Cadent
Your Gas Network

Appendix 2

Climate Resilience Strategy

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Contents

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Executive Summary

This strategy document focuses on climate resilience and the physical impacts of climate change on our assets. It addresses the capabilities that we need to develop to help enhance our resilience, so that we can continue to provide high standards of service to our customers and reduce the impact of significant climate related disruptions.

The accelerating changes to global climate adds great uncertainty to our future operating model as society's needs change around us. In developing our Climate Resilience Strategy, we have distinguished the type of risks to which we aim to adapt our network. This is based on our understanding of climate exposure, as well as to align with international reporting and disclosure frameworks i.e. Task Force for Climate Financial Disclosure (TCFD). This includes the following risks:

- Acute: Severe storms (wind), riverine flood events (pluvial and fluvial causes), coastal flooding, wildfire, heat stress, cold extremes.
- Chronic: Warmer winters, soil subsidence and erosion (from drought conditions), asset inefficiency due to heat, impact of heat / cold on gas demand / supply.

These are the hazards that we will be adapting our network for as the physical risk they present to our assets will evolve with the changing climate.

We will prioritise adapting our network for acute events, as chronic events will materialise over a longer time horizon. We recognise that our network's scale and use may change dramatically over the coming decades as methane usage declines and is replaced either by electrification, hydrogen, or other sources. Focusing initially on acute events, therefore, allows us to maximise the impact of our adaptation to minimise risks in the period when we are most confident our network is required.

Whilst we have taken some important steps to understand our risk exposure to climate change, we recognise that we are at an early stage of our journey in fully understanding the complexities of the challenges that we need to respond to. Our focus has been on short term tactical, reactive interventions when it comes to understanding and managing the impacts of climate change on our assets.

For RIIO-3 we will be changing our focus to build capabilities to allow us to move towards a proactive, strategic, and long-term view of climate resilience and embedding this into our asset management processes and thinking. We will also need to consider interdependencies beyond our network boundaries and will need to collaborate more widely, working with a broader range of stakeholders, to understand these risks (i.e. distribution network operators, water networks, transportation etc.).

Our Climate Resilience Strategy comes at a time when the impacts of climate change are already being felt. RIIO-3 offers an important opportunity to make vital and significant progress towards embedding climate resilience across our organisation.

Our strategy sets out our role and the importance of understanding climate change; key drivers impacting our climate resilience agenda; what we do now and our plans for RIIO-3. It will serve as a roadmap for embedding climate resilience across our business, guiding our actions and plans for the future.

Our forecasted cost to deploy the structural changes into our organisation are [cost sensitive], comprising spend on developing our engineering response, IT data and digitisation to model risk, and integration of the net result into our Asset Investment and Engineering frameworks.

1. Our role and the importance of understanding climate change

1.1. How climate impacts us

Climate change is significantly important to our business and something that we monitor and adapt to as society's needs change around us. As part of our daily operations, Cadent has to make climate sensitive decisions across a range of processes to keep the energy flowing.

For example, the Energy Control Centre within Cadent is responsible for the safe and efficient operation of the gas distribution networks (GDNs) and utilises weather data to support the overall gas demand forecasting process.

In addition to this, damage from natural environmental conditions including lightning, wind, sun, snow and ice, and flooding is a key threat to gas supply and could lead to a critical transportation constraint within the distribution network. We therefore must ensure it is resilient to natural events and climate change. This resilience is currently established through risk assessments and risk controls as well as operational responses to hazards and potential events. However, we are still immature in the way we manage and track the longer-term impact of climate on our networks (see section 3.6).

As a business, therefore, we recognise the urgent challenges and importance of climate change, both to successfully navigate different pathways to net zero, as well as the impacts that climate change can have on our assets and the service that we provide to our customers.

As such, within our business, we consider climate change from two angles:

- Transition: We believe that we have an important role to play to help lead the way to a cleaner, greener future and are taking steps to address this. For example, we have set environmental commitments with our supply chain partners, launched our green fleet, and have a role to play to ensure our networks are ready to transport greener gases.
- Climate resilience: In addition to our role to help with the energy transition and net zero, we need to be prepared and resilient to the impacts that climate change is currently having, and will continue to have, on our assets and operations. Understanding the physical risk to our assets and being able to embed this into our decision-making processes, such as climate resilience considerations into strategic investment planning (SIP) decision-making is key.

Whilst we have taken important steps to improve our understanding of our risk exposure to climate change and developing climate resilience, we recognise we are at an early stage of our journey.

We understand that we need to move beyond tactical responses (i.e. responding to weather-related risks and problems) to mid to long term strategic resilience (i.e. embedding climate resilience into asset management decisions).

To further build on the work that we have done, we require a cultural shift in our business; new capabilities and ways of working across teams to make sure that we can effectively respond to the physical impacts of climate change.

We also need to look beyond just our network and our own response to climate change. We need to better understand the dependencies we have with other systems which may also be impacted by climate change in similar or other ways (i.e. distribution network operators, water networks, telecommunications, and transport sectors). Understanding the impacts of climate change in relation to cascading and escalating failures of infrastructure across other independent sectors will also play an important role in our response.

Accordingly, this document is focused on the physical impacts of climate change and the resilience that we develop against this. As a provider of critical national infrastructure and essential services, climate resilience is critical, and we recognise the need for open and forward-looking data, cross-industry collaboration, and investments to provide a resilient and reliable service to customers.

1.2. Our current asset management landscape

1.2.1. Our Network Asset Management Strategy frameworks

Our Network Asset Management Strategy outlines our long- and short-term ambitions to transform our asset management approach.

Our focus in RIIO-2 was to transform our business performance and in RIIO-3 we will focus on digitising our business. This will allow us to move from reactive to proactive management of our network and enhancing our resilience. Climate resilience forms a component of this stage of our strategy.

In transforming our business performance, we have established an enduring strategic asset management framework, underpinned by robust data and enduring tools that will be refined and managed as part of business-as-usual. This framework allows us to quantify the risks to services (monetised risk) and assess those risks against the cost of intervention.

Our Network Asset Management Strategy for the next five years and beyond is shaped by the pillars as shown in Figure 1, please also refer to Appendix 10: Network Asset Strategy. In developing our strategy, we ensure consistent, data-driven quantified assessment of service risk (i.e. risk to the services we provide to customers) is undertaken and enable systematic costing and cost benefit analysis (CBA).

Figure 1: Network asset strategy investment framework

Our Network Asset Strategy outlines our ambitions to evolve our investment framework to embed resilience, specifically climate resilience, so that our investments can holistically consider wider risks and benefits to better inform our future investments.

We have defined a resilience framework within our Network Asset Strategy, which comprises several thematic controls which contribute to the resilience of our networks.

Resilient Network Design	The design and construction of integrated and resilient networks, with the intent to minimise or control single points of failure.
Risk Based Asset Investment	Asset investment which is driven by the asset condition risks to ensure reliable and robust network assets. Includes adaptation.
Alarm & Early Warning Systems	Systems designed to provide early warnings of asset condition failures to mitigate risks of failure
Asset Maintenance and Repair	The continuous monitoring, maintenance and repair of assets to respond to changes in condition.
Resilient Asset Design & Construction	Design of each network asset such that it meets minimum level of asset reliability and performance.
Cyber and Physical Security	Management of physical and cyber security controls on assets to control risks from external and internal threats.
Continuity Planning	The development of suitable and sufficient contingency arrangements to manage

Figure 2: Network asset strategy resilience framework

To embed resilience into our investment framework we will need to evolve our service risk framework to model how resilience hazards will change the risk (likelihood and / or severity) of failure of our assets. This will largely build upon the existing methodology used for asset health. By developing our modelling and assessment capability, we will be able to quantify and assess climate risks alongside other risks when making investment decisions. This means we will be better equipped to make dynamic and efficient investment decisions.

Our adaption pathways similarly will need to be defined to incorporate into the Unit Cost Workbook and Workbank Model, so that we are able to identify the appropriate interventions to respond to the climate risk and accurately estimate costs for each intervention type.

These evolutionary steps will allow us to quantify the risk posed by the climate hazards and accurately estimate intervention costs, which will ultimately allow us to undertake dynamic CBA in a consistent and considered way.

1.3. Our Engineering Framework

Underpinning all of our activities and asset investments is our Engineering Framework. Figure 3 shows the key features of our engineering framework. This comprises Policy, Procedures, Competence and Compliance controls, and is designed to ensure that Cadent complies with Legal and Regulatory requirements to ensure Safe Transportation, Sustainability, Security of Supply and Efficiency. This ensures that we can keep people warm and protect the planet.

We are actively participative in industry working groups including the Energy Network Association ((ENA) which gas networks are leaving and transition to Future Energy Networks) and Institute of Gas Engineers and Managers (IGEM) to develop common standards for use in the gas industry and ensure these are reflected in our Engineering Framework.

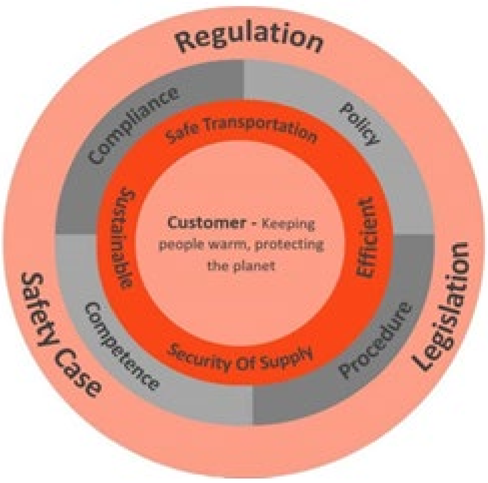

Figure 3: Our engineering framework

Our Engineering standards are constantly iterated, driven by changes in regulation, industry standards, technology, and best practices. These changes can be deployed quickly into our working practices through updates to documentation and training.

Our expectation is that this iterative approach will suit deployment of climate resilience, as it will allow us to quickly deploy new requirements and 'fail forward' through ongoing asset investment programmes.

2. Key drivers impacting our climate resilience response

Our strategy for the next five years and beyond for adapting to climate change is shaped by our legal and regulatory obligations, our priorities and ambitions as a transporter of gas, Government policy, the priorities of our customers as well as our RIIO-3 company-wide objectives. At a company level, our overall aims for RIIO-3 include:

- Accelerating the shift to a net zero energy system.
- Ensuring consistently high standards of service for customers.
- Maintaining security of supply and strengthening the resilience of our energy infrastructure to future threats.
- Delivering consistent, fair returns to investors reflective of the wider market environment.

This section provides further detail on the key drivers impacting our climate resilience response as an organisation, as we aim to grow our capabilities over the RIIO-3 period and beyond.

2.1. Scientific research on the speed and scale of climate change

The Committee on Climate Change reports annually to Parliament on the UK's progress in adapting to climate change[1]. The most recent report in 2023 sets out the latest evidence regarding observed global climate change and observed and projected changes in the UK's weather and climate.

Global observations over recent years show that carbon dioxide (CO_2) concentrations continue to increase. It is estimated that global, human-induced warming has now reached nearly 1.3ºC above 1850-1900 temperatures. At the present rate of increase, this would exceed 1.5ºC above pre-industrial levels by the early 2030s.

Observed climate change in the UK shows annual average temperature over the last decade (2013-2022) has risen by around 0.75°C above the average of the 1981-2000 period. 2022 was the warmest year on record for the UK; it was the first year to exceed an average temperature of 10°C and a new UK maximum temperature of 40.3°C, exceeding the previous record temperature of 38.7°C set only three years ago.

Projected changes in UK climate and weather[2] include warmer and wetter winters, drier and hotter summers as well as continued sea-level rise and more frequent, extreme weather events. By 2050, the UK's average winter could be around 1ºC warmer than it was on average over 1981-2000 and around 5% wetter. An increase in both the intensity of winter rainfall and the number of wet days is expected. By 2050, the UK's average summer could be around 1.5ºC warmer than it was on average over 1981-2000 and around 10% drier. These additional changes in the UK's climate to 2050 are largely insensitive to the pathway of global greenhouse gas emissions over coming decades.

Long-term UK climate risks depend on both the ambition and implementation of global emissions reductions. If global emissions continue at a high level through to mid-century and beyond, global temperatures will continue to rise beyond 2050 and associated climate changes in the UK and elsewhere will continue in the second half of the century. If, however, global emissions have been significantly reduced by mid-century and are brought to net zero soon after, then many aspects of global and UK climate in the second half of the century can be kept close to that experienced at mid-century.

Even if the UK successfully achieves its net zero targets for 2050, current ambition for global emissions reduction is expected to be consistent with a central estimate of 2 - 3ºC of warming above pre-industrial levels by 2100.

Crucially, this means our actions to adapt to climate change must continue, regardless of the pathway the UK follows to achieve net zero by 2050.

As such, compared to RIIO-2, we now expect faster, larger, and more impactful increases in temperature and consequent impacts on our assets and operations. This means we need to make sure that we are prepared for the impacts of climate change.

[1] Progress in adapting to climate change - 2023 Report to Parliament - Climate Change Committee
[2] CCRA3-Briefing-Energy.pdf

2.2. Our obligations

We have a variety of legal and regulatory duties to provide and maintain a safe and resilient network[3]. This includes, for example, assessing the risk of an emergency occurring and having plans in place to ensure security of supply to our customers. Uncertain and changing climate futures present many more disruption and damage modes to our assets than our historically stable climate. Subsequently, continuing to meet our legal obligations requires us to adapt to climate change.

Our most recent Climate Change Adaptation Report highlights the main climate impacts on gas networks using the latest Met Office UK Climate Projections (UKCP18). These are, for example, predicted temperature increases, increase in winter rainfall and summer droughts, as well as predicted increases in storm surges. We need to be able to adapt to these and have mitigating actions in place to make sure that we can continue to meet our legal and regulatory duties.

It is also worth considering, however, that existing obligations and duties may not be sustainable in an uncertain climate future. For example, regulators may need to consider whether existing standards of service conceived in a 1990's climate world are still applicable and as a result what may constitute an acceptable level of service in a world with greater climate risk.

2.3. Aligning with our RIIO-3 objectives

We see adapting to climate change as a key part of our operations now and in the future. Climate change is already beginning to impact our assets and service delivery.

We build, maintain, and operate our assets to high standards to provide safe, secure, and resilient supplies for our customers. To maintain this position, we need to respond to changes in the underlying risks to these high standards. For RIIO-3, we see this as including workforce resilience, cyber resilience, and climate resilience.

Climate resilience cuts across each of these objectives, which we have detailed in below. Our RIIO-3 company-level objectives are a key driver impacting our climate change response and we will ensure that this Climate Resilience Strategy aligns with our key company-level RIIO-3 objectives.

Accelerating the shift to a net zero energy system

Whilst this objective is not necessarily linked to building resilience to climate change, it still focuses on the broader climate change transition and our role in this.

The natural gas that we distribute has a direct and indirect impact on climate change. Methane is a potent greenhouse gas and leakage of it should be minimised. The burning of methane in heating systems also creates carbon dioxide which adds to overall emissions.

We have a clear strategy to reduce our impact through the proactive reduction in methane leakage from our pipes, supporting consumers to use less gas through efficient and hybrid heating systems' increasing the amount of green gases such as biomethane and blended hydrogen that we distribute and making the network ready for hydrogen for when it is needed.

The leakage of methane from our pipes is directly impacted by climate change which causes ground movements through droughts and flooding. Effective management of our asset base (including protecting it from climate induced failure) will therefore be more important as climate change has greater impacts.

Ensuring consistently high standards of service for customers, and maintaining security of supply and strengthening the resilience of our energy infrastructure to future threats

Understanding the different climate hazards (i.e. flooding, heat and wind) and building climate resilience based on the likelihood / severity / time period of the event increasing, will help to ensure that we are able to better withstand the impacts of climate change.

This will help to make sure our networks can maintain service during adverse conditions, allowing high standards of service to customers to be maintained as well as security of supply in the face of the impacts of climate change.

[3] Including but not limited to The Gas Act (1986), The Pipeline Safety Regulations 1996 and the Pipelines Safety (Amendment) Regulations 2003. The Gas Safety (Management) Regulations 1996, The Health and Safety at Work etc. Act 1974, Network and Information Systems Regulations 2018, and other safety legislation and policies (such as REP-2).

Delivering consistent, fair returns to investors reflective of the wider market environment

Understanding different climate hazard risks across our network, adaptation costs and benefits so that they can support strategic asset investment planning and decision making will help to ensure that we deliver consistent, fair return to our investors.

For example, by assessing climate hazard risks we can identify potential vulnerable assets across our network and feed this into SIP decisions, so that we can invest in measures to build asset resilience to climate change (i.e. elevating an asset to reduce a flooding risk or upgrading infrastructure to withstand a climate hazard).

In turn, this can help reduce the likelihood of costly disruptions, potential penalties, thereby safeguarding returns for investors.

Understanding the impacts of climate change in relation to cascading and escalating failures of infrastructure across other independent sectors will also play an important role in our response to climate resilience.

2.4. Wider benefits

Whilst the primary focus of this strategy is on better preparing our asset base to be resilient to climate hazards, there are a number of secondary benefits that will be established through successful implementation.

Weather and climate is a key factor in determining our long-term demand and capacity needs. Further longer-term granularity of the effects of climate will help us to improve long-term forecasting to better understand how our network is likely to change. Couple that with the ongoing developments of the UK energy policy with regards to net zero and we will be able to improve the accuracy of our forecasting.

Similarly, longer-term weather and climate data will help us safeguard our operational resources and provide them with the necessary personal protection, support, tools, and equipment to safely work in changing conditions. Being able to see the expected changes will help us prepare those controls well in advance of the weather patterns directly affecting our operations.

Other non-operational assets will be similarly affected by changing weather patterns. For example, our telecommunications and IT infrastructure will increasingly need to be designed to accommodate the environmental conditions they operate within. Similarly, our property portfolio and vehicle fleet will be affected by changing conditions. By understanding these conditions more clearly we will be able to reflect the changing conditions in our requirements, which in turn will be reflected in the design and supply chain choices we make.

3. What we do now

We have taken important steps to improve our understanding of our risk exposure to climate change. Nonetheless, we recognise we are at an early stage of our journey and a cultural shift is needed to help us grasp the complexities of the challenges that we need to respond to in the near future.

This section details our current understanding of climate risk, the reports that we publish, some of our key working groups, current capabilities, as well as innovation projects relating to climate change.

We have subsequently used our understanding of what we do now to help inform this Climate Resilience Strategy and ambitions for RIIO-3, which are detailed in section 4 of this document.

3.1. Our current understanding of climate risk and interdependencies with other sectors

We have undertaken analysis of the climate risks relevant to Cadent and reported these as part of our Action Reporting Process (ARP) ARP3 report[4]. Hazards that are expected to impact our network include high-temperature days, prolonged rainfall events, hourly rainfall extremes, sea-level rise, extreme sea-level events, increased risk of wildfire, and increased extreme diurnal cycle events. These are all expected to increase in frequency and intensity across the next few decades. On the other hand, the overall number of snow and ice days are expected to decrease.

The societal response to climate change has also been considered in the context of hazards to the gas network. Impacts of the weather hazards on the network are likely to come in the form of an altered dependency between weather and both supply and demand.

Interconnections between different industry sectors is a major source of risk for us, with failures from other sectors frequently causing impacts on our gas networks. Power generation, other utilities (specifically water), telecommunications and road transport are considered to be the most notable sources of risk. There is an interdependency on power generation installations as short-term spikes in demand affect the operation of our network; and similarly, an impact upon our network will affect generation. Failures of other utilities also pose a risk to our assets with a noticeable trend in recent incidents linked to failures of water utilities (for example, Stannington, Eastern network. See Annex 1).

Telecommunications are already important for automated and remotely controlled equipment, and for communication with personnel in the field. The risk from telecommunications failure has the potential to increase in the future with greater reliance on smart systems and the requirement for real-time updates. Road transport is often essential for the restoration of supply of goods and movement of employees, and access to assets for routine maintenance and emergency restoration. Societal responses to climate change may also increase the risk on the road network from the electricity network, as electric vehicles and charging locations become more commonplace.

Our response to climate risks has primarily focussed upon our response to short-term climate hazards and our preparedness to safeguard life and property. Our capital expenditure (Capex) is focussed on upon either repair and restoration of services where the extreme weather event has caused damage; or due to long-term, chronic climate hazards damage; typically soil or river bank erosion. This does not presently consider long-term implications of climate change, or adaptation.

[4] Climate Change Adaptation Report

3.2. Reports that we publish

As part of our journey to improve our understanding of climate change, we regularly publish different climate change and sustainability reports.

Our Climate Change Adaptation Reports are based upon a sector template report prepared by a task group of gas and electricity distribution network operators who form part of the ENA. The reports outline a range of risks and mitigation measures based on the headline climate change impacts from the Met Office UKCP18 tool.

The Third Round ARP was our first independent report for Cadent (having been part of National Grid for the earlier rounds) and was published in December 2021[5]. Our ARP3 submission sought to provide an update on existing risks, mitigation measures, and programmes, as well as identify new risks to help provide a more complete picture of the potential climate change impacts that could affect our network.

In addition to this, we also publish a Sustainability Report[6] which describes our sustainability commitments and the progress we are making against them.

Our Environmental Action Plan[7] sets out our environmental ambition as well as the key steps to drive improvements between 2021-2026.

We use our Environmental Report[8] to provide an update on our RIIO-2 environmental performance to date, our environmental efficiencies, and broader environmental matters

We also publish a Climate Related Financial Disclosures Report, which sets out our commitments to delivering net zero as well as our strategy for responding to climate change.

3.3. Climate resilience working groups

3.3.1. Internal working groups

In addition to the publication of aforementioned reports, we also have internal working groups and are part of industry-level fora on the topic.

Internally, we have set up a Natural Events Working Group (NEWG) which is chaired by our Director of Safety Health and Environment. This working group is made up of senior leaders from across our business in areas relating to operations, environment, engineering, asset investment and capital delivery.

The working group has a bi-monthly meeting where a variety of topics are discussed. This helps to deepen our understanding of resilience and ensuring that we are aligned with what we mean by resilience across different parts of our organisation, as well as our response plans to different climate change hazards.

Key findings and decisions from this working group are fed into a variety of internal committees and forums, to ensure stakeholders from across the business are kept abreast of decisions and topics being discussed as part of the NEWG. This includes sharing information with our Resilience Committee, Safety and Engineering Committee, Asset Strategy Committee as well as our Asset Management Community of Practice.

3.3.2. Stakeholder engagement and forums

In addition to internal working groups and committees, we are actively engaged in and regularly present at a variety of industry forums including the ENA's Climate Change Resilience Working Group and the ENA Gas Environment Group.

We are also providing thoughts and insights from a GDN perspective into the Department for Energy Security and Net Zero's (DESNZ) Climate Services for a Net Zero Resilient World (CS-NOW) programme. This is a 4-year research programme that will use the latest scientific knowledge to inform UK climate policy.

The below diagram provides an overview of the different groups and committees that we engage with on the topic of climate resilience.

[5] Climate Change Adaptation Report
[6] 26204_Cadent_SR_2022_v10-(1).pdf
[7] APP_CAD_07-04-00-Detailed-Environmental-Action-Plan.pdf
[8] Annual Environmental Report 2023

We understand that more is needed, however, we believe that we have the right foundations and governance in place to further embed climate resilience across our business and to also influence industry and thinking.

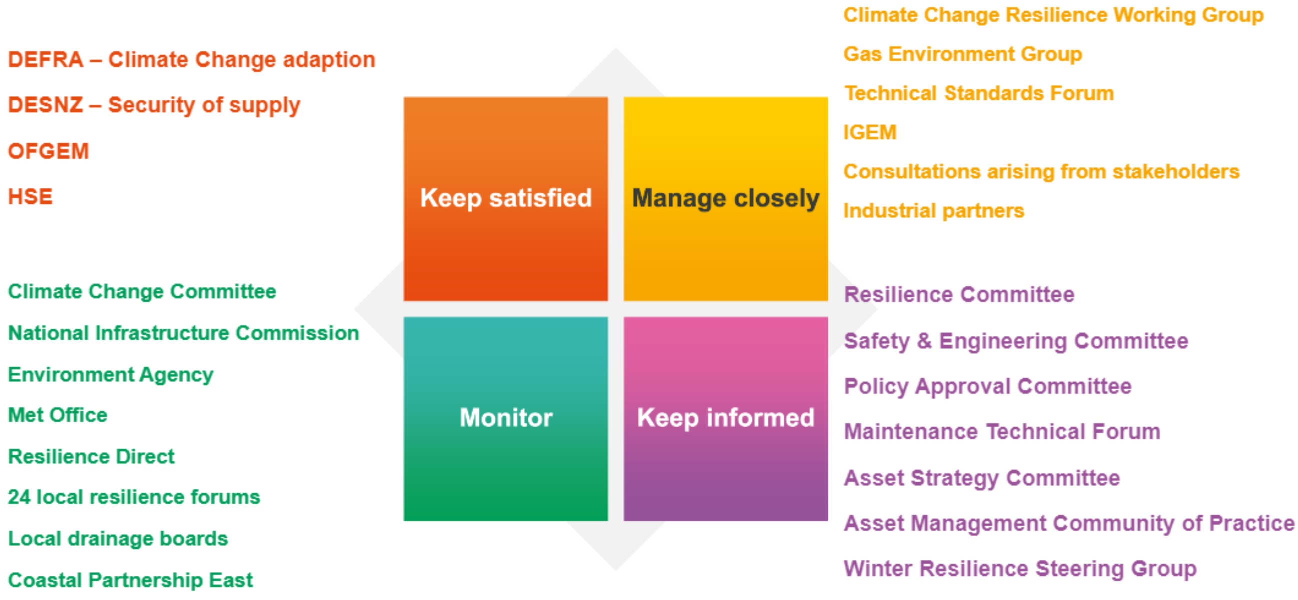

Figure 4: Our stakeholders

3.4. Current capabilities – Flood resilience framework

Triggered by our ARP3 reporting, we evaluated the recent historical climate events and identified flood risk as the most significant current climate threat to our network. Accordingly, we have developed a flood resilience framework which is made up of 3 key steps:

- **Step 1: Risk Foundation:** This step defines and sets out what constitutes a flood, the desired level of network resilience and our risk appetite. We also look at data and information, which helps us to understand
  - What return period should be considered for resilience to flood risk
  - What source data we should utilise.

- **Step 2: Risk Assessment:** This step focuses on conducting a risk assessment based on 4 key areas. This includes an Asset Threat Matrix which provides a high-level mapping of different flood risks (i.e. inundation, debris, landslip) against our network asset classes (i.e. Offtake, pressure regulating station (PRS), Mains). We then conduct a Hazard Identification Study (HAZID), which builds on the Asset Threat Matrix and provides a more detailed assessment of the hazards, risks, and controls (i.e. the vulnerability of our assets to flood and a series of recommendations to ensure safe operation in flood situations have been addressed). The final step in our risk assessment process is to conduct Asset / Network Modelling which takes the theory of the HAZID studies and applies it to a digital model of both the network and environment. The modelling has been carried out against Open Data sources from the Environment Agency.

- **Step 3: Risk control:** Using the findings from the risk assessment, we have developed an Engineering Management Procedure Document for Extreme Weather Events[9]. This procedure document provides a framework to anticipate, prevent, withstand, respond, and recover promptly from disruptive challenges posed by flood events impacting the GDN. In particular, the document details:
  - The departmental roles and responsibilities in relation to responding to potential flood events
  - The notification and triage process for potential flood events
  - The operational response to threats posed by flood events, describing activities carried out before, during, and following an event.

[9] CAD/PM/EM/82

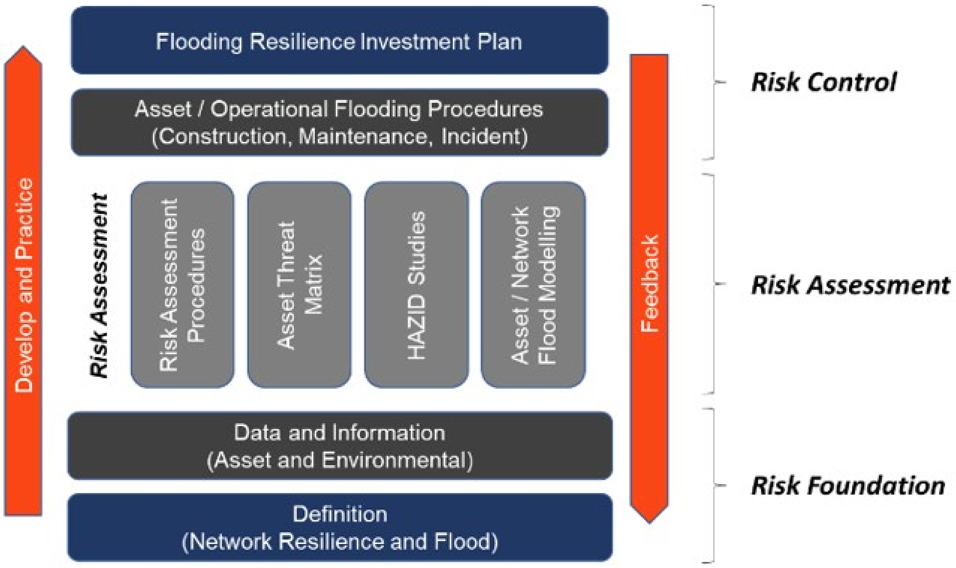

Figure 5: Our flood resilience framework

Whilst we have a framework in place, we only developed this for flood hazards for above-ground assets and the data does not consider the impacts of climate change over the lifespan of the asset. Likewise, it prioritises short-term controls over long-term adaptation. Further work is needed for additional hazards (i.e. heat) as well as developing long-term adaptation pathways to ensure that we are proactive and strategic in our asset management approach. Please refer to Annex Item 1.1 which provides more detail on each of the key steps of our current flood resilience framework, as well as limitations that exist in our approach.

Case study: Flood resilience framework – Storm Babet October 2023

Storm Babet hit the UK between 18th and 21st October 2023, leading to widespread disruption. Our Eastern and North West networks were the most significantly impacted part of our network. The storm provided us with the first opportunity to test our operational Engineering Management Procedure for Extreme Weather Events (Flooding).

We used the Environment Agency's Targeted Flood Warning Service to successfully identify 61 flood alerts and flood warnings (fluvial and tidal flooding) for sites across our network (i.e. Offtakes, PRS's and District Governors). We also used the Flood Guidance Statement from the Flood Forecasting Centre to identify sites and above ground assets potentially at risk of flooding. 82 exposed pipeline sections and 80 sites were identified in Amber risk areas.

This allowed us to prepare contingency plans within the first day of the alert so we could ready our resources whilst the impact of the storm was monitored.

3.5. Innovation and climate change

3.5.1. Scenarios for Extreme Events – Strategic Innovation Fund Project (SIF)

We understand that high-impact, low-probability extreme events can have serious impacts on Great Britain's energy systems. The increasing frequency of extreme weather events along with influences of other geopolitical events can also have direct and indirect impacts on these systems.

Whole energy system impacts and interactions between energy vectors and other sectors (i.e. water, telecoms, transport etc.) during high-impact, low-probability events are currently not systematically captured.

As such, we are one of the project partners on National Grid ESO's Scenarios for Extreme Events SIF project, which is focused on building a better understanding of how whole-energy system resilience can be impacted by extreme events, identifying vulnerabilities, and informing future investment planning decisions.

The project is currently in Alpha phase, which is focused on creating a prototype model that predicts the impacts of future high-impact, low-probability events with the view that this capability can subsequently be integrated into business as usual activities, including resilience planning and the NESO's Future Energy Scenarios (FES).

The aspiration is that all networks, operational and planning teams could use the project outputs to better understand and pre-empt the impact of extreme events on the grid and wider energy system.

3.6. Known challenges and constraints

In developing this strategy, we utilised the experiences from key internal stakeholders who have directly worked on climate resilience activities during RIIO-2. Whilst this is a small sample (only 10 persons across the company), figure 6 shows a sample of their user stories, which represents the common challenges and constraints we have experienced during RIIO-2. This section outlines the known challenges which we have used in developing our strategy and our investment plans in sections 4 and 5.

Dan
Engineering Team

"I need to understand our climate risk exposure so I can ensure that the engineering framework contains preventative measures embedded into the design of new and replacement assets and that we have risk controls in place for existing assets"

Needs:
- I need to ensure climate risks are considered for the design life of an asset and beyond
- I need to understand the risk exposure of our existing asset population
- I need to ensure we have operational response procedures in place for acute climate hazards affecting our assets

Challenges:
- Data sources often don't contain the effects of climate change
- We have limited in-house capability to interpret external data sources to ensure correct application and output
- Conducting representative geospatial analytical risk assessments at scale due to poor data sources (internal and external)

How the climate strategy will help:
- Provide an agreed level of resilience to be achieved and an appropriate representative concentration pathway for climate change
- Turning us into an informed buyer / user of data sources
- Advancement of asset data strategy providing granular 3D asset data for analytical purposes

Gemma
Safety, Health & Environment Team

"I need to understand our climate risk exposure so I can ensure interventions, continuity plans, environmental frameworks and reporting are in place"

Needs:
- A clear strategy to proactively manage climate change risk which is adaptable to the changing environment and informs decision making
- Tools which help us understand climate risks, timeframes and financial implication
- Understanding of adaption pathways and costs
- Consistent collaboration which informs environmental frameworks to reporting standards and requirements

Challenges:
- No tools to assess above / below ground risks to assets from climate events
- Collaboration across a complex business structure
- Common cross business understanding of other climate change impacts (e.g., social, supply chain)

How the climate strategy will help:
- Single climate change strategy which can be embedded across the business
- Risk assessments for short . Long term climate risks
- Financial assessments to determine cost implications of risks and adaption options

Tara
Asset Investment Planning Team

"I need to understand the long-term climate adaption needs to prioritise them relative to other drivers and create an optimised investment programme"

Needs:
- I need clear understanding of drivers for climate risk adaption to create investment programmes
- I need predictable long-term volumes of work and costed adaption options.
- I need ways of assessing benefits and costs for climate resiliene which is integrated into investment our decision processes.

Challenges:
- Climate adaptions are reactives historic events meaning costs and volumes are unpredictable.
- Cannot prioritise climate risk relative to other drivers because the risk is not quantified.
- Cliamte risk is not emebedded in investment decision making processes, requiring manual intervention.

How the climate strategy will help:
- Long-term adaption volumes with financially quantified risk to use in cost benefit analysis
- Fully costed adaption options for each asset
- Climate integrated into asset investment processes to allow for optimised programmes.

Tom
Energy Operations Team

"I need to understand the climate risks so I can design our sites to be safe and resilient and I can prepare should the risk materialise"

Needs:
- I need to know which assets are at risk, the priority and what activities are needed to control the risks
- I need to know what volume of work and budget is in place to complete adaption work
- I need to ensure where we need emergency plans in place should the climate risks materialise

Challenges:
- The impacts of climate are reactive or based upon local knowledge, rather than predictable
- There are limited instructions for how to adapt for climate risks, so there is no standard approach
- There is no funding available to adapt out assets
- There is no clear priority to respond to the risks

How the climate strategy will help:
- Clear prioritised list of assets exposed to climate risks
- Fully funded long-term adaption programme at named sites
- Clear engineering standards in place for adaption and procedures to account for climate risk

Figure 6: User stories

The themes identified from business stakeholders indicated seven key themes:

1. Alignment and collaboration with industry
2. Consistent climate modelling data
3. Consistent adaptation options for different climate risks
4. Tracking and traceability of climate related activities
5. Asset data availability and completeness for use in modelling
6. Data analytics tools and capabilities to undertake modelling
7. Quantifying and measuring climate risk to drive adaptations

In this section we outline some of the specific constraints and challenges aligned to these themes. Items 1-3 are general constraints and items 4-7 are specific to our infrastructure.

1. *Alignment and collaboration with industry*

The RIIO-ED2 price control triggered the initiation of the Climate Working Group hosted by ENA, of which Cadent have been an integral member. The gas networks have elected to withdrawn from membership of the ENA at the end of 2024 and Future Energy Networks company has been created to replace its function. Therefore, we will no longer be part of the current Climate Resilience Working Group and will be reforming this working group. This is an immediate constraint in developing consistent sector wide resilience metrics and adaptation pathways as the new organisation takes shape.

We see potential challenges with consistency in accepted risk tolerance used to trigger adaptation across the energy sector. Our experiences to this point indicate that each organisation can have different levels of risk appetite. A common benchmark for level of risk would provide much needed clarity.

Our assets interactions with other non-energy sector assets managed by stakeholders including the canals and river trust, highways agency, and network rail. These stakeholders will be similarly affected by climate change events. It is important that the correct climate resilience interventions are in place for all assets as there is risk of interaction between them. Where there is a common need to assess and increase resilience of assets, there may be efficiencies applying these geographically rather than by sector.

We see the potential for differences between Ofgem and other governmental departments including DESNZ and Department for Environment, Food and Rural Affairs and encourage the climate resilience group to include those governmental stakeholders to ensure consistency. We are conscious that Climate resilience adaptations will need to be consistently applied with appropriate levels of funded to make them achievable.

2. *Consistent climate modelling data*

Our climate risk analysis to date is focussed upon the risk posed by current and historic climate risks and not forward-looking effects of climate change. We have identified multiple data sets, both governmental and private organisations, which represent the same climate hazards and include different variables that materially alter the level of risk exposure. To ensure consistency of response across the energy sector, there is a need for consistent, open & available data sets or data standards.

We have experienced challenges identifying robust and comprehensive data sets which accurately represent the risk exposure to climate risk. For example, flooding risk exposure can be materially altered depending upon whether flood defences are included in the modelling. It is therefore important that the data sets ensure these considerations are included as it can materially change the climate risk exposure of our assets.

Some of the climate risk data sets we have used to date have not been open and easy to be integrated into our own core systems, which has resulted in upfront cost and complexity. Using industry standard data integration techniques will help to ensure rapid ingestion and use of data.

3. *Consistent adaptation options for different climate risks*

We recognise that our understanding of climate risk is limited and focussed on the current effect of climate hazards. This is reflected in our current technical standards. As the climate changes it is likely to require changes to technical standards, not just through adaption of plant, but tools and techniques also. We need to model climate resilience so that we can determine adaption needs and inform where our technical standards need to evolve.

Gas Industry Standards through ENA or IGEM are heavily used to drive consistency over the safe design and construction of gas assets. We anticipate the need to develop or enhance existing standards to adapt assets for threats posed by climate change. Developing technical standards is a known challenge, both in terms of lead time and consistency across the industry. These will also need careful consideration for rolling out and adopting within Cadent once available.

4. *Tracking and traceability of climate related activities*

Financial tracking and classification of climate interventions and resource allocation is also not defined at a granularity that allows ease of reporting for financial and work volume reporting purposes.

Whilst we track our investment cost and volumes we do not routinely trace the root cause of the intervention and attribute it to a specific cause. Therefore, while some data exists, the clarity of classification is not sufficiently granular to fully inform our climate change financial disclosures. The data would strengthen our TCFD disclosure, climate change adaptation reporting and strategic risk management processes.

One specific example which illustrates this point is related to Reduced Depth of Cover interventions as seen in Annex 1: Case Studies. Whilst we know the costs and volumes of interventions, we are unable to trace the trigger for the issue. In this case it could be resultant from agriculture or effect of climate.

This limitation also limits our ability to develop robust cost modelling and forecasting for climate related interventions, using similar mechanisms to asset health driven investments.

5. Asset data availability and completeness for use in modelling

Through the limited modelling during RIIO-2, we have already identified new data sets within our own asset attribute data which will be required to fully understand climate risks exposure in the longer term.

As we assess the risks from other climate hazards there is a strong likelihood that further data improvements to be identified to enable allow robust risk assessment. One immediate example is regarding to the location of assets; current data sets include X-Y coordinates of sites but not altitude nor site boundaries, which means specific assets cannot be fully assessed against climate risk (e.g. flooding level).

6. Data analytics tools and capabilities to assess risk

At present our data sets and data analytics tools are limited in availability, as is the number of competent resources to use them. This results in bottlenecks in assessing climate risk. This results from the ongoing digitalisation of our operations, which started in RIIO-2 and will continue into RIIO-3. This prevents us undertaking climate risk exposure assessments quickly and consistently to inform our investment plans.

To mitigate this challenge, we have aligned the IT and climate resilience strategies to ensure delivery is appropriately prioritised. In section 5 and 6 we outline the workstreams and investments in tooling and resource required to develop the capabilities to model climate risk.

7. Quantifying and measuring climate risk to drive adaptations

There is presently no common measurement of resilience, which makes defining the implications and benefits of adaptations challenging. Within this strategy we define our proposed approach to develop quantitative risk exposure assessments so that we can consistently measure and target where climate adaptation are required and the direct risk reduction benefit of undertaking the adaptations.

We recognise through the ENA Climate Working Groups that there are workstreams seeking to develop climate resilience metrics. We also recognise that the risk exposure to different climate hazards is relative to the asset being managed and not absolute. For example, the level of risk from flooding may be more significant for electrical infrastructure compared to gas infrastructure. We see developing relative climate resilience metrics that represent the energy sector as a significant, but necessary challenge.

There is also limited consistency over how to quantify the risk of uncertain climate resilience risks to form robust CBA for investment purposes. We believe that consistent measurement of climate resilience risk is a key enabler to achieving this, but we recognise that the CBA methodology will need to be consistent to ensure cross energy sector investment decisions have suitable parity.

3.7. Customer Perception

In preparation for our RIIO-3 business plan submission we have undertaken extensive research to ensure that our proposals represent value to the customers that we serve. We have undertaken a combination of online survey, face to face regional workshops and customer value working groups to understand what services our customers value. We have tested what our customers are willing to pay for each of these services to allow us to assess our value proposition for investment in our assets and services. During these assessments we have also spoken to communities which have experienced a long duration outage to our network to understand how their views differ from those who have not had direct experience of our organisation.

Customer understanding of the services we provide was limited, particularly where they have had no immediate interaction with us. This notably increases in regions where there were long duration outages. In those areas the understanding of our business was increased and the feedback on our services was extremely positive, specifically the level of communication and support provided to communities during our response to the outage.

It is clear from the research that our customers consider safety and resilience as critical non-negotiable cornerstones of the services we provide. They told us that they value the investments we are making to improve the safety and reliability of the networks we operate, particularly mains replacement. This was seen as a higher priority to other drivers including net zero, increasing biomethane, and improving customer experience. They also told us that they were generally supportive of us investing in reducing the risk of large scale loss of supply events as they felt it was ultimately a question of safety.

Cost of living continues to shape customers view of value. Most customers express general unhappiness and fatigue with the cost of living. Most customers were not aware of the small proportion of the bill which covers our services, but most felt as though there should be enough money in the sector to pay for improvements. This was shown to be linked heavily to high energy prices, rather than specifically the service we provide.

4. Our climate resilience strategy

4.1. Our climate resilience ambition

We operate our GDN at a high level of reliability in terms of security of supply (99.9%). We need to build resilience to withstand and quickly recover from current and future climate events threatening our network. This is illustrated in figure 7.

One of the key levers we have to increase resilience is through deploying a range of targeted investment in our infrastructure to reduce the customer impact either through either reducing the likelihood of failure, reducing the number of customers affected, or by reducing return to service time.

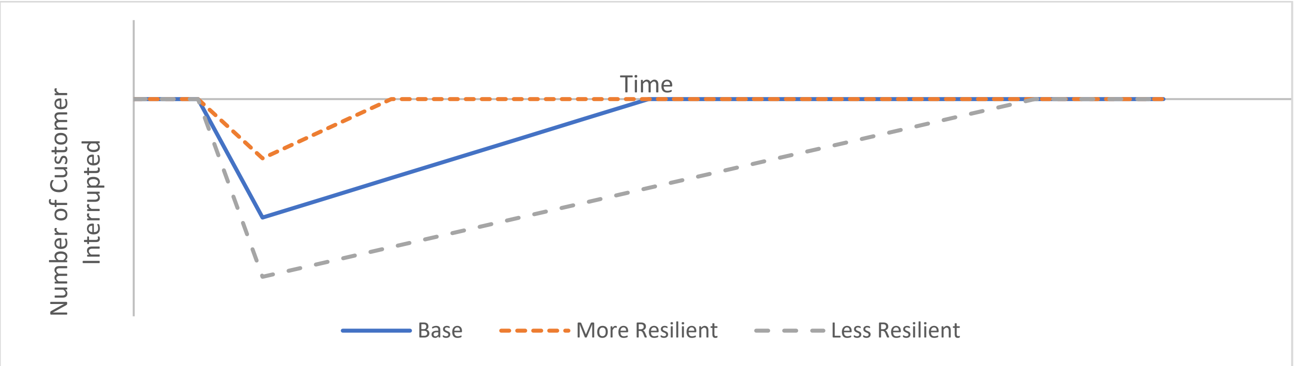

Figure 7: Changes to customer impact with and without investment

From our Third and Fourth Round ARP, and based on our latest understanding of the UK's regional climate risk exposure, we have established the following climate risk hypothesis:

Our climate risk hypothesis

The most urgent climate hazard risks to our asset base will be riverine flood events (pluvial and fluvial causes), severe storms (wind), coastal flooding, heat stress and cold extremes. In the longer-term, we also expect impacts from warmer winters, soil subsidence and erosion due to drought conditions, asset inefficiency due to heat and the impact of heat / cold on gas demand.

Figure 8: Out climate risk hypothesis

In order to be responsive to current flooding risks we have put in place a flooding risk management framework (see section 3.4) to ensure we can respond quickly to emerging flood risks on our networks. We expect that our experience will provide valuable foundations for managing this risk in the future but recognise that preventative asset adaptions are likely to be required where there is a high risk of damage through flooding.

We also recognise that there are emerging risks to our assets from the changing climate that we are yet to experience, such as extreme heat stresses affecting our above ground equipment. We expect that this will require new adaptation techniques to be developed.

Beyond our climate risk hypothesis, our overall climate resilience ambition for RIIO-3 is:

Our overall climate resilience ambition for RIIO-3

Our overall climate resilience ambition is to build and maintain effective capability to proactively anticipate, adapt, respond, and recover from disruptive climate challenges across all business functions and activities; helping to protect our assets and infrastructure and maintain high standards of service, whilst building relationships, partnerships, and collaborations, internal and external, to support climate resilience.

Figure 9: Our overall climate resilience ambition for RIIO-3

We will change from being ‘resilient by response’ to become more proactive and ‘resilient by design’ to disruptive climate challenges. We will proactively design and manage our network to meet or exceed the required standard of resilience. This will not only minimise risk to our customers’ services but will also reduce the impact of climate effect on our customers’ bills.

We aim to build high quality internal climate capabilities to assess risks and deploy adaptation at a speed that is proportionate to the scale of risk, with clear measures of progress. We intend to achieve this iteratively, so that climate resilience risk controls can be deployed in an agile way and alongside other investments.

We will deploy our learning through our established engineering frameworks and investment programmes to move towards a more resilient position. This ensures that we can use well established processes and good practices to enact the learning in a rapid fashion.

This strategy sets out where we are now, establishes our short- and long-term plans, and outlines the actions necessary to achieve these plans. This will deliver cost-efficient protection from the effects of climate change on gas distribution for our customers and safeguard life and property. We will prioritise adapting our network for acute hazards.

4.2. Maturing our climate resilience capabilities over time

Improving the resilience of our gas network to the future potential impacts of climate change is an evolving area of business planning. As the concentration of CO_2 continues to increase in the atmosphere and the science around the future impacts this may have on the UK’s climate continue to improve, we will respond by continually maturing our climate resilience capabilities.

We have and will continue to take a leading role in the gas distribution industry. However, we recognise we and the rest of the industry will need to continually respond to the changing climate in future. Our current capabilities, although fit for purpose in the climate in which we presently operate, will need to adapt, and improve in future. We therefore expect our capabilities to change over time to achieve incremental “levels” of maturity.

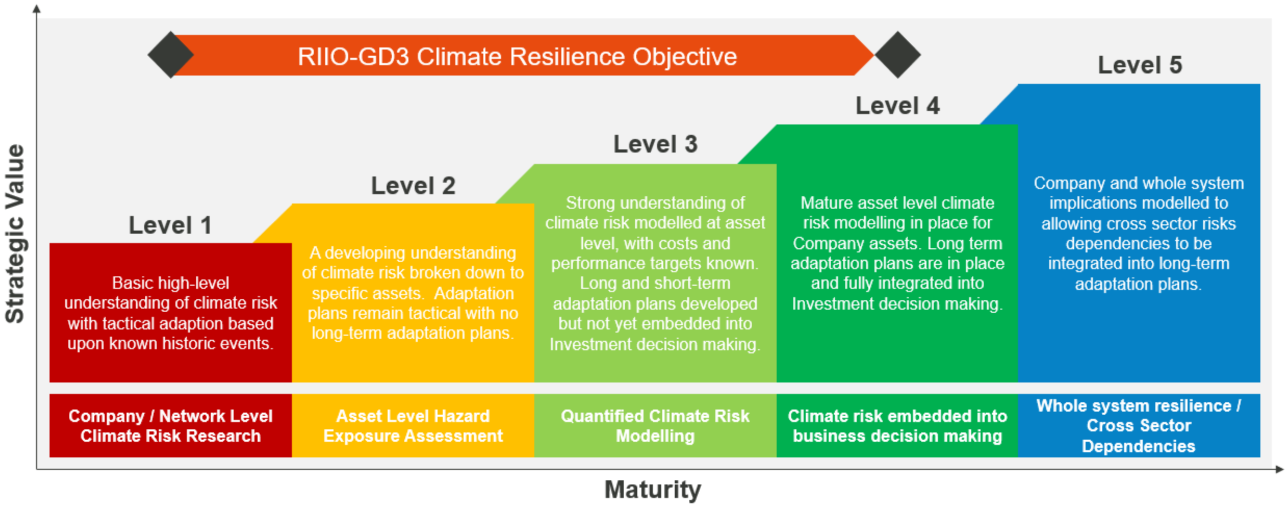

Figure 10: Climate resilience maturity levels

In summary, we expect these maturity levels to have the following features and capabilities, building incrementally over time; before, during and after the RIIO-3 price control period:

Level 1: Company / Network-level climate risk research

- Climate risk stakeholder education (i.e. informing the business of key climate hazard types / climate risk scoring framework)
- Tactical climate risk interventions (e.g. historical flood site management)
- No standardised adaptation responses; only consideration at design phases e.g. through HAZID for new assets, where applicable.
- High-level basic climate disclosure reporting (i.e. our current ARP reporting)

Level 2: Asset-level Hazard Exposure Assessment

- Asset-level climate scenario modelling
- Asset-type failure map
- Resilience baseline (ideally common, supported by industry & regulators)
- Probability of asset damage / failure due to different climate hazards
- Centralised asset-climate database
- Regulatory climate disclosure reporting (i.e. TCFD, ARP)

Level 3: Quantified Climate Risk Modelling

- Financial cost of climate risk per priority assets and adaptation analysis
- Short-term / long-term resilience plan (i.e. prioritised asset level actions based on climate risk / costs)
- Quantified cost-benefit adaptation options
- Transparent climate risk KPI's (i.e. metrics for asset resilience investment and common industry-wide resilience metrics)
- Leading climate disclosure reporting

Level 4: Climate risk embedded into business decision-making

- Strategic Asset Investment Plans
  - Climate risk embedded into SIP (i.e. climate risk feeding into our Common Risk Framework / Unit Cost Workbook)
  - Using adaptation pathways and linking them to timeframes and financial plans (i.e. sequence of potential actions to cope with a range of scenarios that allow for investment in the most appropriate action)
  - Thresholds and decision points which can be used to inform programmes of work
- Stress testing
  - Annual dynamic approach to stress test climate resilience and business strategy
  - Low probability, high impact event analysis

- Other
  - Supply-Demand forecasting (FES)
  - Field force efficiency (i.e. Optimising routes to avoid hazards)

Level 5: Whole system resilience / Dependencies with other sectors

- Understanding cascading climate risks between other sectors
- Cross-sector climate change resilience analysis (i.e. ability to consider the impact of climate change in relation to cascading and escalating failures of infrastructure across independent sectors)
- Create a whole system view upon which network asset resilience depends. For example, outside-in view of risk and resilience (e.g. distribution network operators, water, local authorities, telecommunications, etc.)
- In developing our Climate Resilience Strategy and our maturity framework, we recognise BS 8631 as good practice for asset climate adaptation planning. Our strategy has been purposely developed to align with this standard. Annex 2: Alignment with BS 8631 demonstrates the alignment to sections of this document to BS 8631.
- Within the following sections we will detail our ambitions and plans over the short term (before and early RIIO-3), long term (mid to late RIIO-3 and beyond). We will detail our assumptions and key working decisions. We will outline the 8 key workstreams which broadly aligned to 4 critical themes shown in Table 1.

Theme	Workstream	Timeframe
Develop modelling capability to assess and quantify climate risk exposure.	Workstream 1 - Information Technology Setup Workstream 2 - Failure Mode Matrix Workstream 3 - Asset-level climate hazard exposure assessment Workstream 4 - Quantified Climate Risk Modelling	Before and early RIIO-3
	Workstream 7 - Evolution of climate modelling and stress testing Workstream 8 - Cascading risks and dependencies with other sectors	Mid to late RIIO-3 and beyond
Develop adaption pathways and embed those into our Engineering and Investment frameworks.	Workstream 5 - Climate Resilience Working Group and resilience metrics Workstream 6 - Adaptation Pathways	Before and early RIIO-3
Develop immediate adaption programmes for assets which exposed to high climate risk.		Mid to late RIIO-3 and beyond
'Fail forward' climate adaptions as part of ongoing investment for assets exposed to lower risk.		Before and early RIIO-3

Table 1: Strategic themes and workstreams

We intend to use Resilience re-opener mechanism[10] built into RIIO-3 to speedily invest in the critical adaptions required to protect our services, without requiring up front funding at the start of the period for requirements before they are well-defined.

We outline our strategic roadmap in figure 11.

[10] [commercial-sensitive data]

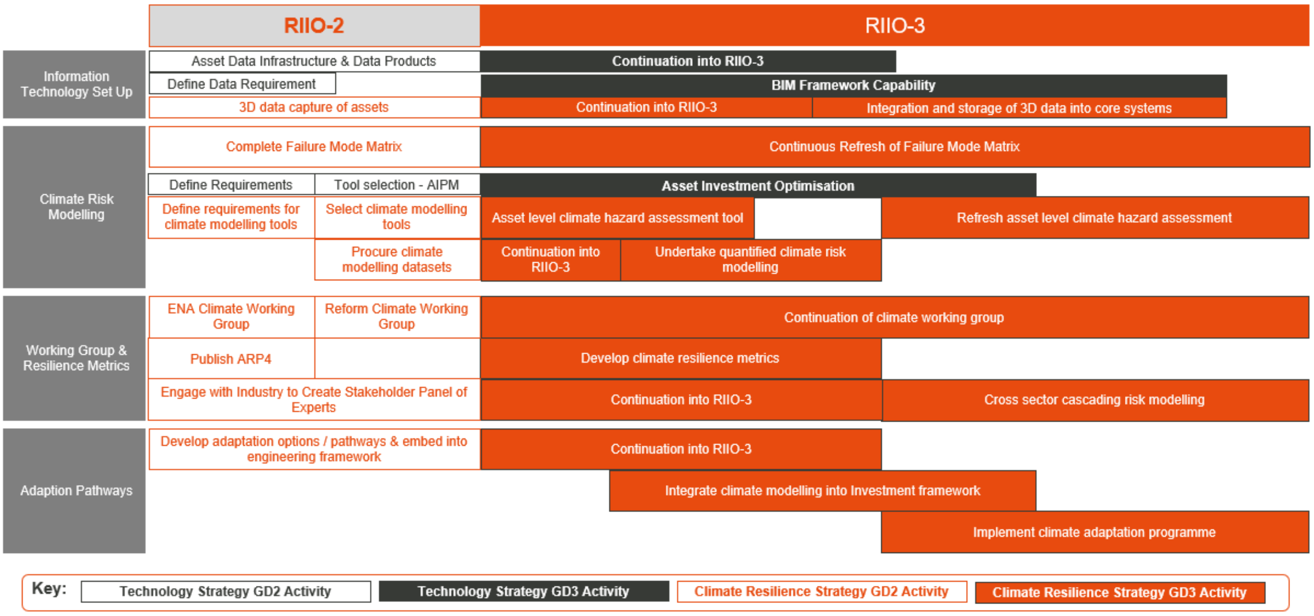

Figure 11: Climate resilience roadmap

4.3. Short-term ambition (before and early years of RIIO-3)

In the short-term, our focus is to move our climate resilience capability from being ‘resilient by response’ to ‘resilient by design.’ In other words, we wish not only to respond effectively to climate-related events but to design our infrastructure to reduce the likelihood and / or impact of those events in the first place. This will move us from Capability Level 1 to Capability Level 3 in our maturity framework.

To do so, we need to enhance the granularity and accessibility of our asset data and obtain climate risk data at that same level of resolution. This will allow us to understand the probability of asset damage or failure due to the different climate hazards detailed in figure 8.

We will move from tactical interventions to a more cohesive strategic response by leveraging and building upon our current climate risk understanding and all the frameworks and controls that we have developed in flood risk management. We will do this iteratively by prioritising the climate hazards that are most impactful upon our assets.

Our short-term plan (before and early years of RIIO-3) details the capability and information system investments we will pursue to help us develop and mature our climate resilience capabilities. The insights from our short-term plan will inform our long-term asset-investment plan.

4.4. Long term ambition (mid to latter years of RIIO-3 and beyond)

Our long-term ambition is to ensure security of supply for our customers, regardless of the future climate and energy scenarios. That means building a climate-resilient, climate-intelligent distribution network that is adapted to provide security of supply and safeguard life and property. Our long-term ambition will help us to achieve Capability Level 4 and 5 in the climate resilience maturity roadmap, with our ambition to have met Level 4 by the end of the RIIO-3 period.

To do this, we must invest in hardening our assets through both climate resilience metrics and climate analytics. We need to set a risk / resilience tolerance in order to understand the cost and size of the adaptation pathways. Our approach will be to define long-term resilience metrics as a function of event impact severity [number of customers impacted] and the likelihood of the event causing asset failure [asset resilience design /retrofit level].

We aim to embed climate analytics into our core asset management framework. Climate analytics will serve to give certainty over climate impacts and identify highest risk assets to target investment programmes. We will also take account of metrics such as numbers of supply points impacted by loss of gas supply to certain elements in the network, as well as factors such as the vulnerability of those customers and wider social and security of supply considerations.

To account for the uncertainty of the role of gas in the UK energy mix, we will consider alternative FES to ensure that we are prepared and are making asset investments accordingly. Our current working assumption blends the National Grid ESO FES24 Holistic scenario, which assumes gas will continue to be part of the energy mix beyond 2050, with Ofgem's short-term directive of biomethane adoption. The implications of changing FES24 scenarios on assessing physical climate risk is on asset necessity and lifespan. We will work with the CS-NOW / new Climate Change working groups to ensure alignment across the energy sector to do this. However, it is important to note that anything less than a Leading the Way scenario, especially any scenarios that assume continued fossil fuel consumption, will lead to a more severe future operating climate.

4.5. Our short-term plan (before and early years of RIIO-3)

We have identified six workstreams which will improve the foundational requirements upon which we can achieve our short- and long-term ambitions. These are:

- Improving our Information Technology Setup, specifically data on the physical representation of our network in our digital systems.
- Develop the failure mode matrix for each asset exposed to climate change.
- Develop an asset-level climate hazard exposure assessment across our entire network.
- Develop quantified climate risks modelling for each asset.
- Develop enduring climate resilience metrics which will enable us to benchmark and target improvement.
- Develop adaptation pathways which will allow us to adapt our networks to protect our services from effects of climate events.

4.5.1. Workstream 1 - Information Technology Setup

The first challenge we will address, starting immediately in RIIO-2 and completing in early RIIO-3, is closing any data gaps within our internal systems that can support with climate risk modelling. The future work we plan to undertake relies on an information systems foundation to improve how we record and manage climate data. This includes, but is not limited to, financial classification (to enable financial and volume tracking), asset elevation, topography maps, relevant engineering constraints (e.g., stress / strain limits, temperature limits etc.), climate model outputs and asset climate resilience metrics.

A critical input to a high-quality climate risk assessment is accurate 3D geospatial data. Our geographic core system master dataset already holds detailed site data (examples of mastered sites includes Offtakes, above ground installations ((AGI) and district governors). However, the mastered site data only holds x-y grid references, while accurate enough for current purposes, will require increased accuracy for climate resilience analysis. Currently, the database holds grid references which are located at different point on the site (e.g., entry gate vs centre of site). Having more specific site location data is important, especially for climate risks with a high hazard gradient. For example, flood risk is extremely sensitive to the boundaries of the asset and topography of the surrounding land.

Furthermore, the physical shape and size of the site varies depending on the equipment and processes on site, meaning buffers cannot be confidently applied.

To build on the accuracy of our climate risk modelling, we plan to gain benefits from the organization strategy to deepen our asset mapping capabilities including the use and management of three-dimensional (3D) asset data. For example, a 3D laser scan would produce CAD files and photogrammetry models that can be used in conjunction with 3D hydrological simulations to improve testing of the vulnerability of an asset (e.g., through risk assessment and / or stress testing).

We aim to be able to integrate these climate analytics with other asset investment criteria such as leakage and reliability to enable to us to perform holistic whole-life cost-benefit analysis and system planning. This will require us to build a data transfer infrastructure to allow these systems to communicate with each other and maintain an updated dataset that will be able to capture and respond to the rapidly changing asset operating environments in future.

We aim to be able to integrate these climate analytics with other asset investment criteria such as leakage and reliability to enable to us to perform holistic whole-life cost-benefit analysis and system planning. This will require us to build a data transfer infrastructure to allow these systems to communicate with each other and maintain an updated dataset that will be able to capture and respond to the rapidly changing asset operating environments in future.

4.5.2. Workstream 2 - Failure Mode Matrix

We are in the process of integrating our current climate risk understanding by developing our failure mode matrix, whereby we are assessing the implications of climate threats to identify the critical points of vulnerability of our network by asset type. By completing this assessment, we will be able to identify adaptation gaps in our current framework and be able to scale the likelihood and severity of the risks posed by different climate threats. During this exercise, we are also identifying the current known controls and adaptation options, which will feed our full adaptation pathway development during workstream 6. It should be noted that these will only reflect historical reactive responses.

Beyond the failure modes identified in our ARP3 framework, we will incorporate learning and best practice from historical climate failures and climate failure modes identified in the UK Climate Change Committee's latest Climate Change Risk Assessment (CCRA3). We will also broaden the hazards considered from the original set in UKCP18, which we used for our ARP3 report, to consider all those in the Intergovernmental Panel on Climate Change (IPCC) Assessment Report 6 (AR6).

It is also worth noting that our asset resilience is strongly dependent on the resilience of other utility and asset operators. A re-analysis of our incident log highlights that water main bursts are a significant and growing failure mode which has affected our GDN. Water mains are susceptible to climate impacts such as freeze / thaw and heat, including associated ground movement.

Accordingly, developing and enhancing our understanding of climate risk will enable us to better understand the failure modes of the assets across our network, based upon the latest climate science information.

4.5.3. Workstream 3 - Asset-level climate hazard exposure assessment

We have performed a network-level climate risk assessment in our Climate Change Adaptation Report using the ENA sector guidance, to understand how changing climate variables can impact our asset network as a whole.

As such, this workstream will be focused on performing an asset-level climate hazard exposure assessment using industry best practice. We will utilise one or more publicly available forward-looking climate scenario datasets and their associated narratives (i.e. Intergovernmental Panel on Climate Change data, International Energy Agency, and Inevitable Policy Response Scenarios). We will seek to agree common data sets between stakeholders in the Climate Change Working Groups where practicable.

These scenarios will provide us with the relevant physical climate risk assumptions at a granularity suitable for exploring the potential future business operating context. The methodology we will follow will be to examine three scenarios:

- A baseline scenario that uses the same input data on direct human influences as the scenario simulations but combines these with climate input data that represent counterfactual stable preindustrial conditions for the entire 1861–2100 time period (no warming).
- A 'net zero' (2°C) pathway to align with the Paris climate agreement.
- A 'business-as-usual' (4°C) pathway (e.g. Shared Socioeconomic Pathway P5 – Representative Concentration Pathway 8.5).

We will examine each of our assets for exposure to six climate hazards: wind, heat, drought, flood, coastal flooding, and freeze / thaw, across four time horizons (Pre-industrial, 2030, 2050, 2100). This hazard framework aligns with the global reporting authorities' recommendation such as the Taskforce on Climate Related Financial Disclosure and Science Based Targets initiative.

Whilst we will examine the exposure of our assets to each of the climate hazards described above, we will seek to prioritise the most impactful hazards for assessment first so that we are able to prioritise the development of quantified assessments, adaptation pathways, integration into our Network Asset Strategy framework, and develop high risk investment programmes around threats that are already affecting our networks. The hazards are flood events (pluvial and fluvial causes), severe storms (wind), coastal flooding, heat stress and cold extremes (see our climate risk hypothesis).

The level of exposure to extreme events is contingent upon the degree to which human populations and economic assets are susceptible to these occurrences. Exposure is influenced by various human-related factors, such as geographical settlement patterns and land use practices, including water, forest, and agricultural management. Leveraging process-based climate impact models enables the disentanglement of these factors, allowing for a systematic isolation of individual drivers and their respective impacts on changes in exposures.

In order to produce our exposure profile, we will overlay the geographic distribution of our assets against the simulated hazard scenario maps. The scenarios we examine will capture both a baseline view of our asset base exposure to climate risks today and an understanding of these evolving hazards out to 2100.

Our modelling will start with an initial coarse spatial resolution in order to identify highest risk assets. We will then undertake more detailed, high-resolution climate risk modelling to properly quantify and assess asset investment decisions for those identified highest risk assets. This asset-level insight will allow us to scan our portfolio of assets for high risks before conducting any high-resolution modelling for assets most at risk.

This will allow us to understand which assets are and are not at risk for the six climate hazards analysed, and how that hazard risk will evolve. That will allow us to prioritise resilience investments through a quantified climate cost-benefit analysis (see section 4.5.4 below).

4.5.4. Workstream 4 - Quantified Climate Risk Modelling

Once we have undertaken the asset-level climate hazard exposure assessment, we will incorporate a measure of asset vulnerability. Combined with climate hazard and climate exposure, these three components will enable us to quantify the climate risk of individual assets in our network as part of this workstream.

The hazard screening approach (section 4.5.3 above) means we only need to perform quantified climate risk assessment for a subset of our asset network (i.e. high priority and / or at-risk assets). We will continue to prioritise the most impactful climate hazard first

We will seek to leverage industry experts and academia through innovation or other routes to ensure we are able to understand the relationship between the climactic event and the failure mode and frequencies so that we are able to accurately quantify the risk of failure in our models.

The quantified climate risk modelling will translate the climate risk exposure from the asset-level hazard exposure modelling into value-at-risk measure by hazard type. The damage and disruption thresholds will be based on asset design principles and asset owners' historical experience managing the reliability of the asset. Key information that will flow into building the vulnerability curve of an asset are the asset age & deterioration, asset type, asset profile and configuration, and the associated costs of downtime / damage. Workstream 1 Information Technology Setup step seeks to ensure that our data systems have this information recorded at the asset level. Cross-industry work like the NARM model will also provide standard assumptions for the whole sector around cost of disruption (£/hr downtime).

This workstream will also require us to move from publicly available climate model data to purchased high-resolution climate data sets (e.g. 30m x 30m resolution). These datasets will be acquired for the identified failure modes and at-risk assets from climate data vendors including but not limited to Fathom, XDI, Jupiter Intelligence, Flood and Climate X. Overlaying the asset-specific vulnerability curve against the high-resolution climate data gives us the probability of asset failure due to climate impacts.

We will combine the probability of failure with our data on downtime / disruption costs and replacement / repair costs to calculate the expected loss due to these climate risk variables. Given our assets' design life (c.40 years), we will calculate the lifetime probability of failure, in addition to the annual risk. The lifetime risk is a calculation that incorporates the remaining useful life of a generating asset to support comparison of assets with different risk profiles and retirement years.

Understanding the lifetime value-at-risk allows us to construct a cost-benefit analysis of different resilience adaptation options. We will therefore be able to optimise the operational efficiency of implementing our long-term climate plan and developing optimised adaptation pathways.

4.5.5. Workstream 5 - Climate Resilience Working Group and resilience metrics

As part of broader industry engagement and alignment regarding climate resilience, we will have a dedicated workstream focused on helping with the development of an industry level 'climate resilience working group' that we aim to get established in the early years of RIIO-3. This, however, will require collaboration and alignment with other GDNs, as well as other sectors. This will be reformed following the impending separation of the Gas Distribution companies from the ENA.

We will support the development of the terms of reference for the climate resilience working group as well as share best practice in relation to the capabilities that we will develop as part of our own climate resilience strategy.

One of the key outputs from the working group will be the development of industry-wide climate resilience metrics that can be used to measure the resilience level of networks and the impact of any adaptation measures that are subsequently implemented. This will support our investment cases, as it will enable a consistent rationale for investment to be established to benchmark costs against.

The RIIO-ED2 triggered industry working group has initiated a Climate Resilience Metrics (CRM) project of which Gas Networks are active participants. Whilst the Gas Industry has elected to leave the ENA, we will continue to develop CRMs.

We recognise that the diverse topography of our networks affects the frequency and consequence of climate events on our assets. We also recognise that climate events will have a differing consequence and therefore risks to our network assets in comparison to other sectors. We believe these factors need to be considered when developing resilience metrics.

Our intent is to align the outputs of the quantitative risk exposure assessments to measure and baseline our performance at start of the period. Having the base quantitative risk exposure assessment would allow flexibility on our reporting and allow us to report against different levels, for example down to asset class or by volume of customers affected.

An example of our initial thinking on climate resilience metrics relative to our assets is shown in Figure 12.

		Wildfire		Extreme Heat		Extreme Cold		Storms		Flood		Total Climate Risk	
		2026 (Actual)	2031 (Target)	2026 (Actual)	2031 (Target)	2026 (Actual)	2031 (Target)	2026 (Actual)	2031 (Target)	2026 (Actual)	2031 (Target)	2026 (Actual)	2031 (Target)
High Likelihood	Proportion of Assets	10%	5%	10%	5%	10%	5%	10%	5%	10%	5%	10%	5%
	Risk Exposure (£m)	10.00	5.00	10.00	5.00	10.00	5.00	10.00	5.00	10.00	5.00	10.00	5.00
Medium Likelihood	Proportion of Assets	%	%	%	%	%	%	%	%	%	%	%	%
	Risk Exposure (£m)	£m	£m	£m	£m	£m	£m	£m	£m	£m	£m	£m	£m
Low Likelihood	Proportion of Assets	%	%	%	%	%	%	%	%	%	%	%	%
	Risk Exposure (£m)	£m	£m	£m	£m	£m	£m	£m	£m	£m	£m	£m	£m
Minimal Likelihood	Proportion of Assets	%	%	%	%	%	%	%	%	%	%	%	%
	Risk Exposure (£m)	£m	£m	£m	£m	£m	£m	£m	£m	£m	£m	£m	£m
Total assets with likeihood	Proportion of Assets	%	%	%	%	%	%	%	%	%	%	%	%
	Risk Exposure (£m)	£m	£m	£m	£m	£m	£m	£m	£m	£m	£m	£m	£m

Figure 12: Initial climate resilience metric example

In this example we would measure the number of affected assets against the likelihood that each extreme climate events would have an impact upon our services across the four time horizons defined in section 4.5.3. We would use this benchmark to propose intervention targets and costs to reduce our risk exposure. Note that numbers and percentages are illustrative only.

We recognise further work is needed throughout RIIO-3 and the industry working groups to further develop a common set of resilience metrics that can be used throughout the industry. In the example above, this is an example of relative metrics which apply to Cadent. We acknowledge that there may also need to be absolute metrics which equally apply to our assets.

We also understand the importance of being able to demonstrate progress against our strategy. As such, in RIIO-3 we will also focus on developing and publishing regular reports which will look back on the key actions that we have taken in relation to climate resilience; how we are developing our climate resilience capabilities; how this aligns with our strategy; and any forward-looking plans and activities that we have regarding climate resilience.

4.5.6. Workstream 6 - Adaptation Pathways

The key outcome of our short-term plan which we aim to achieve between the end of RIIO-2 and the early years of RIIO-3 is to develop asset network adaptation pathways that link the investment required to specific timescales.

There are a number of foreseeable decisions that have been identified through our Failure Mode Mapping, which will need to be fully assessed in order to develop robust climate adaptation pathways. These include:

- The tolerance on levels of risk to customer supply (i.e. number of customers) which triggers an intervention. It may be suitable to use existing frameworks (e.g. DEZNZ classification of critical national infrastructure)
- Adaptation pathways will need to consider the implications of FES on the asset lifespans, a position which is currently relatively uncertain. As stated in section 4.6, our planning assumes FES24 Holistic scenario blended with Ofgem's Biomethane adaptation directive. FES modelling will define long term need for the asset and lifespan, which will for a key decision point on adaptation pathways.

- We will need to assess whether climate risk can be mitigated through existing controls (enhancing maintenance) or with new maintenance techniques; or whether capital investment to modify or rebuild (i.e. relocation) will be required. Our existing adaptations typically involve ongoing repair or modification, but this situation may change as extent of climate risk evolves and is better understood.
- We will need to assess whether existing materials, tools and techniques are suitable for the changing climate. For example, existing painting and coating and pipe materials may no longer be suitable if more extreme temperatures are experienced, particularly on above ground assets. This may require new testing, materials, tools, or techniques to be established.
- We will also need to consider whether the least regrets investment actually comes from intervention on assets owned by third parties. For example, it may be better value and customer lower impact to remediate river courses or flood protection rather than specifically investing in Cadent assets. In workstream 8 in section 4.6.2 we outline our approach to developing panels of experts, which will be crucial when considering adaptations of this nature.

The investments and timescales that anchor the adaptation pathway will be a function of asset investment priority ranking and climate adaptation cost-benefit analysis.

Between the end of the RIIO-2 period and the mid-to-latter years of RIIO-3, we will build a library of adaptation options with associated costs for each asset type in our network. We will use the cost-benefit analysis approach detailed in section 4.5.4 to build an optimised adaptation logic for our asset portfolio.

To build the adaption options we anticipate that we will need to leverage a number of different research routes including engineering studies and innovation, plus industry led best practice through the working groups. We expect this activity to include liaison with other asset operators (for example the canals and river trust) to ensure that all feasible options are considered. This is important as in some instances adaption of non-Cadent assets may be least the cost and lowest impact option.

We will deploy climate adaptions based upon asset specific quantitative climate risk assessment. We expect to deploy adaptations in two ways during the period:

- For critical assets or assets which are exposed to high or acute climate risk we will create an immediate 'least regrets' adaption programme to protect those assets, which we intend to trigger via an Resilience re-opener mechanism.
- For assets which are exposed to lower climate risks we will embed the adaption options into our enduring engineering and investment frameworks iteratively, such that adaption will continue gradually as part of established investment programmes without the need for large scale, one-off programmes.

We will embed climate risk and the adaption pathways into our enduring Asset Investment framework, as defined within our Appendix 10[11] We will use this mechanism to assess the cost effectiveness of climate resilience adaptation investment by the ratio of benefits to costs, as we currently do for other asset investments. The benefits will be calculated from the reduction in all types of risk that the investment secures for the duration of the asset's useful life, starting in the year the investment is made.

We will use a discounted net present value approach of the benefit-to-cost ratio for the basis of our adaptation pathway development (asset prioritisation and cost optimisation).

Our Asset Investment framework ensures we prioritise interventions by benefit-to-cost ratio aligned to the budget, given financial and resource constraints by year. Asset optimisation will consider the benefit-to-cost ratio changes for each investment depending on the investment year. The objective is to maximise benefit-to-cost ratio, subject to financial and resource constraints. This is consistent with the established engineering justification paper and CBA mechanisms in place.

The latest IPCC assessment report, (AR6), acknowledges that the initial step in addressing future climate change involves reducing vulnerability and exposure to current climate variability. It is important to note that certain short-term responses to climate change might inadvertently constrain future options. Integrating adaptation strategies into SIP processes, including policy development and decision-making, can create synergies with development initiatives and disaster risk reduction efforts. Nonetheless, there is a risk of maladaptation if planning and implementation are inadequate, prioritise short-term gains or fail to anticipate future consequences adequately. This could lead to increased vulnerability or exposure for targeted groups or other areas. For example, while enhancing protection for exposed assets may seem beneficial, it could also create dependency on further protection measures, potentially locking-in vulnerabilities.

[11] Network Asset Management Strategy, section 2.2, page 3

4.6. Our long-term plan (mid to latter years of RIIO-3 and beyond)

Our long-term plan will help us to achieve Capability Levels 4 and 5 detailed in the climate resilience maturity roadmap at the start of this section. Our aspiration is to achieve at least capability level 4 by the end of the RIIO-3 period.

We have identified two workstreams that will help us to achieve our long-term ambitions and detailed them below.

4.6.1. Workstream 7 - Evolution of climate modelling and stress testing

As climate science continues to evolve, we plan to continually update our assessment of risks based on the latest available science. We will perform our climate risk assessments in step with the Coupled Model Intercomparison Project (CMIP), currently in its 7th iteration. The CMIP is an output from the IPCC and reflects the latest understanding of climate science.

Where we identify limitations with future climate scenarios and want to understand the impact of compound risks to our asset network, we will develop stress testing scenarios representative of high impact and low probability scenarios. Methodologies will be assumptions-based given the limited data on impact assessment for compound events (i.e. high impact, low probability events).

4.6.2. Workstream 8 - Cascading risks and dependencies with other sectors

In the middle years of RIIO-3, once we have developed our internal capabilities, we aim to achieve a whole-systems capability and understanding of climate resilience that allows us to assess and improve the climate resilience of our network assets in conjunction with other networks out to 2100.

Whilst the timeline for this workstream is middle years of RIIO-3 onwards, we will immediately seek to formally or informally create partnerships with stakeholder panel of experts with other utilities, academia, and wider industry, with particular focus on stakeholders where we have a known interdependency today. This will not only allow gain valuable insights and shared learning but has the potential to shape the way that we undertake the quantitative climate exposure risk assessment. Our initial discussions with other stakeholders have indicated value, for example, in having common data standards that will allow future modelling to be at a significantly lower cost and complexity. This may also unlock potential areas of common innovation which we can pursue.

Interdependencies between different industry sectors is a source of risk, with failures from other sectors frequently causing impacts on our assets and customers. Likewise, failure of our assets also has an interdependency on other sectors. An example of these interdependences was seen at Stannington, Sheffield in the Eastern network (Annex 1: Case Studies), where failure of a water utility cause loss of gas supply. During this outage, the electricity network was strained by additional load from customers heating and cooking using electricity instead of gas.

Known climate triggered threats to our assets and operations are from other utilities, telecommunications, waterway and dam operators, and road transport.

- Electrical utilities will be affected by climate change risk. Failure of their assets can directly affect our ability to operate through loss of electrical supply to our telemetry and pre-heating facilities. To mitigate this risk, we have historically used battery backup and in RIIO-3 are assessing options for generators and solar PV systems. We also may experience difficulties in charging our growing fleet of electric vehicles during major outages, which would affect our ability to undertake emergency and maintenance activities.
- Water utilities are susceptible to extreme temperatures. In recent years we have experienced a rise in cascading failures (i.e. failure of an asset causing successive failures in other assets), triggered by failure of water pipelines; for example, Stannington and Ratby, Leicestershire in the East Midlands network. Less immediate is mechanical damage to gas mains following ground movement caused by water pipe leaks, which may occur over a longer period.
- Telecommunications are already important for automated and remotely controlled equipment, and for communication with personnel in the field. The risk from telecommunications failure has the potential to increase in the future with greater reliance on smart systems and the requirement for real time updates.
- Operators of waterways and storage are not only responsible for maintaining their primary assets (e.g. dams, canals) but also their flood protection assets. The risk of failure of waterway and storage assets on our assets has the potential to be significant.
- Highway and road infrastructure transport is often essential for restoration of supply of goods and movement of employees, and access to assets for routine maintenance and emergency restoration.

Failure of our assets due to climate events could also have a significant impact to local gas turbine power generation plants. In 2023 National Grid ESO reported that natural gas contributed 32% of electricity generation to the UK. Therefore, increasing threats from climate not only has potential to affect flow of gas, but also affect power generation to our customers. In our network we have 179 gas fired power generators, producing 2.2Gw of generation capacity, equivalent to 8% of the UK's total generation capacity.

As such, developing our capabilities and being able to better understand climate resilience beyond our network boundaries is an important step for us, which we will focus on from the middle years of RIIO-3 onwards.

4.6.3. Our plans beyond RIIO-3

We will need to build flexibility into our climate resilience capabilities. This is because, although climate science is improving, there are still significant uncertainties on the pace and scale of the future impact from different climate hazards. Our climate assessment set out in ARP3 is that the three current highest priority hazards are from:

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

These may change in future as signals within climate projections become clearer. For example, risk of strong winds is currently considered low and assessed in the current climate only, while several other hazards such as sea level rise, snow and ice and wildfires are also considered lower priority.

We will mitigate these longer-term risks by frequently re-assessing the scientific data and latest scientific consensus. This will be correlated with observations on our own and other gas networks, nationally and internationally. Our objective will be to reduce risks based on metrics developed that align with current and possible future hazards.

4.7. Governance

We have well established internal governance to monitor & evaluate performance of key deliverables including price control deliverables and investment portfolios, notably the Asset Strategy Committee. We will continue to use these governance forums to monitor and evaluate delivery performance, cost and benefit realisation of the investment deliverables defined within this strategy.

In addition, we will use the Resilience Committee and NEWGs, defined in section 3.3, to act as the technical governance to manage the assess the quality and completeness of the deliverables.

Externally we will continue to actively engage with the Climate Resilience Working Group to assess progress and alignment with Ofgem and other gas transporters. We will also continue to publish existing disclosure reporting as defined in section 3.2, plus our Regulatory Reporting Pack.

5. Climate resilience investment areas

Section 4 provides details of the workstreams needed to deliver our climate resilience plans for RIIO-3. This section sets out the scope of investments required in building our climate resilience capabilities to align with our strategy.

This section also details the rational for the costs key included in the climate resilience memo table M8.23. There are two principle costs included the first is the IT costs associated with creating the modelling capability; the second is an enduring uplift in resource to manage the engineering development and deployment of modelling. Costs for high risk adaptations and any cost increases from iterative deployment of investments will be deployed via Resilience re-opener mechanism.

The breakdown of projected spend over the RIIO-3 period is in table 2.

Cost Item	Projected Spend (£)	Notes
Engineering Resource	[cost data]	These are the resources allocated for climate resilience within our Engineering and Asset Management functions. See section 5.5.
Engineering Studies (Non-innovation)	[cost data]	This is the cost allocated for engineering studies. See section 5.5.
Engineering Studies (Innovation)	[cost data]	This represents the proportion of cost associated for Climate Resilience in Appendix 8[12]. See section 5.5.
Data and Digitisation[13]	[cost data]	This represents the proportion of cost associated for Climate Resilience from Appendix 14[14] including 3D modelling, data collection and infrastructure. See section 5.1, 5.2 and 5.3.
Total	[cost data]	

Table 2: Projected climate resilience costs for RIIO-3

5.1. Information system enhancements and asset data collection

5.1.1. The outcomes this investment will support

Table 3 below briefly summarises the key outputs and outcomes that this investment area supports.

Key outputs enabled	Outcomes supported
Integration of other mapping sources into Cadent mapping systems, enabling other sources information to be obtained and used (i.e. Google Satellite and Streetview) Improve the accuracy and granularity of asset data from within our internal systems to allow us to carry out asset level climate hazard exposure assessments (i.e. asset elevation, construction material, type of asset, failure thresholds etc.) Improved accuracy and understanding of grid references for digitised sites (i.e. Offtakes, AGIs and district governors) to allow for better use of geospatial analytics.	Ability to easily ingest and manipulate third party data sources help provide a repeatable output to what we do now (e.g. Environment Agency flood risk data to help us with our existing flood risk capabilities) Ensure that we have all of the right asset data to allow us to conduct climate risk assessments across all of our assets Ensure we have site polygons for digitised sites to continuously improve geospatial analytics Improved accuracy of site polygons will allow Cadent to better understand asset locations and therefore enable climate resilience modelling Once we have this information, we can then consider whether this information can be shared / updated through open-source layers

Table 3: Outputs enables and outcomes supported: Information system enhancements and asset data collection

[12] Innovation Strategy, Table 2, page 20
[13] The underpinning IT infrastructure documented in our IT and Telecoms strategy is proportioned within the costs for Data and Digitisation as these will be shared services amongst multiple initiatives.
[14] Data and Digitalisation Strategy, Open Data Roadmap, page 50

5.1.2. Key investments required

To deliver these outputs and outcomes, we propose to invest in:

- Data cleanse: Conduct a data cleanse activity for digitised sites to ensure that we have we have improved and more granular site polygons (i.e. Offtakes, AGIs and district governors). This will allow us to continuously improve geospatial analytics.
- Data capture: Conduct an enhanced data capture exercise for all of our assets to make sure that we have the relevant information needed to allow us to conduct asset level climate hazard exposure assessments (i.e. asset elevation, construction material, type of asset, failure thresholds).
- Integration and storage: Once we have captured all the information, we will need to store this in a relevant system so that we have a single view of asset data that can support us with conducting asset level climate hazard exposure assessments.
- Integration of with other mapping sources into Cadent core systems to allow greater information to be obtained and used: Investing in this will help to enhance our existing flood risk capabilities as well as general map improvements, ensuring that we have a repeatable output rather than our current manual processes for obtaining flood risk data (i.e. from the Environment Agency)

The abovementioned investments fall within the Data Infrastructure and Data Products investment within our Appendix 14[15].

5.2. Asset level climate hazard assessment and risk modelling

5.2.1. The outcomes this investment will support

Table 4 below briefly summarises the key outputs and outcomes that this investment area supports.

Key outputs enabled	Outcomes supported
Climate risk modelling tool which allows asset-level hazard exposure assessment and quantified climate risk modelling Embedding climate analytics into asset investment decision-making Ability for climate risk assessments to be conducted at scale either as a self-service or an agile basis	Improved hazard identification, risk assessments and risk management to demonstrate safe, secure, and reliable operation of our assets and to run the gas network in the most cost-effective manner Asset-level network climate scenario modelling Asset type failure map Resilience baseline Probability of asset damage / failure due to different climate hazards Prioritised asset level actions based on climate risk / costs Quantified cost-benefit adaptation options Transparent climate risk metrics (i.e. KPI's for asset resilience investment) Climate risk embedded into SIP (i.e. climate risk feeding into Asset Investment Management)

Table 4: Outputs enabled and outcomes supported: Asset level climate hazard assessment and risk modelling

5.2.2. Key investments required

To deliver these outputs and outcomes, we propose to invest in:

- Asset level climate hazard assessment tool: As a first step, we will need to invest in conducting a climate hazard assessment across all of our assets. This initial analysis will allow us to understand which assets are at risk from different climate hazards, how that hazard will evolve over time and which assets are not at risk.
- Climate data and quantified climate risk modelling: For the assets identified as having a high risk of exposure to a climate hazard, we will need to purchase high-resolution climate data sets to allow us to conduct a more granular analysis of the hazard and risk to the asset (i.e. more granular data will allow us to understand projected flood depths and at which flood level the asset fails). Doing this will allow us to understand the probability of failure of an asset due to climate impacts and the value at risk (i.e. downtime / disruption costs / replacement / repair costs). We anticipate that this will be an area where

[15] Data and Digitalisation Strategy, Open Data Roadmap, page 50

we will need to leverage innovation through academia and recognised industry experts to develop this tooling at pace.

- Integration into SIP framework: We will need to systematically integrate the findings from the asset level climate hazard assessment into our SIP decision making processes. For example, we will need to evolve our business processes and ways of working to understand the value at risk for an asset so that a cost-benefit analysis can be developed of different resilience adaptation pathways. These findings will need to be considered as part of our SIP framework (i.e. embedded into our unit cost workbook and common risk framework).
- Periodic refresh of asset level climate hazard assessment tool: We will also need investment to periodically refresh our asset level climate hazard assessment tool to ensure our risk modelling is maintained. For example, we will need to refresh the analysis whenever the IPCC and CMIP groups release their assessment reports (roughly every 2-3 years).

The abovementioned investments fall within the Asset Investment Optimisation investment within AEJP05.

5.3. 3D asset data for data analytics

5.3.1. The outcomes this investment will support

Table 5 below briefly summarises the key outputs and outcomes that this investment area supports.

Key outputs enabled	Outcomes supported
3D data capture of assets to allow for more representative risk assessments to take place, along with simulations and emergency exercises to stress test organisational response	More representative climate risk assessments (i.e. height above ground asset information) recorded in core systems so that flood risks can be assessed systematically without the need to visit site Simulation and stress testing of organisational responses to climate risks

Table 5: Outputs enabled and outcomes supported: 3D asset data for data analytics

5.3.2. Key investments required

To deliver these outputs and outcomes, we propose to invest in:

3D data capture of assets: 3D laser scanning in order to produce CAD files and photogrammetry models

Integration & storage of 3D data into core systems: Investment to improve Cadent systems to allow for easy upload, hosting, and transfer of 3D asset data. Once the system hosts this data, the 2D analytics and become 3D analytics.

The abovementioned investments fall within the Data Infrastructure and Data Products investment within our Data and Digitisation Strategy.

5.4. Critical Adaption Programme - Uncertainty mechanism

5.4.1. Context & Justification

Our work over the remainder of RIIO-2 and in the earlier years of RIIO-3 will crystalise asset investment requirements for climate change resilience. This will enable us to identify the assets most at risk and the work required to bring them up to the necessary resilience standards. It will also enable us to understand the levels of risk in the context of other risks to our assets and their underlying quality. We will then begin the asset investment activity to bring our climate resilience to the right level.

In some cases, where our overall risk profile is unchanged, this better understanding of asset risk will allow us to reprioritise asset investment – putting assets at most risk to the 'top of the queue.' In other cases, this will require additional investment. This is an additional risk on top of existing risks and so requires additional work to mitigate.

We also recognise that climate science is evolving quickly, and our understanding of the underlying physical risks, their likelihoods and consequences will evolve with this over time.

For these reasons we are not asking for substantial additional funding for asset climate resilience investments in our business plan. Our customers cannot be asked to commit to paying for resilience we cannot yet well-define.

Instead, we will utilise RIIO-3 Resilience re-opener mechanism to request only the funding we need, for well-defined projects, when we need it. Subject to the final mechanism design, we will use the resilience re-opener as the specific mechanism to seek such funding. Whilst the underlying resilience risk (climate change) is well-known, the most economical way for us to respond to it is not. Only once we have successfully reached this level of maturity is it right for us to invest appropriately.

This also ties into the timeline for the UK future energy strategy, specifically the future of the gas network. By evaluating climate risk at a point when there is greater certainty over the FES will allow us to evaluate the CBA for climate adaptation plans more robustly, therefore ensuring our investments represent best value.

5.4.2. Purpose, Scope, and Benefits

The purpose of the reopener would be twofold:

- To undertake climate adaption to specific assets to manage intolerable risk from extreme climate events
- To define changes in cost for iterative investments, triggered by certainty over adaption pathways. This will be declared where there are material difference to cost to those declared in our base plan.

The scope of activities aligns with existing business plan data table costs and volumes. The critical tables include:

- CV5.01 – LTS, storage and entry, where adaption is required on Offtakes, PRS and pipeline assets
- CV5.04 – Governors, for adaptions to district governors including electronic pressure control equipment
- C4.07 – IT and Telecoms, for adaptions to Electrical, Telemetry and Instrumentation equipment
- C5.06 – Other Capex, for below 7 bar crossings including reduce depth of cover.

We anticipate a mixture of Opex costs for additional activities to mitigate climate risk, and preventative Capex investments above our baseline business plan activities. We anticipate that Capex is not always the most efficient solution to manage the risks posed by climate events.

The benefit of this approach is that there is uncertainty over the volume and the unit costs, which will be addressed by delivery of our climate resilience workstreams. This protects our customers from this uncertainty.

5.5. Managing our Engineering Response – Iterative Adaptions

5.5.1. The outcomes this investment will support

Table 6 below briefly summarises the key outputs and outcomes that this investment area supports.

Key outputs enabled	Outcomes supported
Identify and manage engineering studies to allow greater understanding of likelihood and consequence of failure posed by climactic hazards Engineering support of the quantitative climate risk exposure modelling Technical lead for developing adaptation solutions Development of industry and company standards and competency frameworks for adaptation pathways Ability to actively engage with industry working groups.	Enduring technical competency is developed and embedded into our Engineering function Improved engineering specifications, policies, and procedures to reflect changing climate threats. Asset type failure map Probability of asset damage / failure due to different climactic hazards Delivery of technical adaption solutions

Table 6: Outputs enabled and outcomes supported: Asset level climate hazard assessment and risk modelling

5.5.2. Key investments required

To deliver these outputs and outcomes, we propose to invest in:

- Engineering Resource We recognise that to deploy our climate resilience strategy effectively and efficiently we will need additional technical expertise and resource upfront. This will be required to lead the development of the failure map by assessing probability of asset damage from different climate events. They will also be required to manage the development of adaptation pathways and the associated engineering standards, both internally and with the wider gas industry and beyond. They will also need to define and coordinate the asset data collection, validation of risk assessments, deployment of adaption pathways and tracking and tracing of climate resilience workloads and costs.

- Engineering Studies: Whilst we are yet to determine the extent of our climate risk exposure, we anticipate the need to undertake detailed engineering studies and research to assess how climactic hazards affect the risk of failure of our asset. We anticipate this will be an area for to use innovation mechanisms. This will be crucial learning in enabling us to quantify the risk in our enduring investment framework.

The abovementioned investments fall within our Totex costs for headcount and Engineering Studies and our Appendix 8[16].

[16] Innovation Strategy, Table 2, page 20

6. Annexes

6.1. Annex 1: Case Studies

Stannington

This section contains details of costs incurred during the Stannington gas supply incident in December 2022. Although not linked to climate change, the freezing temperatures at the period increased the impact. The case study also demonstrates the interdependencies between different utility sectors in the same geographic area and the impact the local topography can have on the severity and response to incidents.

The incident occurred on the evening of 2nd December 2022, when a 10 inch cement water main on Bankfield Lane in Stannington, Sheffield burst during a period of freezing weather. More than 2 million litres of water entered the gas network via a 250mm polyethylene gas main, which was damaged by high pressure water (6 bar) leaking from the burst water main. The water flowed through gas pipes down hillsides throughout the Stannington and Hillsborough area. Due to the water pressure and exacerbated by the change in altitude, water caused damage to domestic services, meters and boilers and appliances damage, and also caused damage to gas pressure control equipment.

During this incident, the gas supply to 2,943 customers was interrupted as a result of the water ingress, with an average outage time of 8,012 minutes per customer across the 13 days of the incident. There were also intermittent electrical outage across the area as customers switched to electrical appliances for cooking and heating, putting the electricity network under strain.

The incident was complicated by the local topography, with the water entry point being on high ground creating a head of water, high pressures and flows resulting in water stressing and damaging our network and downstream meters and appliances and the wide spread of water across an area of 10 square kilometres. This exacerbated the service recovery time.

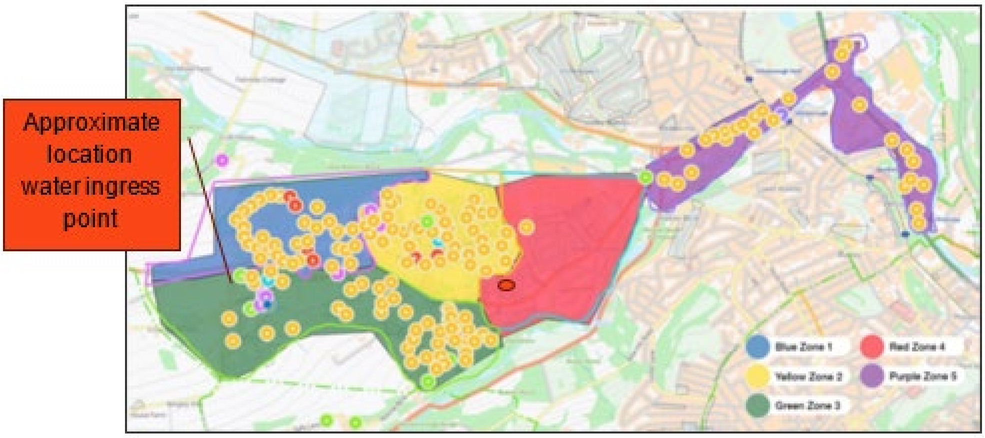

Figure 13: Map of Stannington area showing gas mains and approximate water ingress point

Cadent incurred multiple costs during the incident, notably resourcing to facilitate the extraction of water, repair, and restoration of service to customers, customer interruption compensation, and wellbeing facilities for customers and Cadent response teams. Additionally, engineering integrity inspections were required on the affected network to ensure that the pipes had not incurred any mechanical damage caused by the pressure of the water in the main. The high-level cost breakdown is shown in table 7.

Cost Type	Description	Cost (£) 23/24 Prices
Customer Repairs	Repairs to customer property resulting from the incident	[cost data]
Compensation Payments	Compensation paid to customers (domestic and commercial) resulting from unplanned outage to gas supply (GSOP1 and GSOP3 Payments)	[cost data]
Network Repairs	Cost of materials, traffic management, permitry and specialist labour to repair network assets.	[cost data]
Labour Costs	Cost of staff and industrial labour to manage the network repair	[cost data]
Fleet and Logistics	Cost of fleet and logistic services required to manage the incident	[cost data]
Incident investigation	Cost of leakage survey and Forensic investigation	[cost data]
Customer Welfare	Cost of mobile support unit, customer engagement centre, catering, boiler exchange, hot plates & heating, winter clothing, alternative accommodation	[cost data]
Grand total		[cost data]

Table 7: Stannington incident cost breakdown

J Cropper diversion

As a result of extreme weather and associated flooding on the 6th and 7th December 2015 the integrity of the 6" pipeline operating at 7 bar and supplying the James Cropper paper mill in Kendal, Cumbria was compromised. This was a direct result of the bridge over the river Kent to which the pipeline was connected being structurally damaged.

The damaged bridge has been held in place with steel anchorages attached to surrounding trees, and it's structure braced with steel tubing. The structure of the bridge was assessed, and it was identified that the replacement of the bridge should be carried out as soon as is practicable.

A 100m pipeline section of 6 inch intermediate pressure pipeline was successfully diverted under emergency conditions (Green Intermediate Pressure main shown in Figure 14.

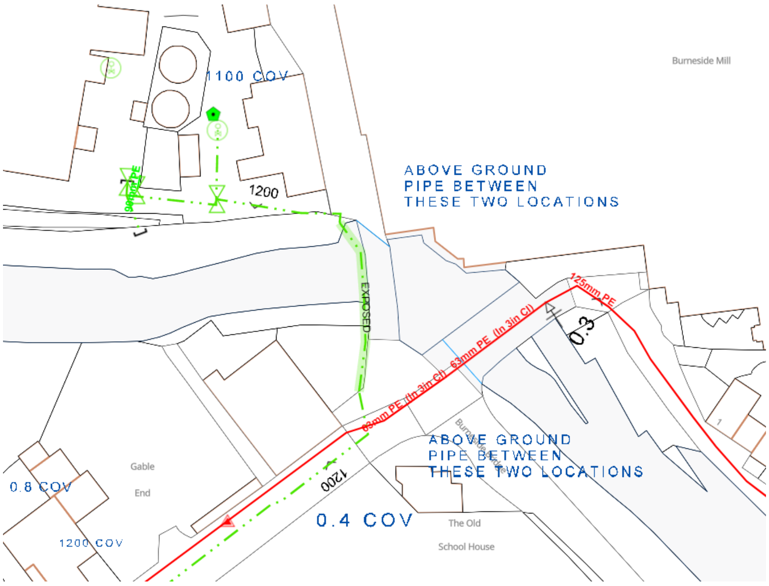

Figure 14: J Cropper diversion map

The total cost of the J Cropper diversion is broken down as per Table 8.

Cost Type	Description	Cost (£) 23/24 Prices
Design Works	Topography, Surveys, Mechanical and Civil Design, Construction Pack, Principle designer preliminary activities	[cost data]
Preliminary Activities	Site investigations, project management, administration, set up of site security and welfare facilities	[cost data]
Construction	Mobilisation, stopped preliminaries, carriageway works, construction of new pipeline, testing, tie in, decommissioning and removal of redundant pipework, reinstatement	[cost data]
Project Management	Cadent supervision, materials, inspections	[cost data]
Grand total		[cost data]

Table 8: J Cropper diversion costs

6.2. Annex 2: Alignment with BS 8631

BS 8631 Section	Climate Resilience Sections
5.1 – Step 1: Planning. Define problem, aims, objectives and constraints	Section 1 (defining problem) Section 2 (defining problem) Section 3 (aims, objectives, constraints) Section 4.5.1 (planning - specifically Workstream 1)
5.2 – Step 2: Understand the risks and opportunities from current climate	Section 3 (Understanding risks) Section 4.6.2 – 4.6.3 (Understanding risks)
5.3 – Step 3: Understand risks and opportunities from a range of future climate change scenarios, including the highest climate scenarios	Section 4.6.2 – 4.6.3 (Understanding risks)
5.4 - Step 4: Consider adaptation options for different levels of risks and opportunities and their thresholds	Section 3.4 (flood response) Section 4.5.6 (adaptation pathways)
5.5 - Step 5: Identify and evaluate the implications of interdependencies with other drivers	Section 4.6.3 (Cascading risk & interdependencies)
5.6 - Step 6: Assemble a route map of adaptation pathways	Section 4.5.6 (Workstream 6 adaptation pathways)
5.7 - Step 7: Evaluate and choose adaptation pathways	Section 4.5.6 (Workstream 6 adaptation pathways)
5.8 - Step 8: Report preferred adaptation pathways	Section 4.5.6 (Workstream 6 adaptation pathways)
5.9 - Step 9: Set out implementation, monitoring, and evaluation plans	Section 4.6. & 5 (Implementation) Section 4.7 (Governance)

Table 9: Alignment with BS 8631

6.3. Annex 3: References

No.	Document Name	Author	Date
1	Progress in adapting to climate change – 2023 Report to Parliament	Climate Change Committee	2023
2	Findings from the third UK Climate Risk Assessment (CCRA3) Evidence Report 2021	UK Climate Risk	2021
3	Climate Change Adaptation Report	Cadent	2021
4	Sustainability Report	Cadent	2022
5	Environmental Action Plan	Cadent	2019
6	Annual Environmental Report	Cadent	2023
7	CAD/PM/EM/82 – Engineering Management Procedure Document for Extreme Weather Events	Cadent	2022
8	IGEM/G/4 Ed 2 – Definitions for the gas industry	IGEM	2012
9	Cadent Multiple Angles Research 2024	DJS Research	2024
10	National Energy System Operator 2023 Electricity Review	NESO	2024

7. Glossary

Definitions used within this document are in accordance with ‘IGEM/G/4 Ed. 2 – Definitions for the gas industry’ unless otherwise identified below.

Term	Definition
AGI	Above Ground Installation
ARP	[Climate] Action Reporting Process
Capex	Capital expenditure
CO_2	Carbon dioxide
CBA	Cost Benefit Analysis
Climate	Climate is the mean and variability around that mean, of meteorological variables in a specific region over a given time span (usually of the order of 30 years).
Climate Change	Climate Change refers to long-term shifts in climate patterns, in general this is the forecast rise in global average temperatures, though the effects of climate change at a regional level will vary. The consequences of climate change commonly include, among others, intense droughts, water scarcity, increased wildfires, rising sea levels, flooding, melting polar ice, increased storm (Wind and/or Precipitation) frequency, and declining biodiversity.
Climate resilience	A climate resilient network company is one where the physical network assets and company procedures have the measurable capacity to withstand impacts of current and future foreseeable climate hazards to provide a continuation of the primary service in line with existing standards of performance, or to facilitate a rapid service recovery from a climate hazard.
CMIP	Coupled Model Intercomparison Project
CRM	Climate resilience metric
CS-NOW	Climate Services for a Net Zero Resilient World
DESNZ	Department for Energy Security and Net Zero
ENA	Energy Networks Association
FES	Future Energy Scenarios
GDN	Gas Distribution Network
HAZID	Hazard Identification Study
IGEM	Institute of Gas Engineers and Managers
IPCC	Intergovernmental Panel on Climate Change
KPI	Key Performance Indicators
NEWG	Natural Event Working Group [Cadent internal group]
PRS	Pressure Regulating Station
SIF	Strategic Investment Funding
SIP	Strategic Investment Planning
TCFD	Taskforce for Climate-related Financial Disclosures
UKCP18	Met Office UK Climate Projections