letter of Concern Reputation: Internal impact within business and stakeholders, industry press and local media interest supported by regulator, some business criticism Environment: Minor, potentially reportable incident affecting local environment (< one year), quick resolution Asset/Security of Supply issues: Minor asset damage or failure leading to localised loss of supply for a short period of time, firm contract customer supply affected
Insignificant/Minimal	Limited impact - can be managed within “business as usual” processes

	Financial: Cost dependent on GT/GDN impact (≤ £5M, typically < £500K) Safety: Minor injury/medical treatment/near miss/negligible Reputation: Internal issue from local event, negligible inconvenience, minimal local media coverage Environment: Non-reportable incident with negligible environmental impact or damage, immediately resolved Asset/Security of Supply: Limited impact on assets and supplies, limited disruption to interruptible supplies

Likelihood

Rating	definition
Almost certain	The risk is expected to be realised and may already be under active management as an event. No controls in place to reduce likelihood of risk being realised. Guideline: >90% or at least once a year frequency.
Likely	More likely and probably will occur, mitigations not fully effective, control weaknesses are known but being managed. Guideline: 60-90% or 1 in 5 years frequency.
Possible	Equally likely as unlikely, mitigations are in place, control measures are under active management. Guideline: 30-60% or 1 in 10 years frequency.
Unlikely	Events are rare and unlikely but could occur, required mitigations in place, controls are effective. Guideline: 10-30% or 1 in 15 years frequency.
Very Unlikely	No known event or extremely rare or remote chance of occurring, controls are fully effective to reduce likelihood of risk being realised. Guideline: <10% or 1 in 20 years or greater frequency.

ARP3 Risk Matrix (Gas)

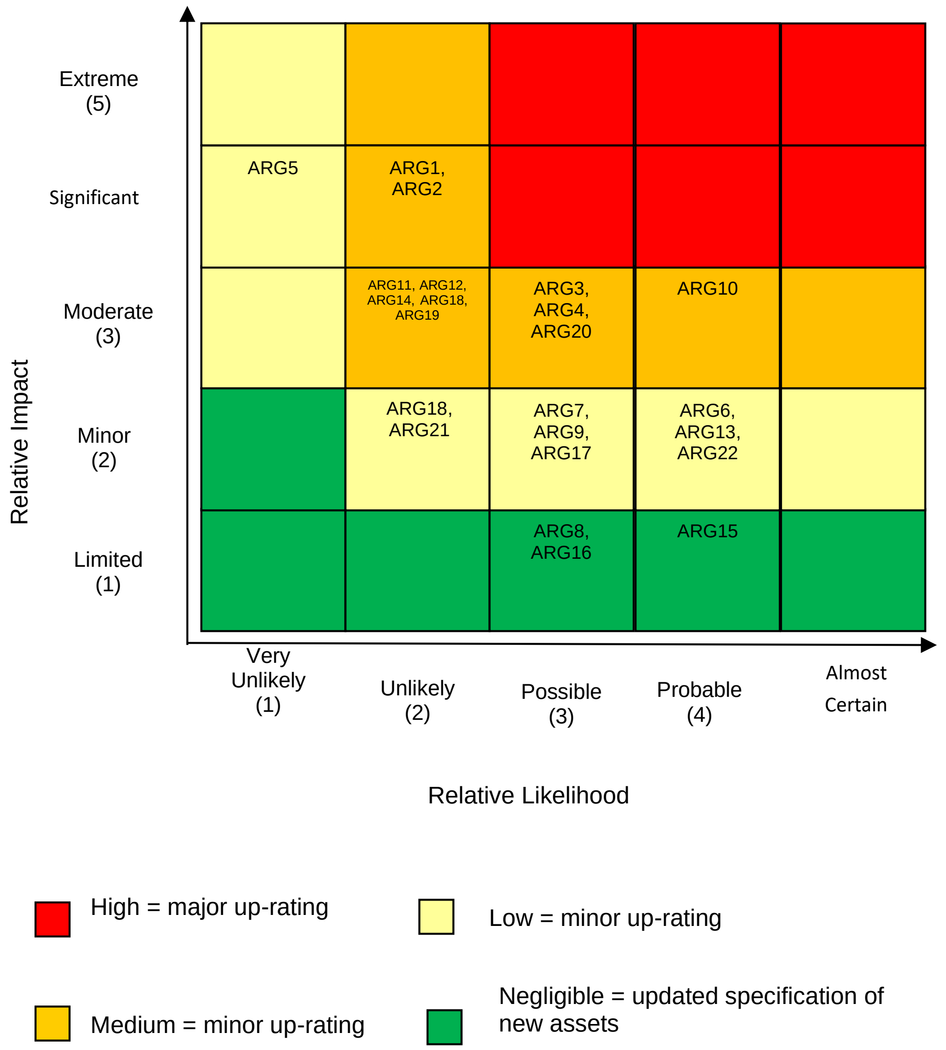


Figure 3

Please note, the above matrix is the consolidated view of the risks from climate change to the gas distribution and transmission networks. There may be minor differences between networks arising from their specific function and regional location, and the individual network reports should be referred to for individual network risk scoring and accompanying narrative.

7. Interdependencies

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.

The electricity networks are also aware that other infrastructure operators and society in general are reliant on having a reliable and resilient supply. DNOs and the National Grid Electricity System Operator (NGESO) 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.

8. 2050 Risk Score Narrative

Energy networks have not been able to provide a risk score for 2050 as there are too many variables that could affect the magnitude of climate change impacts. Networks will, however, continue to monitor the impacts of Net Zero strategies, review climate change impacts and develop and implement mitigation and management strategies for as long as they are supported by the regulatory mechanism and as they become Business as Usual activities.

9. Assumptions (including on data, operational, regulatory changes, etc)

Energy networks expect that future regulatory settlements will support the continuance of specific work programmes and schemes designed to respond to and manage the impacts of climate change.

UKCP18 data hasn't indicated any significant changes in risk nor has it suggested that there are any new hazards likely to impact energy network operations. This provides network operators with the assurance that measures and approaches used in adaptation and protection will continue to support network operation as climate change impacts are realised.

SP Energy Networks

Climate Adaptation Report, Round 3

December 2021

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