Third Round Climate Change Adaptation Report

National Grid Gas plc

October 2021

nationalgrid

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Executive Summary

National Grid Gas plc (NGG) has submitted responses to the two previous Climate Change Adaptation Reporting cycles. This report fulfils our commitment to the third-round reporting cycle.

Since the publication of our second-round report, our understanding of potential climate change impacts has advanced with the publication by the Met Office of the UKCP18 climate model. National Grid, in 2020 also committed to reduce its carbon emissions to Net Zero by 2050 and for the fifth year running, we have secured a place on global environmental not-for-profit charity CDP's prestigious 'A List'.

We are also a Principal Partner for COP26, the UN Climate Change Conference being held in the UK in 2021 and since 2019 have been reporting through the Task Force on Climate-Related Financial Disclosures (TCFD).

This report also represents a step change in our climate adaption assessments. For the first time, in conjunction with the Energy Networks Association (ENA) and Gas Distribution Network (GDN) partners, we have completed a fully scored risk assessment. To provide comparison we have also retrospectively undertaken the assessment for ARP2 and in line with DEFRA requirements, have taken a view to 2050.

For the assessment, in recognition of our commitment to understanding our climate change impacts, NGG has also undertaken a full gap analysis of its risks; collating 86 potential risks and formally assessing 41 in this report.

The risk assessment has identified 1 high risk and 10 medium climate risks. While more detailed in their nature, they are broadly consistent with previous NGG adaptation reports:

- Raised Temperatures
- Erosion
- Flooding
- Ground Movement
- Wind Damage
- Vegetation Growth
- Lightning

This third-round assessment has found that risks from raised temperatures and erosion (specifically pipeline crossings) have increased since the publication of the second-round report. There has however, been minimal change in the remaining risks.

The assessment of risks in 2050 included a qualitative assessment which assumed present day 'business as usual' processes and risk management continued. Based primarily on the findings of a report developed by the ENA Climate Adaptation Group and the Met Office, the assessment identified four potential high-level risks and 17 medium risks. The high-level risks saw the continued impact of raised temperatures alongside increased impacts from flooding and erosion.

As a result of the assessment, NGG has committed to next steps relating to standards and specifications, flood risk assessment and river scour modelling to help mitigate the present and anticipated impacts of climate change.

While high and medium risks have been identified, the National Grid Gas assessment is consistent with previous reports and those of our ENA partners. The business remains inherently resilient but recognises the need to continually reappraise its climate risks and engage with regulators on financing adaptation measures to ensure it remains so.

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Introduction

The Adaptation Reporting Power (ARP) set out in the Climate Change Act 2008 provides for the Secretary of State 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.

Reports are requested to 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 which in turn supports the Government's National Adaptation Programme and future UK Climate Change Risk Assessments.

This report supports this process by fulfilling the requirements of ARP Round 3 (ARP3) for NGG and covers the period 2016 to 2021.

National Grid Group plc

National Grid Group plc lies at the heart of a transforming energy system, spanning the UK and the US.

Our businesses supply gas and electricity, safely, reliably and efficiently to millions of customers and communities. But we also drive change through engineering innovation and by incubating new ideas with the power to revolutionise our industry.

In the UK, we have a unique position at the heart of Britain's energy system, connecting people to the energy they use, safely and reliably. We keep the lights on and the gas flowing, so people can go about their daily lives. And we're working to build a cleaner, fairer and more affordable energy system that serves everyone.

Facts: National Grid UK

4,481 miles (7,212 kilometres) of overhead electricity lines

1,391 miles (2,239 kilometres) of underground electricity cables

4,740 miles (7,630 kilometres) of high-pressure gas pipes

By 2030, 90% of electricity imported by our electricity interconnectors will be from net zero carbon sources

By 2024, National Grid's electricity interconnectors will import enough energy to power 8 million homes

In 2020, National Grid committed to reduce its carbon emissions to Net Zero by 2050.

With our role at the heart of the UK energy system we are committed to facilitating decarbonisation and helping to deliver a clean energy future.

For the fifth year running, in 2020, we have been recognised for leadership in corporate sustainability, securing a place on global environmental not-for-profit charity CDP's prestigious 'A List'. We are also a Principal Partner for COP26, the UN Climate Change Conference being held in the UK in 2021.

In recognising the importance of our approach to climate change, we also voluntarily undertake financial reporting through the Task Force on Climate-Related Financial Disclosures (TCFD).

In order to understand the future impact of climate change on our business, in 2020, we embarked on an ambitious TCFD Climate Modelling Project to quantify our climate risks during the rest of the century.

National Grid Gas plc

National Grid Gas plc, part of National Grid UK, owns and operates the Gas Transmission System throughout Great Britain which consists of approximately 7,800 km of high-pressure transmission pipelines together with associated valve installations and gas compression assets.

Our licence is established under the Gas Act 1986. It requires us to develop, maintain, and operate economic and efficient networks and to facilitate competition in the supply of gas in Great Britain. They also give us statutory powers, including the right to bury our pipes under public highways and the ability to use compulsory powers to purchase land so we can conduct our business.

NGG itself does not sell gas. We transport gas from terminals to power stations, directly connected industrial users, interconnectors and the Gas Distribution Networks who supply gas to homes or businesses.

Since the publication of ARP2, National Grid Group plc has sold its Gas Distribution Network. It now operates as a separate company (Cadent Gas) and will therefore produce its own response to ARP3. Unlike the previous ARP reports therefore, this report focusses on NGG gas transmission operations only.

Recently National Grid plc has announced that it plans to sell a majority stake in the Gas Transmission business. This sale is not expected to complete until mid to late 2022.

Gas Transmission: National Transmission System (NTS)

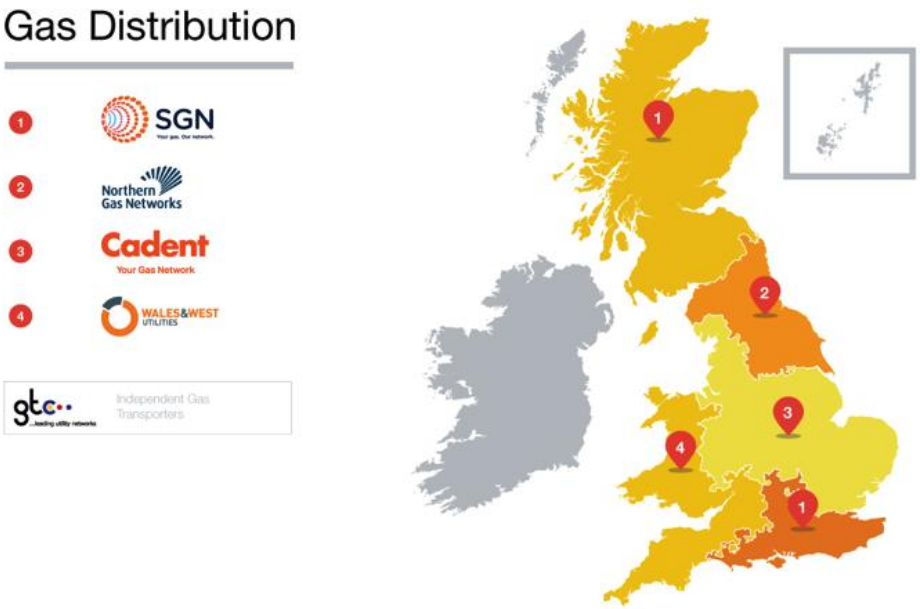
Energy Networks Association

The Energy Networks Association (ENA) is the trade association for the energy networks. Its members own and operate the wires and pipes which carry electricity and gas into communities, supporting the economy.

NGG are members of the ENA Climate Change Adaptation Reporting Group and the Gas Environment Group – Adaptation Subgroup (the 'ENA Gas Adaptation Subgroup'). The Subgroup is comprised of NGG; Northern Gas Networks; SGN; Wales & West Utilities and Cadent Gas.

The ENA Gas Adaptation Reporting Group has worked closely with colleagues in the electricity distribution companies and National Grid Electricity Transmission to develop an overarching approach to ARP3. The businesses will continue this collaborative approach to progressing climate change adaptation in the newly formed ENA Climate Change Resilience Working Group.

ENA Members: Gas Distribution Companies



Facts: Energy Networks Association

The gas network in the UK and Ireland comprises around 300,000km of pipes – enough to go round the world seven times

The electricity network in the UK and Ireland comprises around 1,000,000km of cables – enough to go round the world 25 times

Around 30 million homes and businesses are connected to the electricity networks

Around 22 million homes and businesses are connected to the gas networks

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

- In ARP 1, ENA established the response as a collaborative project amongst electricity network operators and identified key risks to network assets and operation posed by climate change impacts. The key messages for the gas network businesses similarly revolved around the resilience of the gas networks and any climate vulnerabilities.
- In ARP 2, ENA built on its understanding of the risks and updated DEFRA on industry mitigation measures being put into place on the networks. It developed the consistent reporting methodology from ARP 1 and provided further evidence of actions taken in response to key climate risks.

- In ARP3, the aim has been to provide an update on existing risks, mitigation measures and programmes but will also look to identify new risks being realised in order to provide a fuller picture of the potential for climate change impacts to affect networks. More importantly the ARP 3 report aims to consolidate Gas and Electricity network reports to provide a consolidated Energy industry response.

The ARP 3 energy sector response has been prepared by a task group of gas and electricity distribution and transmission network operator members of ENA and is intended to provide a response to climate change adaptation on behalf of the energy network operators. This report continues the progress made since the second round of reporting and should be read in conjunction with the 2nd Round Report.

Adaptation First Round Report

National Grid were approached directly by Government to respond to the First Round of Adaptation Reporting (ARP1) in 2010, which was designed to:

- Assess the current and predicted impact of climate change in relation to the companies' functions; and
- Outline the proposals and policies for adapting to climate change in the exercise of those functions and the timescales for introducing those proposals and policies.

The main categories of weather events and environmental risks were identified as follows:

- Flooding and heavy rain fall (including saturated ground conditions);
- Snow and ice;
- Increases in temperature, heat waves and drought conditions;
- Coastal erosion from sea level rise;
- River erosion; and
- Storm events and high winds.

Using information drawn from United Kingdom Climate Projections 2009 (UKCP09) and working alongside the Meteorological Office Hadley Research Centre, the Environment Agency and the Scottish Environmental Protection Agency, the key risks and opportunities facing the businesses were identified.

High emissions projections to 2050 and 2080 were used to determine worst case scenarios and for correlation against the lifetimes of existing assets. Account was taken of the expected increase in number, frequency and intensity of weather events.

It was highlighted that network assets and processes may be vulnerable to certain aspects of climate change. However, the national and regional infrastructure has a significant degree of resilience to these impacts and none of the identified risks were considered to be high.

Adaptation Second Round Report

The Second Round of Adaptation Reporting (ARP2) followed the same methodology as ARP1.

There had been no significant changes in understanding of climate change impact between ARP1 and 2, with the exception of limited development of environmental regulators' flood mapping.

The overall level of uncertainty for gas networks was assessed as low as the sector has a high level of inherent resilience due to the level of safety awareness and regulatory overview. The assessment itself was however expanded to include a greater number of hazards and identified the following risks:

- Increased solar heat
- Increased heavy rainfall
- Sea level rise
- Increased lightning
- Wind and gale
- Snow, sleet, blizzard and freezing fog
- Increased flooding
- Increased coastal / river erosion
- Increased subsidence / land slip

Key higher-level risks identified were:

- Increased River Erosion: Potential exposure of pipelines within water courses including rivers and estuaries, which could lead to a security of supply issue.
- Increased Coastal Erosion: Loss of supply due to loss of a gas terminal.
- Increased Temperature: Potential security of supply issues as compressor stations are not designed to run at elevated temperatures. Climate change, in itself, is not the only factor. The issue being that units are now being run in a more flexible manner, in order to respond to system demands. This combined with the impact of climate change will cause an issue.
- Increased Flooding: The primary impact is the unavailability of localised compression, which has the potential to constrain the gas network if the compressor in question is required and a substitute is also unavailable. If compressor stations are affected by flooding, they can be bypassed without significantly affecting gas supply.

The report noted that the initiation of the Feeder 9 tunnelling project on the River Humber was a recognition of changing tidal patterns, although certainty of whether this was climate change driven was limited. It also recognised that further analysis was required on the impact of subsidence / landslips and the extent to which climate change will influence ground movement. River and coastal erosion, having been highlighted as a risk, already had significant monitoring and risk management regimes in place.

In recognition of the developing consideration of climate risks, interconnections were highlighted as a concern though the level of risk was seen to be low given the level of co-operation within the gas sector and working with organisations like the ENA.

The report concluded there were a mix of low probability risks based on the present level of understanding and management through existing business controls was presently sufficient.

Adaptation Third Round Report Introduction

In 2018, National Grid was invited by DEFRA to participate in the Third Round of Adaptation Reporting.

Since the publication of our ARP2 Report, our understanding and response to climate change has evolved, not least our commitment to Net Zero and TCFD. Additionally, since the publication of ARP2, the Met Office has also released its updated climate modelling (UKCP18) which provides the most up-to-date assessment of how the UK climate may change in the future.

As a result, our intention has been to undertake a full reassessment of our climate risks. Our objective for ARP 3 has been 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 NGG; and
- Incorporate the latest climate information provided by UKCP18.

NGG has therefore undertaken a full gap analysis of its climate change risks, with consideration given to:

- The outputs of UKCP18;
- Hazards assessed in modelling undertaken by the Met Office for the ENA Climate Change Adaptation Sub-Group (‘the ENA Met Office Report’);
- Relevant and associated risks identified in National Grid Electricity Transmission ARP Reports;
- Hazards identified in preparation for the National Grid TCFD Climate Modelling project;
- Interdependencies with external factors, such as telecommunications; and
- Compound climate risks such as heavy rainfall that follows drought conditions.

Previous NGG, GDN and ENA Gas ARP reports did not include a standardised risk matrix. For ARP3, NGG has been working with ENA partners to develop a framework which is consistent with that used by the DNOs in previous ARP reports. As a result, NGG has undertaken a retrospective risk assessment for ARP2 to enable suitable comparison alongside ARP3 and the DEFRA requested position for 2050.

The 2050 assessment is qualitative and based on current ‘business as usual’ processes and risk management continuing combined with our understanding of future climate. Wherever possible, this has been undertaken using information contained in the ENA Met Office Report and any findings are therefore consistent with impacts seen under a high emission scenario (discussed in the next chapter).

In total, NGG has considered 86 potential risks, with 41 being considered in this report. This is intended to provide a benchmark for future climate work within NGG, provide a repository of climate change knowledge while linking to wider climate research and adaptation efforts within National Grid.

ENA Met Office Climate Research

In spring/summer 2020, on behalf of its members, ENA commissioned the Met Office to undertake a review of the UKCP18 data and existing studies in to order to understand the changes in potential impact to energy infrastructure assets from climate change. The report from this research has been used to assess the current risks to NGG and inform future mitigation or management.

Hazards were identified by the ENA Climate Change Adaptation Group which includes National Grid (both NGG and National Grid Electricity Transmission businesses) and the respective Gas Distribution Networks and Electricity Distribution Network Operators (DNOs).

The group requested the highest Representative Concentration Pathways (RCP8.5) was used to provide a worst-case scenario and timeframes out towards the end of the century.

Because of the number and diversity of the hazards, it was decided to prioritise those which posed the highest risk to energy network assets as an overall system. The assessment process was also graded to provide focus. A full climate assessment was produced for the highest priority hazards, these being:

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

Since there is currently no strong signal within the climate projections for a change to future storm intensity the risk of strong winds was assessed in the current climate only.

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

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

Many of the hazards identified by ENA members are projected to increase due to future climate change:

- Increased frequency of high temperature days;
- Prolonged rainfall events; hourly rainfall extremes;
- Sea-level rise;
- Extreme sea level events (storm surges);
- Increased risk of wildfire and increased extreme diurnal cycle events are all expected over the 21st century.

However, the frequency of snow and ice days are expected to decrease.

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

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

Interconnections between different industry sectors is a major source of risk for the energy network, with failures from one sector frequently causing impacts. Telecommunications and road transport are thought to be the most important sources of risk. Telecommunications are already important for automated and remotely controlled equipment, (including satellite and broadband) and for communication with personnel in the field. Risk from telecommunications failure has the potential to increase in the future with greater reliance on smart systems (dependent on telecommunications). In turn, risk from the energy network is likely to increase risk for the road network as electric vehicles become more commonplace.

ARP3 Risk Narrative

Introduction

This chapter presents the context of the risks identified, their present and future impacts and any relevant case studies.

The risks are presented in groups. For conciseness, some groups are formed from a number of risks where the impact or mitigation is similar. Otherwise, they are dealt with separately.

The codes presented relate to National Grid gap analysis and the ENA Climate Change Adaptation Sub-Group, namely:

- **ARG**: ENA Climate Change Adaptation Sub-Group
- **ET**: Gap Analysis between National Grid Gas Transmission and National Grid Electricity Transmission
- **TCFD**: Risks considered by the TCFD Working Group Climate Modelling Project, but not considered in previous ARP Reports.
- **MO**: Risks considered by the Met Office Report, but not considered in previous ARP Reports.
- **ADD**: Additional risks identified during consultation with NGG stakeholders during development of the report.

1. Policy and Procedure

ARG1: Policy - Lack of climate change management procedure

ARG2: Policy - Lack of specific policies and procedures governing risk assessment process on climate change

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

Background

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.

Discussion

National Grid has a corporate risk for climate change which drives business risk management. It is also driving our commitments under TCFD and its associated climate modelling and risk assessment work. Within NGG, the risk is currently owned by the Head of Solutions Delivery.

The business considers the present risk management framework within NGG as appropriate for the present impact of climate change. Existing arrangements are a combination of:

- Reactive mitigation in the form of business resilience;
- Risk identification work in the form of ‘line walking’ and helicopter surveys (to identify erosion, land movement and excessive vegetation growth);
- Proactive measures (including Environmental Impact Assessments (EIA)) for new assets and sites where physical impacts of climate such as flooding are accounted for; and
- Local escalation of known issues through existing reporting lines.

The pace of climate change impacts on the business will be kept under review, particularly the output of the TCFD Climate Modelling Project. This is in addition to the prevailing regulatory expectations to determine whether a specific procedure would benefit the business.

2. Raised Temperatures

ARG6b: Above ground assets affected by raised temperatures

TCFD10: Electricity demand growth in summer due to increased cooling load

Background

Gas network assets are manufactured to international standards and designed to operate within particular temperature parameters. Increasing temperature impacts all plant and equipment and increases may reduce their rating and asset performance leading to reduced operating capacity.

Temperature increases, particularly during the summer, potentially coupled with an increased demand for electricity to support a growth in demand for electric road vehicles may present a significant change in operation for gas networks. The potential for increased consumer demand for electricity that is driven by increased adoption of air conditioning may result in increased demand for gas driven generation. As a result, there may be reduced maintenance windows, challenges to asset operation and potentially network reinforcement.

Discussion

This is an emerging risk for NGG. Increased temperatures have the potential to produce societal changes in energy demands with, for example, the increased adoption of home air conditioning units. The increased demand for electricity could drive a corresponding increase in gas demand from power stations if there is insufficient renewable electricity available, resulting in compressors needing to run more often in hotter temperatures.

However, there is a level of uncertainty related to the speed of temperature increases, the future energy mix and whether the additional demand will be met through the uptake of renewables or gas fired generation. Gas fired generation will however be relied on increasingly to balance the network if insufficient renewable electricity is available).

The gas transmission network is primarily designed to operate at maximum load during the winter months in line with the historical peak demand for gas being driven by low ambient temperatures. Higher demand for gas in warmer months presents several challenges:

- There are potential implications for gaining access to the system to undertake essential maintenance across the network, particularly where compressors or pipelines do not have a suitable bypass or back-up.
- Gas turbines used to drive compressors produce less power as the ambient temperature increases. In extreme cases this could limit the capacity of the compressors to move the required volumes of gas
- The enclosures within which gas turbine driven compressors are located (necessary to provide weather protection and noise abatement) are force-ventilated to remove heat released by the gas turbine. Heat removal rates are a function of ambient air temperature and most cabs are designed for winter operation with low ambient temperatures reflecting historical usage patterns. An increasing requirement for summer operation of some compressors means that temporary chillers are required to avoid overheating of compressor cabs. This requirement (or major modifications to cab ventilation systems) has the potential to increase.

Modification work has already been undertaken at several compressor sites to mitigate the impact of running during the warmer months of the year. NGG operations continue to monitor affected compressor station cab temperatures and further works are being implemented.

The impact of temperature increase is being considered in the TCFD Climate Modelling Project being undertaken by National Grid. Any replacement compressor units will be designed for the climate in which they will operate.

NGG will continue to monitor customer requirements and societal changes to ensure an appropriate response is undertaken. This will also include consideration of Future Energy Scenarios produced by National Grid ESO.

NGG will continue to review its standards and specifications for new plant and equipment. Any significant changes to standards and specifications may require additional investment in the network to ensure it remains resilient to the impacts of climate change.

3. Low Temperatures

ARG6a: Above ground assets affected by lower temperatures

Background

Gas network assets are designed and manufactured to international standards and designed to operate within particular temperature parameters. Lower temperatures can impact equipment operating performance from both a temperature and (water) freezing perspective. There are also safety concerns for colleagues who are required to free or fix the impacted equipment.

Discussion

The gas National Transmission System (NTS) is designed for 1 in 20-year weather extremes.

The NTS is buried for the most part at a depth where low ground temperatures which could cause embrittlement of pipework is considered implausible. The primary risk is related to ancillary equipment, for example, the freezing of valves at Above Ground Installations (AGIs) and icing of gas turbine air intake filters at compressor stations.

In the long-term as the ENA Met Office Report notes, low temperature days will become less frequent. This itself may however present a risk to NGG, due to reduced cold weather operational experience in the workforce.

Given the expected decrease in cold weather periods related to climate change, the business does not expect this to be a significant risk as we look further into the century. NGG will continue to review its standards and specifications for new plant and equipment. Any significant changes to standards and specifications may require additional investment in the network to ensure it remains resilient to the impacts of climate change. Icing of gas turbine air intakes can occur at temperatures above freezing, it is thus important to ensure that anti-icing heaters continue to be included in any new gas turbine air intake systems.

4. Temperature Cycles

TCFD12: Fast cycling between temperature extremes

MO14: Diurnal temperature range

Background

Fast changes to ambient temperatures have the potential to induce material stress in assets. Where this is associated with water, additional stresses may be seen which can impact assets further.

This may also induce physical erosion of soil and rock, impacting foundations and asset integrity.

Discussion

While this issue presents itself in GDN pipe networks, it is not considered to be a risk for NGG given the robustness of the feeders and depth at which they are buried.

Compressors and AGIs are robust and issues such as ‘icing’ and condensation are already managed through existing risk management procedures.

5. Fluvial Flooding

ARG4 Flood risk of above ground assets

ET8c: Shifting flood areas may affect existing sites in the future

Background

There is a risk of physical damage to assets located in flood plains (fluvial) or to other assets from extreme and extended rainfall (pluvial). Whilst feeders and block valves are able to operate if submersed in water, electrical and electronic equipment may be susceptible to damage or will require isolating if flooding is anticipated. This will be exacerbated if flood defences are ineffective and/or plant relocation is not possible.

Discussion

Pipelines and valve work which form the majority of the NTS are generally resilient to flooding. Where there is a known risk of flooding or where pipelines cross saturated ground anti-buoyancy coatings can be applied to avoid issues with pipelines floating out of the ground. Issues can arise where areas not normally susceptible to flooding / high water table become saturated for extended periods.

There are however three related risks to the system. The first is related to ancillary equipment (e.g. electrical supplies to sites, control systems or electrified security fencing) which are vulnerable to flooding; secondly, compressor stations contain a number of ‘pits’ that contain pipework and equipment which are easily flooded; and finally, flooding presents a challenge to site access which could impact the operation and maintenance of assets.

For fixed sites, the business presently has a robust change control procedure which considers potential environmental impacts. This includes the potential for flooding and mitigation such as elevating electrical equipment above the likely flood level.

New developments are subject to a flood risk assessment through the EIA process which includes a consideration of climate and flood risk. Such assessments typically look at 1 in 100 or 1 in 200-year flooding events.

The last NGG Flood Risk assessment was completed in 2008. In 2021, the TCFD Climate Modelling Project will provide additional high-level flooding information about NGG assets. This information will be used to consider where the likely risks are located and whether a response is required.

6. Pluvial Flooding

ET8b: Pluvial flooding resulting in NGG sites being stranded

Background

There is a risk that while asset owners may protect their own sites, the impact of surface water flooding on the surrounding area may leave them inaccessible. Typical issues may be flooded roads or tunnels and other transport routes.

Discussion

Pluvial flooding presents a similar risk to that from rivers and tides, with key vulnerabilities including access, damage to incoming electrical supplies, security and ancillary electronic equipment and telecommunications.

There is a significant interdependence with landowners surrounding NGG sites, as the ability of drainage systems in combination with those in the highway will determine the extent of pluvial flooding. The other issue with pluvial flooding is washing out of ground cover on river crossings (primarily related in this section to inland rivers rather than big estuary crossings such as the Humber).

At present the risk is considered to be limited. It is well managed from both a local awareness and resilience perspective. However, the ENA Met Office Report has shown that climate change will bring additional challenges as rainfall patterns change in both length and intensity.

In some cases, those changes have the potential to accelerate at a greater speed than any respective improvements to the capacity of existing surface water drainage. This may not only require additional investment, but a co-ordinated approach across sectors, regulators and landowners.

MO1: Increased intensity of short duration rainfall leading to flooding

Background

Flooding (pluvial or fluvial) is associated with a broad range of impacts including access issues, asset damage and reduced performance. It presents a risk to many ENA business areas including gas distribution, fixed level assets and linear overhead assets.

Intense, short duration rainfall events have the potential to overwhelm existing drainage systems and the grounds' natural ability to allow percolation. As a result, surface water flooding presents a risk even for assets located away from watercourses or the indicative fluvial flooding zones.

Discussion

At present, NGG has not seen an increase in short duration rainfall events that have led to flooding. The majority of sites are resilient, generally having open space for infiltration and drainage systems that are well maintained.

The ENA Met Office report suggests these events will become more frequent in the future. Although there is nothing to escalate to a strategic level at present, examination of the risks posed, particularly in vulnerable locations (such as small or narrow river catchments) will be required in the future.

7. Sea Level Rise & Coastal Change

ARG20: Tidal Flooding of above Ground Assets due to sea level rise

Background

Regardless of the source, the impact of flooding on above ground assets is the same. There is a risk of physical damage to assets. Although pipework is generally resilient to being submerged in water , electrical equipment is not. Loss of telemetry and communications has the potential to significantly impact site operation and the wider network.

At a strategic level, with likely sea level rise, this will be exacerbated if flood defences are ineffective and/or plant relocation is not possible.

Discussion

NGG owns and operates a number of significant assets in coastal locations, including two gas terminals at Bacton in Norfolk and St Fergus in Aberdeenshire.

While the Bacton terminal is located approximately 30m above sea level and afforded a level of direct impact (although erosion and possible stranding could be a factor), the terminal at St Fergus is located at sea level behind a dune system.

No systematic assessment of the risk posed by sea level rise has as yet been undertaken by NGG. Modelling undertaken in the ENA Met Office Report suggests the greatest impact will be seen in the south and east of the UK as a combined impact of climate driven sea level rise and crustal rebound associated with the last glacial period. A number of NGG assets are located in these areas due the nature of North Sea gas supplies.

At surface installations, electrical equipment presents the greatest risk to NGG operations. Assets including control systems, telecommunications and electric security fencing are vulnerable to flooding. While gas pipes and valves are inherently resilient, access for NGG operators is compromised in flood situations.

Some AGIs are located in sensitive areas, with current risk management procedures resulting in local adaptations being implemented (such as raising of electronics above known extreme tidal levels). A single AGI is located outside EA maintained flood defences and may be at risk as climate change develops. Significant investment may be necessary to protect or move these assets.

Below ground assets are more resilient to surface flooding of any type. However, the impact of corrosion caused by saline water at the coast and the potential for floating pipes in saturated ground may cause adverse stress to the assets. The impact of this is limited at present but could start to manifest itself in coming decades.

Given the findings of the ENA Met Office study, it will be necessary for the rate of sea level rise and the associated long-term impacts to be regularly reviewed.

ET2a: Changes in erosion due to climate change and sea level rise

Background

The coast is a dynamic environment with local geology, tides and currents determining the level of erosion or deposition. In some cases, the impact of erosion may be greater than that seen by sea level rise alone. In the future, the combination of higher sea levels, even without a corresponding increase in wave height will see increased erosion.

Discussion

At present, the impact of coastal change has been limited and primarily to the associated risk of flooding already described.

It is not therefore clear at present whether any NGG assets are at risk from coastal erosion. As discussed above, a number of NGG assets are located by the coast, the most significant of these include St Fergus, which is low-lying but protected by an extensive dune system and Bacton which is elevated (c.30m above sea level) but within the influence of the coast.

Work led by Norfolk County Council and the local Coastal Partnership has already been undertaken near the Shell Bacton Terminal (which is sited on the coastal side of the NGG terminal) and the villages of Bacton and Walcott following the loss of 10m of cliff during the North Sea Surge of 2013. The 2019 sandscaping project attempted to provide natural reinforcement to absorb the impact of the sea before it reaches cliff and sea defences.

Given the potential impact of coastal erosion, the identification of vulnerable coastal locations and high-risk assets will be required in the future. Engagement with local regulators and stakeholders will also be required.

ET2b: Coastal Management Policy

Background

Sea level rise and changes to storm patterns will result in different patterns of erosion. While this will result in physical changes, there are corresponding policy decisions which may have impact on infrastructure. There has been a recognised shift in approach from coastal defence to coastal management in recent years in order manage the coast in a more sensitive and pragmatic manner. In some cases however, actions such as managed retreat may result in impacts to assets.

Discussion

NGG considers this risk to be minimal at present. As a responsible business, NGG will always engage with regulators and those managing coastal environments on policy decisions which might influence the businesses assets.

NGG recognises the important role played by Shoreline Management Plans and the other spatial planning regimes that include coastal management. NGG will therefore continue to monitor the development of the policies and work with stakeholders and regulators. It should however be recognised that extra investment may be necessary where NGG assets are subject to the impact of sea level rise and the development of regional coastal adaptation plans.

ARG21: Saline contamination and increased corrosion rate of above and below ground assets from sea water

Background

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

Discussion

NGG has significant experience of operating subsurface assets in saline environments. It already operates pipelines in areas of salt marsh and flood or tidal zones subject to saline inundation without seeing significant impacts. The combination of cathodic protection and regular inspection to examine corrosion growth is employed.

Transition zones between saline and freshwater groundwater does present a challenge. However, these marginal areas tend to be less corrosive due to the tidal influences preventing the permanent exposure to saline water. Management of these areas is already undertaken given the need to balance cathodic protection to prevent excess protection in the fresh-water environments.

Coastal areas or those subject to inundation tend to pose a more significant risk of accelerated corrosion to above ground assets or at above ground transitions e.g., wind and water lines where the concentration of chloride can occur but where no or limited cathodic protection can be applied. In this instance chloride contamination is considered an accelerated corrosion mechanism for above ground pipework (when compared to normal atmospheric corrosion). As stated, NGG have significant operational experience of managing and maintaining above ground asset in or around costal environments and so this risk is not considered to be significant.

TCFD2: Flooding due to sea level rise and storm surge

Background

Storm surges present the potential for greater magnitude flooding in coastal areas. The compound impacts of sea level rise, erosion and tidal influences present the potential for assets to be flooded to a greater extent or in perceived lower risk areas.

Discussion

The majority of NGG assets are sufficiently inland or in elevated positions. However, assets on the east coast and particularly along estuaries may be vulnerable to extreme events that surpass general tidal events.

Storm surges also present a compound impact on pipeline river crossings with increased erosion of the riverbed and banks. Helicopter surveys and riverbed surveys which look at the depth of sediment present are routinely undertaken. In situations of increased risk, NGG has robust procedures in place and works with external stakeholders such as the Environment Agency and the relevant Port Authority where navigable waterways are involved to design and implement solutions.

Where such remedial measures have not been successful, NGG has sought investment to construct alternative routes. One such example is the Feeder 9 crossing of the River Humber where sudden and unpredictable changes to the riverbed led to unacceptable spanning of the original feeder. To mitigate these risks, the original riverbed crossing has been replaced by a new tunnelled crossing.

All new construction works are subject to robust Environmental Impact Assessments which take into account climate change and other physical risks based on the best available data at the time.

8. Storms

ARG7: Wind damage to above ground assets from storm events

MO11: Warm, wetter conditions combined with rainfall and / or wind

Background

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

Discussion

This is unlikely to present significant impacts to NGG assets, with the greatest business risk considered to be personnel being impacted by flying debris.

National Grid land at Compressor stations and AGIs is kept free of trees through maintenance contracts. AGIs are more susceptible to vegetation growth outside of the fence line due to their often-rural location and because NGG often doesn't own the surrounding land, thus making vegetation control more difficult. Line walking of linear assets is undertaken on a regular frequency and any areas of concern highlighted with our contractors.

Increases to the peak strength of wind may mean an adjustment to design specifications, particularly where Euro codes are updated. The business will therefore regularly review these specifications and incorporate them into the business' standards.

A second order risk is the potential for downed trees to prevent access to locations. While this isn't in the control of NGG, the business ensures its access and egress points are clear and engages with external stakeholders wherever necessary.

9. Groundwater

ARG22: Groundwater flooding of below ground assets leading to water ingress to pipes

Background

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

Discussion

Given the operating pressures and mechanical integrity of NGG pipelines, the ingress of groundwater is not considered to be an issue. Water ingress to a pipeline operating at 70 bar would require a column of water 700m high to overcome the pressure of the gas in the pipeline. This risk is therefore confined to low pressure distribution systems where groundwater pressures can readily exceed those of the gas in the pipe resulting in water ingress.

ADD1: Changes to groundwater levels resulting in floating of pipelines without buoyancy coatings

Background

There is a risk of physical damage to pipelines caused by buoyancy in saturated ground. Additional stresses placed on the pipeline by changes to groundwater levels can result in plastic deformation and eventually rupture. This will be exacerbated with changes to groundwater levels, particularly at the coast, associated with sea level rise.

ARP3

In general, pipelines are routed away from known areas where the ground is saturated. Where this is unavoidable, pipelines located in saturated ground are laid with additional concrete anti-buoyancy coatings.

Changes to rainfall patterns are likely to affect inland groundwater conditions and with sea level rise, also influence coastal groundwater levels. Changes could potentially lead to unprotected pipelines lines becoming buoyant and increasing stress levels which could lead to rupture.

NGG monitors its pipelines for deformations and line walking and helicopter surveys continue to identify saturated areas. However, given the subsurface nature of the issue and likelihood of further saturation at the coast due to sea level rise, this issue will require additional consideration in the future. Additional investment may also be required to undertake remedial work.

10.Erosion

ARG10: Risk to underground pipelines from river erosion

ET2d: Changes in erosion due to climate influenced groundwater and surface water change

Background

Pipelines can be exposed and then susceptible to physical damage from external impact or from being unsupported. More frequent flooding and increased river and watercourse flows will increase this level of risk.

Discussion

The ENA Met Office Climate Report suggests that changes to rainfall patterns and intensity will occur. We can therefore expect that corresponding river flows and erosion might also change.

Existing river crossings are monitored regularly as part of the routine integrity management process, the frequency of monitoring being set by individual risk assessments. Where an issue with erosion leading to risk of the feeder being exposed is identified, specific action plans are developed to resolve the issue, including working with stakeholders such as the Environment Agency.

New crossings are installed considering the best available technique for the environmental conditions. This may involve open cutting, tunnelling, micro-tunnelling or use of techniques such as HDD to route the feeder safely under the river. In addition to issues with the feeder becoming exposed across the riverbed, flooding can lead to erosion of the riverbank leading to the feeder ‘swan-neck’ being exposed which has occurred on the Feeder 11 crossing of the river Eden near Carlisle.

The new Feeder 9 River Humber tunnel, which replaced the original pipe that lay in a trench beneath the riverbed is a recent example of this process.

Case Study: Feeder 9 Tunnel

Changing tidal patterns have driven significant investment in one of National Grid Transmission’s key gas pipelines. We recognised that one of our key Gas Transmission pipelines that crosses the river Humber, over time had become exposed due to these changing tidal patterns eroding the riverbed that covered the pipeline.

The 5 km pipeline is a critical part of the gas infrastructure, connecting the Easington Gas Supply Terminal to the national network. We developed an innovative engineering solution to protect it and ensure continued operations of the pipeline in the short term. This solution involved filling exposed areas with gravel-filled bags and placing concrete ‘mattresses’ over the top with plastic fronds to mimic seaweed and encourage the settlement of sand and silt. We subsequently carried out detailed environmental and technical studies consulting with local communities on a number of options to determine the best solution for replacing the pipeline.

The best long-term solution was to construct a replacement pipeline in a tunnel dug beneath the River Humber. This minimised the impacts on the river and surrounding environment. More detailed information on the project can be found on the project website https://www.nationalgrid.com/uk/gas-transmission/land-and-assets/river-humber-pipeline-replacement

Accelerating changes to the climate and the time needed to identify, finance and initiate any actions (particularly the significant engineering required for diversions such as Feeder 9) may require monitoring to be undertaken at an increased frequency. In these circumstances, additional funding may need to be sought.

TCFD10b: Increased rate of loss of level in areas with already low depth of cover (e.g. Fenland areas)

Background

Increased temperatures and reductions in rainfall may result in shrinkage of clay and organic soils, resulting in reduced cover for pipes. The shrinkage and associated drying of soils also make it vulnerable to wind or water driven erosion, further compounding the issue. The resulting soil loss may make pipes more prone to strikes and bursts.

Discussion

For safety reasons, depth of cover over gas pipelines is an important issue as this provides a primary level of protection from accidental third-party interference. The land the NTS crosses is not owned by NGG but is subject to easements which control activities which can be undertaken within the boundaries of the easement.

Much of the land that the NTS crosses is agricultural and although normal agricultural practices are permitted within easements, there is a risk of accidental damage particularly in areas devoted to arable farming and where depth of cover is low. There has been a change in the recommended depth of cover over feeders with time. The recommended depth of cover (to the crown of the pipe) has increased from 0.9 to 1.2m to provide added protection.

Increasing temperatures and reductions in seasonal rainfall will continue to dry out soils, particularly those that are organic and prone to significant shrinkage. The additional impact of increased erosion due to the added friability of the soil and potential contribution of wildfires may exacerbate the issue.

While there is an expected increase in temperatures, the ENA Met Office Report suggests that areas may also receive additional prolonged or intense rainfall. While this will in some way counterbalance the impact of increased temperatures, there will be a consequence for erosion and infiltration. Increased infiltration may itself lead to increased pipe floating and associated physical stress on the asset.

Established mechanisms exist for managing areas with unacceptably low depth of cover and helicopter surveys and line walking are already in place to manage the risk. However, increased monitoring, particularly in vulnerable areas may be necessary as the century progresses.

Work is ongoing to assess the use of membrane markers above feeders to provide an extra level of protection from strikes. However, this and other potential mitigation measures would require intervention and excavation on third party land which would be complex and require significant investment.

11.Ground Movement

ARG12: Ground movement due to drought conditions and dry ground

MO 4: Repeated cycles of drought and rainfall causing ground movement

Background

Ground movement caused by drying and shrinkage may exert additional tensile forces on underground assets. Coupled with other issues, this could lead to mechanical damage and the potential fracture of pipelines leading to a gas release, fire and possible explosion.

Discussion

Ground movement and the influence of rainfall and groundwater is a known issue in parts of the NTS, primarily impacting pipelines. These have the potential to cause significant stress within the pipe, having the potential to result in a catastrophic burst. Issues include:

- Ground level changes: Settlement or subsidence caused by the underlying geology, impacted by climate, water or engineering issues.
- Feeder floating: Areas with shallow groundwater can cause feeders to float creating stress within the pipe.
- Slope stability: Locations where the angle of slope combined with unstable geology, rainfall and groundwater may lead to general movement or undermining of assets.

It is known that some fixed sites have settlement issues which are managed at a local level, but not deemed to be significant.

At present, there is no significant reason to believe that gas leaks as a result of ground movement exist under current conditions. Routine helicopter surveying, line walking with depth finding and pigging runs (which can detect imperfections in the pipes) are undertaken on the NTS at regular intervals. The robust construction and engineering of the NTS provides it with a good level of resilience.

The ENA Met Office Report suggests that ground movement may increase in coming decades with changes to rainfall (location and intensity) and temperature and so extra monitoring may be required.

12.Land Contamination

ARG11: Ground contamination and transport of materials from flooding of contaminated sites

Background

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.

Discussion

The likelihood of significant land contamination, particularly that associated with former town-gas production, being associated with NGG assets is limited. The majority of potentially contaminated land has been transferred to National Grid Land and Property for management and remediation.

The NTS, and particularly the compressor stations, are also of later construction, (associated with the uptake of North Sea Gas) and therefore the majority are located on former greenfield sites.

While some residual or historic contamination may exist within feeder corridors, the impact on the environment is limited. Where issues are discovered, significant support is available through risk management services provided by National Grid Land & Property.

ET4: Polluted ground fires and increased release of contamination from old mine workings

Background

Legacy contaminated ground and former industrial areas pose not only environmental but also safety challenges. These might be from the substances contained within them, but also the potential fire risk from hydrocarbons, ground gases and highly organic made ground. As a result of climate change, contaminants might become increasingly mobile and more readily combustible.

Discussion

As discussed above, the majority of NGG assets were constructed after the discovery of North Sea Gas and much of the former town gas infrastructure (which is no longer used operationally) has been passed to National Grid Land & Property for management and remediation.

There are no known sites associated with mine workings and as a result the risk of impact to the NGG network is very low.

13.Snow & Ice

ARG9: Asset impact from snow/ice falls and accumulation

Background

The risk to above ground assets is expected to gradually decrease due to less frequent snow events. However, a risk remains of physical damage from excessive snow or ice falls, for example increased loading on building roofs. There is also the risk that access might be compromised, delaying routine or emergency work.

Discussion

The implications of colder temperatures are discussed above, however, the 2018 ‘Beast from the East’ which included significant snow accumulations provided a significant challenge which the business responded to successfully. However, as a responsible business, NGG undertook a lessons-learned review following the event.

Periods of extended cold weather (including snow) tend to be associated with peak demands on the NTS. During periods when heavy snow is expected, arrangements are made to permanently man critical compressor stations and manned terminals to ensure operation of critical assets can be maintained. Sites are equipped with sufficient stores and backup systems to enable them to run for periods without outside support. Operational teams also have access to 4x4 vehicles, allowing them to access difficult locations.

A further implication for wider consideration is related to the reduction in extreme cold weather events. Although counterintuitive, this change may increase risk as the reduced frequency of events offers less opportunity to test systems in real world conditions. It may also make justifying additional investment in the equipment needed to manage extreme weather situations more challenging. A corresponding reduction in priority might therefore cause vulnerabilities during the next event.

As the climate warms, there may also be an intervening period or greater incidence of 'wet snow' 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 are enough to manage any impacts on NGG.

14.Lightning

ARG8: Extreme weather impacts from lightning

Background

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

Discussion

Lightning strikes are not considered to be a significant risk to NGG assets. Electronic control and communication systems are robust. Systems are also surge and lightning protected.

There are no significant risks to pipework, while venting stacks have nitrogen suppression systems installed to extinguish any fires which may result and the sterile area surrounding the vent stacks removes any risk to personnel from radiation from fires.

Lightning may however indirectly impact incoming electricity supplies and while NGG sites generally have backup supplies, battery backups and failsafe systems, longer outages may cause issues. Due to the robustness of the wider network, alternative compressors are likely to be available to compensate and compressors can be returned to service quickly, so the loss of local supplies for a short period is not considered to be a significant risk.

15.Wildfire

ARG14: Asset damage if no wildfire risk assessment or remediation measures in place

Background

Wildfire is a consequential risk of increased temperatures and reduced precipitation and, whilst difficult to forecast, pose a significant risk to above ground assets where they are located in susceptible areas. These include open heathland, grassland or forested areas and may be in remote locations. The risk of pipelines damage is increased in the absence of vegetation clearance within 3m of site boundaries.

There is also a significant human component in the cause of wildfires in combination with local geological and vegetation characteristics.

Discussion

Wildfire is an emerging risk, particularly following the events at Saddleworth Moor in 2018 which although did not impact the NTS, represents the size and scale of significant wildfires. Three risks have been identified relating to NGG assets:

- Wildfires (especially in peat moorland areas) may burn through the surface layers resulting in a reduction in surface cover and in extreme circumstances may continue to burn down through the sub-strata to the extent that the pipe wrapping may become damaged (particularly older coal tar coatings).

- Permanent sites are often surrounded by vegetation. Whilst some of this is non-operational land is owned by NGG, much is owned by third parties and thus might not be controlled to the extent that might be required to help mitigate wildfires.
- Some permanent sites have an incoming (wooden) pole mounted electricity supply or from neighbouring DNO substations. This interconnected risk might compromise electric driven compressor station, even in the event of a wildfire some miles from the NGG site (also recognised as an interdependency with external operations).

Vegetation surrounding permanent sites is managed through National Grid contracts and as such, an additional growth of vegetation on National Grid owned land will be controlled accordingly.

Feeder routes are also monitored, given the need to limit vegetation growth in the corridor. Work with third party landowners is undertaken to manage the vegetation where possible. It is also considered that given the depth of NGG pipelines, it is unlikely that fires will burn for a sufficiently long period to reach the depth required.

Areas of elevated risk have been identified in the ENA Met Office Report based on future weather conditions and vulnerable geology. Higher temperatures and lower rainfall in summer suggests this may be an emerging risk as climate change progresses. Therefore, further work is needed to understand the risk in these areas and to understand (at a broader scale) the influence of human activity on the incidence of wildfires.

16.Vegetation Growth

ARG15: Vegetation Growth

Background

Increases in both temperature and precipitation will lead to increased vegetation growth. Above ground assets will be impacted by any increased growth of trees adjacent to operational equipment. This will lead to increased levels of maintenance and reduced access issues. Similar issues may be encountered with the accelerated growth of plants or invasive species.

Discussion

Vegetation growth presents challenges to NGG, particularly where assets are surrounded by third-party land. Access is required to sites, pipelines and other assets for both routine and emergency purposes. Maintaining appropriate security at fixed sites, particularly related to clearing areas around fence lines is also significant.

While increased natural vegetation growth and tree planting (as part of offsetting or wider biodiversity improvements) may be seen as climate change progresses, the overall risk is considered to be minimal in the short term.

Anecdotally, the business is starting to see increased levels of vegetation clearance as part of its routine work. As this impact increases, additional funding may be required to mitigate potential impacts on the business.

Existing risk management processes including maintenance, line walking and helicopter surveys are considered to be sufficient. However, in the longer term, additional investment may be needed to ensure the frequency of these activities and the corresponding remedial work keeps pace with changes in the landscape.

NGG will continue to consider the impact of vegetation growth as climate change progresses and continue to review its standards and specifications for monitoring and clearance as appropriate.

17.Wildlife

ARG16: Wildlife Impacts

Background

Changes to breeding patterns, nesting seasons and species distribution as the result of climate change has the potential to impact operations. Access to locations where protected species are present, and the care and attention required to minimise impacts or implement mitigation may cause adverse impacts on operations.

Discussion

Wildlife presents a number of challenges to National Grid's operations both at fixed and non-fixed locations.

Nesting birds in particular are attracted to the open space, structures and security of NGG sites, including ground nesting species that utilise the chippings. Rabbits and other burrowing species can also impact assets, particularly cables and other ancillary equipment.

Non-fixed locations and development sites are subject to significant constraints which include protected species and habitats which must be carefully assessed and managed.

It is uncertain how, or if, climate change will influence both the type and activity of wildlife that access NGG locations. However, as a responsible business, we always try to work in a sensitive way with wildlife. This includes undertaking significant pre-planning for projects and construction and working with our ecological consultants to implement management plans. As a result, existing processes are considered to be suitable at this stage, however, given significant changes, additional resource and investment may be required.

18.Business Continuity Management

ARG18: BCM plans affected due to severe travel difficulties resulting from extreme weather events

Background

Severe weather has the potential to disrupt service to customers and business operations. Critical locations and systems may be impacted alongside a number of safety and logistical challenges in operatives gaining direct access to assets. The potential to compound emergency situations or slow the mitigation of their impacts may be an issue.

Discussion

National Grid has a robust resilience framework. The plans are focussed on disruption of service, for example as a result of severe weather, rather than specific climate risks. The risk posed by climate change is discussed in response to ARG1.

19.Compound Events

TCFD7: Extreme weather events including a combination of wind, rainfall, temperature or snow

Background

Extreme and compound weather events have the potential to cause widespread disruption. The combination of high winds, low temperatures and snow could present significant challenges to networks, by causing negative impacts and delaying mitigation efforts. These may be particularly compounded when events combine with high demand for gas.

Discussion

This is not considered to be a significant risk to NGG, with the main driver being the singular impact such of snow accumulation. The business' above ground assets are resilient in their design and nature, with the majority being in discrete and relatively isolated locations. Vulnerable installations (such as vent stacks) are also regulated under Health & Safety legislation, ensuring they are robust.

TCFD8: Perfect Storm of a cold winter, high gas demand and heavy persistent rain

Background

The compound risk of high demand and persistent rainfall could lead to pinch points on the network being inundated at a time of greatest loading. At the same time, resilience and redundancy in the system would be challenged.

Discussion

Pinch points on the network could be inundated with water; valves in pits, electrical ancillary equipment overwhelmed. For NGG, the perceived impact of this compound event is primarily driven by cold temperatures rather than precipitation. As critical infrastructure, mitigation and resilience in these circumstances is already in place.

20.Solar Storms

MO15: Solar Storm

Background

The impact of solar storms falls into two categories: asset damage and damage to telecommunication 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.

Discussion

The likely impact of solar storms is on satellite telecommunications. While there are potential impacts, systems would revert to landline communications and then manual intervention. As critical national infrastructure, NGG mobile communications are also part of the Government Telephone Preference Scheme (GTPS).

21.Interdependencies

A number of potential climate hazards may manifest themselves outside the control of NGG yet impact the business. Two such examples have been discussed in previous sections, namely:

- Wildfires impacting incoming electricity supplies;
- Environmental regulator costal management policy; and
- Pluvial flooding which may be caused or exacerbated by external drainage systems, such as those in the highway or within adjacent sites.

There are however, a number which can be addressed as individual risks.

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

Background

Extreme precipitation can lead to dam overload and failure. Where assets are located far enough away from dams, the impact of water inundation from a dam burst is no different from “standard” pluvial, fluvial or tidal flooding, and flooding impacts can be considered similar.

Where assets are close enough to dams to be impacted by the full force of a breach, the damage would be substantial. Plant and equipment would not only be impacted by water ingress it is likely to be physically damaged or washed away by the force of water.

Discussion

NGG has undertaken risk assessment work to determine the potential impact of dam failure:

- A single compressor station is located within the potential impact zone of a dam failure. Mitigation through the business’ risk management process has been implemented and incorporated into the site’s emergency preparedness plan. These plans are reviewed regularly and so any change due to climate change will be accounted for.
- A single feeder is located in close proximity to a dam. The feeder is monitored by the business through its existing management processes and engagement with the dam’s owner is undertaken regularly.
- There is also sufficient redundancy in the NTS should these assets be affected; the system would not be adversely impacted.

It is anticipated that the robust regulatory framework in place for dams and the subsequent focus following the Whaley Bridge spillway issue in 2019 will ensure the continued good management of these structures and also account for the impact of climate change.

ARG13: Vulnerability of critical IT systems managed by third parties from extreme weather events

Background

This represents an interdependency with other service suppliers and there is a risk of the loss of critical IT systems and functionality, especially if there is insufficient flood protection or cooling of third-party data centres and/or these cannot be relocated.

Discussion

IT systems are inherently linked to the operating conditions of the associated asset. For example, compressor kiosks are designed to the maximum temperature likely to be associated with its operation.

Around 200 NGG sites have remotely operable equipment, telemetry and field instrumentation. These systems have limited sophistication and have telephone backup systems which offer some redundancy.

While the assets that can be operated remotely by these systems have safeguards in place (such as stay-put valves), the loss of the IT element would require manual intervention should the system need reconfiguring for system or emergency needs. While this means the NTS is inherently safe, there is the potential for delays or a slow response to issues which might impact more customers or at a greater scale.

ARG17: Supply chain impacts

Background

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

Discussion

Disruption to our global supply chain (continuity of supply) is recognised as a key risk within our global procurement division's risk register. Work is underway to understand particular risks from climate change within the supply chain. National Grid, as part of its framework, works with responsible business who themselves consider climate and extreme weather vulnerability as part of their procurement and risk management frameworks.

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

Background

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

Discussion

This risk is considered to be limited. Turbine driven compressors have emergency generators which generally have 4 days of diesel supply which can keep compressors in standby. Batteries are also in place for other systems, providing 24 hours of backup.

Electrically powered Variable Speed Drives always have turbine driven compressors as a contingency to ensure gas supplies can continue. The networks are also resilient and can be reconfigured to compensate for most vulnerabilities.

The primary risk therefore is maintaining appropriate diesel supplies in the unlikely event that electricity supplies cannot be restored. However, additional redundancy is provided by the NTS by utilising other compressor stations, but this itself only provides a limited or short-term solution.

Risk Assessment

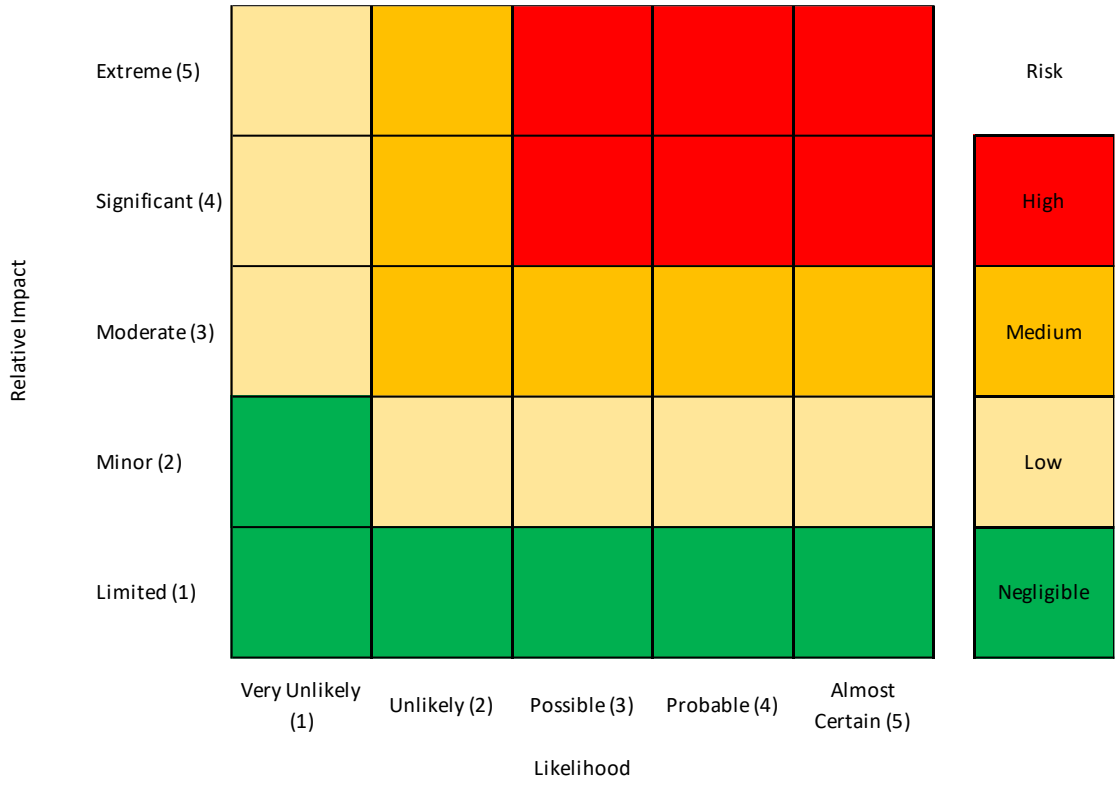
Introduction

This is the first gas adaptation report to include a formal risk assessment. To ensure consistency across members and within the ENA sector response, the ENA Gas Adaptation Subgroup members have developed the following risk matrix.

The matrix builds upon that used for ARP2 and 3 by the DNOs. To reflect the differences between the gas and electricity businesses, the definitions have been tailored to the gas industry.

The full risk ratings for the period under consideration within this report for NGG are presented as Appendix 1, with scoring detailed as likelihood vs impact.

Risk Matrix Template



Risk Matrix Impact Definitions

Rating	Definition
Extreme	Regional area affected with people off supply or significant asset failure which exceeds ability for network intervention or reinforcement. Financial: Financial: Cost dependent on TO/DNO impact (>£50M, >£20M) Reputation: External impact on international stakeholders, company accused of poor practice or negligence, direct blame to company leading to extensive media coverage, significant business and company value impact, potential loss of licence Environment: Reportable incident, serious and lasting environmental damage or loss, enforcement action and fine certain Asset/Security of Supply: Total loss of asset, major conurbation and high customer numbers off supply, national transmission system disruption
Significant	County or city area affected with people off supply or significant asset failure which requires significant network intervention or reinforcement. Financial: Cost dependent on TO/DNO impact (Up to £50M, >£10M)

	Reputation: External impact on national stakeholders, major environmental incident with extensive media coverage, business and company value impact, repeated regulatory intervention Environment: Reportable incident, significant environmental damage or loss, long recovery time, enforcement action expected Asset/Security of Supply: Major asset damage, geographical area off supply, major outage on distribution networks
Moderate	Significant increase in costs of response and network strengthening Financial: Cost dependent on TO/DNO impact (Up to £30M, £1-10M) Reputation: External impact on stakeholders, wider and prolonged adverse media coverage, negative customer impact, regulatory intervention Environment: Reportable environmental incident resulting from breach of consent or permit, medium damage and loss to environment, potential enforcement action Asset/Security of Supply: Asset damage leading to plant shutdown, significant numbers of tariff customers off supply for considerable time
Minor	Cost of network maintenance requirements and impact on business now of concern Financial: Cost dependent on TO/DNO impact (Up to £10M, £1M) Reputation: Internal impact within business and stakeholders, local media interest and complaints, some business criticism Environment: Minor, non-reportable incident affecting local environment, quick resolution Asset/Security of Supply issues: Minor asset damage leading to localised shut down, firm contract customers affected and off supply
Limited	Limited impact - can be managed within “business as usual” processes Financial: Cost dependent on TO/DNO impact (Up to £5M, £500K) Reputation: Internal issue from local event, negligible inconvenience, minimal media coverage Environment: Non-reportable incident with negligible environmental impact or damage, immediately resolved Asset/Security of Supply: Limited impact on assets and supplies, limited disruption to interruptible supplies

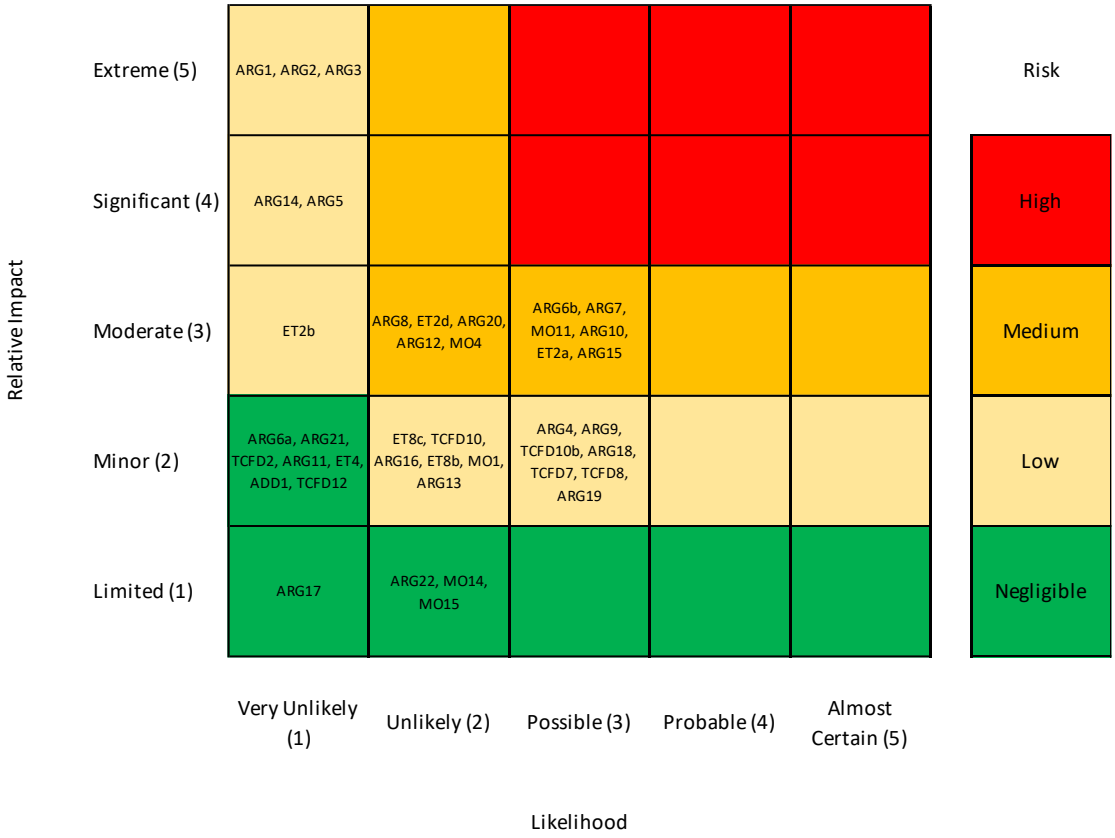
Risk Matrix Likelihood Definitions

Rating	Definition
Almost Certain	The risk is expected to be realised and may already be under active management as an event. Guideline: >90% or once a year frequency.
Likely	More likely and probably will occur, mitigations not fully effective, control weaknesses are known but being managed. Guideline: 50-90% or 1 in 5 years frequency.
Possible	Equally likely as unlikely, mitigations are in place, control measures are under active management. Guideline: 30-50% or 1 in 10 years frequency.
Unlikely	Events are rare and unlikely but could occur, required mitigations in place, controls are effective. Guideline: 10-30% or 1 in 15 years frequency.
Very Unlikely	No known event or extremely rare or remote chance of occurring. Guideline: <10% or 1 in 20 years frequency.

2.ARP2 Risks

As stated, while NGG, ENA and GDNs completed submissions to DEFRA for ARP1 and 2, the reports did not contain a formalised risk assessment. The ENA Gas Adaptation Subgroup, at the request of DEFRA, agreed to undertake a retrospective assessment of their ARP3 risks for the period of ARP2. This section presents the results of this process for NGG.

ARP 2 Risk Matrix



ARP 2 High and Medium Climate Adaptation Risks

Code	Risk	ARP2 Score
ET2a	Changes in erosion due to climate change and sea level rise	3x3
ARG10	Risk to underground pipelines from river erosion	3x3
ARG15	Vegetation growth	3x3
ARG6b	Above ground assets affected by raised temperatures	3x3
ARG7	Wind damage to above ground assets from storm events	3x3
MO11	Warm, wetter conditions combined with rainfall and / or wind	3x3
ARG8	Extreme weather impacts from lightning	2x3
ET2d	Changes in erosion due to climate influenced groundwater and surface water change	2x3
ARG20	Tidal Flooding of above ground assets due to sea level rise	2x3

ARG12	Ground movement due to drought conditions and dry ground	2x3
MO 4	Repeated cycles of drought and rainfall causing ground movement	2x3

No high risks were identified in the retrospective assessment for ARP2, with the majority of risks being categorised as Low and Negligible.

Eleven medium risks were identified. Six of these were rated in the higher tier of having a 'possible' likelihood and 'moderate' impact (3x3) as opposed to the lower tier of 'unlikely' likelihood and 'moderate' impact (2x3). These relate to:

- **River Erosion**: Resulting potential exposure of pipelines.
- **Coastal Erosion**: Where sea level rise and increased erosion presents a threat to low-lying coastal assets.
- **Vegetation Growth**: Where increased growth presents issues for site egress from secondary exits onto third-party land and access to and safety implications above underground pipelines.
- **Raised Temperatures**: Which affect the running efficiency of some turbine compressors, often requiring mitigation in the form of intake cooling.
- **Wind Damage**: Resulting from two impacts; from storm events; and the combined impact of warm, wet conditions with wind, resulting in the greater propensity for falling trees and other flying debris.

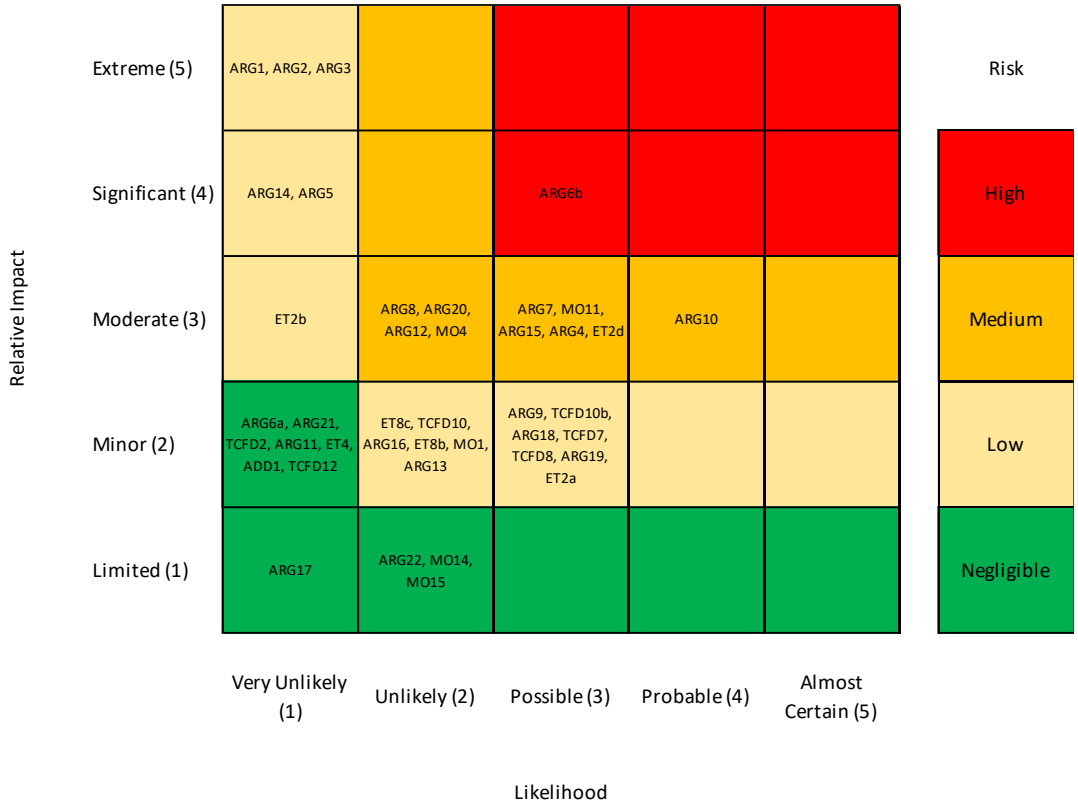
The lower-tier medium risks included:

- **Lightning**: Caused by extreme weather events.
- **Erosion**: Due to climate induced changes to ground and surface water characteristics.
- **Tidal Flooding**: Due to sea level rise.
- **Ground Movement**: Caused by drought conditions (singularly) and a combined risk of drought followed by heavy rain.

3.ARP3 Risks

This round of ARP covers the period 2016 to 2021.

ARP 3 Risk Matrix



ARP 3 High and Medium Climate Adaptation Risks

Code	Risk	ARP3 Score
ARG6b	Above ground assets affected by raised temperatures	3x4
ARG10	Risk to underground pipelines from river erosion	4x3
ET2d	Changes in erosion due to climate influenced groundwater and surface water change	3x3
ARG15	Vegetation growth	3x3
ARG4	Flood risk of above ground assets	3x3
ARG7	Wind damage to above ground assets from storm events	3x3
MO11	Warm, wetter conditions combined with rainfall and / or wind	3x3
ARG8	Extreme weather impacts from lightning	2x3
ARG20	Tidal Flooding of above ground assets due to sea level rise	2x3
ARG12	Ground movement due to drought conditions and dry ground	2x3
MO 4	Repeated cycles of drought and rainfall causing ground movement	2x3

A single high risk has been identified for ARP3 namely the impact of **Raised Temperatures on above ground assets**, which has increased from a moderate risk in ARP2.

Another medium risk relating to **River Erosion** has increased its likelihood score from 'possible' (3x3) in ARP2 to 'likely' (4x3), making it the highest of the medium risks.

Five risks have been identified in the medium tier of having a 'possible' likelihood and 'moderate' impact (3x3). Three remain unchanged from ARP2; namely, **Wind Damage** (from both storms and the combined impact of wet conditions and wind) and **Vegetation Growth**.

The remaining higher tier medium risks are emerging issues in ARP3:

- **Flooding**: The risk of impacting above ground assets. This was assessed to be a low risk in ARP2.
- **Erosion**: Due to climate induced changes to ground and surface water characteristics. This was assessed to be a medium risk in ARP2.

The lower tier medium risks, being 'unlikely' but having a 'moderate' impact (2x3) remained unchanged from ARP2. These are:

- **Lightning**: Caused by extreme weather events.
- **Tidal Flooding**: Due to sea level rise.
- **Ground Movement**: Caused by drought conditions (singularly) and a combined risk of drought followed by heavy rain.

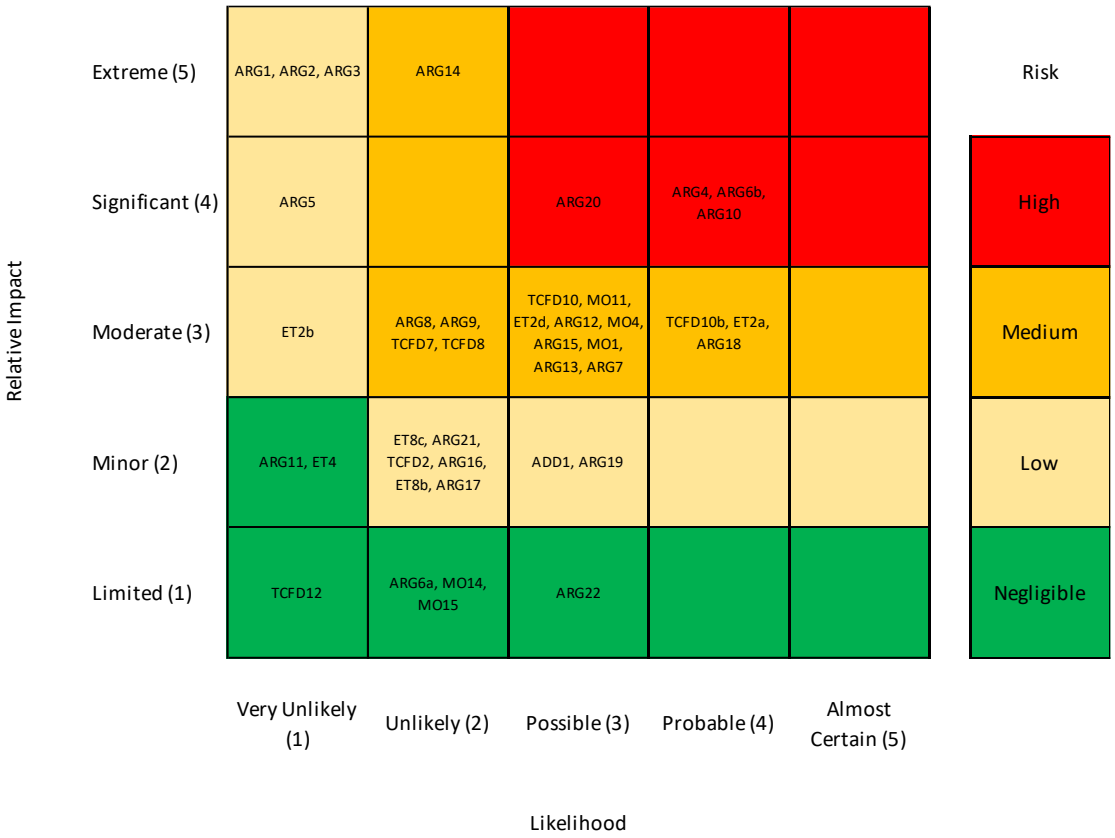
4.2050 Risks

DEFRA has requested an assessment of the position in 2050 based on business as usual.

This assessment has therefore been undertaken from the perspective that the NGG network and working practices remain the same. To be consistent with the ENA Met Office Report, the assessment has been based on a high emission (worst case) scenario.

The results should therefore be treated as a worst-case assessment rather than an indication of future performance.

2050 Risk Matrix



2050 High and Medium Climate Adaptation Risks

Code	Risk	2050 Score
ARG4	Flood risk of above ground assets	4x4
ARG6b	Above ground assets affected by raised temperatures	4x4
ARG10	Risk to underground pipelines from river erosion	4x4
ARG20	Tidal Flooding of above ground assets due to sea level rise	3x4
ET2a	Changes in erosion due to climate change and sea level rise	4x3
TCFD10b	Increased rate of loss of level in areas with already low depth of cover (e.g. Fenland areas)	4x3
ARG18	BCM plans affected due to severe travel difficulties resulting from extreme weather events	4x3

ET2d	Changes in erosion due to climate influenced groundwater and surface water change	3x3
TCFD10	Electricity demand growth in summer due to increased cooling load	3x3
ARG12	Ground movement due to drought conditions and dry ground	3x3
ARG13	Vulnerability of critical IT systems managed by third parties from extreme weather events	3x3
ARG15	Vegetation growth	3x3
ARG7	Wind damage to above ground assets from storm events	3x3
MO 1	Increased intensity of short duration rainfall leading to flooding	3x3
MO 4	Repeated cycles of drought and rainfall causing ground movement	3x3
MO11	Warm, wetter conditions combined with rainfall and / or wind	3x3
ARG14	Asset damage if no wildfire risk assessment or remediation measures in place	2x5
ARG8	Extreme weather impacts from lightning	2x3
ARG9	Asset impact from snow/ice falls and accumulation	2x3
TCFD7	Extreme weather events including a combination of wind, rainfall, temperature or snow	2x3

Four high-level risks have been identified in the 2050 assessment. Raised temperatures remain, with flooding, sea level rise and river erosion seeing an increased risk:

- **River Erosion**: Resulting potential exposure of pipelines.
- **Raised Temperatures**: Which affect the running efficiency of some turbine compressors, which often require mitigation in the form of intake cooling.
- **Flooding**: The risk of impacting above ground assets. This was assessed to be a low risk in ARP2.
- **Sea Level Rise:** Resulting in tidal flooding of assets.

Seventeen medium risks have been identified in the 2050 assessment. The three risks in the highest tier, having a ‘likely’ likelihood and ‘moderate’ impact (4x3) are:

- **Coastal Erosion**: Where sea level rise and increased erosion presents a threat to low-lying coastal assets
- **Erosion**: Resulting in loss of cover above pipelines, particularly in fenland areas.
- **Business Continuity Plans**: Potentially being significantly tested due to the impact if extreme weather events.

Seven of the remaining fourteen medium risks were identified as such in the ARP2 and ARP3 assessments:

- **Erosion**: Due to climate induced changes to ground and surface water characteristics.
- **Wind Damage**: Resulting from two impacts; storm events and the combined impact of warm, wet conditions with wind, resulting in the greater propensity for falling trees and other flying debris.

- **Ground Movement**: Caused by drought conditions (singularly) and a combined risk of drought followed by heavy rain.
- **Vegetation Growth**: Where increased growth presents issues for site egress from secondary exits onto third-party land and access to and safety implications above underground pipelines.
- **Lightning**: Caused by extreme weather events.

The remaining seven medium risks are emerging and have been identified below. Of note is the emergence of **Wildfires**, which while deemed to be unlikely, has the potential to cause a significant impact, which is the highest rating in the medium category. The emerging medium risks are:

- **IT**: The ability of third-party IT systems being vulnerable to extreme weather events.
- **High Intensity Rainfall**: Short-term events that result in flooding.
- **Wildfire**: Asset damage if no preventative measures are taken.
- **Raised Temperatures**: Electricity demand growth in summer due to increased demand for air conditioning.
- **Asset Impacts from snow and ice**: As a result of having less operational experience and justification for investment in less frequent events.
- **Combined Weather Events including wind, rainfall, temperature or snow**: Where low temperatures are the driver for NGG.
- **Perfect Storm Conditions**: Of high gas demand, low temperatures and rainfall.

ARP3 Risk Narrative

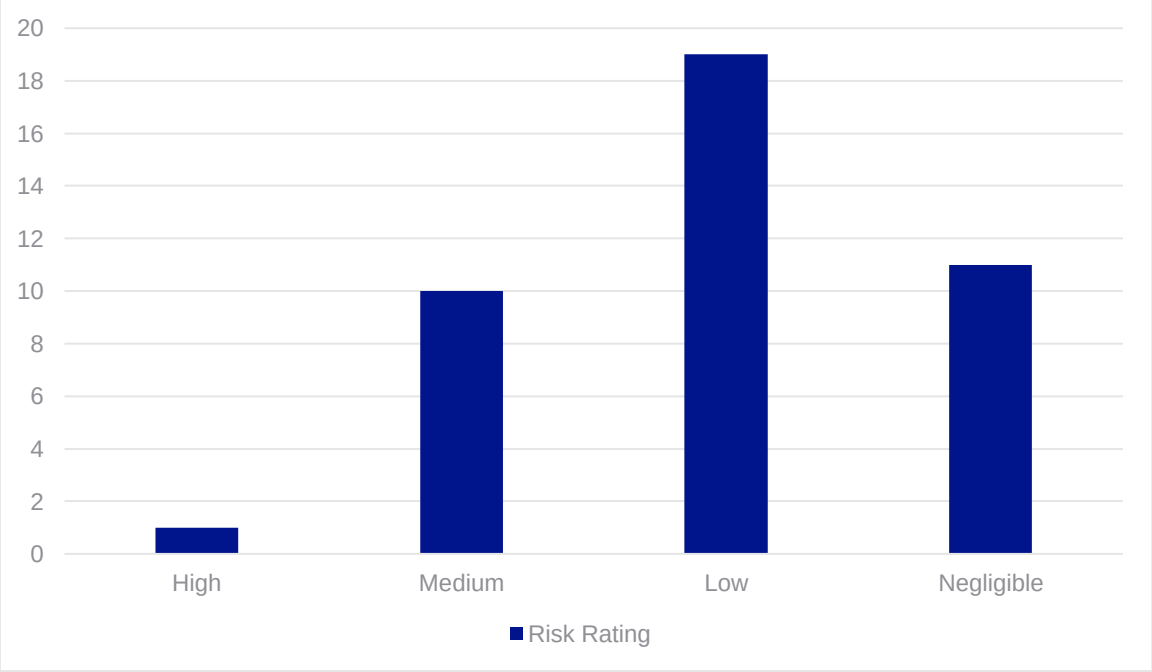
Introduction

This chapter discusses the findings of the NGG risk assessment. Although scoring has been undertaken for ARP2, the assessment is used here as a basis for comparison with the ARP3 and 2050 risk assessments. Detailed discussion of the specific risks can be found in the NGG ARP2 report.

As discussed, NGG undertook a detailed gap analysis of its risks associated with climate change. A total of 86 risks were initially identified by NGG as part of the screening assessment for ARP3. These came from previous and present ENA risk assessments, the ENA Met Office Report and NGG Climate Risk and TCFD Climate Modelling Project. Of these, 41 were carried through for detailed assessment.

The high and medium risks are discussed below. The overall scores and risk ratings can be found in Appendix 1. A summary chart of the risk ratings for ARP3 are shown in the following table.

ARP3: Number of Risks by Category



High Risks

Raised Temperatures

The highest risk identified in ARP3 is the impact of raised temperatures on above ground assets. This is focussed on the ability of gas turbine compressors to operate in elevated temperatures. Raised temperatures impact the operational efficiency of turbine compressors and above certain temperatures, intake cooling is required to ensure they remain effective and within their emissions standards.

Raised temperatures can also affect the demand for gas, particularly as the demand for electricity increases during the summer (e.g. as the growth of air conditioning accelerates) further increasing the need for summer running.

Medium Risks

The medium NGG climate change risks can be broadly categorised into six areas. These are reflective of the ENA Met Office climate study and are broadly consistent with the findings of

ARP2, however, it should be noted the assessment found the risks related to erosion have increased since ARP2.

The context of these medium risks should be noted. Given the inherent resilience of the NGG network, these risks are not significant at present. The commentary and actions should therefore be considered in that context.

Erosion

Changes to water volumes and flow rates in surface water and groundwater have the potential to significantly impact NGG operations. Erosion presents a key challenge, particularly at vulnerable locations, such as river crossings. This has been demonstrated on the River Humber and the need to construct a new tunnel following the exposure of the original pipe on the riverbed. The assessment considered there to be a small, but escalating increase in the risk of river erosion since ARP2 and that it will continue to develop towards 2050.

Flood Risk

Flooding, whether from rivers, surface runoff or sea level rise, presents a number of challenges which were highlighted in the assessment. Although pipes are robust and will not generally allow water ingress, ancillary electronic systems and mains supplies are vulnerable.

Some NGG sites have (or are in the process of having) such systems raised above likely flood levels. Whilst backup systems are in place to ensure the safe running of the network, increased flooding could impact the operation of the wider network.

The assessment considered that site access might also be compromised by flooding, potentially also limiting the ability of operational colleagues attending site. From a wider perspective therefore, whilst there are alternative network configurations, responses to secondary emergencies (e.g., diverting or stopping gas flows) might be delayed.

Storms

Two risks were considered in the assessment. Firstly, wind damage from storms and secondly, the impact of warmer, wetter conditions. The primary driver in each case relates to wind damage and the potential impact of debris from local trees and vegetation. In the case of the second risk, wetter conditions may make trees more vulnerable to falling or creating debris.

There is a challenge to mitigating this risk, particularly where NGG assets are surrounded by third-party land, where responsibility for controlling vegetation lies elsewhere. Additionally, as discussed below with reference to the ‘vegetation growth’ risk, climate change is producing longer growing seasons and so increased vegetation growth may compound storm damage as climate change progresses.

Ground Movement

Ground movement presents a risk to NGG in stressing assets, particularly pipelines. Rising temperatures, particularly the increased incidence of warm dry summers and drought conditions in parts of the UK is causing soil shrinkage and movement. Although not yet seen on the NGG network, areas of predominantly peat or clay soils (outlined in the ENA Met Office Report) present a particular risk due to their ability to swell and shrink, but also to erode quickly.

The risk is further compounded as a significant amount of the NGG network is located on third-party land and dependent on land management practices outside the direct control of NGG.

Vegetation Growth

The assessment considered the ENA Met Office Report findings that climate change is starting to produce a longer growing season. Some evidence suggests this has been the case for the past decade at least. Anecdotally, other parts of National Grid have seen increased requirements for vegetation cutting. The risk presents itself in two areas:

- For safety and access, there are limitations on the types of species that can be planted close to gas pipelines. However, self-seeding, increased growth rates and the uptake of planting for carbon off-setting may compound the risk.
- At fixed sites, vegetation growth on adjacent third-party land is already presenting issues at egress points and significant effort is being made to resolve this.

A continued extension of the growing season will compound these impacts.

Lightning

Lightning has been included in the risk assessment because of its risk to safety and ancillary electronics and IT systems. It is considered only to be a temporary issue given the significant number of backup and safety systems in place.

Interdependencies

Seven interdependencies have been considered in the risk assessment namely:

- ARG14: Asset damage if no wildfire risk assessment or remediation measures in place.
- ET2b: Coastal Management Policy.
- ET8b: Pluvial flooding resulting in NGG sites being stranded.
- ARG5: Flood risk of above ground assets (governors and pressure reducing equipment) from catastrophic dam failure.
- ARG13: Vulnerability of critical IT systems managed by third parties from extreme weather events.
- ARG17: Supply chain impacts.
- ARG19: Knock on effect on GDN operations from variable electricity supply due to impact on DNOs.

At present, all are considered to be low risk, with the exception of supply chain impacts which has been assessed as negligible. NGG will continue to monitor these risks during the period to ARP4.

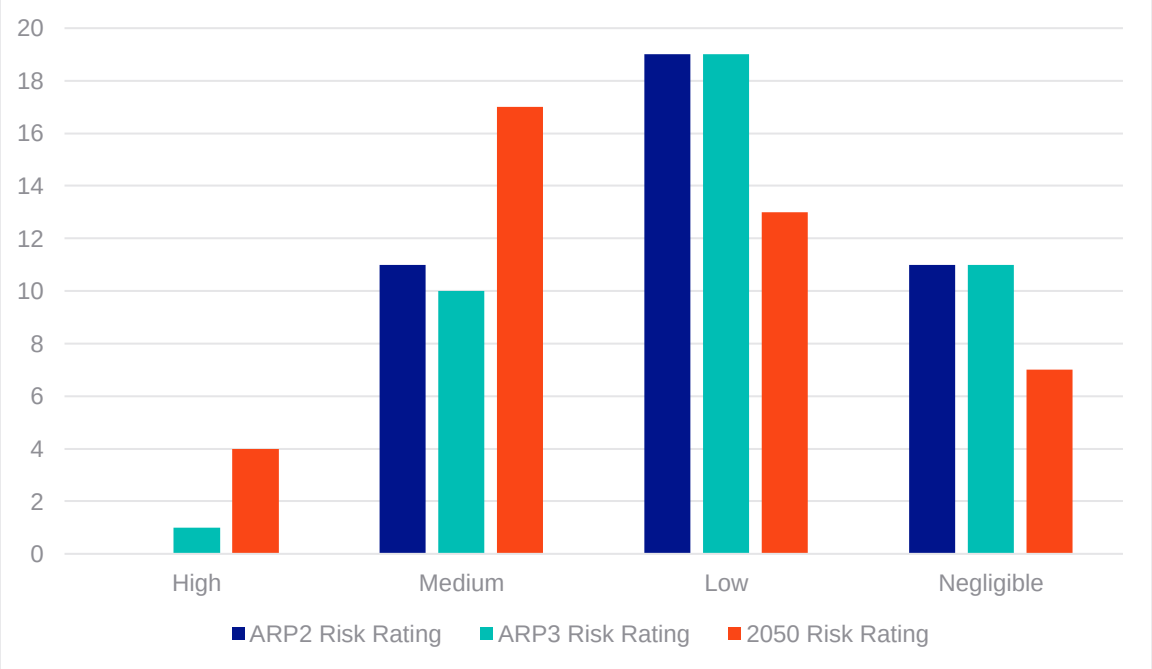
2050 Risk Narrative

Introduction

For ARP3, DEFRA requested the risk assessment look to the potential business impacts in 2050 should a business-as-usual approach be taken.

NGG therefore took the same approach as the main ARP3 assessment, utilising information from UKCP18 and the ENA Met Office Report. It is however important to recognise that the assessment is qualitative and reliant on a wide range of assumptions.

2050: Number of Risks by Category and comparison with ARP2 and ARP3



As would be expected there are a greater number of high and medium risks identified in the 2050 assessment. Based on business as usual, NGG would have four high risks and seventeen in the medium category rather than the one high risk and ten medium risks identified in ARP3.

High Risks

Above Ground Assets Affected by Raised Temperatures.

This risk carries over from ARP3. Evidence from UKCP18 and the ENA Met Office Report demonstrates that average and peak temperatures will rise through the century and so the potential impact on gas turbine compressors will continue to increase.

While future energy supplies will be subject to change, the assessment also considered the consequential increase in summer demand for air conditioning, which may be picked up through increased gas demand. This is reflected in the corresponding risk (TCFD10 - Electricity demand growth in summer due to increased cooling load) being identified as a medium risk in 2050.

Tidal Flooding

The ENA Met Office Report was clear in outlining the likely extent of sea-level rise through the century. As a result, the assessment considered this to be an escalating risk to NGG assets at the coast, but one which is heavily dependent on local geology, topography and human interventions. Impacts are already being seen on the NGG network and the evidence suggests this will only increase.

Flood Risk of Above Ground Assets

Inland (pluvial or fluvial) flooding continues to escalate, becoming a high risk by 2050, from a medium risk in ARP3 and low risk in ARP2.

This follows both recent weather trends and the ENA Met Office Report which outlined increased rainfall in the west and north of the UK; an increase in intense, short-duration rainfall; and a signal towards wetter autumns. This may also be combined with hot and dry summers which make soils less able to allow infiltration, resulting in greater volumes of surface water runoff.

The risk of increased intensity of short duration rainfall leading to flooding risk (MO1) also increased in the 2050 risk assessment (to a medium) based on the ENA Met Office Report findings.

Risk to Underground Pipes from River Erosion

This has been a consistent medium risk within ARP2 and 3. By 2050, influenced by the rainfall and temperature patters described above, it is anticipated that the impact of river erosion will increase.

Erosional processes generally place highly in the 2050 assessment with the following also included in the medium risk category:

- TCFD10b: Increased rate of loss of level in areas with already low depth of cover (e.g. Fenland areas).
- ET2a: Changes in erosion due to climate change and sea level rise.
- ET2d: Changes in erosion due to climate influenced groundwater and surface water change.

Medium Risks

Seven medium risks identified in ARP3 remain within that category. There are however ten new medium risks highlighted in the 2050 assessment. These are:

- TCFD10b: Increased rate of loss of level in areas with already low depth of cover (e.g. Fenland areas).
- ET2a: Changes in erosion due to climate change and sea level rise.
- ARG18: Electricity demand growth in summer due to increased cooling load.
- MO1: Increased intensity of short duration rainfall leading to flooding.
- ARG9: Asset impact from snow/ice falls and accumulation.
- TCFD7: Extreme weather events including a combination of wind, rainfall, temperature or snow.
- TCFD8: Perfect Storm of a cold winter, high gas demand and heavy persistent rain.
- ARG13: Vulnerability of critical IT systems managed by third parties from extreme weather events.
- ARG14: Asset damage if no wildfire risk assessment or remediation measures in place

Interdependencies

The interdependencies discussed within ARP3 show little change with exception of Wildfires (ARG14) and the vulnerability of IT systems (ARG13) which have increased to moderate risk from low.

Conclusion and Actions

This report represents a step change in NGG's climate adaption assessments. For the first time, in conjunction with the ENA and GDN partners, we have completed a fully scored risk assessment. To provide comparison we have also retrospectively undertaken the assessment for ARP2 and in line with DEFRA requirements, have taken a view to 2050.

For the assessment, in recognition of our commitment to understanding our climate change impacts, National Grid Gas has also undertaken a full gap analysis of its risks; collating 86 potential risks and formally assessing 41 in this report.

The ARP3 risk assessment has identified 1 high risk and 10 moderate climate risks. While more detailed in their nature, they are broadly consistent with previous National Grid Gas adaptation reports:

- Raised Temperatures
- Erosion
- Flooding
- Ground Movement
- Wind Damage
- Vegetation Growth
- Lightning

The assessment found that since ARP2, the considered risks from raised temperatures and erosion (specifically pipeline crossings) has increased. There has however, been minimal change in the remaining risks.

The view to 2050 illustrated the continued impact of raised temperatures alongside increased impacts from flooding and erosion.

Temperature, flooding and river scour are therefore considered to pose the greatest climate risk to NGG. A number of next steps have been identified to address these risks and to allow the business to prepare for potential or escalating impacts. NGG therefore will:

1. Review its standards and specifications for construction of new assets/plant to ensure resilient operation from the impacts of climate change throughout their life cycle.

2. Undertake a flood risk assessment using the latest available flood risk mapping, updating its 2008 assessment.

3. Undertake a river scour risk modelling exercise for gas transmission pipelines at river crossings using the UKCP18 Met Office climate change scenarios to inform its future depth of cover inspection regime and mitigation plans where appropriate.

While high and medium risks have been identified and next steps are necessary, the NGG assessment is consistent with previous reports and those of our ENA partners. The business remains inherently resilient but recognises the need to continually reappraise its climate risks and engage with regulators on financing adaptation measures to ensure it remains so.

Assumptions

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

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

Appendix 1: NGG ARP Scoring Matrices

ARP2 Risk Ratings

Code	Risk	ARP2 Score
ET2a	Changes in erosion due to climate change and sea level rise	3x3
ARG10	Risk to underground pipelines from river erosion	3x3
ARG15	Vegetation growth	3x3
ARG6b	Above ground assets affected by raised temperatures	3x3
ARG7	Wind damage to above ground assets from storm events	3x3
MO11	Warm, wetter conditions combined with rainfall and / or wind	3x3
ARG8	Extreme weather impacts from lightning	2x3
ET2d	Changes in erosion due to climate influenced groundwater and surface water change	2x3
ARG20	Tidal Flooding of above ground assets due to sea level rise	2x3
ARG12	Ground movement due to drought conditions and dry ground	2x3
MO 4	Repeated cycles of drought and rainfall causing ground movement	2x3
ARG4	Flood risk of above ground assets	3x2
ARG9	Asset impact from snow/ice falls and accumulation	3x2
TCFD10b	Increased rate of loss of level in areas with already low depth of cover (e.g. Fenland areas)	3x2
ARG18	BCM plans affected due to severe travel difficulties resulting from extreme weather events	3x2
TCFD7	Extreme weather events including a combination of wind, rainfall, temperature or snow	3x2
TCFD8	Perfect Storm of a cold winter, high gas demand and heavy persistent rain(GT)	3x2
ARG19	Knock on effect on GDN operations from variable electricity supply due to impact on DNOs	3x2
ET8c	Shifting flood areas may affect existing sites in the future	2x2
TCFD10	Electricity demand growth in summer due to increased cooling load	2x2
ARG16	Wildlife Impacts	2x2
ET8b	Pluvial flooding resulting in NGG sites being stranded	2x2
MO 1	Increased intensity of short duration rainfall leading to flooding	2x2
ARG13	Vulnerability of critical IT systems managed by third parties from extreme weather events	2x2
ARG1	Policy - Lack of climate change management procedure	1x5
ARG2	Policy - Lack of specific policies and procedures governing risk assessment process on climate change	1x5

ARG3	Policy - Risk and action owners not identified at senior leadership team level	1x5
ARG14	Asset damage if no wildfire risk assessment or remediation measures in place	1x4
ARG5	Flood risk of above ground assets (governors and pressure reducing equipment) from catastrophic dam failure	1x4
ET2b	Coastal Management Policy	1x3
ARG22	Groundwater flooding of below ground assets leading to water ingress to pipes	2x1
MO14	Diurnal temperature range	2x1
MO15	Solar Storm	2x1
ARG6a	Above ground assets affected by lower temperatures	1x2
ARG21	Saline contamination and increased corrosion rate of above and below ground assets from sea water	1x2
TCFD 2	Flooding due to sea level rise and storm surge	1x2
ARG11	Ground contamination and transport of materials from flooding of contaminated sites	1x2
ET4	Polluted ground fires and increased release of contamination from old mine workings	1x2
ADD1	Changes to groundwater levels resulting in floating of pipelines without buoyancy coatings	1x2
TCFD12	Fast cycling between temperature extremes	1x2
ARG17	Supply chain impacts	1x1

ARP3 Risk Ratings

Code	Risk	ARP3 Score
ARG6b	Above ground assets affected by raised temperatures	3x4
ARG10	Risk to underground pipelines from river erosion	4x3
ET2d	Changes in erosion due to climate influenced groundwater and surface water change	3x3
ARG15	Vegetation growth	3x3
ARG4	Flood risk of above ground assets	3x3
ARG7	Wind damage to above ground assets from storm events	3x3
MO11	Warm, wetter conditions combined with rainfall and / or wind	3x3
ARG8	Extreme weather impacts from lightning	2x3
ARG20	Tidal Flooding of above ground assets due to sea level rise	2x3
ARG12	Ground movement due to drought conditions and dry ground	2x3
MO 4	Repeated cycles of drought and rainfall causing ground movement	2x3
ARG9	Asset impact from snow/ice falls and accumulation	3x2
TCFD10b	Increased rate of loss of level in areas with already low depth of cover (e.g. Fenland areas)	3x2
ET2a	Changes in erosion due to climate change and sea level rise	3x2
ARG18	BCM plans affected due to severe travel difficulties resulting from extreme weather events	3x2
TCFD7	Extreme weather events including a combination of wind, rainfall, temperature or snow	3x2
TCFD8	Perfect Storm of a cold winter, high gas demand and heavy persistent rain(GT)	3x2
ARG19	Knock on effect on GDN operations from variable electricity supply due to impact on DNOs	3x2
ET8c	Shifting flood areas may affect existing sites in the future	2x2
TCFD10	Electricity demand growth in summer due to increased cooling load	2x2
ARG16	Wildlife Impacts	2x2
ET8b	Pluvial flooding resulting in NGG sites being stranded	2x2
MO 1	Increased intensity of short duration rainfall leading to flooding	2x2
ARG13	Vulnerability of critical IT systems managed by third parties from extreme weather events	2x2
ARG1	Policy - Lack of climate change management procedure	1x5
ARG2	Policy - Lack of specific policies and procedures governing risk assessment process on climate change	1x5

ARG3	Policy - Risk and action owners not identified at senior leadership team level	1x5
ARG14	Asset damage if no wildfire risk assessment or remediation measures in place	1x4
ARG5	Flood risk of above ground assets (governors and pressure reducing equipment) from catastrophic dam failure	1x4
ET2b	Coastal Management Policy	1x3
ARG22	Groundwater flooding of below ground assets leading to water ingress to pipes	2x1
MO14	Diurnal temperature range	2x1
MO15	Solar Storm	2x1
ARG6a	Above ground assets affected by lower temperatures	1x2
ARG21	Saline contamination and increased corrosion rate of above and below ground assets from sea water	1x2
TCFD 2	Flooding due to sea level rise and storm surge	1x2
ARG11	Ground contamination and transport of materials from flooding of contaminated sites	1x2
ET4	Polluted ground fires and increased release of contamination from old mine workings	1x2
ADD1	Changes to groundwater levels resulting in floating of pipelines without buoyancy coatings	1x2
TCFD12	Fast cycling between temperature extremes	1x2
ARG17	Supply chain impacts	1x1

ARP3 2050 Risk Ratings

Code	Risk	2050 Score
ARG4	Flood risk of above ground assets	4x4
ARG6b	Above ground assets affected by raised temperatures	4x4
ARG10	Risk to underground pipelines from river erosion	4x4
ARG20	Tidal Flooding of above ground assets due to sea level rise	3x4
ET2a	Changes in erosion due to climate change and sea level rise	4x3
TCFD10b	Increased rate of loss of level in areas with already low depth of cover (e.g. Fenland areas)	4x3
ARG18	BCM plans affected due to severe travel difficulties resulting from extreme weather events	4x3
ET2d	Changes in erosion due to climate influenced groundwater and surface water change	3x3
TCFD10	Electricity demand growth in summer due to increased cooling load	3x3
ARG12	Ground movement due to drought conditions and dry ground	3x3
ARG13	Vulnerability of critical IT systems managed by third parties from extreme weather events	3x3
ARG15	Vegetation growth	3x3
ARG7	Wind damage to above ground assets from storm events	3x3
MO 1	Increased intensity of short duration rainfall leading to flooding	3x3
MO 4	Repeated cycles of drought and rainfall causing ground movement	3x3
MO11	Warm, wetter conditions combined with rainfall and / or wind	3x3
ARG14	Asset damage if no wildfire risk assessment or remediation measures in place	2x5
ARG8	Extreme weather impacts from lightning	2x3
ARG9	Asset impact from snow/ice falls and accumulation	2x3
TCFD7	Extreme weather events including a combination of wind, rainfall, temperature or snow	2x3
ADD1	Changes to groundwater levels resulting in floating of pipelines without buoyancy coatings	3x2
ARG19	Knock on effect on GDN operations from variable electricity supply due to impact on DNOs	3x2
ET8c	Shifting flood areas may affect existing sites in the future	2x2
ARG21	Saline contamination and increased corrosion rate of above and below ground assets from sea water	2x2
TCFD 2	Flooding due to sea level rise and storm surge	2x2
ARG16	Wildlife Impacts	2x2

ET8b	Pluvial flooding resulting in NGG sites being stranded	2x2
ARG17	Supply chain impacts	2x2
ARG1	Policy - Lack of climate change management procedure	1x5
ARG2	Policy - Lack of specific policies and procedures governing risk assessment process on climate change	1x5
ARG3	Policy - Risk and action owners not identified at senior leadership team level	1x5
ARG5	Flood risk of above ground assets (governors and pressure reducing equipment) from catastrophic dam failure	1x4
ET2b	Coastal Management Policy	1x3
ARG22	Groundwater flooding of below ground assets leading to water ingress to pipes	3x1
ARG6a	Above ground assets affected by lower temperatures	2x1
MO14	Diurnal temperature range	2x1
MO15	Solar Storm	2x1
ARG11	Ground contamination and transport of materials from flooding of contaminated sites	1x2
ET4	Polluted ground fires and increased release of contamination from old mine workings	1x2
TCFD12	Fast cycling between temperature extremes	1x1

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