Climate Change Adaptation Report

National Grid Electricity Transmission

December 2024

nationalgrid

Contents

Executive Summary

National Grid Electricity Transmission (NGET) has submitted responses to all previous DEFRA Climate Change Adaptation Reporting Power (ARP) cycles. This report fulfils our commitment to the fourth reporting cycle (ARP4).

ARP3 aimed to provide an update on existing risks, mitigation measures, research (both completed and ongoing) since ARP3 and any identified new risks to provide a fuller picture of the potential for climate change impacts to affect our network. This report continues the progress made since the third round of reporting and should be read in conjunction with the 3rd Round Report.

Since the publication of ARP3 NGET have undertaken adaptation investment in ensuring our sites are resilient to surface water flooding risks. We have undertaken further research into the high and medium climate change risks identified in ARP3 and continue to build a deeper understanding of our climate change adaptation risk exposure.

Our assessment uses RCP 4.5 as our baseline current climate assessment and RCP8.5 for our 2050 and 2100 assessment. The 2050 and 2100 assessments recognise that some natural evolution of resilience will occur but also recognises that some increased resilience investments may be required.

Across all our assessments we have identified the following element is constant, that it is critical that current levels of resilience be at least maintained and funded into the future.

Any moves to increase levels of resilience will need to be thoroughly researched and agreed across the energy sector. NGET welcomes exploring not only energy sector driven solutions but also potential cross sector options and solutions.

It is anticipated that the new ENSO will play a significant role in developing any potential requirements to increase resilience levels.

For the present and near-term assessment ARP4 report has identified the following key points:

- ARP 4 Reflects the present and near future risks as defined by DEFRA's guidance (to 2030).
- There are no changes to ARP 3 risk scores for the current risk.
- There has been significant advancement into understanding the risks and gaps in knowledge and understanding reflected in the additional background and discussion narrative for each risk grouping.
- The potential increase in frequency in extreme events presents an increased likelihood of impacts.

Our assessment of the 2050 and 2100 climate change adaptation continues to illustrate the escalating nature of climate change risks. We recognise that there is a need to ensure that we continue to appraise its understanding of future climate change risk.

We welcome the moves towards developing any sector resilience standards and measuring metrics. This must be done through full engagement and coordination across the sectors.

Our focus since ARP3 has been to deepen our understanding of our high and medium risks as well as gaining further information on managing the high degree of uncertainty around what future climate change scenarios may bring.

As part of our commitment to climate change resilience we are on track to have our flooding risk sites protected and resilient to flooding to near and mid-term projections.

Following the introduction of ISO14091 Adaptation to climate change — Guidelines on vulnerability, impacts and risk assessment NGET undertook an external audit of our preparedness in adapting to climate change. This audit prompted the production of a high-level Climate Change Adaptation Strategy with key objectives identified.

Smarter Targets	NGET will **improve its understanding of the impacts of climate change** and close the knowledge gaps.
	Continue to **develop new and improve** existing modelling, risk assessment and management **tools.**
	Embed climate change risks into NGET policies, procedures and vision.
	Increase our coordination and engagement with our sector partners and stakeholders to climate-proof standards and to develop new ones for climate adaptation solutions.
	Identify key decision points to ensure NGET is well placed to meet its climate change adaptation challenges.
	Upgrade how NGET monitors and demonstrates its resilience to climate change.
	Where possible **seek carbon negative or neutral adaptation** options
	Work closer with Ofgem and NESO in developing a future proof resilient network.
More Systemic Adaptation	**Increase cooperation across sectors** to increase national resilience.
	Support policy development at all levels across the energy sector
	Seek opportunities to improve resilience with non-traditional partners.
	To improve and support successful regulatory submissions.
	Ensure that NGET has a clear and visible climate change strategy both internally and externally.
Faster Adaptation	**Implement a climate change toolbox** including a knowledge base for NGET staff**.**
	Have ongoing engagement with sector partners including Ofgem not just as part of regulatory submissions.
	Look for **incremental resilience opportunities** which can easily be upgraded at minimum cost.
	Increase training and engagement of climate change adaptation within NGET

Figure 1 Climate Change Adaptation Strategy with key objectives

Introduction

The Adaptation Reporting Power (ARP) set out in the Climate Change Act 2008 provides for the Secretary of State (SoS) to direct reporting organisations (those with functions of a public nature or statutory undertakers) to report on how they are addressing current and future climate impacts.

While the provision gives the Secretary of State the power to mandate reporting, this has not been used since the first round, and the SoS is continuing with a voluntary approach to reporting in round 4.

This report has been developed in response to the requirements placed on reporting authorities by the Climate Change Act under the 4th Round of Adaptation Reporting. Reports should detail:

- the current and future projected impacts of climate change on their organisation,
- proposals for adapting to climate change,
- an assessment of progress towards implementing the policies and proposals set out in previous reports.

ARP aims to ensure that organisations of a public nature with climate-sensitive responsibilities are taking appropriate action to adapt to the impacts of climate change. It does this both directly, through engaging organisations in reporting, and indirectly, through raising awareness, building capacity in organisations, and making examples of good practice publicly available.

The Government's Adaptation Sub-Committee review the outputs of the ARP process and it supports the Government's National Adaptation Programme and future UK Climate Change Risk Assessments.

We have produced an adaptation report for each of our 3 UK business units – National Grid Electricity Transmission (NGET), National Grid Electricity Distribution (NGED) and National Grid Ventures (NGV).

The ARP3 report for NGET can be accessed here. Previous reporting by NGED (as Western Power Distribution) was included as part of the Energy Networks Association (ENA) response and can be accessed here. This is the first time we have reported for our NGV business, following a request from the Department for Environment, Food and Rural Affairs (DEFRA).

National Grid at a glance

National Grid plays a critical role in the energy sector, operating in both the United Kingdom and the northeastern United States. With a mission to Bring Energy to Life, we are dedicated to delivering safe, reliable, and sustainable energy solutions to millions of customers. Our company is at the forefront of the energy transition, focusing on the decarbonisation of energy systems and the integration of renewable energy sources into our networks

To achieve our vision of being at the heart of a clean, fair and affordable energy future in a focused way we have a strategy that sets the bounds of our business. Guiding our efforts within this are five strategic priorities:

1. Enable the Energy Transition for All: We have a pivotal role in enabling the energy transition across all sectors of the economy through our networks. We work with policymakers, regulators and the wider industry to shape the policy and regulatory frameworks needed to reach net zero by 2050.
2. Build the Networks of the Future Now: We will scale a once-in-a-generation increase in capacity to connect to, and transport electricity across, our networks. We will modernise our electricity networks to improve capacity, visibility, security and reliability.
3. Deliver for Our Customers: We will provide excellent service to all our customers, ensuring they can connect to the network in a timely fashion, that their energy provision is reliable and that we are easy to do business with.
4. Operate Safely and Efficiently: Our priority is to keep our colleagues safe. Being efficient means we play our part in making the energy transition affordable by investing in the right projects and solutions, and delivering them on (or ahead of) time and budget
5. Build Tomorrow's Workforce Today: All of this is enabled by our people. The energy transition is happening right now, so we need to build tomorrow’s workforce today, with the diverse talent and skills needed to deliver our vision. Our ambition is to be the employer of choice for people who want to have a career in a company where they can have a clear and positive impact on the energy transition

These strategic priorities reflect our commitment to addressing the challenges of the energy transition while ensuring that our operations are aligned with the needs of customers, communities, and the environment.

Our UK business units that have reported under ARP4 are:

National Grid Electricity Transmission (NGET):

- NGET is responsible for owning and operating the high-voltage electricity transmission network in England and Wales. It plays a critical role in delivering electricity from generation sources to distribution networks and ensuring the stability of the electricity system. Our Transmission business includes our Strategic Infrastructure (SI) business unit, established in April 2023, which focuses on delivering major infrastructure projects under the Accelerated Strategic Transmission Investment (ASTI) framework

National Grid Electricity Distribution (NGED):

- NGED manages the electricity distribution networks for the East Midlands, West Midlands, Southwest, and South Wales. It is responsible for delivering electricity at lower voltages to homes and businesses and includes a Distribution System Operator (DSO) that oversees the distribution network's operations

National Grid Ventures (NGV):

- NGV is our non-regulated UK business and focuses on competitive markets and operates 6 electricity interconnectors and a liquefied natural gas (LNG) import and storage facility at Grain. NGV is involved in projects that enhance energy security and facilitate the transition to low-carbon energy sources.

Further information on NGET is set out below.

National Grid Electricity Transmission (NGET) owns and operates approximately 4,500 miles of high voltage overhead lines and underground cables that constitute the electricity transmission system in England and Wales.

NGET itself does not sell electricity. We transmit electricity from the generators to Distribution Network Operators (DNO) who supply and sell to homes or businesses.

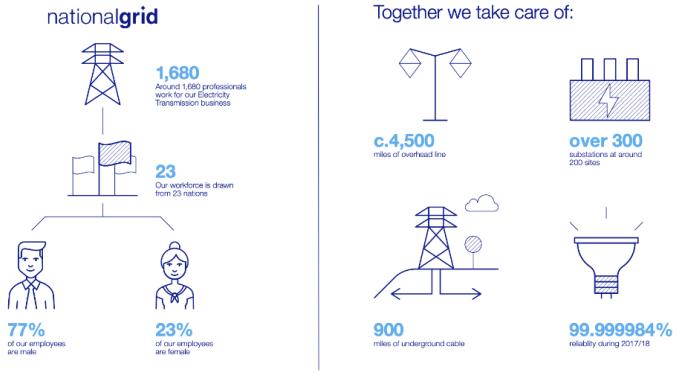


Figure 2 Electricity Transmission: Our Network in Numbers

National Grid's ARP1 and ARP2 reports for electricity, covered our operations as Transmission Owner and System Operator.

Since the publication of ARP3, the System Operator has been divested away from National Grid Group and now operates as National Energy System Operator (NESO). In addition, Western Power Distribution has been acquired and integrated into National Grid Group and now operates as National Grid Electricity Distribution (NGED). Finally, unchanged since ARP3 is our Interconnector businesses under National Grid Ventures (NGV).

As a result, this report focusses on the physical risks solely to assets under the ownership and operation of NGET not NGED or NGV who will both publish their own separate ARP submissions.

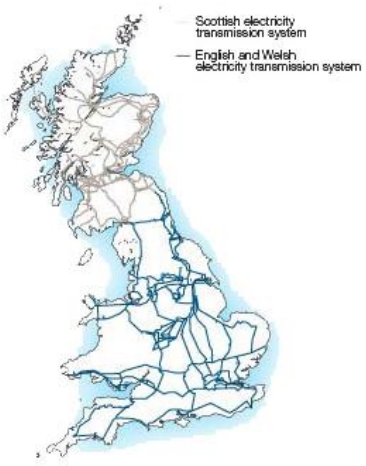


Figure 3 Electricity Transmission System

National Grids Commitment to Climate Resilience

Section Key Points:

- **As one of the first companies to participate in the UK's National Adaptation Programme we have a long-established history of reporting on climate resilience.**
- **We have incorporated each of the Taskforce for Climate Related Financial Disclosures (TCFD) recommendations and will work with the International Financial Reporting Standards Foundation (IFRS) on updating our position in our next annual report.**
- **Our Responsible Business Charter sets out our sustainability commitments including to "Report on our climate change risks and opportunities and our investment in climate change adaptation activities."**

UK National Adaptation Programme

In 2008 the UK Climate Change Act set out a five-year reporting cycle for climate change risk assessments, forming the basis for the country's ongoing action plan to adapt to climate change. NGET was an early participant in the first adaptation reporting cycle, ensuring that each reporting cycle forms a solid foundation for understanding industry wide climate-related challenges and the corresponding resilience of our network.

In this case, resilience is defined as the ability of the electricity transmission network in England and Wales to withstand disruptive events, and the organisational capability of NGET to reduce the magnitude and/or duration of disruptive events. Including the capability to anticipate, absorb, adapt to and/or rapidly recover from such events. Thus, ensuring that electricity continues to reach consumers safely, reliably and efficiently.

Task Force on Climate-Related Financial Disclosures (TCFD)

National Grid has disclosed against the TCFD since 2017/18 and our disclosures now cover all of the TCFD's recommendations and recommended disclosures around governance, risk management, strategy and metrics and targets. NGET contributes to the annual TCFD disclosure by demonstrating how the business is responding to climate change. This may be through case studies such as Ofgem funded net zero innovation projects, performance against our GHG emissions targets and examples of how extreme weather events have impacted NGET networks to outline the long-term risks and opportunities associated with climate change.

It will be necessary for NGET to continually appraise its understanding of climate risk and the potential scale and timing of impacts on its assets. This will be through a range of measures including climate modelling, risk assessment, process development and engagement with external stakeholder and policy makers.

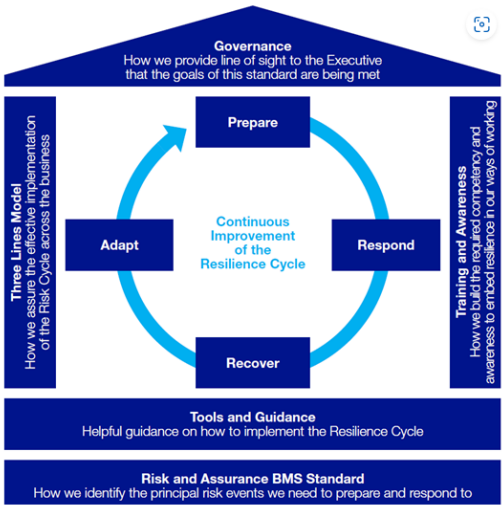
In its final status report, published in 2023, the TFCD remarked that "estimating potential financial impact from climate change requires expertise from different functions within a company. As a result, it may be useful to set up a cross-functional team for such efforts. This statement reflects our understanding of what it will take to appropriately implement the commitments within this document.

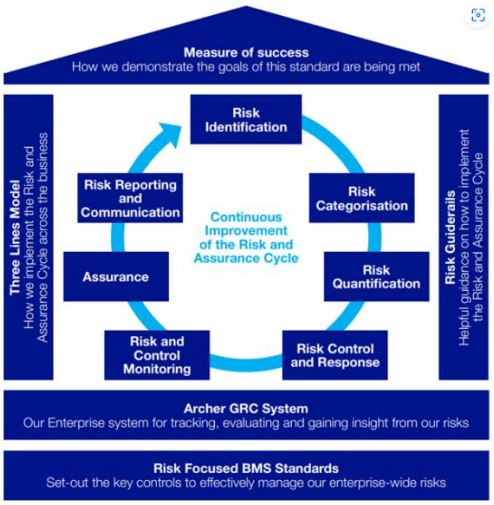
How we assess and calculate risk to our network

Climate adaption and mitigation activities to address our physical risks are embedded into our core business processes. The Chief Risk Officer leads the development of climate adaptation frameworks across the Group to ensure there is a consistent approach to assess the vulnerability of our energy assets and to guide strategic investment planning to ensure network resilience. Further delegation is given to our core operational businesses including Business Unit Presidents who are accountable for delivering the net zero roadmaps for their businesses. Corporate Affairs, Group Finance, Sustainability, Safety & Health and People teams support the businesses in achieving their net zero pathways.

National Grid has resilience standards in place to ensure the continuity of services we provide to our customers and the communities we serve:

- The Enterprise Risk and Assurance Standard is used to anticipate and respond to threats and opportunities, thereby successfully delivering our strategy and objectives (Figure 4 Risk Management and Assurance Standard)
- The National Grid Business Resilience Standard drives continual improvement in the way we prepare for, respond to, recover, and adapt from significant business disruptions (Figure 5 Business Resilience Standard).





Figures 4 and 5– Our resilience approach

These standards are high level approaches that in themselves do not specifically address climate change hazards and require consideration alongside specific risk assessment and mitigation.

Climate Change and Enterprise Risk Management

Climate change is a significant risk for our organisation, and we have integrated it into our ERM process as one of our Group Principal Risks (GPRs).

Our ERM framework and process consider the physical and transition risks associated with climate change, as well as the potential impact of these risks on our business operations, financial performance, and reputation.

For our climate change GPR risk there are two distinct elements:

1. Climate Change (mitigation GPR): The standalone mitigation risk is aligned to our strategic objective 'Enable the energy transition for all', with a focus on delivering clean, decarbonised energy to meet our net zero goals.
2. Significant Disruption of Energy (adaptation GPR): The adaptation, or physical risk activity, absorbed within the control framework associated with the 'Significant Disruption of Energy' risk, has helped ensure we continue to deliver energy reliably for our customers, with a focus on resilience.

This allows us to have greater oversight, focus and adoption of two distinct and proportionate control frameworks in line with the new Group risk appetite – mitigating downside risk, and maximising opportunities, where applicable.

How we manage and monitor our climate-related risks

As part of our risk management process, we have assigned key controls to manage both our climate change mitigation and adaptation risks.

The controls for our climate change mitigation GPR are in line with our strategy and regulatory frameworks and are also reflected throughout other relevant risks, for example: regulatory outcomes; political and societal expectations; and significant disruption of energy. The key overarching mitigation controls involve tracking progress against targets, identifying changes that could trigger additional transition risks, and implementing procedures and proposed solutions to overcome them.

Our key climate change adaptation controls include the following:

- Fit for Future of Electricity Strategy: A corporate strategy that considers the steps to ensure our business remains resilient in the future, such as enhancing design standards, and investments on asset hardening and flood protection.
- Engineers Governance forums: Group Chief Risk Officer and engineering duty holders sharing guidance and data on key topics such as resilience.
- Resilience and Asset Management Business Management Standard (BMS): Sets out minimum requirements and a framework for resilience capability and managing asset risk to ensure each business unit is prepared for the next disruptive event.
- Establishment of the Business Resilience and Crisis Management organisation: Reporting to the Group Chief Risk Officer and Group Legal, this team is focused on building resilience to all threats and hazards. This includes the development of crisis management and business continuity plans, training, and exercises to help align and coordinate our response to severe weather and other crisis events; but is also leveraging innovative technologies to improve our intelligence, looking strategically at evolving risks associated with climate change. We are also expanding our network of external stakeholders to identify and leverage industry thought leadership and play an active role in shaping new policies and regulations.

ARP Risk Assessments

Background to UK Climate Resilience

Climate science that has been well understood for many years now indicates that changes to our environment are inevitable. The latest climate projections for the UK are set out in UKCP18 and form the basis of adaptation reporting and risk management by national agencies. Whilst the next round of projections is expected to be published in around 2026, we do not expect a significant change in current strategy as a result. To provide assurance, the Energy Networks Association commissioned the Met Office in 2020 to undertake a review of UKCP18 highlighting the following hazards as those which posed the highest risk to energy network assets:

- Prolonged rainfall leading to flooding
- Extreme high temperatures
- Heavy rainfall/drought cycles

The inevitability of these risks have prompted a response from governments and industry alike to adapt and implement resilience by design. In March 2023 the Climate Change Committee (CCC) published its latest report on the UK's adaptation efforts. The energy industry was determined to have made 'mixed' progress towards their sector specific targets but commended transmission companies on the progress they had made with their climate adaptation strategies.[3] More recently the CCC published their proposed methodology for their fourth independent climate change risk assessment[4] which will inform the UK's updated National Adaptation Programme. In their publication the CCC outlined three key priorities for NAP4:

1. increase cross-government collaboration
2. tackle barriers to investment
3. improve monitoring and collection of data

Whilst the first of these relies on governmental action, NGET has taken steps to ensure the other priorities are embedded within its business/regulatory strategy – targeting innovation, digitisation and asset health improvements for the next investment period.

How we assess and calculate risk to our network

NGET has resilience standards in place to ensure the continuity of services we provide to our customers and the communities we serve.

The Enterprise Risk and Assurance Standard is used by NGET to anticipate and respond to threats and opportunities, thereby successfully delivering our strategy and objectives.

The National Grid Business Resilience Standard drives continual improvement in the way we prepare for, respond to, recover, and adapt from significant business disruptions.

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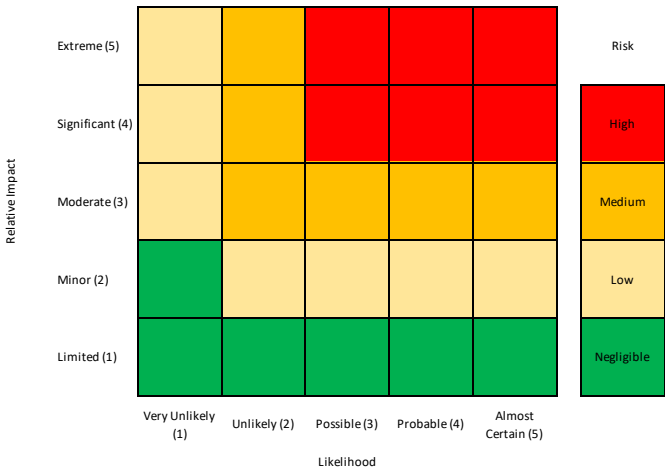
Risk Matrix

This is the second electricity adaptation report to include a formal risk assessment which is consistent with the ENA Climate Adaptation Group approach. To ensure consistency across members and within the ENA sector response, the ENA Adaptation Group members have developed the following risk matrix.

The matrix has been developed by the Group and builds upon that used for ARP2 and 3 by the DNOs.

The full risk ratings from ARP3 assessments are presented as Appendix 1 and are presented as likelihood vs impact.

Risk Matrix Template



Risk Matrix Impact Definitions

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.

Risk Matrix Likelihood Definitions

Rating	Definition

Almost Certain	The risk is expected to be realised 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

Risk assessment Scenarios

The ARP guidance states reporting against 4 scenarios:

1. Present day (near term)
2. Mid century 2°C rise
3. End of century 2°C rise
4. End of century 4°C rise

NGET have used UKCP RCP4.5 for present day scenario, and RCP 8.5 for mid and end of century scenarios.

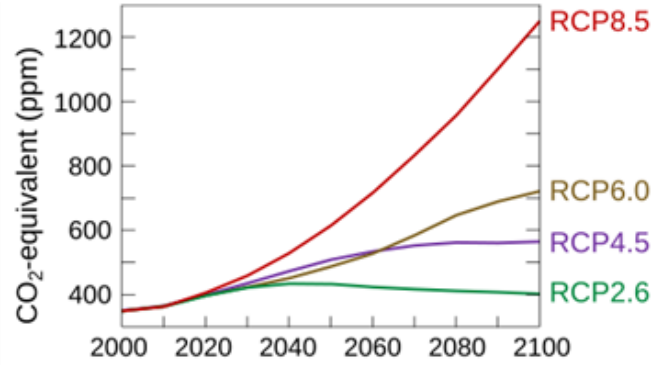


Figure 6 -IPCC Representative Concentration Pathways

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Risk Codes and Groupings

To ensure a consistent approach risk codes and groupings were developed as part of ARP 3 coordinated through the Energy Networks Association Climate Change Adaptation Working Group with DEFRA and Ofgem involvement. The risks that we identified were presented in groups, repeated here in this climate resilience strategy to aid in identifying them when they are referenced. The codes presented relate to National Grid gap analysis and the ENA Climate Change Adaptation Sub-Group, namely:

AR: ENA Climate Change Adaptation Reporting Group Electricity Risks

ARG: ENA Climate Change Gas Adaptation Sub-Group

GT: Gap Analysis between National Grid Gas Transmission and National Grid Electricity Transmission

TCFD: Risks considered by the TCFD Working Group Climate Modelling, but not considered in previous ARP Reports.

MO: Risks considered by the Met Office Report, but not considered in previous ARP Reports.

A full table of the risks and groupings are presented as Appendix 1

Grouping	Code	Risk
Business Continuity	ARG18	BCM plans affected due to severe travel difficulties resulting from extreme weather events

NGET Climate Adaptation Reporting: ARP 2 and ARP 3

In 2016, we published our second round of Climate Change Adaptation Reporting. Although vulnerabilities were noted, the overall risk to NGETs operations was not deemed high, and existing risk management processes were found to be effective. The assessments relied on data from the UKCP09 projections and identified flooding as the most significant risk to our network.

As part of ARP2 we also outlined a few key barriers that we then set out to mitigate, namely:

- A need for more cross-sector planning, and;
- Complications presented by increasing interdependencies between weather events, such as strong winds following heavy rainfall which posed new uncertainties.

In 2018 the UK Government updated its climate projections and in anticipation of the next round of reporting (ARP3) the ENA requisitioned the Met Office to perform a review. As a result of the updated data and to align with the requirements of the CCRA, we took the opportunity to undertake a full reassessment of climate risks - reviewing 86 potential risks and narrowing them down to 50 key ones.

Our objective for ARP3 was to:

- Provide an update on existing risks and mitigation measures described in the previous reports.
- Identify new or emerging risks to provide a comprehensive picture of the potential for climate change impacts to affect NGET; and

- Incorporate the latest climate information provided by UKCP18.

In ARP3 NGET chose to risk assess its assets and processes against the high emissions scenario which is based on the least likely to occur prediction of climate change as of 2080. This was on the basis that should National Grid's assets and process demonstrate resilience against this scenario, it would inevitably be adapted against lower and more likely climate changes. This is also consistent with general planning assumptions within the business.

Our ARP4 assessment uses RCP 4.5 as our baseline current climate assessment and RCP8.5 for our 2050 and 2100 assessment.

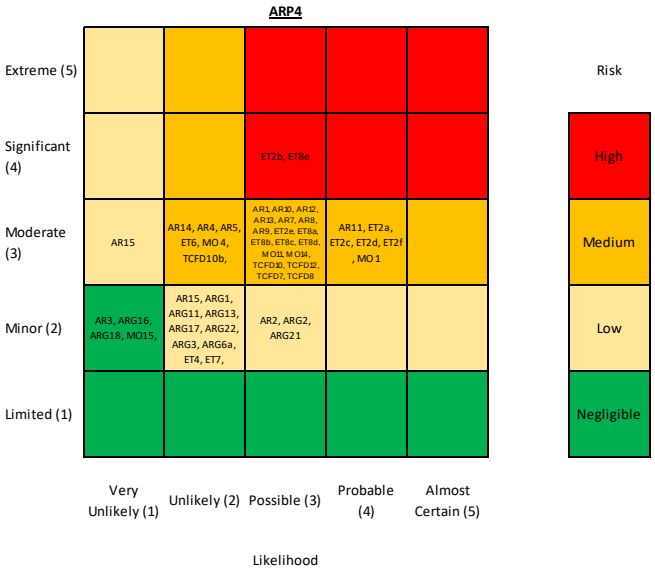
The 2050 and 2100 assessment recognise that some natural evolution of resilience will occur but also recognises that some increased resilience investments may be required.

ARP 4 Risk Assessment

Key Points for this Section:

- **ARP 4 Reflects the present and near future risks as defined by DEFRA's guidance (to 2030).**
- **There are no changes to ARP 3 risk scores for the current risk.**
- **There has been significant advancement into understanding the risks and gaps in knowledge and understanding reflected in the additional background and discussion narrative for each risk grouping.**
- **Our risk assessments are based on industry-agreed standards published by the ENA**
- **Our risk profile has evolved over four rounds of reporting to now include an assessment for 2100, acknowledging a high degree of uncertainty**
- **The most significant hazards posed to our network over the next 25 years are rising temperatures, coastal erosion and flooding**
- **Our adaptation strategy (CCAS) ensures that climate change is embedded into our internal risk assessment framework and cost benefit analysis**
- **Our CCAS will align through the implementation of a governance framework to ensure that strategic objectives are met over the RIIO-3 period**
- **Our assessment uses RCP 4.5 as our baseline current climate assessment and RCP8.5 for our 2050 and 2100 assessment.**
- **The 2050 and 2100 assessments recognise that some natural evolution of resilience will occur but also recognises that some increased resilience investments may be required.**

ARP 4 Risk Matrix Confidence Level Medium to High



High and Medium Risks

High Risks

Grouping	Code	Risk
Sea Level Rise & Coastal Change	ET2b	Coastal Management Policy
	ET8e	Flooding from Storm Surges

Medium Risks

Grouping	Code	Risk
Compound Events	TCFD7	Extreme weather events including a combination of wind, rainfall, temperature or snow
	TCFD8	Perfect Storm of a cold winter, high electricity demand and heavy persistent rain
Erosion	ET2c	Riverbank Stability and Scour
	ET2d	Groundwater & Geohazards
	ET2f	Surface Water Runoff Scour
Fluvial Flooding	AR10	Substations affected by river flooding due to increased winter rainfall
	ET8a	Fluvial river and coastal flooding of NGET sites
	ET8b	Fluvial river and coastal flooding – neighbouring sites leaving NGET sites stranded
	ET8c	Shifting flood areas may affect existing sites in the future
Ground Movement	AR5	Underground cable systems affected by summer drought and consequential ground movement,
	ET2a	Geo Hazards
	ET2e	Landslips, slope stability, ground creep, avalanche
	MO 4	Repeated Cycles of drought and rainfall
	TCFD10b	Increased rate of loss of level in areas with already low depth of cover (e.g. Fenland area)
Interdependencies	AR13	Substations affected by water flood wave from dam burst
	ET8d	Reservoir / Canal Failure
Lightning	AR14	Overhead lines and transformers affected by increasing lightning activity
Pluvial Flooding	AR11	Substations affected by pluvial (flash) flooding due to increased rainstorms in Summer and Winter
	MO 1	Increased intensity of short duration rainfall leading to flooding
Raised Temperatures	AR1	Overhead line conductors affected by temperature rise.
	AR4	Underground cable systems affected by increase in ground temperature,
	AR7	Transformers affected by temperature rise
	AR8	Transformers affected by urban heat islands and coincident air conditioning demand
	AR9	Switchgear affected by temperature rise
	TCFD10	Demand growth in Summer due to increased cooling load
Sea Level Rise & Coastal Change	AR12	Substations affected by sea flooding due to increased rainstorms and/or tidal surges
Storms	ET6	Severity, Intensity and Frequency of Storms

	MO11	Temperature / Precipitation: Warm, wetter conditions combined with rainfall and / or wind
Temperature Cycles	MO14	Diurnal Temperature Range
	TCFD12	Fast Freeze-thaw cycles

Risk Grouping Narrative

Business Continuity

Code	Risk	ARP3	ARP4	2050	2100
ARG18	BCM plans affected due to severe travel difficulties resulting from extreme weather events	1x2	1x2	1x2	1x2

Additional Background to ARP3 Submission

NGET's BCM plans are regularly tested through planned exercises however this previously did not always factor in potentially unrelated factors which may reduce the effectiveness of a BCM plan.

Additional Discussion to ARP3 Submission

Through our regular emergency planning exercises, we robustly test our resilience to climatic hazards. The scenarios of which these exercises take place are drawn from realistic weather extremes taking real events and amplifying them. In the future we are planning to make use of digital twin environments not only for exercise purposes but also to undertake more detailed 'what if' so called multi hazard events.

2050 Discussion

Although NGET expect to maintain its high level of BCM planning and exercises there may be some additional exposure to supply chain risks which are discussed in the interdependency section.

2100 Discussion

Although NGET expect to maintain its high level of BCM planning and exercises there may be some additional exposure to supply chain risks which are discussed in the interdependency section.

Compound Events

Code	Risk	ARP3	ARP4	2050	2100
TCFD7	Extreme weather events including a combination of wind, rainfall, temperature or snow	3x3	3x3	3x4	3x4
TCFD8	Perfect Storm of a cold winter, high electricity demand and heavy persistent rain	3x3	3x3	3x4	3x4

Additional Background to ARP3 Submission

Extreme and compound weather events have the potential to cause widespread disruption.

Additional Discussion to ARP3 Submission

As part of NGET's research into climate change we are exploring how separate hazards may combine to amplify impacts and how the resilience to one hazard may be reduced following the impacts of a hazard. Research into which compound events or combination of events is limited. We have undertaken an assessment which has identified which combination of hazards to be more likely and may have an impact on our system and assets.

- Very wet period followed by an extreme rainfall event such as storm systems or atmospheric river.
- Very wet snowstorm coinciding with a very sharp drop in temperature with high winds leading to increased ice accretion on conductors.
- Extended drought period leading to extremely dried out soils followed by intense periods of rainfall leading to increased run off and flash flooding.
- Extended drought period with very hot weather leading to increased wildfire outbreaks.
- Warm wet spring continuing into summer driving increased vegetation growth followed by an extended very hot period which dries out vegetation and increased fuel sources for wildfires.
- A major solar storm event coinciding with another severe weather event.

While the climate change risks associated with high energy demand coupled with low generation supply could pose a system risk are predominantly a National Energy System Operator risk NGET has a supporting stakeholder role.

2050 Discussion

As the impacts of climate change increase there is an assumption that there will be an increase in the frequency of storm activity which may lead to a greater exposure of extreme events overlapping. It is likely that an increased frequency leading to reduced recovery timescales. With increased frequency there is evidence that occurrences of the extreme events will increase.

It is expected that the learning from significant events will continue to be implemented together with a greater understanding of how compound events will increase using digital twin technologies.

It is anticipated that any increased investments to ensure the existing levels of resilience will continue to be funded.

We are seeking to expand our awareness of these compound risks via innovation projects working with our partners and stakeholders.

2100 Discussion

Essentially a continuation of the 2050 assessment with increased extreme events becoming the new norm. it is anticipated that the energy sector will continue to evolve and adapt to climatic changes.

Contaminated Ground

Code	Risk	ARP3	ARP4	2050	2100
ET4	Polluted ground fires, Old Mine workings	2x2	2x2	2x2	2x2

Additional Background to ARP3 Submission

As a result of climate change driven changes to the water cycle, contaminants might become increasingly mobile.

Increased 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.

Additional Discussion to ARP3 Submission

Increased flooding activity on old industrial land may lead to increased transportation of pollutants either onto or off our sites.

In some cases, as with Ground granulated blast-furnace slag (GGBS or GGBFS) the contaminants can have serious corrosive implications to any buried copper such as earthing mats. This material has been widely used as a substrate layer and as an additive to increase concrete durability. The risk materialises

in areas of high-water table where stray current earthing combines the pollutants for electrolysis to occur in the most extreme cases the earthing mat can rapidly corrode.

NGET no longer uses GGBS or GGBFS on any of its sites and this has been written into site design standards.

2050 Discussion

This risk is linked to any changes to the water cycle. The decade from 2012 to 2021 was on average 2% wetter than 1991 to 2020 and 10% wetter than 1961 to 1990 for the UK. Five of the ten wettest years in the UK series going back to 1836 have occurred since 2000: in order of wettest 2000, 2020, 2012, 2008 and 2014. Should this trend continue its likely that there may be some increased instances of ground pollutant transportation.

There is some linkage to the risks posed to our sites and assets from old mineworking's and increased groundwater levels these are discussed in the groundwater and ground movement sections

2100 Discussion

There is a great deal of uncertainty as to what rainfall patterns may become the new norm towards the end of the century, we are already experiencing increased annual rainfall volumes. Whether this increased trend continues or perhaps changes to longer periods of increased rainfall interspersed with extended semi drought conditions.

Erosion

Code	Risk	ARP3	ARP4	2050	2100
ET2c	Riverbank Stability and Scour	4x3	4x3	4x4	4x4
ET2d	Groundwater & Geohazards	4x3	4x3	4x4	4x4
ET2f	Surface Water Runoff Scour	4x3	4x3	4x4	4x4

Additional Background to ARP3 Submission

Foundations of OHL towers and cable routes can be undermined by riverbank erosion, subsurface flow and surface water runoff. More frequent flooding and increased river and watercourse flows will increase this level of risk.

Foundations may be undermined through sub-surface chemical processes (e.g. chalk cysts dissolving) or through physical erosion of soil and rock (e.g. sinkholes). Changes to the water cycle where we get increasing peaks of excessive rainfall may increase surface and subsurface flows which may impact an asset location and the rate of these processes. Resulting surface water discharge may also result in erosion and destabilisation of slopes and river channel. Coastal erosion is discussed under the Sea Level Rise & Coastal Change grouping section. Water driven geohazards such as landslips are discussed under the Grounds Movements grouping section.

Additional Discussion to ARP3 Submission

Plans are in place to respond to the most credible emergency scenario, e.g., erosion and destabilisation of OHL tower foundations. In this instance, loss of any one double circuit would not normally result in loss of supply.

This risk is considered to be increasing its impact on the network, although it has a more transient effect than more permanent changes seen at the coast. Research was undertaken during RIIO-T1 that identified potential risk areas, which may be more vulnerable to these impacts during the coming decade.

While sites at flooding risks are dealt with and discussed in the flooding risks sections on non-flooding risk sites the legacy drainage systems where likely installed many years ago, subsequently their performance design standard is unlikely to meet current specifications and struggle to cope with draining

sites during 'normal' very heavy rainfall. While this may not pose a threat to supply the increased frequency of extreme rainfall events will likely place additional strain on the aging drainage systems which is likely to result in an increase in maintenance and failure repair.

NGET has identified those tower and cable assets which are in areas of increased susceptibility to erosion and monitors these sites closely. The towers in erosion prone area are assessed as to whether investment in managing the erosion risks is required as part of route planned refurbishment submissions.

We have based our assessment of assets located in areas of increased vulnerability to erosion and water driven geohazards on the British Geological Surveys Geohazard datasets and the Environment Agencies long term flooding risks.

Fortunately, the majority of issues are relatively small and dealt with under BAU maintenance works NGET are undertaking works to separate this previously invisible climate change adaptation driven cost to ensure that regulatory submissions reflect this potential increasing workload expenditure.

It is likely that investments in managing erosion and geohazard will continue to increase year on year it is anticipated that any increased maintenance costs will be funded.

NGET undertook a piece of work with Liverpool University to better understand our exposure to riverbank erosion and our assets. Using Environment Agency river gauge data this work looked at potentially monitoring and forecasting erosion rates where our tower assets are located in proximity to areas of riverbank particularly susceptible to erosion. Counting the number of 'normal' and extreme flood events with the frequency of occurrence. Implementation of this monitoring process will be assessed through the T3 Regulatory period.

2050 Discussion

Should the implementation of the proposed monitoring process be undertaken it will reduce future exposure to this hazard.

It is likely that investments in managing erosion and geohazard will continue to increase year on year it is anticipated that any increased monitoring and maintenance costs will be funded. It is likely that serious intervention woks become more frequent in the future.

2100 Discussion

It is likely that investments in managing erosion and geohazard will continue to increase year on year it is anticipated that any increased maintenance costs will be funded. It is likely that serious intervention works become more frequent in the future.

Fluvial Flooding

Code	Risk	ARP3	ARP4	2050	2100
AR10	Substations affected by river flooding due to increased winter rainfall	3x3	3x3	4x3	4x3
ET8a	Fluvial river and coastal flooding of NGET sites	3x3	3x3	4x3	4x3
ET8b	Fluvial river and coastal flooding – neighbouring sites leaving NGET sites stranded	3x3	3x3	4x3	4x3
ET8c	Shifting flood areas may affect existing sites in the future	3x3	3x3	4x3	4x3

Additional Background to ARP3 Submission

In 2012 NGET implemented an investment plan to protect all flooding risk sites in line with industry standard Engineering Technical Report 138 (ETR 138) which tasks Transmission and Distribution networks with ensuring its existing and new sites be flood resilient against fluvial and tidal flooding.

Following the availability of surface water risk data this report was updated to include surface water risks.

Flooding remains one of our highest priority risks which is reflected in the focus works undertaken and controls put in place to manage this risk.

The nature of flooding risk is essentially a constant moving target of review and reassessment by the Environment Agency. To efficiently manage this uncertainty our resilience allows for typically riverine and catchment modelling allowances. For existing sites this is climate change allowances out to 2050, and for new sites this is typically 50+ years.

The management of flooding risks to sites is written into our core business policies and procedures. And adherence to ETR 138 a recognised energy sector standard.

Pluvial or surface water flooding and coastal flooding are discussed separately in the Pluvial Flooding and Sea Level Rise and Coastal Change grouping sections.

Additional Discussion to ARP3 Submission

Funding to defend our sites against fluvial and tidal flooding events was received in 2012 with all sites at 1:200 (plus out to 2050 climate change allowance) flooding risk now there are small number of sites at 1:000 flooding risk where works are in progress having been deferred to coordinate with major site works or Environment Agency works. A small number of sites assessed for flooding risk only become vulnerable after climate change allowances levels at 2040 to 2050 are added to current 1:1000 levels investments in these sites has been deferred until a reassessment of flooding risks during what would be regulatory period RIIO T5 (2036). Any additional investments following this reassessment would be subject to regulatory funding agreements. In the interim this small number of deferred sites and any sites where flooding risks are above a 1:1000 flood level would be protected by our mobile demountable barrier system.

To better manage the flooding risks posed to our sites under innovation funding we have developed a prototype severe weather alerts tool which takes flood risk and flooding weather alerts into a dashboard which compares alerts to NGET's sites this gives us clear visibility of the risks to our sites streamlining and automating the risk monitoring of flooding risks to our sites. We are in the process of implementing this tool into NGET.

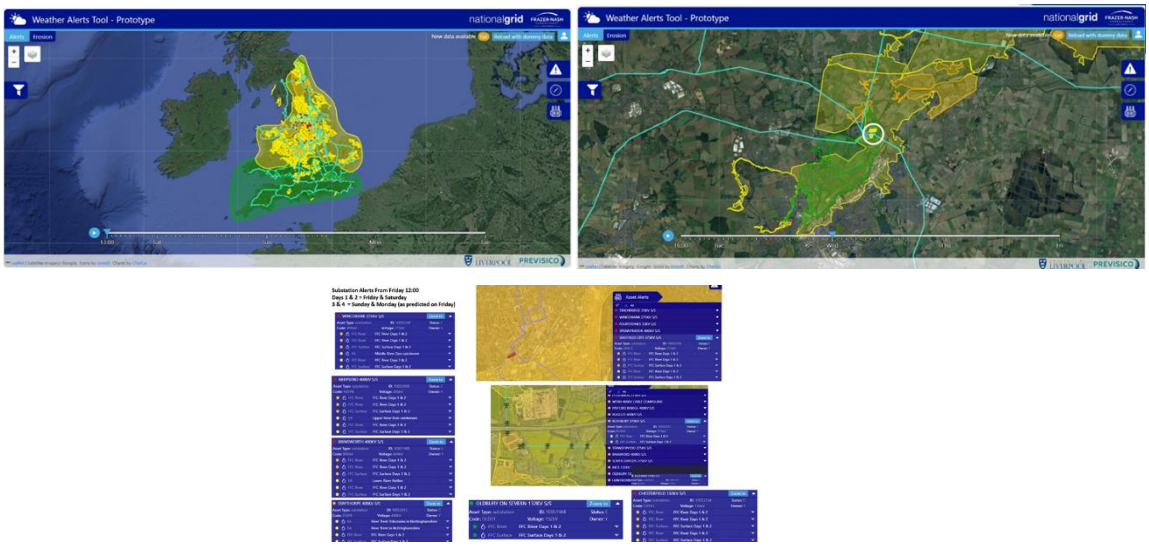


Figure 7. Severe Weather Alerts Tool screen shots.

The severe weather alerts project included the installation of our own water level sensors on a selected sample of sites. We plan to install these on all our flooding risk sites and include cameras to capture still images.

Flooding risk on new sites is managed through our policies and procedures. Where practicable we seek to construct out of fluvial flooding risk areas when this is not possible appropriate mitigation measures are factored into the new site design.

The flooding events of January 2024 had some delay impacts on overhead lines refurbishment works due to accessibility. These scheme delays are somewhat unavoidable however environmental risks are a factor planned for in scheme development such as lay down and storage areas. The severe weather alerts tool includes the location and risk data for our overhead line and cable routes and can be used for increased awareness and risk monitoring purposes.

2050 Discussion

Although we envisage an increase in exposure to these risks as long as the risks continue to be managed any future risk is therefore dependant on the availability of ongoing investment funding. Should there be changes to ETR 138 requirements such as an increase to the 1:000 target resilience level this would be factored into a reassessment of flooding risks.

2100 Discussion

If the risks continue to be effectively managed there may be increased exposure but limited impacts.

Ground Movement

Code	Risk	ARP3	ARP4	2050	2100
AR2	Overhead line structures affected by summer drought and consequent ground movement	3x2	3x2	3x3	3x3
AR5	Underground cable systems affected by summer drought and consequential ground movement,	2x3	2x3	3x3	3x3
ET2a	Geohazards	4x3	4x3	4x4	4x4
ET2e	Landslips, slope stability, ground creep, avalanche	3x3	3x3	4x3	4x3
MO 4	Repeated Cycles of drought and rainfall	2x3	2x3	3x3	3x3
TCFD10b	Increased rate of loss of level in areas with already low depth of cover (e.g. Fenland area)	2x3	2x3	3x3	3x3

Additional Background to ARP3 Submission

Increasing temperatures will, without precipitation, lead to drying of the ground causing it to shrink and potentially be subject to greater erosion. 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 non-piled ground mounted structures.

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 may fail because of flexing, as demonstrated through increased water leaks from water sector pipes during dry periods. Extreme wet-dry and freeze-thaw ground movements will have a similar impact.

Water driven ground movement geohazard risks are generally associated with collapsible deposits, compressible ground, running sand, landslide, shrink-swell, soluble rocks and old mining areas. In these areas, ground deformation may lead to loss of foundation support or deformation of tower infrastructure. More significant or sudden deformation may also be related to events such as landslides, karst and undermining collapse.

Additional Discussion to ARP3 Submission

These risks are on the increase primarily due to changes in the water cycle driving higher than normal water table and near surface water levels. The increase in appearance of sinkholes and washouts demonstrates this risk is growing.

NGET have assessed its assets against the BGS's geohazard and the EA's flooding risks datasets to identify those assets in risk areas. We have developed weighted risk banding scores for all tower and cable joint bays to identify those assets in risk areas. This data is used to inform our maintenance and route refurbishment works.

It should be noted that this reflects the asset is in a risk area in most cases the assets foundations have been designed to cope with the sites geohazard conditions such as piled foundations for towers in marshland. The variance now to when assets were installed is the increased fluctuations of groundwater levels and near surface flow rates.

2050 Discussion

This risk is linked to any changes to the water cycle. The decade from 2012 to 2021 was on average 2% wetter than 1991 to 2020 and 10% wetter than 1961 to 1990 for the UK. Five of the ten wettest years in the UK series going back to 1836 have occurred since 2000: in order of wettest 2000, 2020, 2012, 2008 and 2014. Should this trend continue its likely that there may be increased instances of ground movement and destabilisation of foundations and supporting soils.

It is likely that serious intervention works will become more frequent in the future. Investments in managing erosion and geohazard will continue to increase year on year it is anticipated that any increased monitoring and maintenance costs will be funded.

2100 Discussion

There is a great deal of uncertainty as to what rainfall patterns may become the new norm towards the end of the century, we are already experiencing increased annual rainfall volumes. Whether this increased trend continues or perhaps changes to longer periods of increased rainfall interspersed with extended semi drought conditions. Either of these trends pose a potential increase of risks.

Groundwater

Code	Risk	ARP3	ARP4	2050	2100
ARG22	Groundwater flooding of below ground assets leading to water ingress to pipes	2x2	2x2	2x2	2x2

Additional Background to ARP3 Submission

The Skewen flooding of 2021 demonstrated the increasing risk posed by high water table levels flooding old mineworks and bringing the water to the surface in unexpected area.

This risk is heavily linked with contaminated ground risks.

Additional Discussion to ARP3 Submission

While this is an emerging risk which may increase in the future there is currently insufficient evidence to support an increase in our risk score.

NGET have included groundwater risk as part of the sites flood risk assessments. Until there is a methodology of tying the thousands of old disused mine works (many of which there is only limited data available such as shaft location) with associated groundwater levels which may offer potential paths to the surface it is difficult to fully assess this risk. In some respects, treating the mine head as a reservoir breach point and using a lidar terrain model to understand potential flow path may be possible. However, there is uncertainty about who owns and has responsibilities of mapping this risk.

2050 Discussion

If we see changes to rainfall patterns driving much higher groundwater levels, this risk may increase.

2100 Discussion

As with contaminated ground risk there is a great deal of uncertainty as to what rainfall patterns may become the new norm towards the end of the century, we are already experiencing increased annual rainfall volumes. Whether this increased trend continues driving very high ground water levels or perhaps changes to longer periods of increased rainfall interspersed with extended semi drought conditions.

Interdependencies

Code	Risk	ARP3	ARP4	2050	2100
ARG17	Supply chain impacts	2x2	2x2	2x2	3x2
AR13	Substations affected by water flood wave from dam burst	3x3	3x3	3x3	3x3
ARG13	Vulnerability of critical IT systems managed by third parties from extreme weather events	2x2	2x2	2x2	2x2
ET8d	Reservoir / Canal Failure	3x3	3x3	3x3	3x3

Additional Background to ARP3 Submission

Engineered structures such as canals and dams can hold significant amounts of water. Potential structural failure, in combination with water volume and stored energy presents a risk of widespread flooding in downstream areas. Less significant structural failures, requiring the release of water to alleviate stresses, may also lead to localised flooding.

Undertakers are the legal operators or owners of a reservoir and have ultimate responsibility for its safety

The Environment Agency and Natural Resources Wales manages and enforces reservoir safety regulation in England and Wales. All large, raised reservoirs (greater than 25,000 cubic meters of water) with the Environment Agency.

Reservoirs below 25,000 m3 are inspected in accordance with the Health and Safety (Enforcing Authority) Regulations 1998 providing a work undertaking exists which means many of the smaller reservoirs will be inspected by HSE. Mine lagoons do not fall within the Reservoirs Act 1975 but are dealt with by HSE under the Mines and Quarries (Tips) Act. Lagoons associated with quarries are now covered by the Quarries Regulations 1999.

The Canal and River Trust is the charity responsible for maintaining the navigability and safety of canals waterways in England and Wales.

Additional Discussion to ARP3 Submission

Strict enforcement of the regulations is critical in ensuring our sites and assets are not impacted by the failure of third-party infrastructure. This also applies to sites and assets protected by off-site non-NGET flood and coastal defences such as the Thames Barrier.

Most of the UK's canal system is now over 200 years old fortunately canal failures are rare but still occur the volume of water can vary greatly dependant on the distance between locks where our sites and assets are in the flow paths of any breaches damage to assets and scour of ground can occur. Unlike a reservoir breach which will have an established flow path a canal breach location, the volume and speed of discharge and the flow path variables make identifying at risk sites and assets extremely difficult. There are linkages with the groundwater and ground movement risk sections.

NGETs transmission system is heavily interdependent on other industries and networks. If these networks are not equally resilient or adapted to climate change, this could undermine the effectiveness

of National Grid's own adaptation investments, leading to inefficiencies or failures in the broader electricity supply system.

A clear example where differing resilience standards may put a strain on NGET's resilience is generation not being subject to ensuring their sites are as resilient to flooding risk as the transmission and distribution networks. This discrepancy often necessitates construction in flood-prone areas. While customers installing these generation sites may not prioritize long-term impacts, focusing instead on a typical 25-year operational period, NGET must account for these risks when protecting our sites. Our commitment to ensuring a 1,000-year resilience requires us to consider the long-term durability and reliability of these systems, even when our partners may not.

This is why we are committed to ensuring that our innovation projects involve those parties who are required to ensure that implementation of project outcomes are a success.

Mitigation Actions:

- Industry collaboration through innovation projects
- Maintaining working groups in the lead up to key reporting periods (e.g. ARP)

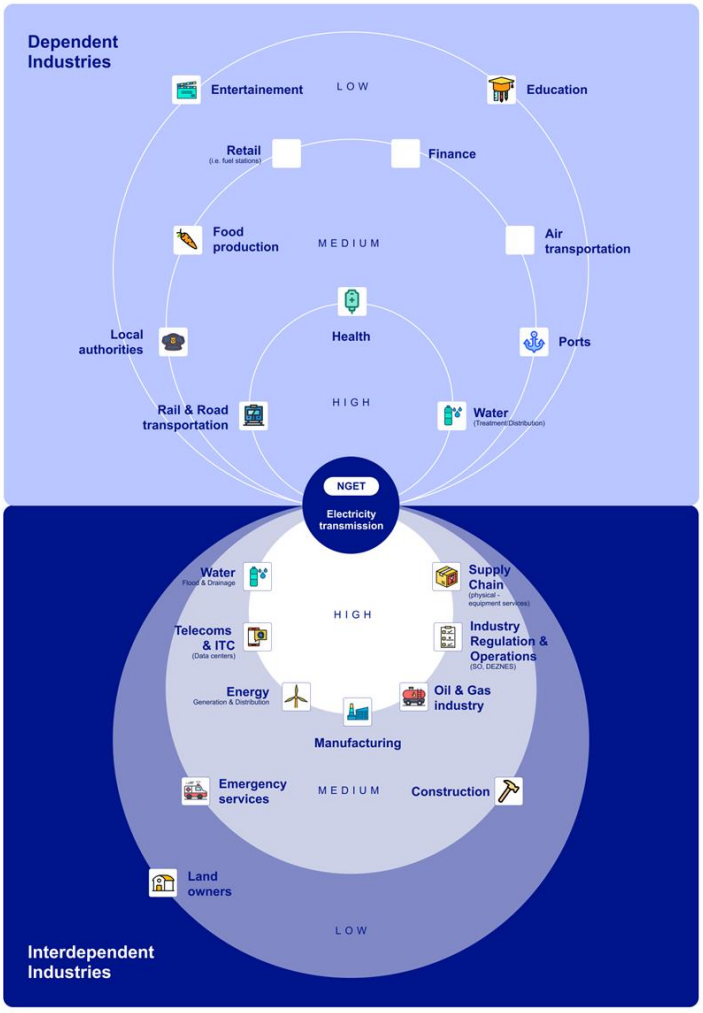


Figure 8 National Grid Electricity Transmission Interdependencies

2050 Discussion

As a large proportion of the UK's reservoirs will then be 100 years old it is critical that strict enforcement of the regulations be maintained.

2100 Discussion

The linkages between changes in the water cycle and rainfall patterns may greatly increase this risk potential in the future.

Lightning

Code	Risk	ARP3	ARP4	2050	2100
AR14	Overhead lines and transformers affected by increasing lightning activity	2x3	2x3	3x3	3x3

Additional Background to ARP3 Submission

The potential for climate change driven warmer wetter periods to increase the frequency, intensity and duration of lightning storms is likely to continue to increase.

Increased storm frequency can lead to increased lightning strike frequency. Where lightning strikes exposed substation plants or, more likely, overhead line assets, the resulting surge will cause circuits to trip under fault condition. Delayed auto reclose or 'DAR's is the mechanism through which a circuit is automatically re-energised following a severe weather event like a lightning strike.

Additional Discussion to ARP3 Submission

If these DARs are unavailable, this raises the risk of a circuit not re-energising. By making available the relevant data sets through our insights hub we have identified high resilience risk DARs and prioritise maintenance schedules.

It is likely that if we experience an increase of the frequency, intensity and duration of lightning storms this may lead to placing an increased maintenance and operational burden on NGET. We are undertaking a study with Bath University into the potential impacts of increased lightning storms and associated strikes may pose to the system.

2050 Discussion

This risk is linked closely with the raised temperatures and compound events risk sections and the reason we foresee a potential increase in impacts from this risk.

2100 Discussion

This risk is linked closely with the raised temperatures and compound events risk sections and the reason we foresee a potential increase in impacts from this risk.

Low Temperatures

Code	Risk	ARP3	ARP4	2050	2100
ARG6a	Above and below ground assets affected by lower temperatures	2x2	2x2	2x2	2x2

Additional Background to ARP3 Submission

Assets are designed to be operated anywhere in the world and so short spells of cold weather in the UK are not considered a significant issue.

Additional Discussion to ARP3 Submission

On above ground assets, ice loading on OHL can prove a particular problem this is discussed in the compound events section.

Extended periods of low temperature with low wind may present the NESO generation challenges.

2050 Discussion

It is likely this risk will reduce.

2100 Discussion

It is likely this risk will reduce.

Pluvial Flooding

Code	Risk	ARP3	ARP4	2050	2100
AR11	Substations affected by pluvial (flash) flooding due to increased rainstorms in Summer and Winter	4x3	4x3	4x3	4x3
ARG11	Ground contamination and transport of materials from flooding of contaminated sites	2x2	2x2	3x2	3x2
MO 1	Increased intensity of short duration rainfall leading to flooding	4x3	4x3	4x3	4x3

Additional Background to ARP3 Submission

NGET has invested in a systematic programme of resilience against flooding risks for over 15 years in alignment with industry led responses to significant events.

Additional Discussion to ARP3 Submission

Prompted by the 2007 summer floods, the Energy Networks Association led an energy sector response to flooding risks to power supplies. The following year was published an Engineering Technical Report ETR138, setting out flooding resilience standards for distribution and transmission substations.

Based on this industry and regulatory combined report, NGET then published our flood defence policy statement; outlining sites at risk of flooding and enabling a scheme to protect those sites. This assessment allowed us to pinpoint £129m of investment in flood defences at 49 substations during RIIO-1 with a further £20m committed in RIIO-2 to complete work on 130 in scope sites.

As at summer 2024, a total of 94 sites are protected from flooding, including sites which are protected by third party defences and those sites where demountable defences are the current flood protection in place. A further 21 sites are in progress, 15 sites are under investigation to establish risks, and 7 sites are on hold because the site is either being refurbished or the site is planned to be decommissioned. If all sites still under investigation require defences, we will then have invested in the total 130 sites in our original assessment.

Moving into T3, flood defences are no longer a retroactive exercise. Where new sites are being built and extensions being sought across our business plan, resilience is inherent by design.

2050 Discussion

As with other forms of flooding regular reviews of the risks will be required to ensure any changes to site risks though changes to EA data is crucial to ensuring ongoing resilience to flooding risks is maintained. A complete review of site flooding risks is planned for during what would be regulatory period RIIO T5 (2036). It is envisaged on going funding requirements to satisfy ETR 138 be available.

2100 Discussion

It is envisaged the existing controls around flood resilience will ensure that this risk is managed effectively.

Policy & Procedure

Code	Risk	ARP3	ARP4	2050	2100
ARG1	Lack of climate change management procedure	2x2	2x2	3x2	3x2
ARG2	Lack of specific policies and procedures governing risk assessment process on climate change	3x2	3x2	3x3	3x3
ARG3	Risk and action owners not identified at senior leadership team level	2x2	2x2	2x2	2x2

Additional Background to ARP3 Submission

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 attributed to damage or reduced operation of an asset.

The traditional development or evolution of the Energy sector could be viewed as being one of a reactive pathway to resilience this can be demonstrated through the implementation of a Transmission and Distribution flood resilience standard in response to the flooding events of 2007 and the subsequent Pitt review.

This reactive pathway may not be the optimal option for managing the risks posed by climate change into the medium to long-term

Additional Discussion to ARP3 Submission

National Grid continues to manage our climate change adaptation risks via our corporate risk register which drives business risk management. Within NGET, the risk is currently owned by the Head of Network Operations and Intelligence and at a group level the Chief Risk Officer - Strategic Engineering Director.

NGET continues to drive our commitments to ensuring current levels of system resilience to extreme weather conditions are managed, reviewed and lessons learned implemented via changes to our and industry policies and procedures.

Work is ongoing to ensure that a robust climate change adaptation strategy is in place and climate change resilience form an ongoing key part of NGET's regulatory period submissions.

We continue to undertake research into climate change impacts and adaption through innovation projects in coordination with our sector partners to ensure active coordination and dissemination of research and innovation findings. This research is to better understand any potential changes to system and asset design are thoroughly understood to ensure the optimal pathway for resilience is identified and undertaken.

Our regulatory submissions make use of a reopener option that should a weather hazard or unidentified resilience impact necessitate a rapid immediate response works and changes can proceed outside of the normal regulatory submissions.

Through our regular emergency planning exercises, we robustly test our resilience to climatic hazards. The scenarios of which these exercises take place are drawn from realistic weather extremes taking real events and amplifying them. In the future we are planning to make use of digital twin environments not only for exercise purposes

Long-term planning of what the resilience of the future energy system will be continues to be the challenge. Justifying additional significant investment based on modelled date which by its nature has a degree of uncertainty which may limit the appetite for major investments now for 50 years in the future.

The pace of climate change impacts on the business will therefore be kept under review. This is in addition to the prevailing regulatory expectations to determine whether a specific procedure would benefit the business.

Business Continuity Plans – Implementing ET BP118

At NGET we are committed to a robust level of business resilience to support the management of our physical network. This commitment is enshrined in our Incident Management Framework [Business Procedure (BP) 118], specifying our initial response and recovery from incidents on our network. Under this framework falls our Extreme Weather Business Continuity Plan which sets out how our control centre will manage risks associated with extreme weather events.

These procedures in isolation do not guarantee the resilience of our network and is why we continue to invest in adoption measures that enshrine these procedures in day to day operations.

We continually exercise was part of our ongoing adherence to the ET BP 118 Incidence Management Procedure. By carrying out a real-life simulation of an extreme weather event we were able to demonstrate the preparedness of our business in light of increasing weather related incidents due to climate change. The exercise focused on a scenario of strong wind and rain, giving managers a certain amount of warning to prepare and put in place mitigation measures. Throughout the remainder of T2 we will continue to expand our programme of simulations to other regions.

2050 Discussion

It is envisaged that we will continue to effectively manage test and refine our policies and procedure working closely with our partners and stakeholders to implement any changes the increase in risk reflects the uncertainty around how resilience is measured and if any increased resilience requirements are required to be implemented.

2100 Discussion

There is a great deal of uncertainty of what the energy system will look like in 76 years.

Raised Temperatures

Code	Risk	ARP3	ARP4	2050	2100
AR1	Overhead line conductors affected by temperature rise.	3x3	3x3	3x4	4x4
AR4	Underground cable systems affected by increase in ground temperature,	2x3	2x3	3x3	3x3
AR6	Substation and network earthing systems adversely affected by Summer drought conditions	1x3	1x3	2x3	2x3
AR7	Transformers affected by temperature rise	3x3	3x3	3x4	4x4
AR8	Transformers affected by urban heat islands and coincident air conditioning demand	3x3	3x3	4x4	4x4
AR9	Switchgear affected by temperature rise	3x3	3x3	3x4	4x4
TCFD10	Demand growth in Summer due to increased cooling load	3x3	3x3	4x4	4x4

Additional Background to ARP3 Submission

The summer of 2022 was highlighted by the Met Office as what could be expected for a ‘normal’ 2050 summer.

Additional Discussion to ARP3 Submission

Rising ambient temperatures and wildfire are an increasingly prevalent risk to the network – the heatwave of 2022 demonstrated that we are currently resilient to such risk

The Met Office issued 'Red' Extreme Heat warnings on Monday 18th and Tuesday 19th July 2022, and in response the UK Government declared a National Emergency, recognising the risk of the heat impacting lives, property and infrastructure. The highest temperature recorded was 31.5°C with several wildfire outbreaks causing extreme stress to the network.

We prepared as per our business continuity plans:

A collaborative incident response with NESO ensured that overall system resilience was maintained. Engagement with the DNOs through emergency co-ordination calls the Northern Eastern Western and Southern Area Consortium (NEWSAC) provided visibility of wider local issues impacting consumer's supply. Critical circuits were identified and inspected by our OHL teams to identify any enhanced fire risks.

Risks to Operational staff were also recognised. Guidance was provided to staff alongside the delivery of situational risk assessments were delivered to highlight any additional controls required (timing of activities, hydration and additional rest periods). We assessed OHL thermal ratings against expected ambient temperatures

Impact to Our Network:

Overall, our network was resilient to the impacts of the extreme temperatures but was put under extreme stress. High ambient temperatures adversely impacted the performance of our supporting air systems, batteries and cooling systems. In particular, the TNCC building required water hose cooling of condensers on the roof to maintain safe temperatures.

Multiple circuits were switched out of service to protect the safety of firefighters as they managed significant fires, particularly in London - reducing the overall resilience of the network. We also recorded 10 wildfires in the vicinity of our overhead with impacts to circuits and DAR, and 3 reactors switched out due to heat.

While we expect ground movements due to excessive drying out during drought periods the associated hazards are viewed as longer term hazards and risk impacting levels of maintenance and repair.

Project Name: Electricity Transmission Heat Effects, Resilience Measures to Manage Asset Lifecycles (THERMAL) Project

Climate Hazard: Extreme Temperature Events – Absolute Temperature, Temperature Changes, Temperature Transients

Opportunity Addressed: At present there is not a clearly defined, tested and validated approach to gain a comprehensive understanding of how extreme temperature events can influence failure modes and overall performance of various HV assets. In addition, climate hazards are often assessed in isolation when in fact they have the potential to occur at the same time, raising the risk of cascade failures to an exposed network. Whilst there has been modelling development to quantify component (mainly Lines and Cables) ageing due to temporary heating (from loading mainly), the analyses do not extend to rapid weather changes with simultaneous loading fluctuations.

Project Outcome: this tool will allow us to simulate extreme weather events and the impact that they may have on our network. The project will run till 2025 and produce a model that could test 'what if' worst case scenarios, quantify risk and help identify the most resilient technologies. In turn we will be able to use this data-first approach to inform future investment strategies, business continuity plans and our evolving climate adaptation strategy.

Timeline: March 2024 – September 2025

Climate Resilience Benefits:

Improve understanding of extreme weather impact to our network

Increase data availability to model future scenarios.

2050 Discussion

This risk is perhaps one with the largest uncertainties in what the future may bring while we expect that existing levels of resilience will be maintained through natural evolution of the energy system. However, we believe there will potentially be a need for increased investment to maintain the current levels of system resilience.

Any requirements to increase resilience levels above current levels will require thorough investigations.

The increase in the risk score reflects the uncertainty of what the future risks may bring as ambient temperature does not easily transpose to asset operating temperatures added to this is the high degree of uncertainty around the regionalisation of risk as well as what the future energy system configuration may be.

2100 Discussion

The high level of uncertainty of how increased ambient temperatures may manifest into extremes is the reason we show an increase in risk score.

Sea Level Rise & Coastal Change

Code	Risk	ARP3	ARP4	2050	2100
AR12	Substations affected by sea flooding due to increased rainstorms and/or tidal surges	3x3	3x3	4x3	4x3
ARG21	Saline contamination and increased corrosion rate of above and below ground assets from sea water or atmospheric salt	3x2	3x2	3x3	4x3
ET2b	Coastal Management Policy	3x4	3x4	4x4	4x4
ET8e	Flooding from Storm Surges	3x4	3x4	4x4	4x4

Additional Background to ARP3 Submission

In 2012 NGET implemented an investment plan to protect all flooding risk sites in line with industry standard Engineering Technical Report 138 (ETR 138) which tasks Transmission and Distribution networks with ensuring its existing and new sites be flood resilient against fluvial and tidal flooding. Following the availability of surface water risk data this report was updated to include surface water risks.

Flooding remains one of our highest priority risks which is reflected in the focus works undertaken and controls put in place to manage this risk.

The nature of flooding risk is essentially a constant moving target of review and reassessment by the Environment Agency. To efficiently manage sea level, rise our resilience allows for existing sites this is climate change allowances out to 2050, and for new sites this is typically 50+ years however we would seek to locate new sites away from sea level risk and coastal flooding risk areas.

The management of flooding risks to sites is written into our core business policies and procedures. And adherence to ETR 138 a recognised energy sector standard.

Additional Discussion to ARP3 Submission

NGET a research and innovation project to understand the long-term risks posed to coastal and estuary assets. Many medium and long-term shoreline management plans entail the creation of salt marsh habitats some of our tower routes run through or are close to these areas this together with increased coastal storm activity are likely to lead to increased saline pollution and this reaching further inland.

Project Name: Investigating Coastal and Estuarine Climate Risks on Electricity Asset Management (ICECREAM)

Climate Hazard: Coastal Erosion

Opportunity Addressed: Erosion and chemical reactions on network assets can cause failure in transmission towers, collapse or inaccessibility. In addition, shoreline management plans and coastal management strategies will be implemented, causing some coastal areas to change in ways that make it impractical or impossible to keep infrastructure in those locations over the next several decades.

Project Outcome: This project aims to assess how different conditions and risks such as higher sea levels, coastal storms and increase in salt deposition is damaging assets such as towers. ICECREAM will implement new cameras and sensors, gathering real-time data to develop national-scale, multi-hazard assessment of the risks posed by flooding and erosion to transmission assets. The initial scope of the project will include 6 proof of concept sites in coastal areas around England and Wales (initial phases being implemented in Liverpool).

As well as the proof-of-concept monitoring sites there will be a full list of sites within shoreline management plan areas with the current and future risk associated with the plans.

The monitoring sites include the installation of saline pollution sensors, mini weather stations, water level gauge (similar to those installed for fluvial flood risk monitoring) and cameras for still images.

Timeline: July 2024 – Jan 2026

CRS Benefits:

- Improve our understanding of the impact of coastal erosion on our network
- Increase data availability to monitor asset health and identify critical risk moments with real-time alerts
- Enable cost benefit analysis and mitigation measures to maintain network resilience

The outputs from ICECREAM will be used in RIIO T3 to identify sites at future risk and inform early consultation on what contingency measures will be most appropriate.

2050 Discussion

Changes to the UK's shoreline management plans will dictate implications of sea level rise impacts. Long term site strategies will have to be agreed with Ofgem. There is some evidence that sea level rise is accelerating if this trend continues and in conjunction with an increase in storm activity both coastal erosion rates and the requirement to increase coastal flooding protection may increase.

2100 Discussion

The rise in risk reflects the uncertainty around what potential changes may occur in coastal management plans the potential rate of sea level rise.

Snow & Ice

Code	Risk	ARP3	ARP4	2050	2100
ET7	Snow & Ice; Severity, intensity and frequency of storms	2x2	2x2	2x3	2x3

Additional Background to ARP3 Submission

While average yearly temperatures are forecasted to rise the ENA Met Office Report details how snow and ice will generally be confined to elevated and northern areas. However, it has been suggested that as these events reduce, there may be an intervening period or greater incidence of 'wet snow' and rapid freezing, which due to its greater mass and potential to freeze may present its own challenges. However, it is anticipated that existing risk management and resilience frameworks should be sufficient to manage any impacts.

Additional Discussion to ARP3 Submission

As the occurrence of significant snow events reduces the ability of the country's to 'cope' may mean a reduction in resilience this is discussed further in interdependencies.

The demand for energy and availability of certain types of renewables such as solar panels covered in snow is viewed as a NESO risk.

2050 Discussion

As major snow events reduce and become rarer the impacts may become amplified. This uncertainty is reflected in our potential increase in the risk score

2100 Discussion

Solar Storms

Code	Risk	ARP3	ARP4	2050	2100
MO15	Solar Storm	1x2	1x2	1x2	1x2

Additional Background to ARP3 Submission

The impact of solar storms falls into two categories: asset damage, and damage to telecommunications, resulting in health and safety considerations and loss of control of technology. Variations in the geomagnetic field, caused by space weather, induce an electric field in the surface of the Earth. This electric field, in turn, induces electrical currents in the power grid, which can cause power transmission network instabilities and transformer burn out.

Although not a climate issue, solar storms this was requested to be included in ARP3.

Additional Discussion to ARP3 Submission

The risks associated with monitoring, cascading risk information and cancelling of alerts is carried out by the NESO. NGET's role is one of support and ensuring that our part of the network is available should any response to an incident be required.

2050 Discussion

It is not anticipated the risk from solar storms will increase their may be some climate change risk in the form of compounded risk where a major solar storm occurs with another major system incident.

2100 Discussion

It is not anticipated the risk from solar storms will increase their may be some climate change risk in the form of compounded risk where a major solar storm occurs with another major system incident.

Storms

Code	Risk	ARP3	ARP4	2050	2100
ET6	Severity, Intensity and Frequency of Storms	2x3	2x3	3x3	3x3
MO11	Temperature / Precipitation: Warm, wetter conditions combined with rainfall and / or wind	3x3	3x3	3x4	3x4

Additional Background to ARP3 Submission

Emergency Planning Managers' Forum (EPMF) is an ENA led group which focuses on resilience and emergency planning initiatives across GB network operators and ESO. NGET actively partake in EPMF forums to discuss both steady state and abnormal operating procedures and we have refined our severe weather trigger levels based on EPMF discussions. The EPMF forum shares lessons learnt from significant storm events and works to identify best practice operating models. NGET have run feedback sessions with the EPMF to discuss outcomes from Storm Ciaran across our network which focused on the impact of loss of site supplies and building damage / debris.

The EPMF includes escalation and trigger levels for storm events and share vulnerabilities or significant impacts. One of the key features of EPMF is to ensures that TO's, DNO's and NESO are aligned in their understanding and processes associated with Emergency Demand Disconnection which may be required during significant storms and asset failures.

The EPMF also coordinates participation in severe weather events which are run across industry participants, inclusive of extreme weather.

The NEWSAC agreement details the application and co-ordination of mutual aid between network operators in the United Kingdom, Ireland and the Isle of Man during and after network electricity supply emergencies, for example major storms. Mutual aid includes the transfer of field resources and supplies between network operators in the United Kingdom, Ireland, The Isle of Man and Jersey. During the T2 Period, NGET did not make any requests for Mutual Aid via NEWSAC. We have supported DNO Operators through the NEWSAC period, most notably during Storm Arwen. NGET are an active participant to all NEWSAC escalations both in the development of the NEWSAC arrangements and actively participating in all Emergency NEWSAC escalations.

Additional Discussion to ARP3 Submission

There were 11 named storms over the winter of 2023-24. During each one, our network showed robust levels of resilience to the weather conditions including strong winds and flooding. We did not suffer any loss of supply during this period and attribute that to the preparedness of our teams and assets.

Storm Ciaran

The Met Office issued multiple amber weather alerts for high windspeed for the South East and South West, for Storm Ciaran – in force from 3am, Thursday 2nd November 2023. Wind gust speeds between 70 and 80mph were experienced on the South Coast, creating widespread disruption.

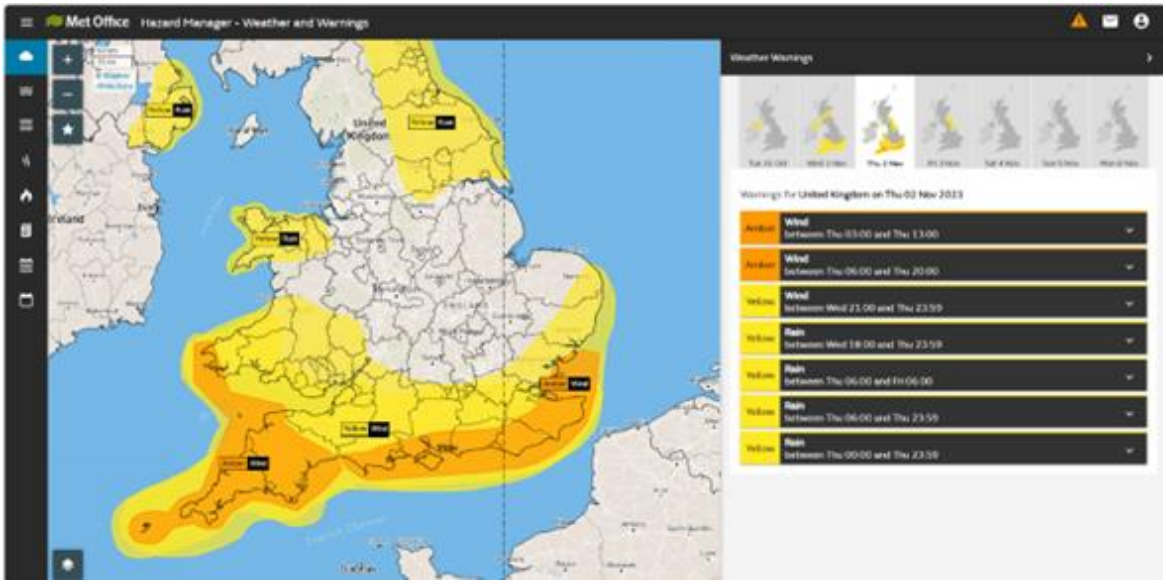


Figure 9. Hazard Manager Storm Ciaran

We prepared as per our Business Continuity Plans:

- TNCC resources were strengthened
- AO standby rotas were reviewed and found to be sufficient
- The outage scheduled was reviewed with no significant site-specific risks identified
- Diesel generators were topped up across all available sites
- Flood defences were reviewed and confirmed in good working order
- Building conditions were assessed, some cladding concerns identified were monitored

Impact to our Network:

Although consumers experienced significant impacts from interruptions to DNO supplies of electricity, NGET experienced no significant power outages. Demand was lost to power station supplies at Dungeness, placing the site on temporary diesel generation. However, supplies to Dungeness were subsequently restored through Business Continuity Management processes.

During Storm Ciaran there was a 36% increase in alarms received into the TNCC from 2685 to 3644. Of those, 90 were recorded in our Safe Grid system which provides a record of those alarms requiring a call out or follow up action. Overall, this increase is within tolerance of our severe weather plan and the types of alarms recorded in Safe Grid were within those categories that we would expect during severe weather.

In summary there were:

- 27 'Supply Abnormal' – due to the failure in supply from DNO, which we back up with diesel generators
- 12 'Security Alarms' – due to electric fences being hit by debris
- 12 'Trip Alarms' – caused by primary equipment switching out of service, due to the high winds. DARs then restored the equipment automatically as intended.

It is expected that storm activity will both increase in frequency and intensity into the future lessons learnt will continue to form a key factor in ensuring the energy sector continues to manage the risks posed to the system.

2050 Discussion

As the likelihood of storm activity is expected to continue, increasing the possibility of significant events occurring consecutively blurring into compound and/or continuous events - amplifying the impacts and impairing any recovery. The levels of uncertainty around this are reflected in our increase in the risk score.

This risk is most closely tied with the compound events risk.

2100 Discussion

The levels of uncertainty around this are reflected in our increase in the risk score. This risk is most closely tied with the compound events risk

Temperature Cycles

Code	Risk	ARP3	ARP4	2050	2100
MO14	Diurnal Temperature Range	3x3	3x3	4x3	4x3
TCFD12	Fast Freeze-thaw cycles	3x3	3x3	4x3	4x3

Additional Background to ARP3 Submission

Rapid fluctuations in ambient temperatures have the potential to induce material stress in assets. Although temperatures are generally rising with climate change, evidence suggests that short term temperature fluctuations are increasing.

On the 28th of February 2024 Wisconsin in the US experienced a swing of almost 33^{0}C in just 24 hours

Additional Discussion to ARP3 Submission

There is the potential for additional stresses to be placed on materials as temperatures swing between very cold to very warm over relatively short time periods.

The uncertainty around how this will manifest in the UK in the future is why we consider this to be a medium risk.

2050 Discussion

Based on the level of uncertainty this has the potential to be one of the unknown future risks. The stresses of swings may cause to assets is one element the other is one around what this could mean to the daily demand for energy during a significant drop in temperatures from a very warm day to freezing during the night.

2100 Discussion

This is very much an unknown and why we consider this to be a medium risk.

Vegetation Growth

Code	Risk	ARP3	ARP4	2050	2100
AR3	Overhead lines affected by interference from vegetation due to prolonged growing season	1x2	1x2	1x2	1x2

Additional Background to ARP3 Submission

Extended growing periods together with warmer wetter conditions promoting increased vegetation growth are likely to lead to increased vegetation management requirements.

Additional Discussion to ARP3 Submission

Our Asset Operations Business Procedure ‘Management of Vegetation in OHL’ sets out the requirements that we adhere to in order to effectively manage vegetation growth around our overhead lines. Effective vegetation management reduces the risk posed by both severe winds during storms and wildfires

As the result of efficiencies gained by cutting more vegetation whilst our contractors are on site and replacing fast growing trees with fencing where appropriate NGET has so far managed this risk effectively. Although this approach increases cost per span, overall, it drives a more efficient annual spend to achieve the desired outcome. It is likely that vegetation growth management workloads and costs will increase in the future therefore effective management may be subject to increased maintenance funding.

2050 Discussion

We envisage this risk to continue to be effectively managed through our maintenance procedure.

2100 Discussion

We envisage this risk to continue to be effectively managed through our maintenance procedure.

Wildfire

Code	Risk	ARP3	ARP4	2050	2100
AR15	Wildfires	2x2	2x2	2x2	2x3
ARG16	Wildlife impacts	1x2	1x2	2x2	2x3

Additional Background to ARP3 Submission

The summer of 2022 highlighted the increasing trend of wildfires in the UK. Multiple circuits were switched out of service to protect the safety of firefighters as they managed significant fires, particularly in London - reducing the overall resilience of the network.

Additional Discussion to ARP3 Submission

Following the wildfires of 2022 NGET undertook a research project with Birmingham University with the aims of identifying which of our sites and assets are in areas more prone to wildfires. This work took wildfire location data for the period 2000 to 2021, land usage (arable, woodland, Urban etc.) and mapped it against our asset's locations. The data showed none of these fires were started by NGET assets.

The risks posed to our assets directly from the fire is low however the circuits generally have to be switched out while the fires are brought under control and extinguished to ensure the safety of those fighting the fire. The individual wildfire incident in isolation is unlikely to have a major impact on the system however the cumulative effect of multiple may pose some security of supply issues.

Along with our National Grid American colleagues we have developed a Wildfire Crisis Playbook. This document forms part of the Incident Response Framework within NGET and is written into incident response procedures.

2050 Discussion

This risk is linked closely with the raised temperatures, vegetation growth and compound events risk sections and the reason we foresee a potential increase in impacts from this risk.

2100 Discussion

This risk is linked closely with the raised temperatures, vegetation growth and compound events risk sections and the reason we foresee a potential increase in impacts from this risk.

1. ARP4 Discussion

As stated, there are no risks from ARP3 which have increased for the ARP4 assessment. ARP 4 Reflects the present and near future risks as defined by DEFRA's guidance (to 2030).

The knowledge and understanding of the risks has expanded, demonstrating the increasing focus NGET is investing in understanding and managing climate change resilience risks. There has been advancement into understanding the risks and gaps in knowledge and understanding reflected in the additional background and discussion narrative for each risk grouping.

NGET continues to focus on all high and medium risks and reflected in the current and future research and innovation works. The increasing awareness of climate change risks and hazards continues to highlight the importance of understanding how hazards interact into compound events with potential amplification of individual hazards.

We continue to manage our current climatic risks effectively as part of our risk management process, we have assigned key controls to manage both our climate change mitigation and adaptation risks.

The controls for our climate change mitigation GPR are in line with our strategy and regulatory frameworks and are also reflected throughout other relevant risks, for example: regulatory outcomes;

political and societal expectations; and significant disruption of energy. The key overarching mitigation controls involve tracking progress against targets, identifying changes that could trigger additional transition risks, and implementing procedures and proposed solutions to overcome them.

Our key climate change adaptation controls include the following:

Fit for Future of Electricity Strategy: A corporate strategy that considers the steps to ensure our business remains resilient in the future, such as enhancing design standards, and investments on asset hardening and flood protection.

Engineers Governance forums: Group Chief Risk Officer and engineering duty holders sharing guidance and data on key topics such as resilience.

Resilience and Asset Management Business Management Standard (BMS): Sets out minimum requirements and a framework for resilience capability and managing asset risk to ensure each business unit is prepared for the next disruptive event.

Establishment of the Business Resilience and Crisis Management organisation: Reporting to the Group Chief Risk Officer and Group Legal, this team is focused on building resilience to all threats and hazards. This includes the development of crisis management and business continuity plans, training, and exercises to help align and coordinate our response to severe weather and other crisis events; but is also leveraging innovative technologies to improve our intelligence, looking strategically at evolving risks associated with climate change. We are also expanding our network of external stakeholders to identify and leverage industry thought leadership and play an active role in shaping new policies and regulations.

We continue to work closely with our partners and stakeholders in deepening and expanding not just our own but also the energy sectors effective management of climate change risks.

2. ARP4 Conclusion

NGET views the current climate change risks as being effectively managed through our internal risk management procedures and externally through maintaining our world-class levels of safety and maintain our service reliability of 99.9999%.

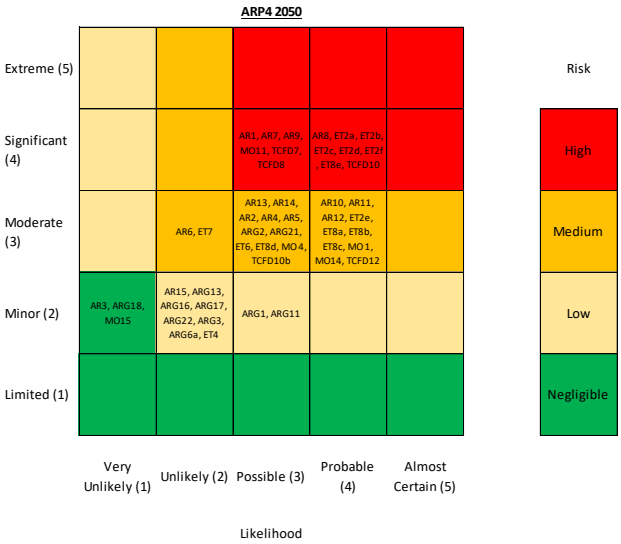
We recognise that in some ways adapting to climate change driven weather hazards is very much a moving target with great uncertainty into what the future may hold for the energy sectors climatic hazards resilience. It is important to recognise that the current energy sector transmission network is highly resilient to climate hazards. The current levels of resilience have been developed through the natural evolution of the network and its responses to resilience challenges. We expect this evolution of network resilience to continue and ensure our network is resilient to climatic risks in the short term.

2050 Risk Assessment

Key Points for this Section:

- **The potential increase in frequency in extreme events presents an increased likelihood of impacts**
- **We continue to consider the use of RCP 8.5 appropriate for critical national infrastructure.**
- **It is critical that current levels of resilience be maintained and funded into the future.**
- **Any moves to increase levels of resilience will need to be thoroughly researched and agreed across the energy sector. It is anticipated that the new ENSO will play a significant role in developing any potential requirements to increase resilience levels.**
- **We welcome the moves towards developing any sector resilience standards and measuring metrics. This must be done through full engagement across each sector and coordinated across sectors.**

2050 Risk Matrix Confidence Level Medium



High Risks

Grouping	Code	Risk
Compound Events	TCFD7	Extreme weather events including a combination of wind, rainfall, temperature or snow
	TCFD8	Perfect Storm of a cold winter, high electricity demand and heavy persistent rain
Erosion	ET2c	Riverbank Stability and Scour
	ET2d	Groundwater & Geohazards
	ET2f	Surface Water Runoff Scour
Ground Movement	ET2a	Geohazards
Raised Temperatures	AR1	Overhead line conductors affected by temperature rise.
	AR7	Transformers affected by temperature rise
	AR8	Transformers affected by urban heat islands and coincident air conditioning demand
	AR9	Switchgear affected by temperature rise

	TCFD10	Demand growth in Summer due to increased cooling load
Sea Level Rise & Coastal Change	ET2b	Coastal Management Policy
	ET8e	Flooding from Storm Surges
Storms	MO11	Temperature / Precipitation: Warm, wetter conditions combined with rainfall and / or wind

Medium Risks

Grouping	Code	Risk
Fluvial Flooding	AR10	Substations affected by river flooding due to increased winter rainfall
	ET8a	Fluvial river and coastal flooding of NGET sites
	ET8b	Fluvial river and coastal flooding – neighbouring sites leaving NGET sites stranded
Fluvial Flooding	ET8c	Shifting flood areas may affect existing sites in the future
Ground Movement	AR2	Overhead line structures affected by summer drought and consequent ground movement
	AR5	Underground cable systems affected by summer drought and consequential ground movement,
	ET2e	Landslips, slope stability, ground creep, avalanche
	MO 4	Repeated Cycles of drought and rainfall
	TCFD10b	Increased rate of loss of level in areas with already low depth of cover (e.g. Fenland area)
Interdependencies	AR13	Substations affected by water flood wave from dam burst
	ET8d	Reservoir / Canal Failure
Lightning	AR14	Overhead lines and transformers affected by increasing lightning activity
Pluvial Flooding	AR11	Substations affected by pluvial (flash) flooding due to increased rainstorms in Summer and Winter
	MO 1	Increased intensity of short duration rainfall leading to flooding
Policy & Procedure	ARG2	Lack of specific policies and procedures governing risk assessment process on climate change
Raised Temperatures	AR4	Underground cable systems affected by increase in ground temperature,
	AR6	Substation and network earthing systems adversely affected by summer drought conditions
Sea Level Rise & Coastal Change	AR12	Substations affected by sea flooding due to increased rainstorms and/or tidal surges
	ARG21	Saline contamination and increased corrosion rate of above and below ground assets from sea water or atmospheric salt
Snow & Ice	ET7	Snow & Ice; Severity, intensity and frequency of storms
Storms	ET6	Severity, Intensity and Frequency of Storms
Temperature Cycles	MO14	Diurnal Temperature Range
	TCFD12	Fast Freeze-thaw cycles

2050 Discussion

We have based our 2050 assessment on RCP8.5 our reasoning is based on there being little separation between the mid-century projections. We consider that due to the criticality of the energy sector to nearly all aspects of modern life and society it be appropriate that RCP 8.5 be used as representing the most reasonably likely 'worst case'.

It is important to appreciate that the energy sector already has high levels of resilience to extreme weather events as well as proven process to review incidents and implement any necessary changes to policies and procedures such as the development of a target design standard for flood resilience and the lessons learned from storm Arwen.

We have assumed that the energy sector will continue to evolve and adapt to climatic changes and challenges through the adherence to, regular reviews of and ongoing development of appropriate resilience standards.

It is anticipated that any future investments to meet current resilience standards continue to be funded this can be referred to as increased investments to ensure the same levels of resilience currently in force be maintained in the future. This may be considered an essentially reactive pathway with proactive allowances such as the use of climate change projections when constructing flood defences.

Any requirement to increase the levels of resilience from current levels will need to be thoroughly researched and agreed across the energy sector. It is anticipated that the new ENSO will play a significant role in developing any potential requirements to increase resilience levels.

An important aspect of why we envisage the 2050 risks to be generally higher centres around the likely increase in the frequency of significant weather events together with the increased frequency of extreme events. Looking back just in the last 24 years clearly shows this increase in significant events.

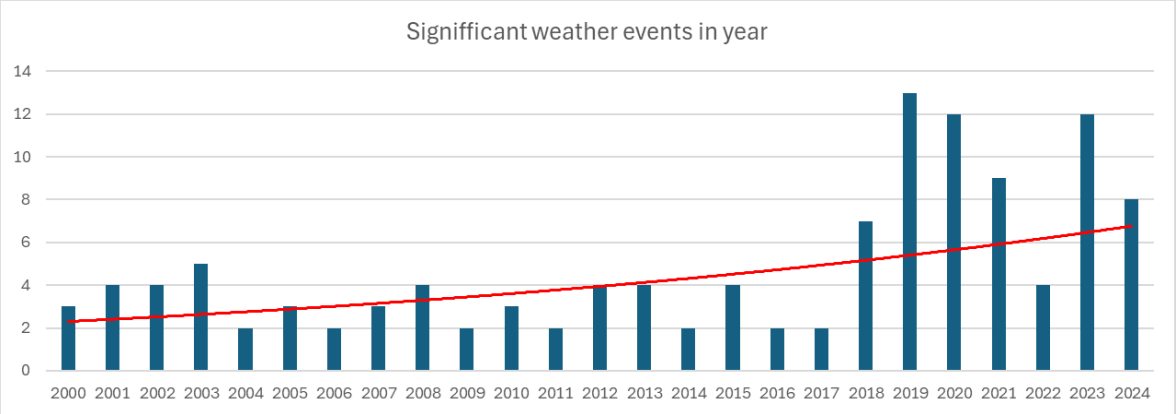


Figure 10. Significant Weather events per year

It is expected that this trend will continue. There is uncertainty as to whether the intensity of storms will increase however given the likely increased frequency the occurrence of higher intensity storms may become more likely.

It is considered that the as the frequency of extreme events increases the likelihood of compound events will increase resulting in overlapping of impact periods potentially amplifying any impacts and complications in recovery reducing resilience to following events.

Examples of this are discussed in the compound events section

- Very wet period followed by an extreme rainfall event such as storm systems or atmospheric river.
- Very wet snowstorm coinciding with a very sharp drop in temperature with high winds leading to increased ice accretion on conductors.
- Extended drought period leading to extremely dried out soils followed by intense periods of rainfall leading to increased run off and flash flooding.
- Extended drought period with very hot weather leading to increased wildfire outbreaks.
- Warm wet spring continuing into summer driving increased vegetation growth followed by an extended very hot period which dries out vegetation and increased fuel sources for wildfires.
- A major solar storm event coinciding with another severe weather event.

We show an increase in the risk score for snow and ice this is primarily because as this becomes rarer in a generally warmer climate, when they do happen society can experience the impacts to be worse. We do not envisage this to be a direct risk but one of accessibility and interdependencies.

2050 Conclusion

We continue to consider the use of RCP 8.5 appropriate for critical national infrastructure.

It is critical that current levels of resilience be maintained and funded into the future.

Any moves to increase levels of resilience will need to be thoroughly researched and agreed across the energy sector. It is anticipated that the new ENSO will play a significant role in developing any potential requirements to increase resilience levels.

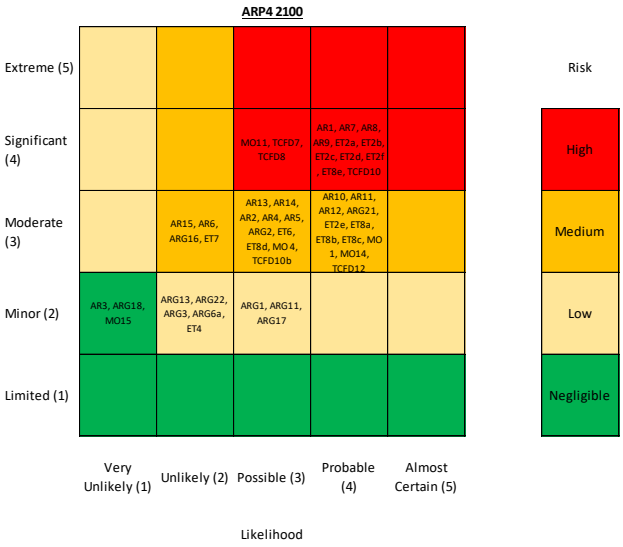
We welcome the moves towards developing any sector resilience standards and measuring metrics. This must be done through full engagement across the energy sector.

2100 Risk Assessment

Key Points for this Section:

- **Increase in risk score for some raised temperature risks**
    - **AR1 Overhead line conductors affected by temperature rise.**
    - **AR7 Transformers affected by temperature rise**
    - **AR9 Switchgear affected by temperature rise**
- **Increase in risk score from wildfires primarily linked to increase in raised temperatures generating the conditions for more wildfires more frequently.**
- **The potential increase in frequency in extreme events presents an increased likelihood of impacts**
- **We continue to consider the use of RCP 8.5 appropriate for critical national infrastructure.**
- **It is critical that current levels of resilience be maintained and funded into the future.**
- **Any moves to increase levels of resilience will need to be thoroughly researched and agreed across the energy sector. It is anticipated that the new ENSO will play a significant role in developing any potential requirements to increase resilience levels.**
- **We welcome the moves towards developing any sector resilience standards and measuring metrics. This must be done through full engagement across the energy sector.**

2100 Risk Matrix Confidence Level Low



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	ET8e	Flooding from Storm Surges
Storms	MO11	Temperature / Precipitation: Warm, wetter conditions combined with rainfall and / or wind

Medium Risks

Grouping	Code	Risk
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	ET8b	Fluvial river and coastal flooding – neighbouring sites leaving NGET sites stranded
	ET8c	Shifting flood areas may affect existing sites in the future
Ground Movement	AR2	Overhead line structures affected by summer drought and consequent ground movement
	AR5	Underground cable systems affected by summer drought and consequential ground movement,
	ET2e	Landslips, slope stability, ground creep, avalanche
	MO 4	Repeated Cycles of drought and rainfall
	TCFD10b	Increased rate of loss of level in areas with already low depth of cover (e.g. Fenland area)
Interdependencies	AR13	Substations affected by water flood wave from dam burst
	ET8d	Reservoir / Canal Failure
Lightning	AR14	Overhead lines and transformers affected by increasing lightning activity
Pluvial Flooding	AR11	Substations affected by pluvial (flash) flooding due to increased rainstorms in Summer and Winter
	MO 1	Increased intensity of short duration rainfall leading to flooding
Policy & Procedure	ARG2	Lack of specific policies and procedures governing risk assessment process on climate change
Raised Temperatures	AR4	Underground cable systems affected by increase in ground temperature,
	AR6	Substation and network earthing systems adversely affected by summer drought conditions
Sea Level Rise & Coastal Change	AR12	Substations affected by sea flooding due to increased rainstorms and/or tidal surges
	ARG21	Saline contamination and increased corrosion rate of above and below ground assets from sea water or atmospheric salt
Snow & Ice	ET7	Snow & Ice; Severity, intensity and frequency of storms

Storms	ET6	Severity, Intensity and Frequency of Storms
Temperature Cycles	MO14	Diurnal Temperature Range
	TCFD12	Fast Freeze-thaw cycles
Wildfire	AR15	Wildfires
	ARG16	Wildlife impacts

2100 Discussion

We have based our 2050 assessment on RCP8.5 our reasoning is based on the criticality of the energy sector to nearly all aspects of modern life and society it be appropriate that RCP 8.5 be used as representing the most reasonably likely 'worst case'.

As with our 2050 assessment we have assumed that the energy sector will continue to evolve and adapt to climatic changes and challenges through the adherence to, regular reviews of and ongoing development of appropriate resilience standards.

It is anticipated that any future investments to meet current resilience standards continue to be funded this can be referred to as increased investments to ensure the same levels of resilience currently in force be maintained in the future.

We have identified that even with ongoing adherence to a resilience standard there are two areas where we envisage the risks to increase without an increase in the resilience standards.

- Increase in risk score for some raised temperature risks
    - AR1 Overhead line conductors affected by temperature rise
    - AR7 Transformers affected by temperature rise
    - AR9 Switchgear affected by temperature rise
- Increase in risk score from wildfires primarily linked to increase in raised temperatures generating the conditions for more wildfires more frequently.
    - The risks posed to our assets directly from the fire is low however the circuits generally have to be switched out while the fires are brought under control and extinguished to ensure the safety of those fighting the fire.
    - The individual wildfire incident in isolation is unlikely to have a major impact on the system however the cumulative effect of multiple may pose some security of supply issues.

2100 Conclusion

Due to the high level of uncertainty in exactly how weather conditions may change due to climate change.

It is critical that current levels of resilience be maintained and funded into the future.

Any moves to increase levels of resilience will need to be thoroughly researched and agreed across the energy sector. It is anticipated that the new ENSO will play a significant role in developing any potential requirements to increase resilience levels.

We welcome the moves towards developing any sector resilience standards and measuring metrics. This must be done through full engagement across the energy sector.

Interdependencies and Collaboration

Key Points for this Section:

- **We will continue to work closely with our sector and wider partners to advance the knowledge and increase awareness of climate change adaptation.**
- **Collaboration is a key element of our CCAS.**

Energy Networks Association

Energy Networks Association (ENA) represents the owners and operators of licenses for the transmission and/or distribution of energy in the UK and Ireland. Our members control and maintain the critical national infrastructure that delivers these vital services into customers' homes and businesses.

ENA's overriding goals are to promote UK and Ireland energy networks ensuring our networks are the safest, most reliable, most efficient and sustainable in the world. We influence decision-makers on issues that are important to our members. These include:

- Regulation and the wider representation in UK, Ireland and the rest of Europe
- Cost-efficient engineering services and related businesses for the benefit of members
- Safety, health and environment across the gas and electricity industries
- The development and deployment of smart technology
- Innovation strategy, reporting and collaboration in GB

As the voice of the energy networks sector, ENA acts as a strategic focus and channel of communication for the industry[1]. We promote interests and good standing of the industry and provide a forum of discussion among company members.

Our members and associates

Membership of Energy Networks Association is open to all owners and operators of energy networks in the UK.

- Companies which operate smaller networks or are licence holders in the islands around the UK and Ireland can be associates of ENA too. This gives them access to the expertise and knowledge available through ENA.
- Companies and organisations with an interest in the UK transmission and distribution market are now able to directly benefit from the work of ENA through associate status.

ENA members

ENA associates

Chubu	Heathrow Airport
EEA	Jersey Electricity
Network Rail	
TEPCO	

Guernsey Electricity Ltd Manx Electricity Authority

Innovation

SIF and NIA funded Climate Resilience related innovation projects we are running throughout T2 and into T3 with a view to better understanding the impact that the climate will have on our network in the future. We are able to achieve this through the support of industry partners and access to the latest digital technologies.

Advancing our modelling capabilities to support climate resilience:

As part of our submission for T3 we are requesting investment funding to build upon our existing Power Systems analysis and modelling, and Building Information Modelling (BIM) basic capability to enable a more resilient network. Our ambition is to combine more advanced tools like digital twins and AI to derive accurate forecasting, real time data insights and model climate impacts on the network.

This in turn will enable us to:

- target climate risks that are less understood in terms of their impact to the network
- evidence ongoing cost benefit analyses for investment in climate resilience
- understand the effect of high impact, low probability events on our network

External Engagement

We maintain regular engagements with external stakeholders, including the Climate Change Committee (CCC), Energy Emergencies Executive Committee (E3C), and the Environmental Agency. These interactions with our industry partners play a crucial role in shaping our understanding of future climate risks, increasing awareness of climate change-related legislation, and comprehending the intersectionality of climate change impacts.

As a TO operating in the UK, NGET collaborates with the ENA to produce its ARP report. In this way, we are able to provide an assessment of climate risk that uses consistent metrics accepted by other industry partners. Through the ENA we have also been able to collaborate with the Met Office who produced an updated assessment of the UKCP18 in 2021 and provided assurance in available climate data against which we assessed network risk.

By staying connected with external stakeholders, we ensure that our strategy aligns with industry best practices, regulatory requirements, and the evolving and complex landscape of climate change impacts.

Emergency Planning Managers' Forum (EPMF)

Emergency Planning Managers' Forum (EPMF) is an ENA led group which focuses on resilience and emergency planning initiatives across GB network operators and NESO. NGET actively partake in EPMF forums to discuss both steady state and abnormal operating procedures and we have refined our severe weather trigger levels based on EPMF discussions. The EPMF forum shares lessons learnt from significant storm events and works to identify best practice operating models. NGET have run feedback sessions with the EPMF to discuss outcomes from Storm Ciaran across our network which focused on the impact of loss of site supplies and building damage / debris.

The EPMF includes escalation and trigger levels for storm events and share vulnerabilities or significant impacts. One of the key features of EPMF is to ensures that TO's, DNO's and NESO are aligned in their understanding and processes associated with Emergency Demand Disconnection which may be required during significant storms and asset failures.

The EPMF also coordinates participation in severe weather events which are run across industry participants, inclusive of extreme weather. This includes coordinating NEWSAC arrangements.

UK Transmission Operators Working Group

NGET have established a working group with SP and SSE to coordinate the publication of climate change related reporting in 2024. This ensures that disclosures, risk assessments and investment plans are consistent throughout industry and provide our customers with a consistent outlook for the future.

Governance

Key Points for this Section:

- **We have incorporated each of the Taskforce for Climate Related Financial Disclosures (TCFD) recommendations. With the transfer of TCFD responsibilities to the IFRS Foundation we are now assessing the impacts of the new standards issued by the International Sustainability Standards Board (ISSB) which provide a comprehensive global baseline of sustainability-related disclosure standards, as well as the SEC climate rules and UK Greening Finance roadmap. NGET also consider our compliance with ISO14090 and ISO14091 through ISO14001 accreditation as a mechanism for demonstrating climate change readiness.**

Alignment of Climate Resilience Strategy to our Climate Change Adaptation Strategy

Whilst our Climate Resilience Strategy reports on our commitment to climate resilience and our corresponding investments, our Climate Change Adaptation Strategy sets out how our internal governance and business risk management processes will be informed by our adaptation pathways.

To align our Climate Resilience Strategy to our Climate Change Adaptation Strategy, we will rely on the roles and responsibilities set out below and housed within an established governance structure.

Governance Structure

National Grid has a robust, established, risk management process in place through which:

- Climate change adaptation risks are controlled.
- Risks are identified in the assets and processes.

Assessments will continue to be controlled in this way. **Error! Reference source not found.** provides an o verview of the governance reporting structure within National Grid to be supported by senior leadership in the strategy.

Task Force on Climate-Related Financial Disclosures (TCFD)

National Grid has disclosed against the TCFD since 2017/18 and our disclosures now cover all of the TCFD's recommendations and recommended disclosures around governance, risk management, strategy and metrics and targets. NGET contributes to the annual TCFD disclosure by demonstrating how the business is responding to climate change. This may be through case studies such as Ofgem funded net zero innovation projects, performance against our GHG emissions targets and examples of how extreme weather events have impacted NGET networks to outline the long-term risks and opportunities associated with climate change.

It will be necessary for NGET to continually appraise its understanding of climate risk and the potential scale and timing of impacts on its assets. This will be through a range of measures including climate modelling, risk assessment, process development and engagement with external stakeholder and policy makers.

In its final status report, published in 2023, the TFCD remarked that "estimating potential financial impact from climate change requires expertise from different functions within a company. As a result, it may be useful to set up a cross-functional team for such efforts. This statement reflects our understanding of what it will take to appropriately implement the commitments within this document.

National Grid has disclosed against the TCFD since 2017/18 and our disclosures now cover all of the TCFD's recommendations and recommended disclosures around governance, risk management, strategy and metrics and targets. NGET contributes to the annual TCFD disclosure by demonstrating how the business is responding to climate change. This may be through case studies such as Ofgem funded net zero innovation projects, performance against our GHG emissions targets and examples of how

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NGET also consider our compliance with ISO14090 and ISO14091 through ISO14001 accreditation as a mechanism for demonstrating climate change readiness.

Our stakeholder network and interdependent industry groups

The table below provides an overview of the key stakeholders with an interest and/or role in implementing elements of this strategy. Ongoing contributions and engagement with the stakeholders have supported:

- Developing a shared understanding of current & future risks
- Facilitating and sharing knowledge
- Providing updates with government and regulators
- Reporting to DEFRA under the Climate Change Act (2008)
- Engaging with Environment Agency to collaborate on works
- Participating in external groups and forums relating to case studies and plans

Government & Regulators	Internal Stakeholders	External Stakeholders
Ofgem	Group Chief Risk Officer	Energy Networks Association (ENA)
Department of Environment, Food & Rural Affairs (Defra)	Group Sustainability Office	Energy Generation, Transmission and Distribution network providers
Environment Agency (EA)	National Grid Ventures – Interconnectors	NESO
Department for Energy Security and Net Zero DESNZ	National Grid Electricity Distribution	British Geographical Survey (BGS)
Department for Science, Innovation and Technology DSIT		Various academic & research groups
Committee for Climate Change		Met Office
TCFD		EPRI Electric Power Research Institute
		IAM – Climate Emergency Programme
		New System Operator
		Natural Environment Research Council
		Critical National, Regional and Local Infrastructure
		Cat 1 and Cat 2 responders

Next Steps

Whilst NGET's commitment to achieving the UK's goal of Net Zero by 2050 sets out a clear need to decarbonise our business and its supply chain, the requirement to adapt to a changing climate forces us to consider ways in which our behaviours and systems will affect the resiliency of our network. As a result of this we are ensuring that both our public and internal facing strategies reflect our commitment to resilience and developing a deep understanding of relevant adaptation pathways.

Throughout the remainder of T2 we will develop our Climate Change Adaptation Strategy we will continue to investigate hazards identified via the ARP process to develop and refine our strategy accordingly to better inform any strategic asset standards. Additionally, outputs from the adaptation strategy assessments will be utilised to support external climate change adaptation reporting to DEFRA and The Department for Energy Security and Net Zero (DESNZ) and supporting the Climate Change Committee's (CCC) suggested targets for the energy industry. It is envisaged that this strategy and outputs will also form part of any future ISO14001 accreditation audits.

Additionally, outputs from the adaptation strategy assessments will be utilised to support external climate change adaptation reporting to DEFRA and The Department for Energy Security and Net Zero (DESNZ) and supporting the Climate Change Committee's (CCC) suggested targets for the energy industry. It is envisaged that this strategy and outputs will also form part of any future ISO14001 accreditation audits.

It must be noted that elements of climate change adaptation are already embedded into the normal day to day operations of the business such as the resilience standard policy for flooding, overhead line design and vegetation management strategies. It is intended that this be expanded by embedding a climate change adaptation procedure into NGET's business procedures with review periods consistent with the preparing of regulatory submissions of our Climate Resilience Strategy.

Our CCAS sets out the following strategic objectives:

Smarter Targets	NGET will **improve its understanding of the impacts of climate change** and close the knowledge gaps.
	Continue to **develop new and improve** existing modelling, risk assessment and management **tools.**
	Embed climate change risks into NGET policies, procedures and vision set out in **Error! Reference source not found.**
	Increase our coordination and engagement with our sector partners and stakeholders to climate-proof standards and to develop new ones for climate adaptation solutions.
	Identify key decision points to ensure NGET is well placed to meet its climate change adaptation challenges.
	Upgrade how NGET monitors and demonstrates its resilience to climate change.
	Where possible **seek carbon negative or neutral adaptation** options
	Work closer with Ofgem and NESO in developing a future proof resilient network.
More Systemic Adaptation	**Increase cooperation across sectors** to increase national resilience.
	Support policy development at all levels across the energy sector
	Seek opportunities to improve resilience with non-traditional partners.
	To improve and support successful regulatory submissions.
	Ensure that NGET has a clear and visible climate change strategy both internally and externally.
Faster Adaptation	**Implement a climate change toolbox** including a knowledge base for NGET staff**.**
	Have ongoing engagement with sector partners including Ofgem not just as part of regulatory submissions.
	Look for **incremental resilience opportunities** which can easily be upgraded at minimum cost.
	Increase training and engagement of climate change adaptation within NGET

Alignment of Climate Resilience Strategy to our Climate Change Adaptation Strategy

Whilst our Climate Resilience Strategy reports on our commitment to climate resilience and our corresponding investments, our Climate Change Adaptation Strategy sets out how our internal governance and business risk management processes will be informed by our adaptation pathways.

Below infographic summarises our roadmap for climate resilience related investment and assessment over the T3 period. Each of these represents a continuation of our work in previous years with focus on new and emerging risks.

There are a few key points to highlight:

1. Our work is aligned to our latest climate hazard risk assessment (ARP3), and with ongoing reporting requirements.
2. Our focus will shift in T3 from our successful program of flooding resilience investment to resilience in the face of coastal erosion and rising temperatures.
3. All our initiatives will be supported by a robust resourcing plan which is essential to the success of this roadmap

Figure 11. Next Steps Aspirations.

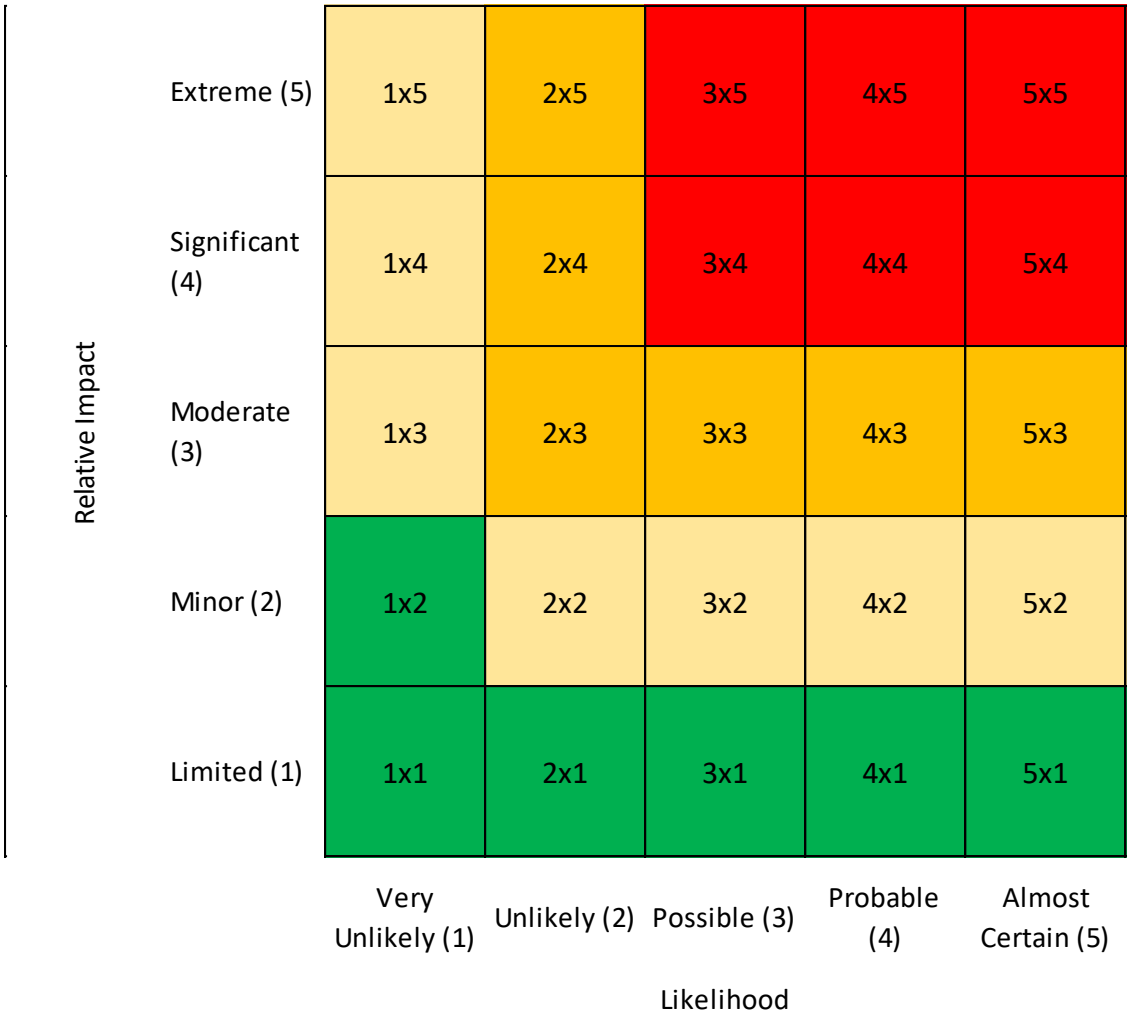
Appendix 1: NGET ARP Scoring Matrices

ARP Risk Groupings, Codes and Scores

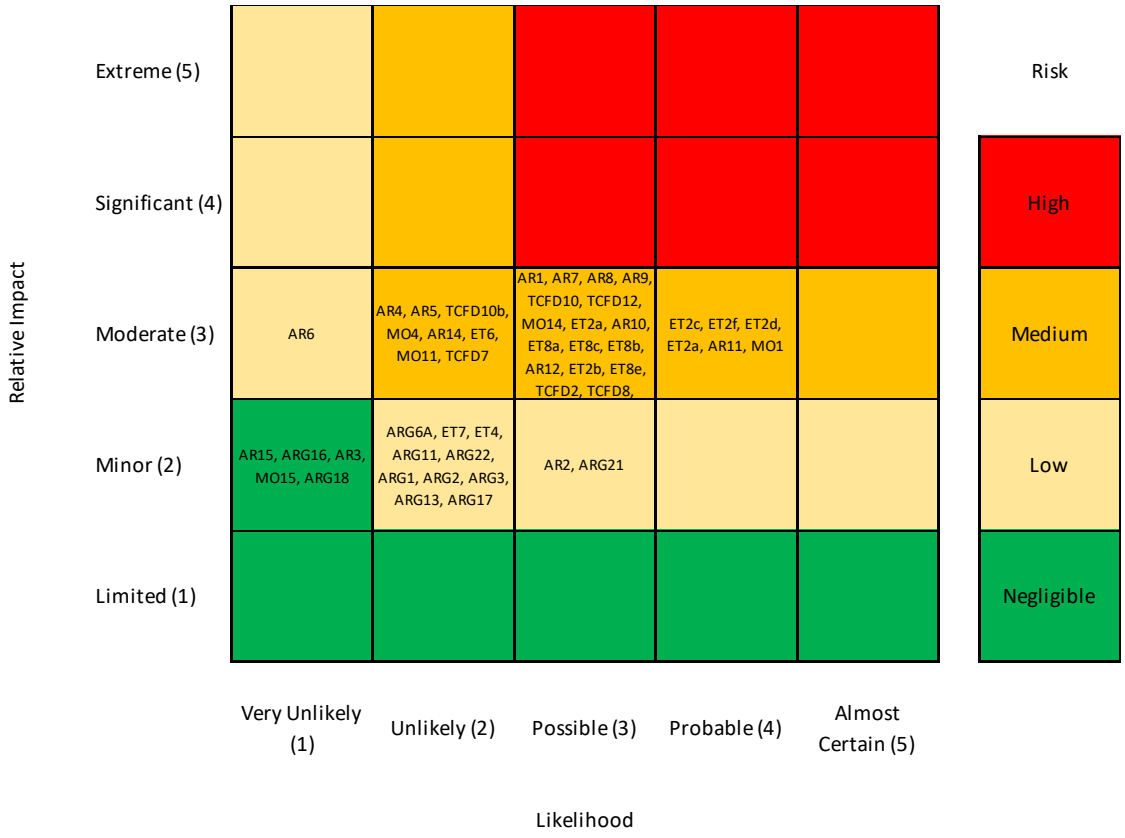
Grouping	Code	Risk	ARP3 Score	ARP4 Score	2050 BAU Score	2100 BAU Score
Business Continuity	ARG18	BCM plans affected due to severe travel difficulties resulting from extreme weather events	1x2	1x2	1x2	1x2
Compound Events	TCFD7	Extreme weather events including a combination of wind, rainfall, temperature or snow	3x3	3x3	3x4	3x4
	TCFD8	Perfect Storm of a cold winter, high electricity demand and heavy persistent rain	3x3	3x3	3x4	3x4
Contaminated Ground	ET4	Polluted ground fires, Old Mine workings	2x2	2x2	2x2	2x2
Erosion	ET2c	Riverbank Stability and Scour	4x3	4x3	4x4	4x4
	ET2d	Groundwater & Geohazards	4x3	4x3	4x4	4x4
	ET2f	Surface Water Runoff Scour	4x3	4x3	4x4	4x4
Fluvial Flooding	AR10	Substations affected by river flooding due to increased winter rainfall	3x3	3x3	4x3	4x3
	ET8a	Fluvial river and coastal flooding of NGET sites	3x3	3x3	4x3	4x3
	ET8b	Fluvial river and coastal flooding – neighbouring sites leaving NGET sites stranded	3x3	3x3	4x3	4x3
	ET8c	Shifting flood areas may affect existing sites in the future	3x3	3x3	4x3	4x3
Ground Movement	AR2	Overhead line structures affected by summer drought and consequent ground movement	3x2	3x2	3x3	3x3
	AR5	Underground cable systems affected by summer drought and consequential ground movement,	2x3	2x3	3x3	3x3
	ET2a	Geohazards	4x3	4x3	4x4	4x4
	ET2e	Landslips, slope stability, ground creep, avalanche	3x3	3x3	4x3	4x3
	MO 4	Repeated Cycles of drought and rainfall	2x3	2x3	3x3	3x3
	TCFD10b	Increased rate of loss of level in areas with already low depth of cover (e.g. Fenland area)	2x3	2x3	3x3	3x3
Groundwater	ARG22	Groundwater flooding of below ground assets leading to water ingress to pipes	2x2	2x2	2x2	2x2
Interdependencies	ARG17	Supply chain impacts	2x2	2x2	2x2	3x2
	AR13	Substations affected by water flood wave from dam burst	3x3	3x3	3x3	3x3
	ARG13	Vulnerability of critical IT systems managed by third parties from extreme weather events	2x2	2x2	2x2	2x2
	ET8d	Reservoir / Canal Failure	3x3	3x3	3x3	3x3
Lightning	AR14	Overhead lines and transformers affected by increasing lightning activity	2x3	2x3	3x3	3x3
Low Temperatures	ARG6a	Above and below ground assets affected by lower temperatures	2x2	2x2	2x2	2x2
Pluvial Flooding	AR11	Substations affected by pluvial (flash) flooding due to increased rainstorms in Summer and Winter	4x3	4x3	4x3	4x3
	ARG11	Ground contamination and transport of materials from flooding of contaminated sites	2x2	2x2	3x2	3x2

	MO 1	Increased intensity of short duration rainfall leading to flooding	4x3	4x3	4x3	4x3
Policy & Procedure	ARG1	Lack of climate change management procedure	2x2	2x2	3x2	3x2
	ARG2	Lack of specific policies and procedures governing risk assessment process on climate change	3x2	3x2	3x3	3x3
	ARG3	Risk and action owners not identified at senior leadership team level	2x2	2x2	2x2	2x2
Raised Temperatures	AR1	Overhead line conductors affected by temperature rise.	3x3	3x3	3x4	4x4
	AR4	Underground cable systems affected by increase in ground temperature,	2x3	2x3	3x3	3x3
	AR6	Substation and network earthing systems adversely affected by Summer drought conditions	1x3	1x3	2x3	2x3
	AR7	Transformers affected by temperature rise	3x3	3x3	3x4	4x4
	AR8	Transformers affected by urban heat islands and coincident air conditioning demand	3x3	3x3	4x4	4x4
	AR9	Switchgear affected by temperature rise	3x3	3x3	3x4	4x4
	TCFD10	Demand growth in Summer due to increased cooling load	3x3	3x3	4x4	4x4
Sea Level Rise & Coastal Change	AR12	Substations affected by sea flooding due to increased rainstorms and/or tidal surges	3x3	3x3	4x3	4x3
	ARG21	Saline contamination and increased corrosion rate of above and below ground assets from sea water or atmospheric salt	3x2	3x2	3x3	4x3
	ET2b	Coastal Management Policy	3x4	3x4	4x4	4x4
	ET8e	Flooding from Storm Surges	3x4	3x4	4x4	4x4
Snow & Ice	ET7	Snow & Ice; Severity, intensity and frequency of storms	2x2	2x2	2x3	2x3
Solar Weather	MO15	Solar Storm	1x2	1x2	1x2	1x2
Storms	ET6	Severity, Intensity and Frequency of Storms	2x3	2x3	3x3	3x3
	MO11	Temperature / Precipitation: Warm, wetter conditions combined with rainfall and / or wind	3x3	3x3	3x4	3x4
Temperature Cycles	MO14	Diurnal Temperature Range	3x3	3x3	4x3	4x3
	TCFD12	Fast Freeze-thaw cycles	3x3	3x3	4x3	4x3
Vegetation Growth	AR3	Overhead lines affected by interference from vegetation due to prolonged growing season	1x2	1x2	1x2	1x2
Wildfire	AR15	Wildfires	2x2	2x2	2x2	2x3
	ARG16	Wildlife impacts	1x2	1x2	2x2	2x3

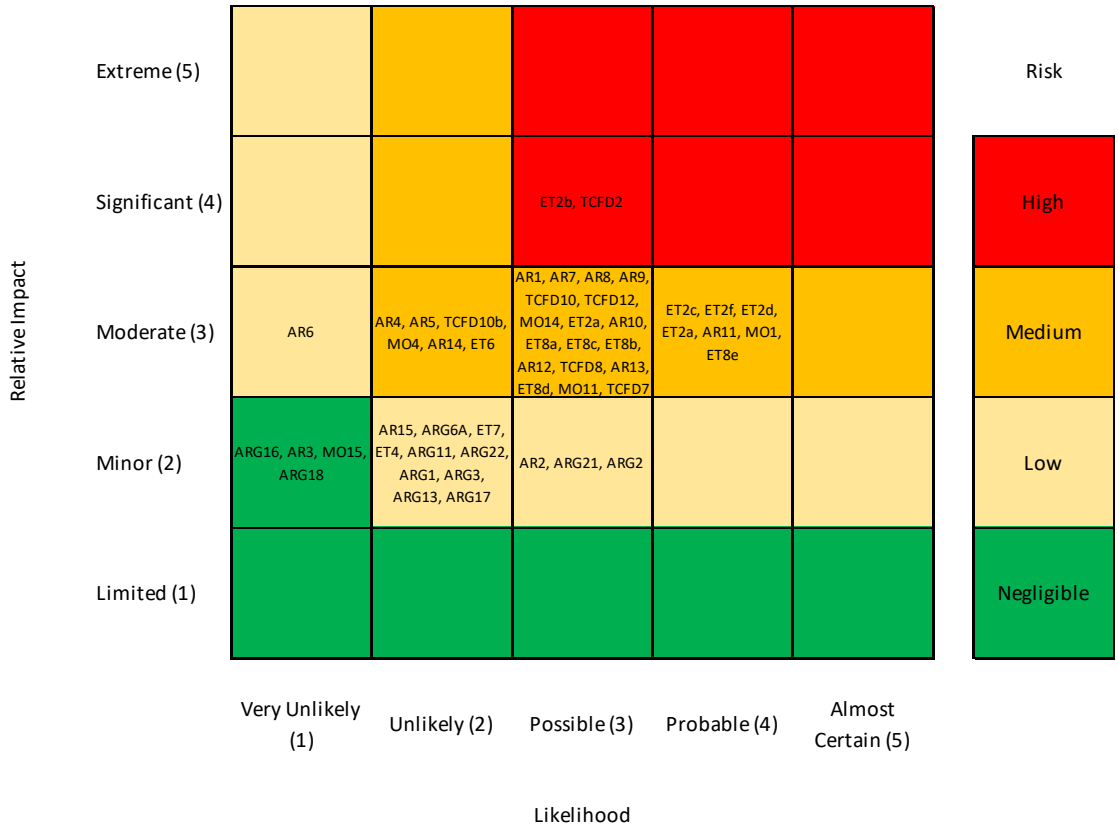
ARP Risk Matrix Scores



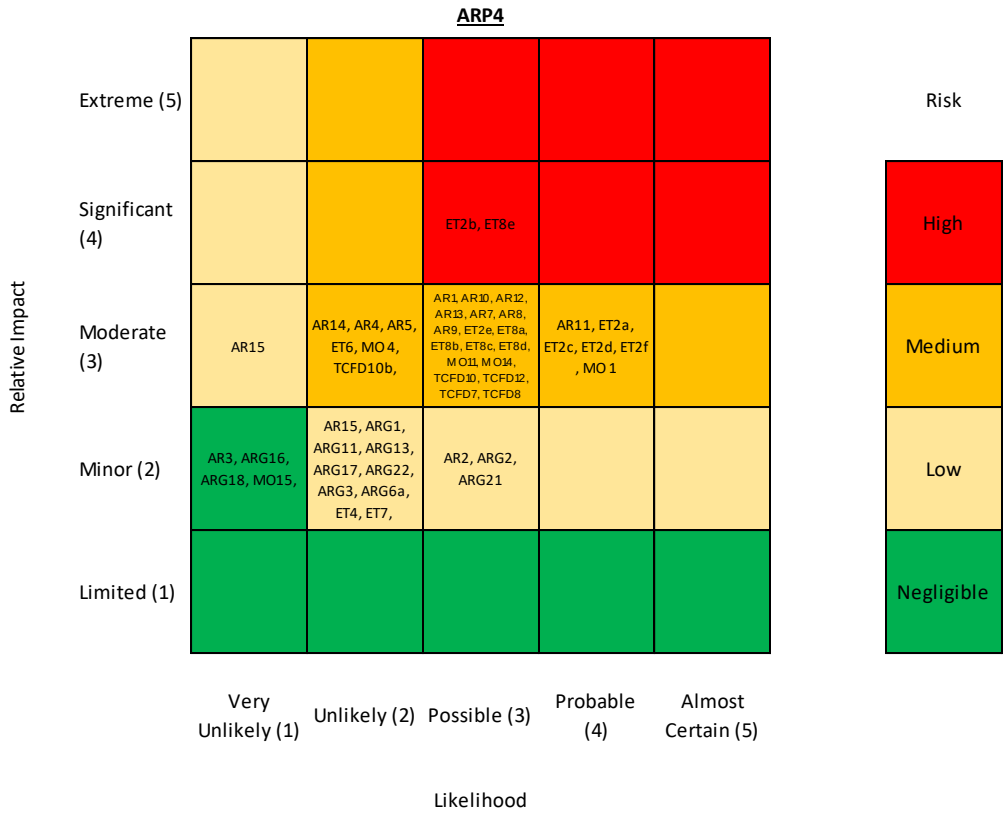
ARP2 Risk Matrix



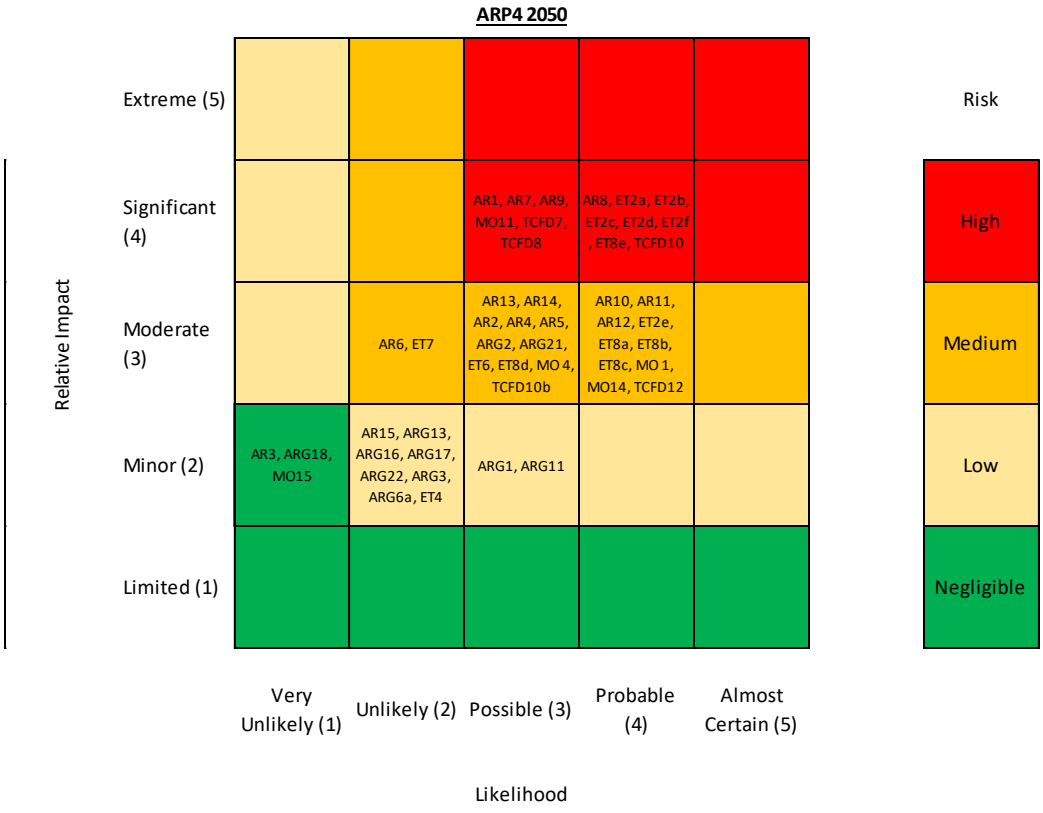
ARP3 Risk Matrix



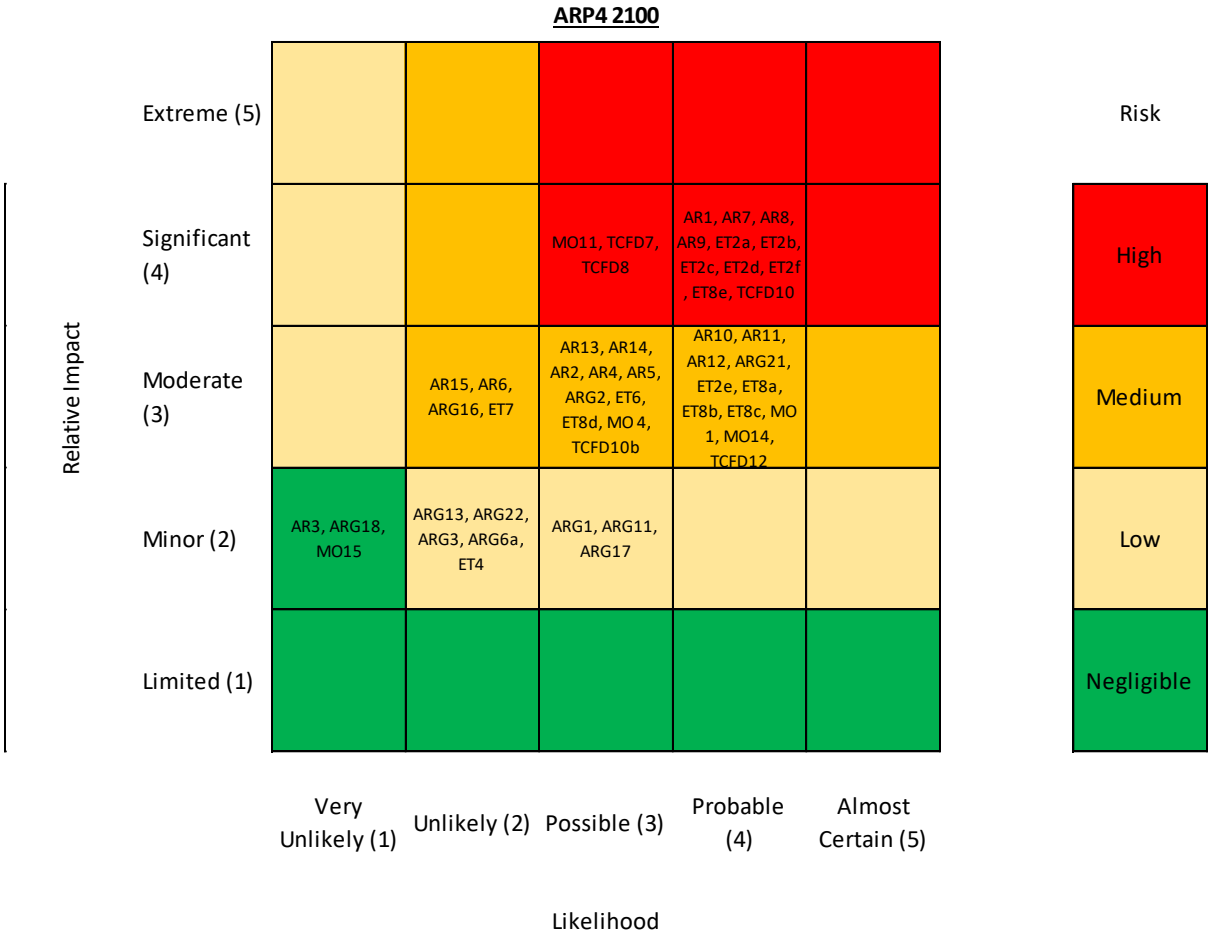
ARP4 Risk Matrix



ARP4 2050 Risk Matrix



ARP4 2100 Risk Matrix



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