CDOIF

Chemical and Downstream Oil Industries Forum

Guideline

Adapting to Climate Change

Foreword

Many businesses across all sectors are vulnerable to severe weather conditions and other climate change impacts. Whilst flooding is the most common and widespread natural hazard event that occurs in the UK, other natural hazards, including storms and high winds, lightning, cold weather, extreme heat, tidal surge, and sea level rise can all impact a business, causing disruption to operations or harm to people and the environment.

Climate change is making extreme weather events and other climate impacts occur more frequently and with increasing severity, which can increase risk to businesses. Preparing in advance can minimise the impact natural hazards and climate change could have on operational activities. Preparing for these risks increases resilience. Businesses that prepare and exercise extreme weather response plans are typically impacted less and recover faster.

Natural Hazard Triggered Technological Accidents[1] (Natech) may be caused directly or further aggravated by extreme weather events, leading to the potential release of hazardous materials. An operator of an industrial facility should understand how natural causes may initiate or escalate accidents or permit non-compliance, and take the necessary actions to protect people and the environment.

The Chemical and Downstream Oil Industries Forum (CDOIF) has brought together industrial site operators, regulators, trade associations and other professional bodies to share the most appropriate information, guidance, and best practice available.

The document is designed to support practitioners' understanding of the risks and what measures, or procedures, could be implemented to help improve resilience to extreme weather events and other climate change impacts. It will help operators of sites that are regulated under the Control of Major Accident Hazard Regulations 2015 (COMAH), and other large industrial sites to review the measures in place to prevent or mitigate accidents, including major accidents initiated by natural causes.

Embedding adaptation into management systems, policies and standards is a rapidly evolving area of work and CDOIF will maintain a watch on developments and application of this guidance with a view to potential for future updates. For example, operators should be aware that there is evolving work on development of standards for climate service providers, developing sector standards for service delivery and extensive work to consider update of engineering standards. The National Adaptation Programme outlines ongoing work.

[1] https://unece.org/industrial-accidents-convention-and-natural-disasters-natech#:~:text=%E2%80%98Natural%20Hazards%20Triggering%20Technological%20Disasters%E2%80%99%20or%20Natech%20refers,to%20a%20cascading%20technological%20disaster%2C%20accumulating%20its%20consequences .

Limitations of the Document

In promoting and leading on key sector process safety initiatives, CDOIF has developed through its members this guideline to assist understanding of Climate Change Adaptation.

It is not the intention of this document to replace any existing corporate policies or processes.

There are no limitations on further distribution of this document to organisations outside of the Chemical and Downstream Oil Industries Forum (CDOIF) membership, provided that:

(a) It is understood that this document represents CDOIF's view of common practice on climate change adaptation risk assessment.
(b) CDOIF accepts no responsibility in terms of the use or misuse of this document.
(c) The document is distributed in a read-only format, such that the name and content is not changed and that it is consistently referred to as "CDOIF Guideline – Adapting to climate change".
(d) It is understood that no warranty is given in relation to the accuracy or completeness of information contained in the report except that it is believed to be substantially correct at the time of publication.

This document does not explore all possible options for demonstrating compliance against relevant regulatory instruments, nor does it consider individual site requirements. The following material is for reference, it is not compulsory guidance and duty holders (operators/employers) are free to take other action.

Contents

1. Executive Summary

Recent years have seen an escalation of extreme weather and climate change impacts, in both frequency and severity. Scientists predict that, even with the most recent commitments to mitigate climate change, the frequency and severity of natural hazards will continue to increase. It is critical that all businesses understand the risks associated with a changing climate and integrate measures to adapt to these changes into their safety, environmental and business management systems. This will enable appropriate management of these increasing threats, while maintaining compliance and enhancing business continuity.

This guideline document outlines the steps for how a business (with a focus on those in the high hazard sectors) can assess and manage the risk of climate change, and signposts where guidance, standards, climate data and models can be accessed. This is to help users understand risks and opportunities impacting today's operations, alongside the changes which may occur in the future. The guidance highlights current best practice for managing businesses in a changing climate and many key available resources. This includes standards, guidance, climate information, training, and case study material to enable sustainable management of climate impacts throughout a business in all its decisions.

The Organisation for Economic Co-operation and Development OECD (2022) document provides a high level introduction to Adaptive Management, and Chemical Industries Association CIA (2021) that puts it in the context of managing compliance and business risks. The CIA document focuses on chemical sector resilience. IEMA (2022) adaptation guidance provides practical advice to practitioners. Environment Agency (2023a and 2023b) provides guidance for sites in England which fall within the scope of the Environmental Permitting Regulations on how to embed climate change adaptation into an environmental management system. These documents are relevant to all COMAH establishments. However, a more extensive list of currently available guidance can be found in Appendix 5.

Also of note is the general strategy influencing global policies, to embed adaptation. This is progressing at pace to influence both legislation and engineering/management standards. For example, see the recently revised OECD Guiding Principles for Chemical Accident Prevention, Preparedness and Response - Third Edition and OECD Decision-Recommendation of the Council concerning Chemical Accident Prevention, Preparedness and Response.

This is a rapidly changing area of work and CDOIF will maintain a watch on developments and application of this guidance with a view to potential for future updates to this guidance.

2. How to Use this Document

2.1. Purpose

This document covers Climate Change Adaptation Risk Assessment (CCA RA), adaptation planning and wider adaptation management principles and approaches. Whilst the focus of this guidance is on risks, the principles and methods are equally applicable to management of opportunities. This is set in the context of the high hazard industries and can be applied proportionately to a wide range of businesses.

The focus of this document is to signpost resources necessary to enable operators to develop their own adaptation risk assessments. It will also enable a sensible conversation on measures employed with the environmental and safety regulators. Site-specific compliance matters and expectations should be discussed with the local regulator.

The focus of this guideline is on Process Safety and Environmental Protection. However, it is recognised that operators may be subject to multiple aspects of legislation where climate change adaptation is relevant - for example, the new requirements linked to the Task Force on Climate-Related Financial Disclosures (TCFD) and the proposed Sustainability Disclosure Requirements (SDR) and investment labels from the UK Financial Conduct Authority. The latest standards in this area of work have been published by The International Financial Reporting Standards Foundation (IFRS), including S2 Climate-related Disclosures.

This document encourages consideration of interlinked requirements, to assess climate change impacts and manage risks or opportunities holistically throughout the business. This document also encourages use of existing studies wherever they are relevant to Major Accident Hazards in order to avoid duplication of work – for example, alignment of COMAH and Climate Change Adaptation reporting information (under the Climate Change Act), where relevant.

2.2. Target Audience

This guidance has been written with a focus on the high hazard industries. However, the information it contains may be applied proportionately to a wide range of businesses. In particular, installations required to have an environmental permit.

The intended audience is:

- Those responsible for assessing and managing climate change impacts and risks associated with safety and environmental protection
- Those who contribute to or oversee that work – Senior managers, engineers, consultants and regulators
- Staff in senior management positions who may also need to understand the issues and their leadership role

The executive summary, together with sections 1-4 of this guidance and the accompanying slide pack may be used by practitioners as a suitable introduction to Natech and adaptation.

Collaboration between teams, departments within organisations and with external stakeholders is to be strongly encouraged. This is to ensure optimal use of resources when seeking to manage risks.

2.3. How to Use the Document

This document signposts existing legislation, best practice, and adds specific information where it is believed necessary to enable practical application of the concepts at site level. Not all the information or management system processes signposted will be relevant to all operators - the amount of information and depth of assessment required will be proportionate to the scale of climate risks to the business.

If users of this document are new to the topic of climate change adaptation, the following links provide a summary of climate risks and opportunities and an overview of how to embed climate change matters into management systems, to manage risks and opportunities: OECD (2022), CIA (2021) , IEMA (2022) and Environment Agency (2023a and 2023b).

A slide pack has been produced alongside this guideline document. It provides a summary of the content of this guideline along with many examples of how climate impacts can threaten safety and environmental compliance, together with many relevant case studies. These slides may be used as an introduction before reading this document. The slides include links to a wealth of detail to support adaptation activities.

- For senior managers, sections 1- 4 of this document should be sufficient to help you understand what good climate change leadership entails.
- For managers and practitioners with responsibility for delivering improved resilience, through the understanding and management of climate impacts and risks, sections 5-12 of this guideline provide detailed guidance on how to embed adaptation into businesses management systems to ensure risks are assessed, control measures implemented, and adaptation action monitored to ensure continual improvement.

3. Principles and Concepts

3.1. Background

Climate change adaptation is relevant to various aspects of a business and is being integrated into several areas of policy (with associated supporting guidance).

- **Process safety** – Climate impacts are increasing the risk of accidents, both their frequency and their consequences. Accidents associated with natural causes are commonly referred to as Natech. Note: a specific focus on Major Accident Hazards is necessary due to the catastrophic consequences if the management of the hazards goes wrong.

- **Environmental permit compliance** – Increasing vulnerability of environmental receptors make them more susceptible to industrial emissions. In addition, increased risk of climate change impacts can affect the ability of operators to comply with their permits and create wider business risks, including compliance related to the prevention of Natech.

- **Land use planning** – For some natural hazards, such as flood risk or wind speed, there is a strong correlation between risk and geographic location, and the most effective adaptation strategy is avoidance of development in higher risk areas, coupled with strategic planning concerning which areas/infrastructure to continue to protect from future events and the level of protection demanded by society.

- **Climate Change Act** – The Act established a framework for identifying and assessing climate change risks. As part of this, adaptation reporting is required for some organisations (e.g. energy, water, ports). The third round of adaptation reporting occurred in 2021 and the published reports include a wealth of examples on good and best practice. The reports have been evaluated by the Climate Change Committee (2022) and support the national Climate Change Risk Assessment (CCRA) and National Adaptation Programme (NAP). A fourth round of adaptation reporting will take place in 2023/24.

- **Wider financial, business, supply chain, and infrastructure resilience** – included in financial and sustainability disclosure requirements. [IFRS S2 Climate-related Disclosures].

- **Guidance published by the** National Audit Office (2021) – to support businesses Audit and Risk Assurance Committees in supporting and advising the business's board and accounting officers in their responsibilities for risk management.

A reflection from Conference of the Parties (COP26 and 27) – "Even if all current policy commitments regarding reductions in emissions are met, the Earth will continue to warm and the frequency and severity of extreme weather events and other climate impacts will increase."

Worst case storm events should not be predicted as if they were a recurrence of events that already happened in the past; instead, industry should increase safety factors to account for changes (both actual and potential) in the environment and in the climate. "Understanding Natech risks due to storms", JRC Technical report (2018)

In some parts of the world, the predicted levels of warming, associated with a 2°C warming scenario, have been said to be a death sentence, for example the impact of rising sea levels on low lying communities (COP26). For businesses, a failure to sufficiently manage risks of extreme weather or climate impacts could lead to a Major Accident or other compliance issues, which could be equally terminal for a business.

3.2. Concepts of Adaptation and Mitigation

In any consideration of climate change, it is essential to understand the difference between Climate Change Mitigation and Climate Change Adaptation.

- **Climate Change Mitigation** – is a human intervention to reduce the sources or enhance the sinks of greenhouse gases (GHGs). These are the actions that will limit or reduce the quantities of GHGs in the atmosphere. The need to mitigate climate change is driving the net zero agenda, seeking decarbonisation of industrial energy systems, greater efficiencies in energy systems and circular economies.

- **Climate Change Adaptation** – is the process of adjustment to actual or expected climate and its effects. These are the actions that will need to be taken to manage risks from climate impacts, now and into the future. Adaptation seeks to reduce or avoid harm, but can also exploit beneficial opportunities. Experts agree that climate change adaptation is most effective when it is integrated into the organisation's processes (such as policies, plans, procedures and implementation).

While mitigation and adaptation are separate concepts, there is a synergy between them - climate change adaptation should be undertaken keeping in view the objective of mitigating climate change. For example, one possible response to managing increasing quantities of flood waters could be increasing water pumping capacities – but this would be counterproductive if the flood water pumps run on a carbon-based energy source, and may cause another site to be flooded as a consequence of moving water to new or unexpected locations. Similarly, mitigation actions need to be taken with climate resilience in mind. Avoid locating tomorrow's net zero energy infrastructure in flood risk areas.

3.3. Climate Change Concepts

This section introduces key climate change concepts. The slide pack also covers key concepts and case studies.

- **Adaptive management** – The process of iteratively planning, implementing, reviewing and modifying strategies for managing resources in the face of uncertainty and change, i.e. the Plan-Do-Check-Act cycle to deliver continuous improvement.

- **Adaptive capacity** – The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to

consequences (ISO 14090:2019). For operators of industrial establishments, the adaptive capacity of the business is influenced strongly by leadership commitments and the resources available, including competencies, to ensure adaptive management.

- **Natech** – Industrial accidents with natural causes, such as flooding, storms, lightning, high/low temperatures, sea level rise, subsidence, wildfire etc. Natechs can degrade protection measures, causing harm to people and the environment, and business assets, operations, and supply chains. Planning for Natechs is essential for process safety and long-term business operability.

- **Natural hazard** – Natural hazards can be a Major Accident Hazard threat or cause, or an escalation/degradation factor.

- **Receptor vulnerability** – Receptors may be becoming more vulnerable to impacts from industry due to climate change impacts and other biodiversity crisis issues, and thus might be more susceptible to harm. (Note, in adaptation, vulnerability is also used to refer to the propensity or predisposition of all systems, built and natural environments, to be adversely affected by climate impacts. See ISO 19091 for further discussion.)

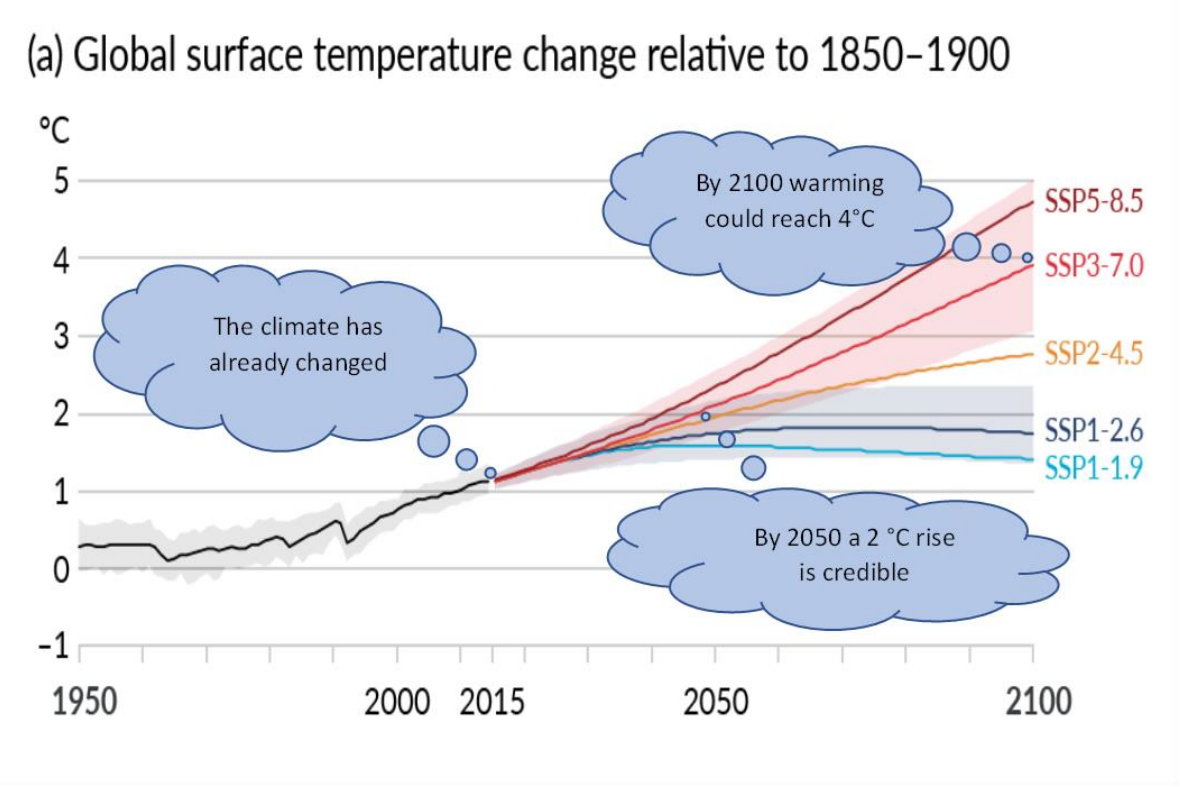
- **Climate vs weather vs climate change** – Climate is the weather conditions prevailing in an area in general or over a long period (typically 30 years or more). Weather is the state of the atmosphere at a particular place and time as regards heat, cloudiness, dryness, sunshine, wind, rain, etc. Climate change refers to a large-scale, long-term shift in the planet's weather patterns and average temperatures. For a simple introduction to climate change, see BBC website.

- **Climate change causes** – Evidence has shown that the high levels of greenhouse gases in the atmosphere are the leading cause of increasing global temperatures. Scientists have been able to rule out natural events as causes of climate change, such as volcanic activity, changes in solar activity, or natural sources of CO_2. These may, however, have additional effect on top of human contributions.

- **Climate change impacts** – Increasing global temperatures have a range of impacts on the climate system, ecosystems, and people. Climate change can affect our climate system in lots of different ways, as highlighted in the climate impacts tool. The key impacts of climate change for the UK are expected to include:
    - Warmer and wetter winters
    - Hotter and drier summers
    - More frequent and intense weather extremes (Including lightning, high winds increased rain fall, increasing flood, heatwave and drought risks)
    - Rising sea levels combined with associated coastal erosion

- **Cascading climate change impacts** - for example when a heavy rainfall event follows a prolonged heatwave where the ground has become hard baked, this may then result in flash flooding, which can impact power systems, then impact industry.

- **Explanation of "Present day", "2°C" and "4°C" climate scenarios**
  In considering climate change, it is important to understand the climate impacts that might occur in the context of present-day impacts. The climate has already changed and impacts are already being experienced by industry. Thinking of the future, what if the globe warms by +2°C, or what if it warms by +4°C? Scientists model global and regional impacts based on various climate scenarios, or pathways, each representing a possible different future with different rates of global warming. For an explanation of the two main approaches, see Representative Concentration Pathways (RCPs) and Shared Socioeconomic Pathway (SSPs). Government outlines its strategy, within its Environmental Improvement Plan, to prepare for +4°C warming. Further discussion of these concepts and policy can be found in the climate impacts tool.



Credit – modified from IPCC 6th assessment report

- **Adaptation pathways, management and planning** – A management systems approach based on an iterative, continual improvement management system cycle, which is suited to managing resources and risks in the face of uncertainty and change. For COMAH, the objective is to ensure that through the Safety Management System (SMS) risk is maintained As Low As Reasonably Practicable (ALARP) in the face of escalating Natech frequency/severity. The approach is informed by potential climate change scenarios (RCPs, SSPs, +2°C or +4°C etc.) and allows decisions to be made today without preventing potential risk reduction options for the future. A classic example of an adaptive approach - if building a flood defence, build it today, but with additional strength foundations and adaptability to allow upgrade to a higher defence in decades to come.

- **High hazard industries** – specifically those that fall inside the scope of COMAH regulations, follow risk reduction and good practice principles. These are widely applicable to all sectors where fatalities and serious environmental harm can result from the impacts of climate change.

- **Interdependencies or dependencies** – is where risks at one point in a system are dependent or interdependent on risk controls elsewhere in a system and this can lead to cascading risks throughout the system. For example, flooding of an electrical substation may result in a loss of power in the electricity supply grid, leading to loss of power to pumps dealing with flood water on an industrial site or electricity dependent process and a subsequent industrial accident.

4. The Adaptive Management Cycle

Adaptive management is designed to enable management of climate impacts and uncertainty, throughout a business. Iterative planning, implementing and modifying strategies for managing risks will improve resilience (i.e. Plan-Do-Check-Act cycle to deliver continuous improvement). A fundamental aspect underpinning this process is developing an understanding of:

- Climate change impacts, which have already occurred, and might already be affecting the business
- The future climate change impacts might further increase risks, especially compliance risks such as safety and environmental protection. This is especially important for any new or existing assets with lifetimes up to and beyond 20/30 years. This process may also highlight opportunities

All subsequent business decisions are therefore based on the identified climate change impacts, risks and opportunities.

This approach should be integrated into existing, cyclical business management systems (MS) for health, safety, environment, quality and finance. This can be achieved by following the requirements of ISO 14090, supported by ISO 14091, which have been designed to dovetail with ISO 14001 and other business MS standards.

The following key stages are required (and the remainder of this guideline also follows these stages):

- Preplanning – Understanding the ability of the organisation to establish The Adaptive Management Cycle, including sufficient resources and competencies (known as an organisation's adaptive capacity)
- MAH ID and evaluation procedure (Adaptation Risk Assessment *Procedure* and
-
- Identify Accident Scenarios and Potential Non-Compliance Matters)
- Identify Potential Impacts
- Risk Assessment – Part A
- Risk Assessment – Part B (sensitivity analysis, risk attribution/trending)
- Identify and Appraise Further Risk Reduction Measures
- Adaptation Plan
- Monitor, Record and Review

Following these steps will also enable an organisation to assess its risk to climate change, while meeting its legal duties under COMAH or EPR/PPC.

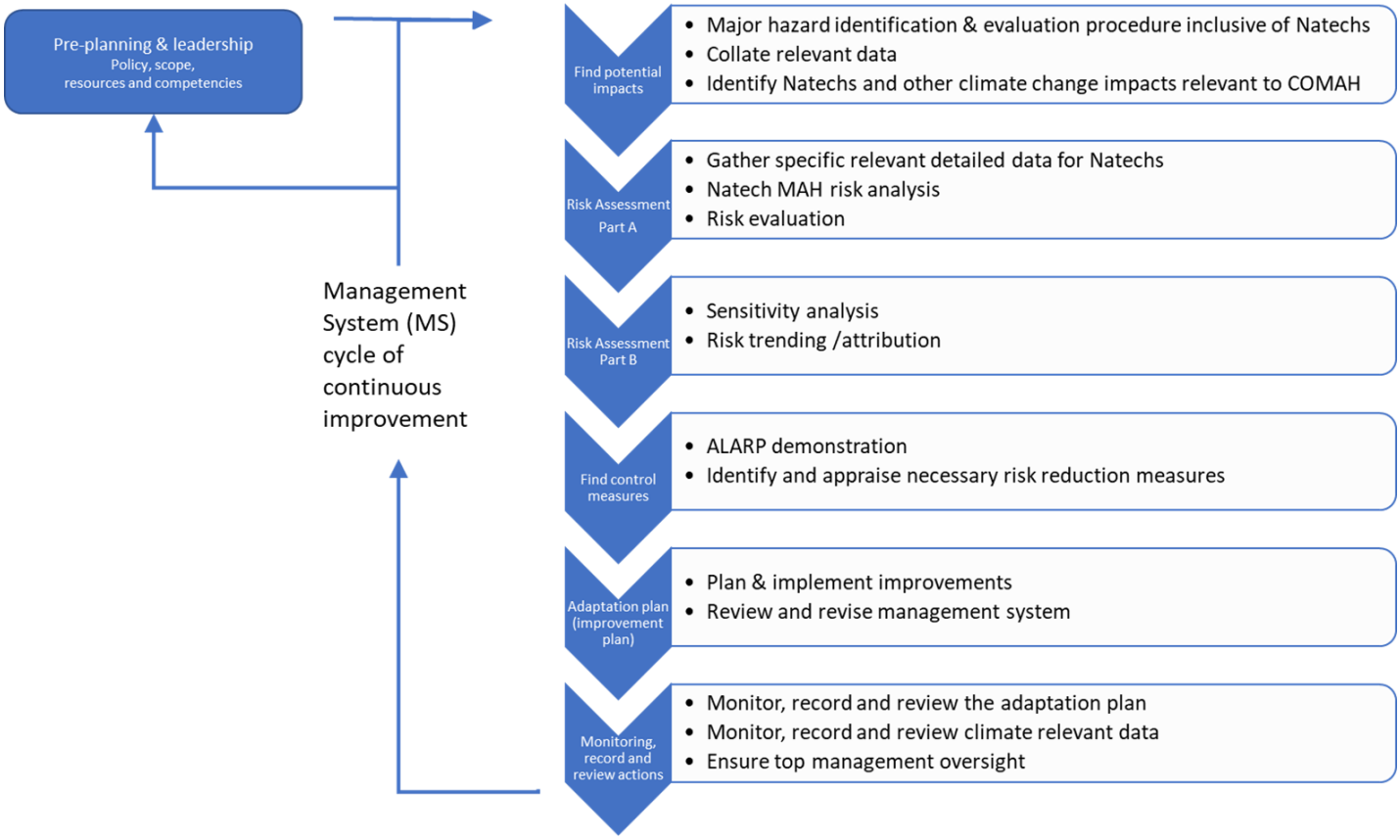
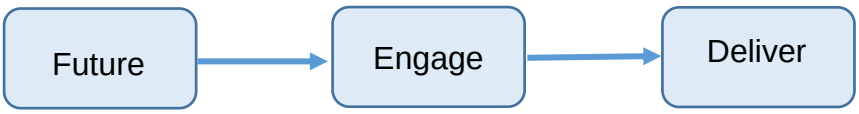


Figure 1: Adaptation management in the context of high hazard industries

4.1. Leadership and Strategy

Successful process safety management requires strong leadership, this is also true in relation to climate change adaptation. Senior leaders may wish to set out the ambitions and strategic intent for their business to manage climate change adaptation. The capability of an organisation to develop and implement an effective adaptation plan is a good measure of senior leadership teams' commitment to adaptation.

This then requires engagement with staff across the business to enable the implementation of that ambition. Ambitious and forward-looking groups within companies can only get so far without leadership enabling practice. If any part of this procedure is missing, the adaptation required for future climate change will be missed.



Steve Radcliffe – Leadership Plain and Simple

Figure 2: Principles of leadership

4.2. Corporate Policy and Approach

Consideration may be given to including and embedding adaptation into an active management system to address all aspects of climate change. This may include developing a policy on climate change adaptation which defines how this will be achieved, through:

- Leadership commitment
- Implementation
- Accountability

The policy can help businesses incorporate relevant aspects of climate change adaptation into organisations wider policies, future strategies, and plans. It can also help in the demonstration of good regulatory compliance and Environmental, Social, and Corporate Governance (ESCG).

Policy commitments may include:

- Inclusion of adaptive management processes into the business (for example, through the adoption of ISO 14090, supported by 14091, within an existing management system).
- Determining the benefits of going beyond legal minimum compliance in relation to climate change adaptation.
- Monitoring the changes in climate impacts that might directly impact business operations and establishing thresholds for these indicators that show when risk reduction action is required. For example, recording indicators such as rising sea levels and local temperatures.
- Ensuring proposals to address threats to the business in relation to climate change are sufficiently planned, resourced and funded to ensure that the business continues to manage its risks appropriately.

Box 1: Adaptation by sector

UK transport sector

The transport sector is widely regarded as leading in embedding adaptation into business strategy and management systems.

Originally driven by the Adaptation Reporting Power requirements under the Climate Change Act, the sector has continued to build adaptive capacity (e.g. competencies and resources), assess risks, and plan for improved resilience through embedding adaptive management approaches into their activities.

For example, Network Rail formally recognises climate change could increase the frequency and severity of extreme weather, which impacts infrastructure and operation of the rail network. More detail of the ongoing work they are planning now in order to provide a safe, reliable network in the future, can be found at: https://www.networkrail.co.uk/sustainability/climate-change/climate-change-adaptation/.

The work Transport for London (TfL) is committing to adaptation, including governance, strategy and risk management approach is summarised in its third adaptation report (2021) and adaptation plan (2023).

4.3. Scope of Adaptive Planning

Senior leaders may wish to consider the scope of adaptation planning appropriate for their business, the risks and legislation which applies to them. They should also consider whether adopting the techniques and approaches outlined in relevant standards such as ISO 14090 (or equivalent standards) are appropriate.

The following should be considered when defining the scope:

- If an appropriate standard or alternative approach will be adopted (for example, using ISO 14090), how will it be incorporated into existing systems (for example, the Major Hazard Management System).
- The extent to which adaptive planning will be incorporated into existing systems, for example:
    - environmental or safety threats, risks, and compliance
    - finance
    - net zero transition
    - specific geographical locations or supply chains
- How risks will be assessed (for example, using ISO 14091).
- How planning for future climate change measures will be addressed (for example, through the adaptation pathways approach defined in BS 8631.
- How legal requirements will be met.

Box 2: Adaptation Standards

The ISO14090 Standard on Adaptation to Climate Change – Principles, Requirements and Guidelines

The senior management of a business will need to make decisions about the scope of adaptation planning required based on the location and operational vulnerability, including whether to adopt techniques and approaches outlined in relevant standards (ISO 14090/91 and BS 8631).

The adaptation standard (ISO 14090) is flexible and can be applied to all activities across an entire business and its supply chain, or selectively to specific locations or business functions. For example, it could be applied with a process safety focus, and not cover financial matters.

Experts believe the most benefit will come from integrating adaptation management throughout all business activities and supply chains, though it is equally possible to focus on a smaller part of the business initially and then plan to expand adaptation management as resources allow, and business need requires it.

Senior management should clearly define the scope of adaptation planning activities, including whether the business will:

- Adopt ISO 14090 (e.g. within environmental and business management system)
- Assess risks in line with ISO 14091
- Adopt the adaptation pathways approach to planning for future adaptation action (BS 8631)
- Decide the extent to which adaptive planning will be integrated into the business, for example:
  - Limited to managing environmental and safety threats, risks, and compliance matters, or to include wider functions also, such as finance and planning for net zero transition and opportunities
  - Limited to certain geographical locations or covering the whole business, and whether to include local supply chains or the complete supply chains, respectively
- As a minimum, commit to meet legal requirements to ensure compliance, such as those required for COMAH, EPR/PPC, planning, or Climate Change Act where relevant

The scope and ambition for integration of adaptive management into the business should be clearly defined.

For further information refer to ISO 14090 section 5.

DEFRA guidance to the Adaptation Reporting Power fourth round includes a summary of adaptation standards in Annex B [Unpublished guidance available on request from CDOIF members]

4.4. Resources, Competencies and Adaptive Capacity

Senior leaders who manage operations and set strategic goals may request information on impacts that may result from climate change over differing time periods, and the risks that these may have on their business. Senior leaders should be sufficiently competent to understand what these risks mean (for example, in terms of safety, environmental protection, and wider business risks). They should also have the strategic capability to direct the actions required to manage them appropriately and proportionately.

Competence at all levels of an organisation is required to ensure the policy objectives are delivered and resilience increased.

Box 3: Adaptive Capacity Framework

An adaptive capacity diagnosis and development framework (CaDD)

Adaptive capacity is the ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences (ISO 14090:2019). The key components of adaptive capacity analysis are described in the standard. For operators of industrial establishments, the adaptive capacity of the business is influenced strongly by leadership commitments and

the resources available, including competencies, to ensure adaptive management and deliver improved resilience.

To understand the gap between required and current adaptive capacity, it is important to first establish the required capacity. This depends on the level of complexity and uncertainty the organisation needs to manage. Once the required capacity is established, then the current capacity can be assessed and any gap identified. The Climate Change Adaptation Capacity Diagnosis and Development (CaDD) framework, upon which the ISO14090 guidance is based, can be used for this assessment. Other compliant frameworks are also available.

Response levels are the backbone of CaDD. By initially determining what response level an organisation needs to be at, it is possible to gain insight into the types of actions and behaviours they should be involved in. Then, by reviewing the level of response the organisation currently has, it can be determined whether a sufficient response is present. Where a gap exists, improvements can be implemented to progress towards the required response level. Not all organisations need to achieve the higher response levels. This depends on the level of complexity/uncertainty the organisation needs to manage. Each response level is built upon the foundation of the response level below.

CaDD recognises 6 predictable response levels.

Credit – Climate Sense

- RL1: Core Business Focused – Short-term focus on normal business activity and does not consider future climate risk.
- RL2: Stakeholder Responsive – Considers future climate risk but only to the extent that it satisfies the demands to key stakeholders, e.g. customers, bank and regulator. Managing stakeholder relationships rather than climate risk.
- RL3: Efficient Management –Takes ownership of its climate risks, and addresses them using improved versions of existing practices, e.g. risk registers.
- RL4: Breakthrough Projects – Finds that more improved current methodologies are not effectively managing climate risks, but the organisation is not yet clear what they need to do differently. This is especially likely where significant climate uncertainty needs to be managed. The organisation begins to try new approaches to risk management. Some may work, these are “breakthroughs”. Others may not work. The organisation may also find that it is not fully in control of the decisions that affect its adaptation. Its adaptation options may depend on the decisions of others. It may need to learn to engage and collaborate with these stakeholders.
- RL5: Strategic Resilience – Once the organisation has worked out what it needs to do differently, it will then mainstream the newly identified practices. Since it expects to manage climate uncertainty at this level, it will remain on the lookout for emerging risks and be agile in responding to them.
- RL6: Champion Organisations – Some organisations choose to go further and seek to lead wider social change.

www.cadd.global

Box 4: Climate Change Adaptation Case Study Project

SEPA/Environment Agency ISO14090 Climate Change Adaptation Case Study Project

Background to the project

The study brought two initiatives together: one by SEPA, the other by the Environment Agency.
The Environment Agency initiative piloted the value of ISO14090 as both a support to enhancing adaptation in COMAH and Environmental Permitting Regulations (EPR) companies, and to explore the value of the standard as a framework for future regulation.

SEPA joined the initiative within its Government Regulators' Pioneer Fund (Industrial Net Zero Regulatory Hub project for the Grangemouth area) to create a UK regulatory environment that encouraged business innovation and growth through a regulatory hub to support the transition to an inclusive and resilient net zero economy.

The study was conducted for Environment Agency/SEPA by Climate Sense. Climate Sense worked with 9 regulated site operators to guide each through the requirements of Clause 5 (Pre-planning). Each company received a report summarising the findings of the adaptive capacity assessment, the organisation's response level goal, any capacity gaps in relation to developing an effective adaptation plan, and useful next steps.

An online workshop reflected on the experience of participating in the study and assessed the value of applying Clause 5 of the ISO 14090 standard for participating organisations and regulators.

Key findings

Adaptation planning work to date: Most operators were in the 'very early' stages of developing an adaptation programme, however most felt 'moderately' at risk from the direct impacts of climate change on their organisation at the site involved in the study. Participating organisations often considered the risks climate change impacts posed to their wider networks as being higher than the direct risks they faced at a site level. Seven of the nine organisations had assessed some risks up to 10 years into the future. About half had not prioritised risk, with the rest having conducted risk prioritisation in some areas of their company.

Adaptive capacity: Six of the nine organisations were given a long-term target of Response Level 5, i.e., 'Strategic Resilience'. Three were given a target of Response Level 3, i.e., 'Efficient Management'. Current response level for all the participating organisations were considered solid at Response Level 2, i.e., 'Stakeholder Responsive' or 'compliance', and all the participating organisations had started Response Level 3 activity. This largely focused on recognising the benefits of being more proactive with respect to adaptation planning and resourcing actions (mainly allocating time to them, rather than finances). Some had also made substantial progress on some Response Level 4 activity ('Breakthrough Projects'). This early activity tended to be around collaborations with other interested parties and consideration of expanded timespans, that better reflect the life of an asset, in decision making.

Motivation for action: Various motivations for action were identified: compliance with stakeholder demands (the only entirely common motivation for all organisations in the pilot); protecting operations, buildings or other assets from weather/climate risk disruption; improving financial, other operational outcomes, or organisational reputation; recent experience of costly extreme weather; desire to 'promote sustainable development/ environmental protection; gaining competitive advantage; demonstrating best practice; and a desire to develop new strategies.

The role of influencers: Influencers (or 'agents of change' or 'champions') understand the importance of the climate change agenda and, through their own understanding and motivation, are able to spearhead action through using their 'soft skills' to win support from others. Roles included: raising awareness in general; raising awareness with senior leadership; and providing technical advice and solutions; building network with other organisations; building networks with internal stakeholders; thought leadership for decision makers and /or risk managers; working with senior leadership on implications for core strategy.

Sources of evidence used: Access to reliable, trustworthy, salient information is known to be a key enabler of adaptation decision making. It can be difficult for organisations to know what information to trust, what level of 'granularity' they need for specific decisions and how to access it. For many decisions, and especially at the initial scoping stage of adaptation planning, 'headline' messages about future climate trends are often sufficient to start the discussion and build the case for acting. It was common for participants to be unsure where to go for relevant climate risk information. They often looked to the Environment Agency or SEPA for guidance and limited their assessment of risk to what they provided. A range of sources of information were cited as being used to inform the participating organisations' work on adaptation, although there is no detail about how the material was being used. Although it is not possible to demonstrate this using the data gathered in this study, it seems likely that the type of evidence considered useful will vary depending on the response level of the organisation. Thus, the type of evidence will change as the organisation moves to a new response level.

Levels of climate change adaptation skills: The project looked at adaptation practice at individual site level. So, whilst the organisation as a whole might have skills, what the project focused on was what skills were applied at site level and how they were supported by the wider organisation. Most depended on the general risk management capabilities that they apply skilfully during the rest of their work. The outcome of that application depended on the quality of guidance risk management staff were given. There is a close link between the range of climate risk information and the quality of climate risk management. The most developed adaptation plan was found in the company with the broadest range of climate risk information, even though this was quite basic information. In this case, the company had a strong Board level commitment to developing climate resilience, and a strong learning culture in anticipation of numerous sources of volatility for their business, including climate change. This meant a number of factors led to them seeking and responding to wider climate risk information. A key limitation resulting from current skill levels, other than the scope of risks and hazards addressed, is the ability to manage the uncertainty of climate impacts for long-term decisions. This is particularly important for companies that make long-term decisions that are likely to experience climate impacts, the timing of nature of which we cannot currently identify. This requires a different type of risk management to those that the participants currently apply.

Learning processes: Investigation showed that the learning culture and processes within the company made a significant difference to adaptation practice.

Stakeholder engagement: Stakeholder engagement is important in understanding who is at risk from climate impacts, and who can support identification and delivery of solutions. Commonly companies only consulted those they had to, e.g., regulators. Some had no consultation on climate risk and its management.

Financial planning: More than half of the participating organisations had financial planning systems with very short-term time horizons in climate change terms (2-5 years) and did not consider risks that are not present today. This could constrain full adaptive decision-making where the costs were higher than business-as-usual options, but where the value emerges over the life of the decision. Knowing that the financial system was unlikely to change soon could demotivate people trying to drive adaptation action in the organisations (often the influencers). There was often more flexibility to take adaptation action where the leadership of a site had some autonomy, e.g. if they had direct control of spending up to a high enough value to adaptive measures. These people often recognised that adaptive investment would be harder to get if it exceeded their spending limits and needed to go to the corporate planning system.

Compliance led: Seven of the nine organisations made it clear that the key driver of any behaviour is compliance in the mode of "if we have to do it, we will, if not, we won't". This led key informants from the companies (often influencers) to commonly comment that without regulation or a direct disruptive climate impact experience, it would be hard to develop and implement a comprehensive adaptation plan. Some

adaptation was clearly emerging from application of current risk assessment processes. It is equally clear that current processes are unlikely to identify and address all of a site's significant climate risks in a timely way, especially those making long-term decisions which require a high level of adaptive capacity to manage effectively.

Suggested next steps

Mapping the adaptation space (and the gaps): Mapping what else is going on in the adaptation space and where gaps remain would enable actors to build on promising practice and support from elsewhere. This would help to hone what it is that the various regulators (and the wider group) are uniquely placed to deliver, collaborating with others where possible (and not stepping on their toes).

Signposting sources of information: Companies recognised that there are many sources of information and that it can be hard to identify what is useful, relevant, appropriately scaled, and trustworthy. Signposting support to relevant data, especially sources of localised data, would be appreciated.

Providing a safe space for dialogue and development of promising practice: The process used in the study provided a welcome space for exploring a new and complex agenda. '*Communities of practice'* are recognised as being a useful place for people who share a common concern, a set of problems, or an interest in a topic, to come together to discuss useful practice and provide support. As well as guidance and climate information facilitating ongoing networking, this is seen as an important aspect of decision support in complex settings.

Supporting and resourcing agents of change or influencers: Recognising, resourcing, and supporting internal influencers can help to explain the importance of the adaptation agenda and open doors across the organisation so that the work is accelerated and mainstreamed. Influencers can also bring in ideas and practices from their wider networks. It would be useful to think through how influencers could be used most beneficially, and how they can best influence senior leaders within their organisations to support the CCA work.

Communications: Influencers could also help to develop communications materials (news items, videos, vlogs and blogs) to drip-feed messages from the regulators about adaptation and signpost to helpful resources.

Working with trade associations: Trade associations have been useful in tailoring the messages of previous guidance and promoting sector-specific discussion and practice strengthening, e.g. relating to COMAH. It would be useful to discuss the value of the ISO 14090 standard with the relevant trade associations to enable them to play a similar 'agents of change' role for climate adaptation for their networks and members.

Box 5: Collaboration on adaptation

Collaboration on adaptation

There is consensus that effective adaptation, including the management of cascading risks, requires collaboration. Many global, regional, and local networks have been established to prepare resources for adaptation and resilience and enable local networks to interact on systemic risks – for example from:

- The Resilience Shift
- The International Coalition for Sustainable Infrastructure
- Adaptation Scotland
- London Climate Partnership
- Yorkshire and Humber Climate Commission

UK industry-specific networks include the Industrial Operators Adaptation Forum (IOAF).

You can also join global networks of virtual collaboration – LinkedIn: #NaTech, #ISO14090 – This can be particularly good for identifying global best practice and industrial accident case studies.

5. Adaptation Risk Assessment Procedure

5.1. Management System Requirements

The management system provides an integral part to manage the risk from hazards. It is therefore important to capture all risks, including those from Natech and other climate change impacts, in the management systems used by a business. These risks include the impact that Natech and climate change may have on process safety and environmental risk, as well as business and financial risks. These should be included in the management system as appropriate and based on individual needs.

The ISO 14091 (assessing climate change risk) methodology provides a useful tool for conducting a risk assessment for determining the risk, vulnerability, and impact of climate change at a site.

The risk assessment procedure should establish the review and revision criteria of the risk assessment. This should include considerations such as revision upon the publishing of new or updated maps and data. To ensure cohesiveness with the reviews and revisions of other risk assessments, this may be linked to an organisation's corporate management of change procedure.

The risk from Natech hazards should be reviewed at appropriate intervals and include the possibility of change due to creeping climate changes. It should be noted that the impact from climate change may be felt over several years. To identify trends in data, sufficient time should be factored in to identify whether creeping change is occurring.

For example, the Met Office[2] has identified that the average temperature of the hottest day has increased from a 26°C average between 1961 and 1990, up to 26.7°C between 1981 and 2010, and finally up to 26.8°C between 2008 and 2017. This is likely to be higher still for a 30-year average that includes 2019 to 2022. Any risk assessment procedure should therefore include the possibility of change in climate impacts and the implications of this change for risk assessment review/revision (for further discussion, see Process Safety Forum (PSF) Knowledge Exchange – 004).

The risk assessment procedure should facilitate a whole system approach. Within Natech hazards, common cause failures may occur that impact more than one plant area and multiple natural causes (wind, flood, lightning etc) can impact simultaneously. Additionally, depending on the type of Natech hazard, multiple plant areas may be impacted at once. For instance, during a flood more than one process area may be affected. Strong winds can have a variety of impacts across a site depending on the geometry of the structures at the site.

For businesses which fall under the scope of the Environmental Permitting Regulations (EPR) (England and Wales), the management system procedure should reflect the EPR Environmental Management System guidance. Separate guidance regarding environmental permitting is available for Scotland.

[2] Met Office. UK and Global Extreme Events – Heatwaves. Accessed from: https://www.metoffice.gov.uk/research/climate/understanding-climate/uk-and-global-extreme-events-heatwaves

For COMAH operators it is necessary to ensure external and natural causes are included in the management system procedure(s) for identifying and evaluating major accident hazards. This should include screening against the full set of external and natural causes (including extreme weather events and other climate impacts) and consideration of how these may impact accident initiation, barrier degradation and accident escalation factors.

Data sources should be identified within the procedure for use within the risk assessment. The sources should be reviewed periodically to ensure that they are still relevant for use in the risk assessment. The risk assessment procedure should also establish and describe the approaches used for the more detailed analysis and evaluation of Natech scenarios, including when a more in-depth assessment of the risk is required (subject to proportionality considerations). The procedure should also link to the corporate risk acceptance/tolerability criteria. Further guidance on environmental tolerability can be found in the CDOIF guideline on Environmental Risk Tolerability for COMAH Establishments.

5.2. Corporate Position on Natech and Climate Impacts Assessment

It is considered good practice for a risk assessment procedure to include information relating to the company position on assessing Natech hazards and climate change. This may include details on the Natech scenarios, and the screening criteria to ensure that the range of threats, under different climate scenarios, are considered (see Table of Extreme Weather Events and Impacts in Section 6.1).

Best practice guiding the procedure for risk assessment of climate impacts includes the need for the following actions to be embedded in risk assessment procedures. It should be noted that these actions are based on existing guidance for EPR and COMAH establishments.

- Firstly, the present day Natech hazards and other climate impacts, based on the current frequency and severity of natural causes, should be identified, assessed and understood (e.g. in terms of implication for safety and environmental protection). In this context, to create a good baseline, the identification of present-day impacts and any changes since the original business/establishment design assumptions are needed. The climate has already changed and may already be causing increased risk.

- Secondary to this, a criterion is required for the assessment of future risks under climate change. This comprises two elements:
    I. Procedures may include the limiting condition that where the remaining lifetime of the installation is short (for example less than 5 years), then the operator can choose to only consider present-day threats and would not need to assess future changes.

    II. For those establishments with a longer lifetime, (especially those which will foreseeably be in operation beyond 2035), the following should be considered, in order to gain insight into the climate impacts that might arise given different possible levels of global warming:
        a. For initial screening to identify relevant MAHs (See Section 7 in this guidance) a worst-case scenario based on +4°C mean global temperature rise should be used.

b. The scenarios identified in the initial screening (Section 7) are carried forward into a risk assessment (Section 8 and Section 9). These should then be further assessed under at least three different climate scenarios. These scenarios are as follows:
   i. Present day
   ii. A +2°C by 2050 scenario
   iii. A +4°C by 2100 scenario

It is important to recognise that the scenarios +2°C and +4°C refer to levels of mean global warming above a pre-industrial baseline. The local or regional impacts including changes to local temperature, precipitation, storminess, sea level rise need to be understood. Practitioners' understanding of the impacts should be based on information from modelling of Met Office climate data such as UKCP18.

EPR (England) EMS guidance and "Supplementary Green Book Guidance: 2020" contain further information and for the expectation of +2°C and +4°C scenario planning. Also, the risk assessment procedure may indicate a high sensitivity to climate impacts and in these cases it may be necessary to expand the risk assessment process to include more climate projections and scenarios or longer timescale assessment and planning for higher risk impacts or higher vulnerability installations or those with longer lifetimes, beyond 2100 (e.g. expanding assessments to include a wider range of climate impacts, based on a wider set of RCP data, or including H++ scenarios).

6. Identify Potential Impacts

This section details how to conduct the initial screening to identify the relevant accident scenarios. In addition, this section will detail how to identify other potential areas of increased risk to, for instance, environmental permit compliance such as abstraction limits and cooling water discharge temperature limits.

Screening should explore:

- The full range of potential natural hazards that pose a risk today and may pose a risk in the future due to climate change. Natural hazards include, but are not limited to, heavy rainfall events, heat waves, strong winds during storms, and thunderstorms (i.e. lightning).
- The potential for the natural hazard to both initiate and exacerbate incidents at a site or degrade barriers, including major accidents for COMAH sites.
- The potential for climate impacts to take an installation out of compliance with its environmental permit, either during extreme weather events, or a gradual change to a non-compliant status.
- The frequency and severity of those threats in a future +4°C mean global warming scenario.

The outcome of the screening is a set of credible Major Accident Hazard Natech scenarios. This can be included as a subset of the installation's current Major Accident Hazards for COMAH. Additionally, any potential non-compliance with environmental permits should also be identified for assessment.

The impact of external factors should be considered, such as loss of utilities and loss of site access and egress for both personnel responsible for operations at the site and emergency responders, even if the site itself is not impacted. It is important that any control or emergency response measures, which are being counted as risk reduction measures, will remain effective under the specific conditions of that Natech hazard. It is also important to note that any response by external emergency responders may be limited. This will depend on the type of Natech hazard. For example, firefighters may be aiding the evacuation of members of the public from their flooded dwellings or aiding in search and rescue. This will affect the number of fire engines/fire fighters which may be able to attend an incident at the site.

6.1. Relevant Screening Data

This section describes the data and information resources required for high level screening to identify potential Natech and climate changes impacts.

The following table details the various extreme weather events and their potential impacts.

Table 1: Extreme Weather Events and Impacts

Natural Hazard	Potential Impacts
Flood (including heavy rainfall)	Flooding of a site can have significant consequences and, depending on the areas affected, may result in releases that lead to a major accident. Additionally, flooding in the wider area can have an impact on the site, even if the site itself is not flooding. Flooding may cause issues for site access, as well as having the potential to disrupt vital utilities to sites (such as electricity). The frequency and severity of flood incidents increase the probability of the release of historic ground contamination, overloading of surface wastewater systems, water ingress into motors, pumps and other electrical equipment, moisture damage to feedstocks, dry stored products and pipework, hydraulic uplift of submerged pipelines, vessels, and foundations.
Lightning/ thunderstorms	Lightning has the potential to be an initiator of a major accident hazard, as a source of ignition, as well as impacting process plant control systems. Thunderstorms may also result in flash flooding due to the intense rainfall events which can occur, and they have the potential to result in loss of electricity.
Strong wind/ windstorms (and tornados)	Windstorms (and strong gusts of wind) can cause damage to the side of storage tanks and other structures due to the force which is exerted on them. Additionally, winds can also knock down trees, carry light debris and damage power lines. Note: Although a tornado is a nature hazard not often thought of in the UK, the UK does have around 30 tornados per year. These are not on the scale of those seen in the USA. However, there is still potential for structural damage to be caused.
Ice/prolonged cold	Icy and cold conditions can have a detrimental effect on the ductility of many materials which may result in equipment failure. Freezing valves may prevent them from operating correctly, which may result in a failure and release of substances. It is often very difficult to undertake repairs, even when the equipment failure has been identified due to the low temperatures. Slippery road surfaces may also increase the risk of forklift trucks, tankers, or other vehicles on a site from skidding.
Heavy snowfall	Heavy snowfall can cause loading on storage tanks (including floating roofs) and buildings, which can result in collapse. Snowfall can also have wider effects on utilities, as well as snow melt having the potential to cause flood events (e.g. 1947 Thames River floods).
High temperature/ heat wave	High temperatures/heat waves can impact the equipment due the additional stresses on systems, including cooling systems. For instance, differential structural expansion together with the impact of wider temperature variation on the integrity of electrical junction boxes. Examples of potential impacts to consider include: • Overheating of electrical equipment leading to fires • Fires from auto-ignition of materials and waste • Over pressurisation of vessels • Emission of hot gases due to overheating vessels • Expansion and stress on pipework and fitting

Natural Hazard	Potential Impacts
Erosion (soil/ coastal)	Coastal erosion or soil erosion occurs as a result of natural processes which can be expedited by natural hazards (e.g. wind storms or flooding). Climate change may increase the frequency/severity of such events, increasing the rate at which erosion occurs. For sites located on the coast, this increased rate of erosion means assets may become at risk sooner than previously predicted. Soil erosion can impact natural flood barriers, making them less effective against the flood level they are designed to. It may wash out access roads or allow flooding in areas not previously prone to flooding.
Subsidence	Subsidence can have multiple initiating events, including earthquakes, dissolution of limestone and groundwater extraction, or increasing groundwater table levels. The movement of the earth can cause damage to tanks, pipework, or process equipment.
Wildfire	Wildfires can pose a hazard to operating sites especially if they occur in close proximity to the site. Additionally, wildfires may impact water resources, can damage vital infrastructure such as electricity lines, and can require the demand of the emergency services which may result in limited resources being available.
Droughts	Droughts can limit water resources. Limited water resources may impact access to cooling water and limit discharge temperatures. It may also impact emergency response.
Sea level rise	Sea level rise is a long-term risk to sites, especially those below, or near to, current sea level heights. Sea level rise will increase the risk of flooding and increase reliance on sea defences to prevent areas of land from flooding. Other examples include increased incidence of storm surge loading of buildings and structures, overloading of surface waste water systems with salt water and restricted access to plants, corrosive salt water ingress into motors, pumps and other electrical equipment, disruption to services such as power, gas, internet and telephone with temporary shutdown of plants, salt moisture damage to feedstocks, dry stored products and pipework, hydraulic uplift and corrosion of submerged pipelines, vessels and foundations, inability for ships to be loaded and unloaded at jetties and docks for feedstock delivery and finished product export.

For further information on the different types of hazards, their impact, risk assessment approaches and climate change assessments see the following resources:

- OECD. The Impact of Natural Hazards on Hazardous Installations
- European Commission. JRC Technical Report. Natech Risk Management
- Chemicals Industry Association. Safeguarding chemical businesses in a changing climate.
- CCPS Monograph: Assessment of and planning for natural hazards

Within Europe there is a strategy to update and embed climate change adaptation into standards, so that content relevant to climate change impacts are updated. For example, moving away from consideration of historic climate information only to an approach that focuses on managing present day and future climate change impacts.
A specific example of a framework to enable this has been produced by CEN/CENELEC (2022). This is a guide for standards committees on how they can include climate change adaptation in infrastructure standards. The guide usefully annexes example climate effects (impacts and consequences), key information sources and infrastructure adaptation case studies. The

primary audience of this guidance is those who develop standards. It is also useful for anyone who owns and manages guidance or corporate standards related to infrastructure that might be vulnerable to climate change impacts. It may also be important for users of standards to recognise that standards will be updated to incorporate climate change adaptation approaches, so users need to periodically review the most up-to-date versions of the standards they use and understand if any changes are significant for them.

Regarding climate change in the UK, the following key resources should be utilised:

- The UK Climate Change Risk Assessment (2022). This outlines the UK government and devolved administrations' position on the key climate change risks and opportunities that the UK faces today
- The Climate Change Committee's (CCC) Independent Assessment of UK Climate Risk (2021) sets out the priority risks and opportunities for the UK
- The UK Climate Projections (UKCP18) provide a set of tools and data which cover all climate risks and impacts and provide authoritative advice on what to prepare for. A BBC and Met Office tool provides a postcode lookup to access UKCP18 projections for local places
- The Environment Agency's climate impacts tool

In addition, for operators of COMAH establishments, the Major Accidents Hazards Bureau (MAHB) publication will be useful for understanding regulatory expectations and information requirements associated with control of Natech.

As an example, in 2021, the CDOIF Adaptation Group industry partners responded to a questionnaire aimed at identifying a baseline assessment of natural hazard risks. As shown in the chart below, the leading risk from extreme weather events was flooding. Flooding is a major risk within the UK, and its impacts, frequency and severity are expected to increase. However, it is essential to consider the full range of climate impacts that might be relevant to safety and environmental protection.

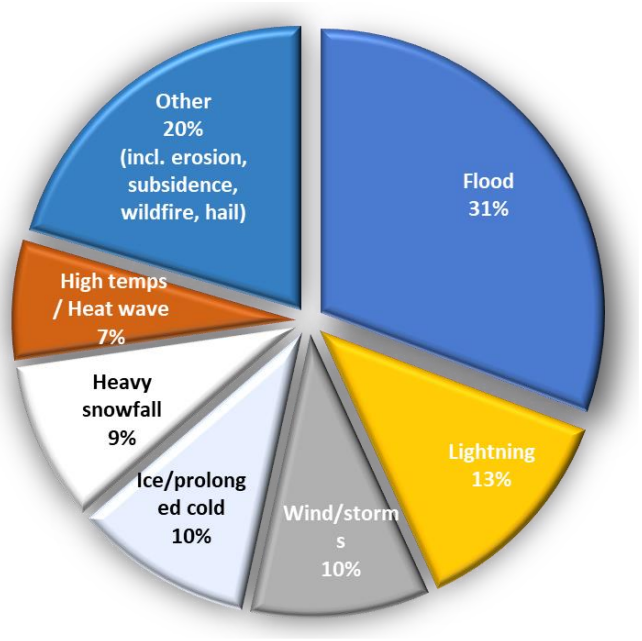


Figure 3 Extreme Weather Threats to GB Sites (survey by CDOIF, 2021)

For each of the different extreme weather and climate impacts, it will be necessary to understand the frequency and severity of these events and the impact climate change may have. This should also include how the natural hazards may impact business either via an initiating event, barrier degrader, or exacerbating event to a major accident hazard or cause other permit non-compliance.

To identify the relevant threats to a business, the following information will provide useful inputs.

6.1.1. Existing site information

Many operators will already hold information relevant to climate impacts in their safety and environmental risk assessments. These assessments will provide a useful starting point for gathering the necessary data for risk screening.

However, climate change frequency and severity may have increased since the data was originally gathered, and therefore all data should be reviewed.

Operators should also adopt a management of (creeping) change philosophy when considering existing climate relevant data which is already held. For further discussion regarding management of change, see PSF Knowledge Exchange – 004.

Relevant data and assessments could therefore include:

- Existing COMAH/EPR/PPC risk assessments, including within permit applications and safety reports
- Existing Climate Change Act assessments and reporting
- Insurance data
- Financial data, including reporting under the Task Force on Climate-Related Financial Disclosures (TCFD) or IFRS

- Existing corporate plant design standards and basis and safety risk assessments, noting this needs to ensure that present day and future threats are assessed, and some threats, e.g. flooding, might be an issue now, where previously it was not considered.

6.1.2. Present day data for Natech and climate impact threats

An understanding of the current Natech risks to the site is required before future risks and their likelihood can be determined. The following table details where information can be obtained for the various Natech and climate impacts. This can be used to help determine which events could put the site at risk.

Table 2: Natech Risk Information Source

Data	Purpose
Met Office Historic Weather Extremes*	Provides data on the national weather extremes. This page is updated monthly to reflect the latest weather across the UK.
Met Office Integrated Data Archive System (MIDAS) Land and Marine Surface Stations Data (1853 – current)	Various historical hourly and daily data resources, including wind, rain, and temperature.
Flood Maps (England) For Planning	Flood maps for planning, identifies the flood zone for a set location, and details whether the flood risk area benefits from flood defences.
Flood Maps (England) For Long Term Flood Risk	Flood maps for long-term risk provide the flood risk from the sea/rivers, surface water and reservoirs.
Flood Maps (Wales)	Flood map for rivers, the sea, reservoirs, surface water and small watercourses. Also provides information on flood defences, flood storage areas and recorded flood defences.
Flood Maps (Scotland)	Flood extent maps for river, coastal and surface water, with information on flood defences and areas naturally susceptible to coastal erosion. Potential flood depth and velocity can also be viewed.
DfI Rivers (Northern Ireland) Flood maps for planning	Flood maps for planning, identifies the flood zone for a set location, and details whether the flood risk area benefits from flood defences.
DfI Rivers (Northern Ireland) Flood maps for long-term flood risk	Flood maps for long-term risk provide the flood risk from the sea/rivers, surface water and reservoirs.
Earthquakes and Landslides (BGS GeoIndex Onshore)	Provides various data, including seismic hazard maps, historical earthquakes, and landslides data.
FM Global Hazard Maps (Flood, earthquake and freeze)	Flood, earthquake and freeze map, risk of hail is also provided for the US only.
FM Global NatHaz Tool Box	Provides details on the different types of natural hazards, including checklists, emergency response plan advice and information on understanding the hazard itself.
EDF, Mott MacDonald and the Met Office - Characterisation of Natural Hazards	Guidance on characterising natural hazards, alongside some case studies. This includes discussion of and signposting to historic and future data. Note, some weather record values have already been exceeded in the few years since publication.

* Note, caution is required when considering time periods of data, for example the highest 24-hour rainfall totals for a rainfall day (0900-0900 UTC) in England was 279mm (Dorset, 1955). For infrastructure assessment it would be more appropriate to consider the highest 24-hour total for any rolling 24-hour period, which for England was (1800 - 1800 UTC) - 341.4 mm (Cumbria, 2015).

6.1.3. Present day understanding of receptor sensitivities

It is recognised that global warming is impacting all aspects of the environment. Consequently, both human and environmental receptors are potentially becoming more

vulnerable to impacts from industrial and human activities, resulting in increased consequences. The CDOIF Guidance – Environmental Risk Tolerability for COMAH Establishments defines "consequence" as a combination of extent, severity and duration of harm to the receptor. Any assessment, or re-appraisal, of risks needs to recognise the potential changes in the receptor vulnerability and sensitivity. See CDOIF Environmental Risk Tolerability for COMAH Establishments to see examples of where to find receptor information. Examples of thinking required include:

- Has the conservation status changed since the last assessment?
    - and is this due to climate impacts which might cause the receptor status to degrade further?
- Has the conservation designation changed since the previous assessment?
    - and could a newly designated receptor be more at risk due to climate impacts?
- Could an exceedance of a water discharge temperature limit coincide with a time when river temperature is at its highest?
    - and could the aquatic environment already be heat stressed and more susceptible to harm?
- Could a release of substance to the environment coincide with a flooding event extend the area affected or reach previously excluded receptors increasing severity of harm?

Similar considerations also needed to be given to the vulnerability of local human populations. For example, a release of dangerous gas at the same time the area is experiencing a poor air quality episode would mean vulnerable populations already susceptible to harm are at increased risk.

6.1.4. Future data

Adaptation risk assessment projects should be used to help determine the potential climate change risks to an operator's site. The UK Climate Projections 2018 (UKCP18), or their successor, are to be used. For the initial screening process, the data relevant to a 4°C rise trajectory by 2100 should be used as a worst-case warming scenario. Information for this scenario is associated with RCP8.5, RCP6.0 (90th centile) or SSP5-8.5 and is sometimes referred to as a "business as usual" scenario. The worst-case scenario should be complemented with a 2°C scenario.

The Met Office maintains the current knowledge on climate predictions. UK climate projects can be viewed using the UK Climate Projection User Interface, which provides various projections at varying scales and for different scenarios. Updates and news regarding the UKCP probabilistic projections are also provided by the Met Office, as is e-learning, which can be accessed by contacting them.

Headline findings for the UKCP18 are provided in a short report from the Met Office. At the time of writing this document, the August 2022 report was the latest version. More recent versions may be available following publication of this document. Data for the 2°C and 4°C scenarios can also be sourced from the UKCP18 Derived Projections.

Additional support is provided by the BBC in the form of a climate change visualisation tool. This provides a range of data regarding the hottest day, number of days in the summer expected to exceed 25°C, average daytime summer temperatures, number of rainy days and the wettest day and winter rainfall outlook.

Similarly, the Environment Agency has published a Climate Impacts Tool, which can be used for screening climate change impacts consistent with a 4°C rise. This helps staff to understand climate risks in the Environment Agency's work and decisions.

For higher risk and higher vulnerability installations, it may be considered good practice to undertake a more detailed assessment across a longer timescale with other projections, such as H++ or High Impact Scenarios (see Use of UK Climate Projections 2018 (UKCP18)).

Additional climate data and tools are available from the UK Climate resilience programme which includes Geographical Information Systems (GIS) style Climate Risk Indicators.

(a) EPR management systems (England)

The guidance and information provided for environmental permitting can be used to support an adaptation risk assessment. This guidance can be accessed from the following resources:

- England
    - Environment Agency – risk assessment and adaptation planning in your management system*
    - Environment Agency – Environmental Permits; Environmental Management Systems, and in particular the "A Changing Climate" * section
    - Environment Agency - Adapting to climate change: industry sector examples for your risk assessment
    - Environment Agency – Climate Impact Tools
    - Environment Agency – River Basin Climate Data:
        - Catchment Data Explorer
        - River Basin Climate Data*

**Note: Environment Agency guidance was revised in April 2023 and sets an expectation for operators under EPR to carry out climate change adaptation risk assessments by April 2024.*

Note: The Welsh Government also advises permit holders to link to these pages.

(b) EPR/PPC management systems (Wales and Scotland)

Natural Resources Wales (NRW) and the Scottish Environment Protection Agency (SEPA) are developing similar requirements for adaptation to be embedded in management systems for EPR/PPC permitted sites.
Further details will be added to a later version of this guideline.

- Wales
    - NRW – River Basin Climate Data

- Scotland

- SEPA – River Basin Climate Data

(c) Major accident hazards

Major accident sites should understand how natural hazards may impact upon their site. This will help when identifying reasonable and practicable measures to help reduce the likelihood, severity and/or risk from such events.

To do this, a review of historic information to inform the credibility of Natechs and their potential impacts should be carried out. This should include:

1. Possible barrier degradation and failure modes
2. The potential extent of such events
3. The severity of impact to their business

Appendix 2: Case Studies and Appendix 3: Illustrations of linkage between extreme weather / climate change impacts and threats to barriers / process safety provide some examples of this.

The following resources may also provide useful information:

- Major Accident Hazard Board, Lessons Learned Bulletin No.6 – Natech accidents, 2014
- UNEP (2023) Climate risks in the industrials sector (Part 2; Physical risks)
- European Commission; eMars and eNatech
- French Ministry for the Environment: ARIA Database and in particular the content on Natech and Climate Risk
- The Central Reporting and Evaluation Office for Major Accidents and Incidents in Process Engineering Facilities - ZEMA
- Safety and Chemicals Agency (tukes) – Damage and accident register caution
- Institution of Chemical Engineers – Loss Prevention Bulletin
  - Issue 277 provides a special Natech issue
- US Chemical Safety Board (US CSB)
  - Extreme Weather Safety Message
  - Investigations; notable investigations include:
    - The Arkema incident following Hurricane Harvey
    - Special safety bulleting following Hurricane Katrina
    - The Bio Lab release following Hurricane Laura*
- Centre for Chemical Process Safety (CCPS) – Process Safety Incident Database (PSID)
- Shippai Failure Knowledge Database: Natural Disasters
- Office for Nuclear Regulation. NS-TAST-GD-013 – External Hazards
- Environmental Permits Industry Sector examples**
- UK Research and Innovation Climate Change Impact LWEC Report Cards

* HazardEx article provides the initial information about the release: Hurricane Laura causes fire to break out at Louisiana Plant.

** It is often beneficial to understand risks across sectors as lessons learnt are often transferable even when a threat has not been highlighted for the specific sector under consideration.

Box 6: Lessons Learned from Previous Incidents

Flood risk – lessons learned from previous incidents

In the UK, flooding is consistently identified as the highest risk threat to industry. Globally, flooding has caused accidents with catastrophic consequences. In one accident, over 400 people died when flammable liquids were carried on flood waters, burning through a town. In several accidents, loss of containment and subsequent contaminated flood waters have caused tens of millions of pounds of environmental harm. On numerous occasions, flooding has caused significant operational interruptions and financial loss. There is much to consider both during and after a flood.

Flood waters are dangerous, so even without a loss of containment there is a risk to safety. Manhole covers can be lifted off drains, which can then be covered by flood waters making this hazardous (as a person walking through flood waters cannot see the missing cover through the murky flood waters). Vehicles can float in floodwater beyond a certain depth, which decreases as the velocity of the floodwaters increases. This includes fire engines which may increase the complication of emergency response (fire engines stop and/or float in approximately 1m of flood waters). Flood waters may mean that booms may not be able to be deployed to control the spread of hazardous materials and the flood water impact on drainage systems may fundamentally change dispersion/pathway assessments.

Recovery after a flood should also be respected as a potential high hazard activity, complicated by the nature of the flood itself. In one accident there were multiple fatalities, caused by an explosion and fire during clean-up following flooding of a firework storage warehouse. Also, the debris which is generated as part of a flood can make the clean-up more hazardous and dangerous – both flood waters and debris can become contaminated (with oils for example) and require management as hazardous waste.

All the above and more needs to be included in the development of business flood risk assessments and flood response plans.

For further information regarding the case study see Appendix 2. Further details regarding flooding can also be viewed in the Chemical and Downstream Oil Industries Forum, Preparing for a Flood: Guidance and Best Practice.

6.2. Identify Accident Scenarios and Potential Non-Compliance Matters

Once all the relevant screening data has been collected and collated, the next step is to outline the high level screening of accident risks to identify potential major accident and non-compliance scenarios to be carried forward into risk assessment (Sections 7 and 8).

Credible major accidents and non-compliance matters should reflect:

- Present day Natech threats and climate impacts
- Future Natech threats that are possible under a 4°C scenario

6.2.1. COMAH establishments

Good practice for an operator of a site that falls under COMAH Regulations would be to identify and describe a representative weather/climate change Natech scenario associated with a 4°C rise. The approach used in environmental permitting may be useful (see below), but a COMAH operator should also develop an understanding of:

- How extreme weather initiates or exacerbates Major Accidents (MA).
- Whether other climate change impacts could initiate additional MA or exacerbate other MA scenarios. For instance, rising sea level, increased vulnerability of receptors

or changes in land stability.

- Through climate change projections, how climate impacts may alter or increase the risk at the establishment over the proposed installation lifecycle.
- The processes that can be made safe and those that cannot be made safe as a process plant that can be safely shut down upon a severe weather event being forecast will have a different adaptation plan to a plant that cannot be shut down.

A Major Accident scenario that is assessed as not credible today, may become credible in the future. It should be noted that, for establishments of limited lifetime, e.g., less than 5 years, closure of the establishment can be an acceptable risk reduction measure. The detailed risk assessment for those sites can be limited to present day risks only. However, it is necessary to gain an understanding of how climate impacts have changed since the establishment was designed to the present day, and whether the present-day risk is ALARP.

6.2.2. Environmental permitting

Site operators with an environmental permit should identify and describe representative climate change impacts relevant to permit compliance, including credible accidents, associated with a 4°C rise trajectory by 2100. Operations should remain resilient at all stages along the projection of a 2°C rise by 2050. Guidance on how to do this is currently being developed (by the Environment Agency, NRW and SEPA). This builds on the Environment Agency's 2022 update to EMS guidance to better reflect risk management practices for a changing climate and includes Climate change: risk assessment and adaptation planning in your management system - GOV.UK (www.gov.uk).

6.2.3. Screening outcomes

Once the risks have been identified, either from a COMAH perspective, an environmental permitting perspective, or both, the risk screening stage should be undertaken.

The purpose of the risk screening stage is to identify any credible Natech events at the site. The screening stage should include the following information (as applicable):

- Accident scenarios (including major accident scenarios for COMAH)
- Other potential environmental permit non-compliance events
- If in scope, other business risks

All associated impacts to the business with a 4°C rise trajectory by 2100.

It is important to recognise at this stage that this does not mean immediate implementation of all measures to control those risks. The following sections explain how assessment and adaptation planning should be implemented. This will help to better understand the risks, identify measures to be taken, and when they need to be implemented.

7. Risk Assessment – Part A

This section of the guidance focuses on the analysis and evaluation of credible major accident hazard Natech scenarios against tolerability and ALARP principles. For impacts identified as relevant for a 4°C rise, it guides how to carry out more specific risk assessment for various scenarios (including 2°C by 2050 and 4°C by 2100 scenarios).

The risk assessment builds on the screening work, which was based on a 4°C scenario. The aim of this is to provide sufficient detail to enable a business to plan and manage the risks associated with a 2°C rise by 2050, without creating obstacles for future adaptation should warming increase beyond this 2°C rise. This avoids lock-in. Allowing businesses to identify appropriate times to develop measures to manage their adaptation response, as well as maintaining compliance and safety risks As Low As Reasonably Practicable (ALARP).

The Joint Research Council Technical Report regarding Natech Risk Management provides further guidance for operators and includes examples of potential damage to equipment.

7.1. Gather Specific Relevant and Detailed Data for Natech

For Natech risks screened, the Natech risk in a present-day context will firstly need to be understood. This should include current weather records to understand the worst-case events that have occurred, but also the extreme weather that could occur in the present, e.g. the 40°C heat experienced in parts of the UK in July 2022. The Met Office provides data on the current UK Climate Extremes. The current risks are important to help establish a baseline of assessment, whether present day risks are ALARP, and will help identify any future creeping change.

In addition to current data, climate change data should also be considered to assess the impacts of the different climate scenarios at the site. A 2°C rise by 2050 and a 4°C rise by 2100 should be considered. Where risks are high, then other climate projections may be used to better understand risks and inform decisions. For example, H++, RCPs 2.6, 4.5, 6.0 and 8.5, SSPs.

The exploration of a range of climate change impact data and its influence on risks to an installation is a vital part of risk assessments to build in resilience options wherever practicable. See guidance and sensitivity analysis and risk trending/risk attribution in Section 8.

Table **2** (Section 6.1.2) and Section 6.1.4 provide sources of information which should be used to determine current and future risk. Key sources include the 2.2 km resolution UKCP18 data, flood map data, and the Met Office [BETA] Climate Data Portal.

7.1.1. COMAH establishments

The COMAH Risk Assessment should include the relevant characteristics of the establishment and its environment. This includes parameters such as meteorological data, flood information, river flow, sea level (where applicable), temperature, fire risk and geological data. In addition, information around topographical data, sites general arrangement, equipment, and design parameters and vulnerabilities, alongside site maps relevant for weather related threats and climate change impacts should also be incorporated into the risk assessment.

From a process safety perspective, much of the toolkit exists and can be achieved by applying those tools with an adaptive management perspective. It is also noted that Natechs will likely already have been considered by many site operators, due to these being risks already faced today. Hazard analysis techniques can be utilised to help determine the risks associated with Natech events, and the future impacts from climate change.

> *"There are hazard analysis techniques that aim to identify and assess risks to safety systems (e.g. temperature sensors, gas sensors, CCTV, permit to work, procedures etc.). One of these techniques is the Emergency System Survivability Study, where the identified hazards and their risks are considered alongside an assessment of how the system will respond to that hazard. It is possible that COMAH establishments consider climate change hazards in these studies. The COMAH risk assessment and ALARP demonstration process should identify them for retrofit if needed to achieve the ALARP or 'all measures necessary' level of safety."* *Garcia et al (2021)*

7.1.2. Using local impacts evidence to identify location specific vulnerabilities

Local evidence of climate change impacts can be valuable in identifying location specific vulnerabilities. The following table details where local information can be sourced. Sources are split out separately for England, Scotland, and Wales.

Table 3 Sources to help identify local specific vulnerabilities

Topic Area	Source	Purpose
England		
Flood Risk and Coastal Change	Strategic Flood Risk Assessments (SFRA) *(Where available, these are often published online by local authorities.)*	SFRA are crucial evidence documents for understanding the impacts of climate change on all sources of flood risk over the anticipated lifetime of development proposed in Local Plans or spatial development strategies.
	Environment Agency's Climate Change Allowances	Inform SFRAs and have been updated to reflect UKCP18. The three main components are peak rainfall intensity, peak river flow and sea level rise. They support understanding of flood risk and inform drainage design, providing a framework for resilience to a 4°C increase by 2100.
	The National Coastal Erosion Risk Map (NCERM)	NCERM shows coastal erosion rates for the short, medium, and long term. These are complemented by Shoreline Management Plans (SMPs), Integrated Coastal Zone Management Plans and Shoreline/Coastal Strategies.
Water Resources and Quality	Water Cycle Studies	Water Cycle Studies and Infrastructure Delivery Plans are important for informing water resources and water quality policies.
	River Basin Management Plans	These provide information on the entire river basin including lakes, rivers, groundwater, estuaries, and coastal waterbodies.
	Water Resources Management Plans (WRMPs)	WRMPs assess pressures on future water supplies. WRMPs are an essential evidence source for ascertaining water availability within the context of climate change
	Water company drainage and wastewater management plans *(Where available, these are often published online by water companies)*	These plans account for climate change, ensuring drainage infrastructure can cope with increased intensity of storms. The Environment Act has made these plans statutory, collaborative and they should integrate into long-term planning documents.
	Integrated water management studies *(Where available, these are often published online by local authorities.)*	Integrated water management studies, which include surface water flood risk, and are particularly relevant in urban growth locations.
	Water Stressed Areas	Environment Agency evidence on Water Stressed Areas can inform need for water efficiency requirements.
Wales		
Flood Risk and Coastal Change	Strategic Flood Risk Assessments (SFRA) *(Where available, these are often published online by local authorities)*	SFRA are crucial evidence documents for understanding the impacts of climate change on all sources of flood risk over the anticipated lifetime of development proposed in DPs.
	Climate change allowances and flood consequence assessments	Determines the climate change allowances to be used in flood consequence assessments. Provides information on topics such as peak river flow allowances, peak rainfall intensity and sea level allowances.

Topic Area	Source	Purpose
	National Coastal Erosion Risk Management (NCERM)	NCERM shows coastal erosion rates for the short, medium, and long term. These are complemented by Shoreline Management Plans
Water Resources and Quality	River Basin Management Plans.	These provide information on the entire river basin, including lakes, rivers, wetlands, groundwater, estuaries, and coastal waterbodies.
	Water Resources Management Plans (WRMPs)	WRMPs assess pressures on future water supplies. WRMPs are an essential evidence source for ascertaining water availability within the context of climate change
	Water company drainage and wastewater management plans *(Where available, these are often published online by water companies)*	These plans account for climate change, ensuring drainage infrastructure can cope with increased intensity of storms.
Scotland		
Flood Risk and Coastal Change	Strategic Flood Risk Assessments (SFRA) *(Where available, these are often published online by local authorities)*	SFRA are crucial evidence documents for understanding the impacts of climate change on all sources of flood risk over the anticipated lifetime of development proposed in DPs.
	Climate change allowances for flood consequence assessments	Determines the climate change allowances to be used in flood consequence assessments. Provides information on topics such as peak river flow allowances, peak rainfall intensity and sea level rise.
	Coastal erosion and flood risk management	Provides information around coastal erosion and flood risk management for Scotland. Including the National Coastal Change Assessments whose results are available in map form from Dynamic Coast.
Water Resources and Quality	River Basin Management Plans.	These provide information on the entire river basin, including rivers and groundwater.
	Water Resources Management Plans (WRMPs)	WRMPs assess pressures on future water supplies. WRMPs are an essential evidence source for ascertaining water availability within the context of climate change.
	Scottish Water drainage and wastewater management plans	These plans account for climate change, ensuring drainage infrastructure can cope with increased intensity of storms.
Northern Ireland		
Flood Risk and Coastal Change	Flood risk assessment - Strategic Planning Policy Statement (SPPS) for Northern Ireland (2015)	2.2.2 The aim of the SPPS in relation to flood risk is to prevent future development that may be at risk from flooding or that may increase the risk of flooding elsewhere. It acknowledges that development can increase the consequences of flooding and identifies the important role of the Local Development Plan in zoning land so as to avoid and reduce the risks of flooding.
	Climate change allowances – Department for Infrastructure (DfI)	Technical Flood Risk Guidance in relation to Allowances for Climate Change in Northern Ireland (DfI Water & Drainage Policy Division (Feb 2019).
	Coastal erosion – Department of Agriculture, Environment and Rural Affairs (DAERA) & DfI	Baseline Study and Gap Analysis of Coastal Erosion Risk Management NI.

Topic Area	Source	Purpose
Water Resources and Quality	Water Cycle Studies and Infrastructure Delivery Plans – Northern Ireland Environment Agency (NIEA)/Northern Ireland Water (NIW)	NIEA regulates NIW discharges to the environment under the Water and Sewage Services (Northern Ireland) Order 2006 and the Water (Northern Ireland) Order 1999, and the Pollution Prevention and Control (Industrial Emissions) Regulations (Northern Ireland) 2013.
	River Basin Management Plans - DAERA/NIEA	The Water (Amendment) (Northern Ireland) (EU Exit) Regulations 2019.
	Water Resource Management Plans – NI Water	Water Resource and Supply Resilience Plan.
	Water company drainage and wastewater management plans - DfI	Living With Water Programme.
	Integrated water management studies – NI Water	Annual Integrated Report and Accounts.
	Water Stressed Areas – NI Water	Water Resource and Supply Resilience Plan.

Natech MAH Risk Analysis

The data derived from following the advice in the previous sections may be used to conduct a risk assessment for the site. A baseline assessment, based on current risks should be conducted as a basis for the climate change assessment. This would also form the basis of future assessments and help show the risk profile changing over time, as climate change impacts may occur as a creeping change. This will help business to determine when to implement recommendations identified in the assessment. Some actions may not be required now (e.g. due to no current risk of flooding) but may be required in the years to come (e.g. due to projections that the site could be significantly flooded in the future due to identified scenarios occurring).

The baseline risk assessment should link the vulnerability of equipment and procedures to extreme weather threats. Special attention should be paid to the original design criteria, to determine if equipment remains within the safe operating envelope. This is to assess whether there is an increasing risk of failure leading to increasing major accident hazard risk. Consideration should also be given to whether the barriers in place to prevent, control or mitigate a major accident hazard would be compromised in the event of a natural hazard event. Loss of utilities is a frequent outcome of a lot of the different natural hazard events and should also be assessed in the baseline assessment.

The assessment should also consider the potential impacts of offsite events in the surrounding area that may affect the site. For example, where a site is not predicted to flood, but the area surrounding the site is, considerations should be given to the impact this may have on the safe operability of the site. Impacts such as loss of utilities and site access and egress are important to establish so that appropriate plans can be made. It should be noted that emergency services may be busy dealing with the natural hazard event, which may impact their ability to respond if there is an incident on the site.

From the baseline risk assessment, the risk from continuing climate change can be assessed providing an understanding of the potential impacts from future risks. This risk assessment

should focus on the predicted risks from climate change, and not the residual risks from any policies and actions that may be implemented to reduce the consequences from climate change. Note, although it is expected for climate change to result in an increase in extreme weather events, gradual changes in climate (e.g. average temperatures) may also have an impact on site operations. Safeguards should be explored where necessary.

The risk assessment should be proportionate to the expected establishment life. For instance, if it is known the establishment is due to be mothballed in the next 5 years, the operator can choose to only consider present day threats and would not need to assess future changes. For those establishments which will foreseeably be operating beyond 2035, the following cases should be considered as a minimum:

- Present day
- 2°C rise by 2050 scenario
- 4°C rise by 2100 scenario

Depending on the sensitivity of the site to climate change, it may be appropriate to look at different climate change scenarios. This should be considered for sites with higher risk impacts or vulnerability, or those sites which have longer lifetimes and are expected to operate beyond 2100. This can include a wider set of RCP data, or including H++ scenarios.

BS EN ISO 14091:2021: Adaptation to climate change – Guidelines on vulnerability, impacts and risk assessments, provides further information on climate change risk assessments.

7.2. Natech MAH Risk Evaluation

The risk from the Natech events should be reviewed, and where required included in the MAH risk evaluation for the site. The risk from Natech events should feed into assessment of both the risk to people and the environment, and the tolerability of both needs to be determined.

The inclusion into the MAH assessments should be proportional to the risk and may include a qualitative or quantitative approach. Where risk may result in a site entering the 'Intolerable region' or close to the 'Intolerable region', a more bespoke risk assessment may be required; an example of a bespoke technical risk assessment (RA) is provided in the Natech Risk Management report by the JRC, and should be discussed with regulators.

Where semi-quantified approaches are deemed applicable (e.g. Layers Of Protection Analysis), the event severity and probability should be used. For flooding, the return period may be used as the starting probability, with sensitivity cases being utilised for increasing return periods as climate change impacts take effect. For example, if the site falls in the 1% flood risk contour, then the initial risk would use this as the starting value. This would then be fed into the process safety approach with the relative modifiers applied. To consider climate change, this 1% may then be altered to 10% (for example), to account for an increase in the frequency of flooding and determine the sensitivity of the risk to those changes.

8. Risk Assessment – Part B

8.1. Sensitivity Analysis

A sensitivity analysis of the conservatism of the assessment may be required, especially where climate change influenced risks are high and may not remain tolerable in the future. There is a level of uncertainty around the impacts climate change may have, due to unknown level of warming which may occur, and the successfulness of any climate change mitigation measures incorporated by governments and countries.

A sensitivity analysis may therefore be required to determine the potential impact of more severe climate change issues, e.g. expanding assessments to include a wider set of RCP data, or including H++ scenarios.

It may also be the case that the site is not expected to remain operational until 2100, but rather be decommissioned in the next 10-20 years. Here the sensitivity analysis may be based solely on the 2050 cases, and a mixture of worst-case scenarios, rather than assessing the risk of climate change to the end of the century.

Any sensitivity analysis should be proportionate to the risks and the operation of the site.

8.2. Risk Trending and Attribution

To determine the change in risk at a site, where possible, the risk from Natech events should be compared to the risk that was determined in previous assessments. This will help to determine where the risk from an event has changed, in comparison to historic data. In addition, where possible, risks should be compared to the major accident hazards at the site, both now and in future.

The following questions should be considered when considering the risk from Natech events:

- Have risks increased significantly from when the establishment was designed and built to the present day?
- Are today's risks tolerable (ALARP)?
- Are there dominant risks from specific weather events, or plant areas where risk is changing more rapidly?
- Will risks remain ALARP in the near future – at least to the time of the next risk assessment review?
- Will risks remain ALARP over the establishment lifetime?
- Considering equipment design specifications and envelope of safety:
    - What is the current understanding of the predicted rate of change of risk over time?
    - Will risks remain tolerable in the future; or will any equipment design envelopes be exceeded, increasing risk of failures and thus increasing MAH risk to become intolerable?

The rate of change in the risk profile needs to be understood. This will aid in identifying potential future risk reduction measures and their lead times. For example, if the site is not at risk of flooding until 2050, installing flood specific risk reduction measures may not be practical today, but may be practical to install in 15/20 years' time. This also reduces the

potential for sites to install measures, which when required, do not meet minimum standards based on updates to flood technology. All measures should be adapted as required based on changes to the risk.

9. Identify Control Measures

9.1. ALARP Demonstration

The ALARP principles should be followed when conducting the ALARP demonstration for Natech events, i.e. inherent safety, prevent, control and then mitigate. The decision-making process should follow the principles outlined in R2P2 for risk to people, and All Measures Necessary for risk to the environment.

9.2. Identify and Appraise Further Risk Reduction Measures

If present day risk is not ALARP, then there is a need to identify and appraise further risk reduction measures. This is to find those control measures which are reasonably practicable and may include any necessary further data gathering and management systems revisions.

Future risks may not remain ALARP due to changing weather threats and climate impacts. If this is found to be the case then there is a need to identify, and implement at an appropriate time, management or other measures to ensure risk will remain ALARP until the next review point and over installation lifetime.

General principles for consideration of further risk reduction measures:

- Use safety and pollution control hierarchies to guide measures
- Ensure new designs incorporate flexibility to allow further risk reduction to be implemented in the future – e.g. when planning measures associated with 2°C by 2050, ensure actions or decisions do not create obstacles for future adaptation that may increase risk later (known as "lock-in").

It is important for users of standards to recognise that standards will likely be updated to incorporate climate change adaptation approaches, so users need to periodically review the most up-to-date versions of the standards they use and understand if any changes are significant for them. The CEN/CENELEC (2022) guidance on inclusion of adaptation into infrastructure standards can be used to support review. Where climate change impacts could be affecting their resilience and potentially increasing risk to people and the environment regular revision of infrastructure design codes and standards should be conducted. This may also include an operator's own design codes.

When reviewing and analysing possible risk reduction measures, the following information should be considered:

- Environment Agency - Adapting to climate change: industry sector examples for your risk assessment

- The UK Adaptation Inventory - documents adaptation on the ground, presenting a selection of sectoral adaptation options, based on national reporting to government by public and private sector organisations and a systematic review of peer reviewed literature
- Lessons learned from historic accidents (see Appendix 2 and 3)

Further resources which can be used to identify further potential risk reduction measures associated with specific natural hazards include (but are not limited to):

- CDOIF Flood preparedness guidance
- CIA Winterisation guidance
- JRC storms guidance
- MAHB Natech risk management

10. Adaptation Plan

10.1. Plan and Implement Improvements

Once appropriate risk reduction measures have been identified then planning for deployment of those measures needs to take place to ensure Major Accident Hazard risk is ALARP. This should be followed by cyclic reviews of implementation progress (monitoring progress with the improvement plan). This is to ensure that the measures are deployed at the right time and remain fit for purpose under creeping change conditions.

- Consideration may be given to an adaptation pathways approach as described in BS 8631.
- Performance indicators and climate impact indicators and identification of key points/thresholds when substantial decisions need to be made with consequences or lead-in times >5 years (e.g. infrastructure, nature based solutions, supply chain contracts) may help delivery of timely management decisions.

Consideration of a cost benefit assessment may be useful measure to help assess the applicability cost and benefit of a potential measure. This may be achieved by assessing potential improvement measures using Section 5 of Chemical and Downstream Oil Industries Forum (CDOIF) Environmental Risk Tolerability for COMAH Establishments.

Plan to audit, review and revise the management system. Test emergency control measures through exercises - ensure the management system remains adequate.

- Plan to make any necessary change to ensure Natech and adaptation are embedded within all aspects of the management system.

Box 7: Adaptation Pathways Approach

Adaptation Pathways Approach – Case Study Thames Estuary 2100

See https://www.gov.uk/government/publications/thames-estuary-2100-te2100

The Thames Estuary 2100 Plan is internationally recognised as a leading example of climate change adaptation. TE2100 is also an example of adaptation in the context of wider strategies (e.g. Environmental Improvement Plan to protect and enhance the environment and creating wider social and economic benefits/growth). TE2100 was designed to be adaptable to different rates of sea level rise and changes affecting the estuary.

"We therefore need to monitor how the estuary is changing. We review the Plan regularly to ensure it still sets out the best approach to manage tidal flood risk. We monitor 10 indicators of change and use these to complete a monitoring review every 5 years. We fully review and update the Plan every 10 years."

An adaptation pathway is a decision-making approach that allows decision-makers to take actions under uncertainty. It enables users to identify what actions can be taken now and in the future. To support this approach see British Standard BS 8631:2021 "Adaptation to climate change - Using adaptation pathways for decision making". This guide, helps organisations create long-term plans and make decisions within the uncertainty and risks of a changing climate.

The following Environment Agency website provides a brief explanation of adaptation pathways approach - *https://engageenvironmentagency.uk.engagementhq.com/adaptation-pathway-programme*

10.2. Review and Revise Management System

To ensure risk control remains adequate for weather Natech, revision cycles are needed to ensure continuous improvement. Risk Assessment review periodicity and monitoring cycles need to be established to review and appraise safety critical equipment and its vulnerabilities. Management of change procedures, covering creeping changes to external threats, ensure Natech risks link to review and revisions of emergency response procedures and competency requirements.

11. Monitor, Record and Review

11.1. Monitor, Record and Review the Adaptation Plan

This section describes the responsibilities for those with management responsibility for owning, implementation and monitoring climate change risk and adaptation measures. This is to ensure action and continual improvement occur to the proposed timescale.

11.2. Monitor, Record and Review Relevant Weather Data

Recording of relevant information detailing climate linked events will help assess the likelihood and severity of potential future events. Information like:

- Near misses/incidents/data, both at the establishment and globally as relevant to the establishment, accident reports and weather data.

Operators may also wish to keep a register of impacts (however small) from severe weather or climate events to feed into the picture about how risks might manifest. There is a tool that exists for local authorities to do this which captures current impacts: Severe Weather Impacts Monitoring System (SWIMS) | Local Government Association.

11.3. Identification of Information to Challenge Existing Risk Assessment

- Weather events/changes/MA knowledge
- Risk assessment data/assumptions
- Consider any that are significant since they could trigger early review/revision (Safety Report and Risk Assessments)

11.4. Senior Management Oversight

To ensure ownership and oversight, inclusion of the organisation's senior leadership team will help to ensure Natech and adaptation are embedded in process safety leadership. This will help expedite decisions regarding management of major accident risks from climate change and improve safety at the establishment.

12. Additional Information

12.1. Abbreviations

Abbreviation	Description
ALARP	As Low As Reasonably Practicable
CaDD	Climate Capacity Diagnosis and Development
CCA	Climate Change Agreements
CCPS	Centre for Chemical Process Safety
CCRA	Climate Change Risk Assessment
CDOIF	The Chemical and Downstream Oil Industries Forum
CHP	Combined heat and power
CIA	Chemical Industries Association
COMAH	Control of Major Accident Hazards
CSF	COMAH Strategic Forum
DAERA	Department of Agriculture, Environment and Rural Affairs
DfI	Department for Infrastructure (Northern Ireland)
DP	Development Plan
EPR/PPC	Environmental Permitting Regulations/Pollution prevention and control
ESCG	Environmental, Social, and Corporate Governance
IChemE	Institution Of Chemical Engineers
IEMA	Institute of Environmental Management and Assessment
IFRS	International Financial Reporting Standards Foundation
IOAF	Industrial Operators Adaptation Forum
MA	Major accident
MAH	Major accident hazard
MAHB	Major Accident Hazards Bureau
MS	Management Systems
NAO	National Audit Office
NAP	National Adaptation Programme
Natech	Natural Hazard Triggered Technological Accidents
NCERM	The National Coastal Erosion Risk Map
NCERM	National Coastal Erosion Risk Management
NIEA	Northern Ireland Environment Agency
NIW	Northern Ireland Water
NRW	Natural Resources Wales
OECD	Organisation for Economic Co-operation and Development
PSF	Process Safety Forum
PSID	Process Safety Incident Database
RA	Risk assessment
RCPs	Representative Concentration Pathways

SDR	Sustainability Disclosure Requirements
SEPA	Scottish Environment Protection Agency
SFRA	Strategic Flood Risk Assessment
SMP	Shoreline Management Plan
SMS	Safety Management System
SPPS	Strategic Planning Policy Statement
SSP	Shared Socioeconomic Pathway
SWIMS	Severe Weather Impacts Monitoring System
TCFD	Task Force on Climate-Related Financial Disclosures
TfL	Transport for London
USCSB	US Chemical Safety Board
WRMP	Water Resources Management Plan
WWTP	Waste water treatment plant

12.2. References

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12.3. Acknowledgements

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12.4. Revision History

Rev.	Section	Description	Date	Changed by
Drafts	All	Pre-publication drafts	2020 - 2023	CDOIF working group*
1.0	All	First issue of guideline	January 2024	CDOIF working group*

* Scripts held by Mike Nicholas (EA) and Simon Wood (Fuels Industry UK) who co-chaired this work

APPENDIX 1 – Examples/Case studies of good and best practice

The slide pack accompanying this guidance provides links to a range of case studies and best practice guidance.

DEFRA fourth round Adaptation Reporting Power guidance - [Unpublished guidance available on request from CDOIF members] – includes case studies, summarises good practice, and signposts good adaptation and reporting practice. The reports provided under the Adaptation Reporting Power summarise action being taken across many sectors of infrastructure – the built and natural environment – and those who finance and regulate.

- Third round reports
- Climate Change Committee analysis "Understanding climate risks to UK infrastructure: Evaluation of the third round of the Adaptation Reporting Power"

See also this guidance:

- Box 1 - UK Transport sector
- Box 2 - Adaptation Standards
- Box 3 - Adaptive Capacity Framework
- Box 7 - Adaptation Pathways Approach – Case Study Thames Estuary 2100

APPENDIX 2 – Case studies – incidents

In addition to the case studies tabled below, the following resources may also provide useful information for operators identifying historic incidents/case studies and lessons to learn, relevant to their activities:

- Major Accident Hazard Bureau, Lessons Learned Bulletin No.6 – Natech accidents, 2014
- European Commission; eMars and eNaTech databases
- French Ministry for the Environment: ARIA Database and in particular the content on NaTech and Climate Risk
- The Central Reporting and Evaluation Office for Major Accidents and Incidents in Process Engineering Facilities - ZEMA
- Safety and Chemicals Agency (tukes) – Damage and accident register caution
- Institution of Chemical Engineers – Loss Prevention Bulletin
  - Issue 277 provides a special Natech issue
- US Chemical Safety Board
  - Extreme Weather Safety Message
  - Investigations; notable investigations include:
    - The Arkema incident following Hurricane Harvey
    - Special safety bulleting following Hurricane Katrina
    - The Bio Lab release following Hurricane Laura*
- Centre for Chemical Process Safety (CCPS) – Process Safety Incident Database (PSID)
- Shippai Failure Knowledge Database: Natural Disasters
- Office for Nuclear Regulation. NS-TAST-GD-013 – External Hazards
- Environmental Permits Industry Sector examples**
- UK Research and Innovation Climate Change Impact LWEC Report Cards

Threat	International Examples/ Lessons	UK Examples
Flood – Coastal Acute surge/ Tsunami See also sea level rise	Fukushima Repsol (Peru 2022) https://www.theguardian.com/world/2022/jan/19/peru-spain-repsol-disastrous-oil-spill (N.B. these events were triggered by a geological hazard, though would increase in impact with increasing sea level rise and some lessons/safety measures are relevant to extreme weather induced tidal surge events)	East Coast surges (2013) UK weather forecast East coast told to prepare for tidal surge - YouTube Incl. port of Immingham https://youtu.be/k37jOVcHDtc and Lessons learned from the coastal flooding of process industry sites on Teesside and Humberside by the storm surge on 5-6 December 2013 (icheme.org) PSF Safety Alert 012 (2017 sea wall collapse) http://www.p-s-f2.org.uk/wp-content/uploads/012-PSF-Safety-Alert-Coastal-flood-Final-v7.pdf TE2100 – adaptive planning strategy https://www.gov.uk/government/publications/thames-estuary-2100-te2100 https://en.wikipedia.org/wiki/Tsunamis_affecting_the_British_Isles

Flood – Fluvial/river	Spolona (Czech) Murphy Oil (Katrina - 2005) Saga steelworks oil spill (Japan, 2019) https://www.sciencedirect.com/science/article/abs/pii/S2212420921005951#:~:text=The%20oil%20spill%20in%20Omachi,of%20the%20whole%20Saga%20plain.	Paper mills (Environment Agency) CSG Sandhurst (from LPB special edition see also storm/lightning) BP Oil Northampton (1998) Storm Eva "Boxing Day floods" (2016) Yorkshire examples (Environment Agency) Carlisle flooding
Flood – Ground-water	US petrol station tank buoyancy incidents The pressure from groundwater can cause interesting phenomena https://www.bbc.co.uk/news/av/world-europe-61273431	UST collapse (Environment Agency) GT diesel tank bund float (Environment Agency) Geohazard note - Groundwater flooding - British Geological Survey (bgs.ac.uk)
Flood – Pluvial/ Surface/ Rainfall	Dronka (1994), https://wmo.asu.edu/content/world-highest-mortality-lightning , https://www.youtube.com/watch?v=X6fWi8vCVYk Arkema https://www.csb.gov/arkema-inc-chemical-plant-fire-/ and Caught in the Storm: Extreme Weather Hazards - YouTube and https://youtu.be/FIXL7igYYBc Argentina refinery (see Marsh) Harbin China Fireworks (2010) Various tailings dams (e.g. Baia Mare) https://www.aria.developpement-durable.gouv.fr/accident/51523/ (French AD/ - waste management loss of control)	Sunken floating roof (SEPA) Canvey Island Flooding 2014 (Flash Flooding) https://www.canveyisland.org/history-2/21st-century-canvey/the_tens/canvey_today_2014/heavy_rainfall_-_flash_flooding/canvey_island_floods_2014 https://www.gov.uk/government/publications/canvey-island-flood-investigation-peer-review
Flood - reservoir	Various international examples of dam failures with loss of life/severe environmental damage	Whaley Bridge (near miss)
Wildfire	Australia 2019/20 US/Canada events 2021, incl. impact on power systems	Met Office fire risk mapping https://www.metoffice.gov.uk/public/weather/fire-severity-index/#?tab=map&fcTime=1653390000&zoom=5&lon=-4.00&lat=55.74 Moor fire > power loss and site power interruption (Environment Agency) And in winter… https://www.bbc.co.uk/news/uk-england-devon-56034312

		UK – Summer 2022 (including impact on wider infrastructure, impact on staff remotely working)
High temps	https://www.aria.developpement-durable.gouv.fr/wp-content/uploads/2020/06/Flash-ARIA-fortes-chaleurs_EN-VF.pdf Evangelos Florakis Naval Base explosion (2011) https://www.aria.developpement-durable.gouv.fr/accident/49833 (French AD / - equipment/sensor failure) Landfill fires - https://abcnews.go.com/International/wireStory/indian-capital-engulfed-smoke-landfill-catches-fire-84339433	UK Summer 2018 heat – https://www.bbc.co.uk/news/uk-45399134 and Parham fire https://www.bbc.co.uk/news/uk-england-suffolk-53781708 Waste fires (fuel, oily rags etc – FPPs - https://environmentagency.blog.gov.uk/2018/08/31/whats-the-burning-issue/) Landfill fires… Industrial Cooling systems https://committees.parliament.uk/writtenevidence/107284/html/ Summer 2022 – IBCs etc fire, power network & data centre outages, refrigerant drum explosion, burst pipes, warped rails, failed instruments etc.
Prolonged dry weather		RPEG 2018 (summer environment incidents – drought stress of receptors)
Increased sunlight/ high temps		In last year's extreme heat one site had an issue with plastic compressed air hoses that had been exposed to long periods of direct sunlight, perishing and then bursting. E.g. an air hose used to activate an auxiliary fuel pump failed, causing the plant to trip. The site has now replaced all its plastic compressed air lines with either metal piping or plastic hoses with a higher UV resistance rating.
Snow		Warehouse roof collapses (SEPA)
Ice/cold	Valero Refinery Sunray Deadleg incident (2007) Texas (2021) https://www.aria.developpement-durable.gouv.fr/accident/49169/ (French AD – freezine equipment/utilities) Cozzani et al (2023) "Natech accidents triggered by cold waves" Process Safety and Environmental Protection 173 (2023) 106–119	Sprinkler systems freezing. If cold snaps happen less frequently, then there may be a loss of knowledge amongst staff to know how to react when one does occur.
Wind/ Storms	Understanding Natech risks due to storms, JRC Technical report 2018	Tank Jacking Safety Alert (HSE) Increased tank wind loading (NRW) Jacking of flat bottomed storage tanks (hse.gov.uk)

	Understanding Natech risk due to storms - Publications Office of the EU (europa.eu) Hurricane Dorian – Caribbean Oil spill 4 fatalities after ship damaged buoy and undersea pipe during storm, releasing fuel and causing pool fire (Greece 1998) https://emars.jrc.ec.europa.eu/en/emars/accident/view/295c68e0-53ca-f2fc-0a38-c17153c36d3d	HSE Safety Alert - Preventing catastrophic failure of luffing jib tower cranes in high winds Cement Kiln Chimneys Isle of Grain Power Station Chimney https://www.kentonline.co.uk/medway/news/power-station-offline-indefinitely-after-storm-damage-262849/ Tank roofs lifting (SEPA) Wind loading on thinning column (HSE) Oil leak wind blow (escalation not cause) - Elsmere port
Lightning	EU data – lightning is most common MA initiator across Europe https://www.aria.developpement-durable.gouv.fr/accident/51672/ (French AD – lightning loss of C&I) Dronka (1994) (see also flood) https://wmo.asu.edu/content/world-highest-mortality-lightning Cuba (2022) https://www-firstpost-com.cdn.ampproject.org/c/s/www.firstpost.com/world/cuba-seeks-help-to-contain-fuel-depot-fire-that-has-killed-at-least-one-injured-over-a-hundred-11022631.html/amp	Milford Haven refinery fire. The explosion and fires at the Texaco Refinery, Milford Haven (hse.gov.uk). Milford Haven FCCU flare system - ppt video online download (slideplayer.com) CSG Sandhurst (see also fluvial flooding). Oxfordshire AD plants

Threats exacerbated by extreme weather/Chronic climate impacts

Threat (and weather cause)	International Examples /Lessons	UK Examples
Chronic coastal erosion (Flood/storm/sea level rise)		Anglian coastal erosion (Environment Agency).
Subsidence/landslip (Freeze/thaw, rain/prolonged dry weather/groundwater levels)	Russia - Norilsk Oil spill 2020 https://en.wikipedia.org/wiki/Norilsk_oil_spill Landslide pipeline risk- Kentucky Ethanol train derailment https://railroads.dot.gov/sit	Associated with summer 2018 rainfall events as high temps breaking – Stonehaven derailment https://assets.publishing.service.gov.uk/media/6274fe0e90e0747a49c94ca/R022022_220310_Carmont.pdf

	es/fra.dot.gov/files/2020-08/HQ-2020-1377.pdf	Containment system degradation examples.
River bank erosion (Rain/flood)		Storm Eva "Boxing Day floods" (2016).
Sea level rise (global ice melt/sea warming)		TE2100 – adaptive planning strategy.
Biodiversity threats - Reduced receptor resilience		
Saltwater intrusion/ incursion https://en.wikipedia.org/wiki/Saltwater_intrusion (exacerbated by drought, excessive extraction of groundwater and sea level rise)	Florida https://www.e-education.psu.edu/earth103/node/901 https://www.nationalgeographic.com/science/article/partner-content-worried-about-water-floridan-aquifer	Water Treatment Plants on river estuaries are getting infiltration of seawater into their influent. It is rotting their steel tanks and causing pinholing with loss of integrity on biodigesters etc. So, Combined Heat and Power plants have to shut down. Also, rising groundwater levels, with infiltration into industrial drainage systems can significantly increase the quantity of effluent requiring treatment and can exceed design capacity.

Common interdependencies

Wide area power/ communications loss (Multiple – flood, wind, wildfire)		Common in UK - Associated with many named storms and fire events. UPS alert - https://www.hse.gov.uk/safetybulletins/ups-systems-industrial-maintenance.htm?utm_source=govdelivery&utm_medium=email&utm_campaign=ups-safety-notice&utm_term=body&utm_content=safety-notice-2-mar-22
Unplanned shutdown/startup issues	see https://www.csb.gov/assets/1/6/extreme_weather_-_final_w_links.pdf and https://www.csb.gov/assets/1/17/CSB_Start_Shut_02.pdf?16301	

Further information is presented in the accompanying slide pack (reference).

APPENDIX 3 – Illustrations of linkage between extreme weather/ climate change impacts and threats to barriers/process safety

The following examples illustrate how extreme weather threats may impact on process safety or permit compliance, often causing multiple simultaneous failures which can initiate or exacerbate accidents or other non-compliance events.

- Heavy snowfall
    - Access restrictions hampering process operation/maintenance
    - Weight on structures causing structural collapse/loss of containment
    - Loss of power/utilities/control and communication systems
    - Compromising secondary/tertiary containment and drainage integrity/functionality
    - Flooding impacts following thaw
    - Hampering emergency response due to unavailable resources or access/egress issues

- Ice/prolonged cold
    - Freezing of process pipework causing no/low flow and associated scenarios causing potential pipework damage and loss of containment upon thaw
    - Instrumentation faults and malfunctions, leading to loss of process control
    - Metal fatigue/other equipment damage causing failures and malfunctions
    - Access issues or freezing of fire systems impacting emergency response

- High temperature/heat wave
    - Insufficient process cooling, particularly where using ambient air as coolant
    - Impact on workforce/reduced human performance
    - Process equipment/instrumentation overheating and malfunctioning
    - Increased fire risk/material decomposition/material auto-ignition

- Prolonged dry weather/drought
    - Impact on cooling water or fire water availability
    - Increased vulnerability of environmental receptors
    - Subsidence/ground movement impacting on equipment supports and containment system integrity

- High winds/storms
    - Structural damage either directly or due to wind-blown debris
    - Access restrictions hampering emergency response
    - Wide area power/communications systems loss
    - Simultaneous impacts from wind/lightning/flood

- Sea level rise
    - Increased risk of local sea/estuary defences failing and sites flooding
    - Increased forces on jetties/coastal structures due to changes in marine/estuarine currents

- Flooding
    - Floating of vessels or impact damage to equipment causing loss of containment (potential multiple losses)
    - Loss of power/utilities/control and communication systems
    - Compromising secondary/tertiary containment and drainage integrity/functionality

- Hampering emergency response due to unavailable resources or access/egress issues

To plan for floods (or indeed any extreme weather scenarios), you need to understand the type - or types - of threats you may face. Each one bears a different impact in terms of how it occurs, how it is forecast, the damage it causes, and the type of protection you need.

A fluvial, or river flood, occurs when the water level in a river, lake or stream rises and overflows onto the surrounding banks, shores and neighbouring land. The water level rise could be due to excessive rain or snowmelt.

A pluvial flood occurs when an extreme rainfall event creates a flood independent of an overflowing water body. A common misconception about flood is that you must be located near a body of water to be at risk. Yet pluvial flooding can happen in any location, urban or rural; even in areas with no water bodies in the vicinity. There are two common types of pluvial flooding:

- Surface water floods - occur when an urban (or industrial) drainage system is overwhelmed and water flows out into streets and nearby structures.
- Flash floods - are characterised by an intense, high velocity torrent of water triggered by torrential rain falling within a short amount of time within the vicinity or on nearby elevated terrain.

APPENDIX 4 – Regulation

For England see:

- https://www.gov.uk/guidance/climate-change-risk-assessment-and-adaptation-planning-in-your-management-system
- https://www.gov.uk/guidance/develop-a-management-system-environmental-permits#a-changing-climate

For nuclear regulation see:

- *https://www.onr.org.uk/operational/tech_asst_guides/ns-tast-gd-013.htm*

Summary of key COMAH requirements:
Reg 5 – All Measures Necessary (In the context of the overall aim – to provide a high level of protection to people and the environment)
SMS & Safety Reports – Need to include identification of MAHs, inclusive of natural causes and need to recognise that natural hazards are increasing in frequency and severity – thus need to incorporate into management systems the review of change in threats and continual improvement of measures to manage the risks, in terms of measures necessary for control of major accident hazards.

SEVESO Inspection Series No. 10 – Natech Risk Management

Assessment of natural hazards in the area of the establishment.
The natural-hazard information should take into consideration the increasing frequency and intensity of some natural hazards due to climate change.

Natech information in Safety reports
Information on the Natech risk analysis's assumptions, limitations and uncertainties.
The effects of climate change on worsening future natural hazards should be considered.

Major Accident Hazard Bureau (2020)

APPENDIX 5 – KEY RESOURCES

Applicable Climate Change Risk Assessment Documents, Data and Tools

Document Title	Web address	Summary
Governance		
Climate Change Act 2008	https://www.legislation.gov.uk/ukpga/2008/27/contents	The Climate Change Act commits the UK government by law to reducing greenhouse gas emissions by at least 100% of 1990 levels (net zero) by 2050. This includes reducing emissions from the devolved administrations (Scotland, Wales and Northern Ireland), which currently account for about 20% of the UK's emissions. The CC Act also establishes a National Adaptation Programme, National Climate Change Risk Assessment and adaptation reporting (specified organisations with public functions/statutory undertakers).
UK adaptation policy	https://www.theccc.org.uk/preparing-for-climate-change/uk-adaptation-policy/	This provides an outline of the policy framework put in place by the Climate Change Act to promote adaptation action in the UK.
UK Climate Change Risk Assessment and Adaptation Reporting		
UK Climate Change Risk Assessment 2017	https://www.gov.uk/government/publications/uk-climate-change-risk-assessment-2017	This report outlines the UK and devolved governments' views on the key climate change risks and opportunities that the UK faces.
Climate change: second national adaptation programme (2018 to 2023)	https://www.gov.uk/government/publications/climate-change-second-national-adaptation-programme-2018-to-2023	This report sets out what government and others will be doing over the next 5 years to be ready for the challenges of climate change.
UK Climate Change Risk Assessment 2022	https://www.gov.uk/government/publications/uk-climate-change-risk-assessment-2022#:~:text=The%20risk%20assessment%20considers%20sixty,and%20species%20from%20multiple%20hazards	This report outlines the UK government and devolved administrations' position on the key climate change risks and opportunities that the UK faces today.

Climate change adaptation reporting: Third round reports	https://www.gov.uk/government/collections/climate-change-adaptation-reporting-third-round-reports	Reports from organisations invited to report under the third round of the climate change Adaptation Reporting Power. These form the basis of the next UK climate change risk assessment and National Adaptation Plan.
Climate change adaptation reporting: Fourth round guidance	Issued to reporting organisations Dec 2023	Unpublished guidance available on request from CDOIF members
Adaptation Risk Assessment Guidance		
ISO 14090:2019 Adaptation to climate change — Principles, requirements and guidelines.	https://www.iso.org/standard/68507.html	This document specifies principles, requirements and guidelines for adaptation to climate change. This includes the integration of adaptation within or across organisations, understanding impacts and uncertainties, and how these can be used to inform decisions. It is applicable to any organisation, regardless of size, type and nature, e.g. local, regional, international, business units, conglomerates, industrial sectors, natural resource management units. It can support the development of sector-, aspect- or element-specific climate change adaptation standards.
ISO 14091:2021 Adaptation to climate change — Guidelines on vulnerability, impacts and risk assessment	https://www.iso.org/standard/68508.html	This document gives guidelines for assessing the risks related to the potential impacts of climate change. It describes how to understand vulnerability and how to develop and implement a sound risk assessment in the context of climate change. It can be used for assessing both present and future climate change risks. Risk assessment according to this document provides a basis for climate change adaptation planning, implementation, and monitoring and evaluation for any organisation, regardless of size, type and nature.
Safeguarding chemical businesses in a changing climate: How to prepare a Climate Change Adaptation Plan	https://www.cia.org.uk/Portals/0/Safeguarding%20chemical%20businesses%20in%20a%20changing%20climate%20-%20How%20to%20prepare%20a%20Climate%20Change%20Adaptation%20Plan.pdf	This guidance aims to help companies develop a climate change adaptation plan in order to make their business more resilient to extreme weather and climate change. Section 1 has provided some background and context to set the scene for why this is necessary and the urgency of identifying adaptations based on climate change risk assessment. The main guidance on how to do this is contained within Section 2.
UK Government and Met Office Endorsed Climate Projections and Modelling Tools (CP18)		

UKCP summaries and headline findings	https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/summaries/index	Summaries of the key information from the latest set of UK Climate Projections (UKCP). Includes data from local, high (2.2 km) resolution to global, coarser (60 km) resolution, in a range of formats.
UKCP User Interface	https://ukclimateprojections-ui.metoffice.gov.uk/ui/home	UK Climate Projections User Interface (note this requires signing up to for access to use). Download and customise climate projections for any region in the UK by using the UKCP User Interface.
CEDA catalogue	https://catalogue.ceda.ac.uk/?q=ukcp18&sort_by=	This gives access to datasets not included in the UKCP User Interface. For example, you can find UKCP Global (60km) and UKCP Regional (12km) data for other parts of the world in the CEDA catalogue.
UKCP data factsheets	https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/data/factsheets	A collection of documents that provide a short overview of the projections for different products and metrics, such as temperature or precipitation.
UKCP data caveats and limitations	https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/data/caveats	Summary of the key caveats and limitations you need to be aware of when using or referencing UKCP data.
Available data, access and data formats	https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18_data_availability_jul-2021.pdf	This is where you can find out more about what datasets are available, how to access them, as well as their characteristics and formats.
How to use UKCP	https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/using-ukcp/index	Guidance on how to use the UKCP User Interface or CEDA catalogue, as well as general advice on using UKCP data in your work, and case studies on how others use UKCP data.
Using UKCP data	https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/using-ukcp/ukcp-data	Guidance on how you can use UKCP data, including information on how to use climate projections in risk assessments, future planning or communications.
UKCP case studies	https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/using-ukcp/case-studies	Examples of how other organisations are using UKCP data in their climate risk assessments and adaptation management.
UKCP E-learning	https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/using-ukcp/ukcp-e-learning	Freely available e-learning course to introduce you to the latest UK Climate Projections.

UKCP science	https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/science/index	The science behind UK Climate Projections (UKCP), including science reports and technical notes.