Impact of Climate Change on Risk and Resilience of COMAH establishments

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Abstract

The Climate Change Act 2008 requires the UK Government to assess the national risks from climate change events; therefore, every five years a UK Climate Change Risk Assessment (CCRA) is published. The latest version of the document was released in 2021 and identified eight priority risks areas to focus on within the following two years.

The Committee on Climate Change have commissioned an evidence review on the impact of climate change to different industry sectors so that adaptation measures can be taken in the near future to build resilience to climate change.

Establishments subject to the Control of Major Accident Hazards Regulations (COMAH Regulations) are amongst those that are being analysed for the next version of the CCRA. A workshop was organised by the Tyndall Centre for Climate Change Research to evaluate the impact of climate change on these establishments.

This paper provides a summary of the workshop, which included discussions on the climate change vulnerabilities for COMAH establishments, adaptation strategies and future actions to take. The paper highlights some of the vulnerabilities that might be common to several climate change hazards, including impacts on access routes, power systems, supply chains, processing operations and damage to property.

Keywords: climate change, COMAH, UK CCRA, resilience, adaptation

Introduction

The Climate Change Act 2008 [The Stationery Office, 2008] aims to enable the United Kingdom to become a low-carbon economy; the Act stipulates that the Government must assess the risks for the UK from the current and predicted impacts of climate change. An Independent Committee on Climate Change has been created under the Act to provide advice to the UK Government on carbon and greenhouse targets and related policies.

The Act requires the Government to produce a UK Climate Change Risk Assessment (CCRA) every five years. The latest version of the UK CCRA [HM Government, 2021] identifies eight priority risk groups where additional action is recommended in the following two years:

1. Risks to the viability and diversity of terrestrial and freshwater habitats and species from multiple hazards.
2. Risks to soil health from increased flooding and drought.
3. Risks to natural carbon stores and sequestration from multiple hazards, leading to increased emissions.
4. Risks to crops, livestock and commercial trees from multiple climate hazards.
5. Risks to supply of food, goods and vital services due to climate-related collapse of supply chains and distribution networks.
6. Risks to people and the economy from climate-related failure of the power system.
7. Risks to human health, wellbeing and productivity from increased exposure to heat in homes and other buildings.
8. Multiple risks to the UK from climate change impacts overseas.

CCRA3 is the third assessment of the UK's climate risk and draws on new commissioned evidence review on how the understanding of risks to various sectors across the UK has changed since the last report, based on better knowledge of climate change impacts and of the vulnerability of different parts of the UK to these impacts. The aim of this exercise is to identify any actions that should be taken within the next five years to build resilience to climate change.

The Control of Major Accident Hazards Regulations (COMAH Regulations) specify the requirements for establishments in which one or more hazardous substances that are considered capable to create a major accident are present at quantities above the specified thresholds. Hazardous substances include Health hazards, Physical hazards including Explosives and Flammables, and Environmental Hazards. Annex 1 includes a detailed table from HSE publication L111 [1] showing the upper and lower thresholds and possible impact pathways for hazard categories and sub-categories. The main impact pathway is flooding (from any source) which has the potential (albeit a low probability) to cause tanks to float, break pipes and cause releases. If involving toxic substances these releases may be especially harmful to the environment. An increased temperature could cause a small increase in corrosion rates that could cause failure of piping and other equipment.

The COMAH Regulations require under Regulation 5 that COMAH operators must take all measures necessary to prevent major accidents and to limit their consequences for human health and the environment [1]. COMAH operators need to have a suitable safety management system (SMS) to ensure that the design incorporates suitable safeguards against all identified hazards; the process is controlled within safe operating limits; all changes are assessed and additional safeguards provided as necessary; operating staff are competent and understand the hazards; and that there is a suitable plan for emergency response. For upper tier sites, these arrangements have to be described in a safety report that is assessed by the regulator (competent authority) at 5-yearly intervals or if there are significant changes. Arrangements at both lower and upper tier sites are inspected by the competent authority.

The COMAH Competent Authority is a joint role between the Health and Safety Executive (HSE) or the Office for Nuclear Regulation for nuclear sites, and the corresponding environmental agency i.e. the Environment Agency in England, the Scottish Environment Protection Agency or Natural Resources Wales. Regulation 22 of the COMAH regulations requires the COMAH Competent Authority to examine the safety report in a reasonable time and communicate the findings of the review to the COMAH operator. If a serious deficiency is revealed then the COMAH competent authority will contact the COMAH operator and evaluate the situation, usually by a site visit. In addition, regulation 25 states that the competent authority must also prepare interventions plans for all establishments. Interventions comprise inspections and the intervention planning determines the inspection resource given to each site, prioritised on the basis of their hazards and risk, using the safety report to inform this. The competent authority also has responsibilities to investigate significant incidents and to take enforcement action, if necessary, following inspections or investigations.

In terms of the UK CCRA, both the infrastructure and the business aspects are relevant to COMAH establishments. To inform evidence that may support the UK CCRA it is of particular interest how COMAH establishments are adapting to, or are capable to adapt to, the climate change hazards that may affect their operability or their business.

Workshop

The Tyndall Centre for Climate Change Research organised a workshop in March 2020 to discuss climate change hazards with reference to COMAH establishments. The intention of this workshop was to get a deeper understanding of:

- The vulnerabilities of COMAH establishments and their supply chains to climate change hazards;
- How the associated risks or opportunities are currently being managed, including any barriers to action or areas where more information might be required; and
- Recommendations on whether actions could be taken in the next five years to better adapt to climate change.

The wide range of participants' expertise (regulatory, academia, research, data analysis, consultancy, engineering and risk management, oil industry, energy sector, finance, environmental epidemiology and public health nutrition) at the workshop allowed the gathering of opinions from different perspectives.

The workshop agenda began with introductory talks describing the purpose of the workshop, background information about the UK Government's approach to climate change, and an overview of COMAH establishments and activities. Three exercises were then run to cover the three objectives listed above. Notes were compiled by the workshop organisers to inform this report.

The main discussion points of the session and further observations are detailed below.

Vulnerabilities of COMAH establishments and their supply chains to climate change hazards

General

The COMAH Regulations already covers a requirement to identify and evaluate those weather-related hazards that may have an impact on the establishment; this is included in the COMAH 2015 guidance (L111) as part of the requirements to be addressed by safety management systems [1]. Guidance for Schedule 3 states:

"(5) Identification and accidental risks analysis and prevention methods –

(a) a detailed description of the possible major accident scenarios and their probability or the conditions under which they might occur including a summary of the events which may play a role in triggering each of these scenarios, the causes being internal or external to the installation; including in particular –

> (i) operational causes;
>
> (ii) external causes, such as those related to domino effects, sites that fall outside the scope of these Regulations, areas and developments that could be the source of, or increase the risk or consequences of a major accident;
>
> (iii) **natural causes, for example earthquakes or floods;**

(b) an assessment of the extent and severity of the consequences of identified major accidents including maps, images or, as appropriate, equivalent descriptions, showing areas which are likely to be affected by such accidents arising from the establishment; "

Regulation 10 states that there should be a review of the safety report no later than 5 years after the previous revision was received by the COMAH Competent Authority.

At the moment, there is no specific regulatory guidance on how to comply with the COMAH Regulations with respect to climate change; one possible reason for this could be that this topic is evolving very rapidly. COMAH operators do consider climate change hazards in their risk assessments although these risks are generally not deeply assessed, mainly because of the limited amount of guidance about how this could be done (as mentioned above in Schedule 3(5)). Consequently the assessment of climate change risks is open to interpretation; operators (or consultants) may not have access to suitable tools or guidance and therefore may be inconsistent in assessment approaches. However, some guidance has been published by the Chemical Industries Association (CIA): "Safeguarding chemical businesses in a changing climate" [2] and a "Flooding Safety Alert" [3]).

Risk assessments for weather-related hazards tend to consider annualised average weather data. The Met Office provides weather data in this form which typically ranges from 50 to more than 100 years in length. If there is a rapid change of climate or climate events over time, of a similar order of magnitude to the 5 year review and update cycle of COMAH safety reports, then these annualised data may no longer be valid; hence, weather data and risk assessments would need to be regularly updated to ensure the validity of the assessments. Otherwise, there would be a need to incorporate more extreme scenarios into the risk assessments.

Coastal erosion and sea level rise

Coastal-located COMAH establishments may not all be affected by coastal erosion and sea level rise in the same way, as this hazard is not uniform across the UK. The influence of local factors may mean, for example, that establishments on the east coast of the UK may experience a greater effect than those in the west [4].

Potential impacts include:

- The erosion or coastal flooding of existing sites either making the long term sustainability of the current site unfeasible; or the release of contaminated land into the sea.
- Increased vulnerability of the site to storm surges and potential inundation (see Floods for further details of this risk).
- Disruption of supply chains and reliant processes due to impacts of sea level rise on port infrastructure. This may lead to port disruptions, possibly affecting the availability of feedstock or the sales of finished products. Supply chain effects may ultimately lead to process disruption and therefore an increase in the number of shutdown and start-up operations performed by process plants, which would increase the risk of major accidents and, over time, may lead to asset integrity issues.

Some of the COMAH establishments which are located in coastal areas were designed a few decades ago when sea level rise was less an issue of concern; therefore, the standards followed at the design stage are possibly no longer valid. Although COMAH establishments should adapt to new standards that supersede the previous ones, it cannot be confirmed that this always happens.

Existing control measures: The Competent Authority conducts inspections and/or assessments of safety reports in which compliance to up-to-date standards may be checked. This could potentially include coastal flood risk if significant for the risk profile of the site.

Flooding

For those COMAH establishments which are located close to rivers or sea, in areas with frequent heavy rainfalls or with susceptibility to groundwater flooding, flood risk is currently a major issue and this will likely be exacerbated by climate change. Flooding may result in a Major Accident to the Environment through the following mechanisms:

- Establishments with open air hazardous waste interceptors may release waste into the wider environment.
- Onsite processing can be affected by flooding, as processes may need to immediately stop; however, operation shutdown requires following the right steps and this can take time. Stopping a process very quickly may result in an additional risk of a major accident, apart from reducing the quality of the final product, or the loss of the product. If flooding occurs frequently and shutdown/start-up operations are required repeatedly, asset integrity would also be at risk. Failure of bund capacity and an increased demand on drainage systems: these issues are critical to ensure adequate environmental protection.

- Utilities can be affected which may impact the safe storage of raw materials, especially in the case of peroxides where they have to be stored at a specific temperature and require electricity to keep the cooling systems functioning, and via failure of generators [5].
- Obstruction of access roads in particular to emergency services. Workers' safety may also be compromised in a flooding event, as well as their ability to access or leave the establishment, which could also be a reason to perform a plant shutdown. This could be due to flooding occurring at the site making the work dangerous to continue or potentially if access was blocked then the workers may not be able to access the site. Emergency services may not be able to access the site in case of an incident. This would be important to address in the COMAH emergency plan.
- Workers that live locally and are also affected by flooding in their residences may suffer health problems that would need to be addressed. If the percentage of workers affected is significantly high, there may be a need to stop operations until sufficient staff are able to return to work.
- Disruption of the supply chain can occur if the transportation of raw materials and final products is disrupted.

Flooding can then have a massive financial impact on COMAH processing establishments, not only because of the cost of property reparations, but also due to the process disruption which implies not being able to sell the final products for a while.

There have been some examples in 2013 in Teeside and Humberside of flooding of COMAH sites, with no injuries or loss of containment. However, electrical and control systems were damaged or destroyed which led to a loss of productions with some taking 4 months to get back to normal production [6].

Guidance has been published by the Environment Agency for COMAH sites [6] and by the CIA as a Flooding Safety Alert [3] with a view to identifying flooding risk and planning to prevent or mitigate risks.

High winds

The main impact of high winds to COMAH processing establishments is through:

- The potential increased loading on structures, for example flare stacks, chimneys, large low design pressure storage tanks and other tall structures such as distillation columns. These stresses may go beyond their original design expectations and potentially cause major accidents or disruption on site.
- Building standards for warehouses may not necessarily be as strict as those for other types of building; consequently, warehouses may be more vulnerable to high winds.
- Warehouses may be more vulnerable in high winds due to the lighter building materials and structure used in the construction of the building. Open warehouses/sheds would be more vulnerable to wind uplift.
- Wind-borne debris could damage power lines and compromise the power supply and other services that may be power dependent, such as communication channels. High winds may affect the supply chain, particularly shipping, which is restricted in high wind conditions; this may result in increased delays and consequently in the risk of plant disruption.

To mitigate these impacts, operators may strategically decide to store higher quantities of feedstocks on site. This would result in an increased risk of major accidents and therefore would need to be considered in the risk assessment.

Existing control measures: Structures are currently built to design specifications (BS EN 1991-14:2005) including wind speeds. The wind speeds used are based on the current climate.

High extreme temperatures

The impacts associated with higher temperatures, especially if they remain high for a considerable amount of time include:

- An increase in the process cooling demand which, under some circumstances, could exceed the design expectations and lead to hazardous situations. In this case, it would be necessary to stop the process and to ensure that the temperature of the contents is reduced to acceptable levels.
- The hazards of some stored substances may be susceptible to temperature changes, so an increase in the ambient temperature may need reassessment and implementation of measures to ensure that these substances are stored under safe storage conditions e.g.:

    (a) Flammable liquids – those stored below but close to their flash point such that ambient temperature rise could make them much more hazardous;

    (b) Substances that could react e.g. polymerise or decompose, exothermically. For some such substances, there is a time delay before exothermic runaway would begin. An increase in ambient temperature could shorten this time and invalidate current control measures. (This is very specific to the particular substance and storage conditions).

    (c) Self-reacting chemicals for which an increase in ambient storage temperature could make runaway reaction due to self-heating more likely.

- If the difference between day-time and night-time temperatures increases significantly for long periods of time, plant ageing may be accelerated, potentially increasing maintenance and replacement costs. If an adequate preventive maintenance plan is not followed, this acceleration in ageing may result in severe consequences.

Existing control measures: Current process and equipment design is built to the current ranges of temperature experienced in the UK. It seems that there are currently no standards in regard to process and equipment design that address how to adapt to 2 degrees or 4 degrees of global warming.

Heatwaves

The impacts associated with the prolonged experience of high temperatures include:

- An increase in cooling demand for processes and a change of hazards for stored substances.

- Increased exposure to wildfires for COMAH establishments in rural areas depending on the surrounding environment. Drier conditions make vegetation more susceptible to wildfires if not adequately managed.
- The buckling of structures and rails, which can affect the transport of raw materials and final products and ultimately affect stock availability.
- Heat stress to personnel onsite potentially increasing human failures due to factors like illness and fatigue.

Existing control measures: Current risk assessments include heatwave risks. Under these circumstances, it is recommended that workers do not spend much time exposed to the sunlight, use some sort of head protection (helmet, cap), use sun cream and keep hydrated. Even following these measures, working may feel uncomfortable and for that reason it would be necessary to reduce the time spent on plant, or even stopping operations in some cases.

Drought

Prolonged droughts like the one in summer 2018 may compromise the water supply to COMAH establishments. The effects associated with limited water supply are:

- Potentially limit the availability of fire water,
- A loss of cooling capacity
- A loss of water-based production capacity and the associated financial costs. For sites in rural areas, dry vegetation around an establishment may help the spread of fire, exacerbated by heatwave conditions, this may be compounded by any loss in the availability of fire water.

Existing control measures: COMAH safety reports need to demonstrate the reliability of fire water supplies, usually involving at least two alternatives, e.g. river and mains water. Fire water storage tanks may also be provided. Furthermore, it is very common for cooling water to be on a recirculation loop via cooling towers so that only evaporation losses need to be supplied.

Potential adaptation measures: There may be a need for investment in storage capacity for water, and a need to provide fire breaks between vegetation and the site. Existing standards for flammable liquid and LPG storage tanks require separation from vegetation or other combustible materials.

Lightning strikes

Lightning strike is largely considered a credible major accident scenario presenting risks including fire and electrical impingement. Upper-tier COMAH establishments have to address this scenario in the safety report, including the mitigation measures in place. Current standards include safety requirements lightning protection, as it would be a potential source of ignition and could cause power surges that adversely affect control systems.

Lower-tier COMAH sites also need to have a suitable safety management system and are required to demonstrate it when requested but do not require a safety report that describes and demonstrates the arrangements. Lightning protection is part of relevant standards that need to be complied with. The integrity of power supplies needs to be covered in the COMAH safety report.

It is possible that production would be disrupted as a consequence of a lightning strike impacting on an establishment, which would affect the supply chain.

Other

The main considerations in this category focused on the potential combination of different hazards, either cascading or in parallel, including non-climate or interacting hazards.

Earth movements such as those caused by drought, erosion or flooding may result in potential structural damage. Prolonged drought followed by rain and high winds may lead to subsidence, particularly on clay soils. The civil engineering supports for structures, including storage tanks, may need checking for continued design validity to prevent failure.

Increased snowfall in some areas may result in roof loading increases, which may require changes to roof design.

Severe prolonged cold weather could potentially lead to operating outside design temperatures, frozen 'wet lines', possible loss of gas supply even when on 'firm' contract (i.e. with a high priority for fuel supply), and other disruptive effects to supply chains and key staff availability and transport [3].

Changes in weather conditions (e.g. temperature, drought, wind and humidity) may alter corrosion rates and other ageing parameters, potentially increasing the risk of failure of equipment.

Utility systems e.g. electricity, fire water, nitrogen etc. can be vulnerable to many climate change hazards, however some establishments overstate their resilience to these.

Similarly, workers on site could underestimate the severity of the natural event. For example in an incident in 2017 a ride out crew underestimated how high the flood waters would get. This led to the loss of generators which could not initiate the emergency N_2 cooling systems which were keeping peroxides stored at a specific temperature. Three trailers caught fire and the other 6 had to be disposed of by controlled fire [5].

The loss of electricity may have other effects on services that depend on this, for example electrical, control and instrumentation items, or communication networks which may be needed to coordinate the emergency response.

The emergency response may be difficult if the emergency services are not able to access an establishment. Road closures may also affect the on-site personnel, who may not be able to enter or leave the establishment.

The supply chain is also susceptible to most climate change hazards, as access routes may be compromised, disrupting deliveries to and from the establishment. Unavailability of jetties and pipelines could increase road transport operations, which could arguably be more hazardous and require more coupling operations. Pipelines importing hazardous substances onshore may be exposed to weather conditions, increasing the probability of a loss of containment of that substance if preventive maintenance is not adequately conducted.

Adaptation strategies

This section is focused on understanding the current processes in place to anticipate and adapt to climate change. It considers how climate related vulnerabilities are currently managed by COMAH establishments, the existing gaps in this area and the existing barriers to building resilience to these hazards.

Management of climate change vulnerabilities

COMAH upper-tier establishments must conduct a flooding risk assessment as part of their safety report and, if flooding is identified as a high risk event, implement risk reduction measures. It was noted that some COMAH operators seem to face difficulties interpreting flood likelihood data and knowing how to use these data. The Competent Authority checks that flood risks are looked at by all COMAH establishments; operators must complete a flood risk questionnaire, the results of which are used to define a site inspection prioritisation process.

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.

Gaps in climate change management

For some climate change hazards e.g. rise in temperature, humidity and higher winds, there is a lack of evidence on the potential impacts on COMAH establishments due to the low number of events that have occurred so far. In addition, there is limited knowledge about how COMAH establishments that have experienced any of these events have responded to them; sharing the experiences and the lessons learnt would be beneficial to all COMAH operators. Having a clearer understanding of potential climate risks and the potential impacts of climate change events may increase the likelihood that operators will invest in measures to manage them.

It seems that current standards, e.g. COMAH regulations, are unlikely to directly address climate change hazards. The publication of new or updated standards addressing such hazards requires a significant amount of time, as would the subsequent implementation on site. In any case, many existing standards are strongly focused on the design stage. As most establishments are already built, this may result in an added difficulty for operators to follow the standards as they would need to act retrospectively.

Some standards are published or updated according to knowledge gained from historical incidents; they can include measures specifically addressed to prevent or mitigate these. Other standards are based on numerical data and focused on controlling risk, e.g. IEC61511 that requires suitable reliability of safety-related control systems. For climate change hazards, new or updated standards may be published when there is a better understanding on their implications as a consequence of climate change events occurring in the future.

Some trade bodies publish industry guidance related exclusively to issues relevant to that sector. It is probable that some of these trade bodies have already published guidance on how to adapt to climate change. As an example the Chemical Industries Association have a document "Safeguarding Chemical Businesses in a changing climate: How to prepare a climate change adaptation Plan. [2]

Over time, good practice measures may change to better address climate change issues. If that happens, all operators should eventually have to adapt to those measures.

Barriers to adapt to climate change

The short-term response to climate change in the UK may be affected by various factors like the economic climate, the UK's exit of the European Union or the COVID-19 impact on businesses. The net zero ambitions and the impact of industrial decarbonisation may also lead companies to other investment preferences.

Long-term adaptation strategies may face difficulties as well. The most common issue that COMAH operators may encounter is the effort required to implement these strategies, mainly cost and time. This may be particularly relevant for those establishments in which the plant design makes it very difficult to implement changes, or on relatively old plants where other changes could also be required.

Depending on the financial impact of climate change adaptation and other factors like the expected life of a plant, it is possible that an operator considers it is not worth investing in building resilience to climate change. In those cases, operators may make strategic decisions such as changing the location of an establishment, ceasing operation or changing the nature of the business.

COMAH establishments that are currently based in strategic locations, like coastal establishments which depend on shipping operations, may be affected more by weather extremes like storms. Long-term planning may be especially difficult for them as they could potentially be amongst those having to move to a different location. However, if the new location is a brand new installation, adaptation measures could be implemented at the design stage.

Given all the circumstances mentioned above, multinational companies may be uncertain about investing in the UK and may decide to invest in different countries instead. On the other hand, if the climate change risks (and other factors) are considered to be preferable within the UK when considered against other countries, companies may choose to invest in UK locations.

Possible actions to take in the near future

The CCRA includes recommendations on actions to take in the near future; these are split into three different categories, which are:

- Immediate actions to address an adaptation gap by implementing 'no regret' or 'low regret' actions that reduce risks associated with current climate change variability, as well as building future climate resilience;

- Actions to intervene early to ensure adaptation is considered in near-term decisions that have long lifetimes; and
- Actions to fast track early adaptable management activities or decisions which have longer lead times or involve major future change.

The participants at the workshop discussed some potential measures to implement at COMAH establishments within the next five years to aid climate change adaptation and resilience. The actions are described below and organised into the three categories listed above. Many of the actions are cross-cutting and could contribute to more than one category.

Actions to address current climate variability and to build future climate resilience

COMAH establishments could modify the provisions of utilities so that resilience to climate change impacts is improved. Possible ways to achieve this would include the installation of utility systems on higher ground or on higher foundations. This action may be difficult to implement in some establishments and it may also involve a high expense which, in some cases, may be considered not a worthwhile investment.

Graceful degradation, i.e. the ability of maintaining functionality when a system (or some parts of it) fails, could be applied to local systems like power supplies or local utilities e.g. cooling water supplies, fire water tanks, stand-by generators , which are more vulnerable to some climate change events. These local systems would fail to a safe state that could include localised backup systems such as uninterruptible power supplies (UPS) or necessary support gases such as nitrogen. This would avoid rapid shutdowns across processing units due to common mode failures and could reduce the number of system failures/escalation, or affect fewer process units.

The creation of a platform to share information related to climate change effects on high hazard industries. Examples of information that could be shared include climate change assessments, description of past climate change incidents or details of the response to these events. This could be extended to overseas operators, which may provide useful inputs as other countries have already experienced more severe climate change effects than the UK.

Risk assessments may need to consider concurrent risks (not necessarily being all climate change risks) to process safety; for example, a large period of water drought followed by a storm with lightning strikes or by a heavy rain resulting in flooding.

Actions to ensure adaptation in near-term decisions that affect long lifetimes

The publication of industry guidance on how to identify climate change hazards and possible measures to address them would be beneficial. It would be worth bearing in mind that environmental conditions captured in current standards, such as wind speeds, may vary in the future. However, design codes tend to be updated when an issue has been detected rather than via a proactive process. It might be useful to include an estimation of the magnitude of an impact throughout different periods of time, which could be factored in cost benefit decisions.

Actions to fast-track early adaptable management activities

Some COMAH establishments may opt to develop their own in-house services for use in emergency situations, as a means to reduce dependency on external services. This would make services like communications less reliant on centralised systems and networks which are vulnerable to external events. UPS or other local power storage systems are generally already available and in use, but establishments may now consider having, for example, a reserve of local utilities. This would allow more time to perform a safe shut down operation; however, if this type of measure is implemented, it would be necessary to evaluate the potential risks.

Emergency response could be improved by the provision of multiple access routes, which may increase the likelihood that emergency services can access the establishment if necessary. This could also allow workers to enter or leave the establishment if required.

The use of multiple supply chain strands e.g. ship, pipeline and road tanker, could help mitigate the impact of a climate change hazard event. Depending on the feedstocks, the types of chemicals that are processed on site or the final products that are being sold, it may not be feasible to implement this type of measure. The capacity of each strand would also play a role in implementing this measure.

Conclusions

The Tyndall Centre for Climate Change Research organised a workshop to discuss the potential impacts of climate change-related hazard events to COMAH establishments. The workshop drew on the expertise of attendees, focusing on climate change vulnerabilities, adaptation strategies and actions to take in the near future to build resilience to climate change. The aim of this work was to collate views and information that could provide input to the UK Committee on Climate Change, so that any relevant information could inform the next version of the UK CCRA.

The climate change hazards that were discussed were coastal erosion and sea level rise, flooding, high winds, high extreme temperatures, heatwaves, drought, lightning strikes and other considerations.

The workshop suggested that there is little specific regulatory guidance on how to assess weather-related hazards; therefore, there are occasions in which these may not be thoroughly assessed. Furthermore, the available averaged weather data may be no longer valid if the environmental conditions change rapidly and no updates are published. It was also evident that there is more knowledge, guidance and regulatory arrangements for some climate change hazards e.g. flooding, than for others.

There are some vulnerabilities that may be common to several climate change hazards. These impacts include:

- Access routes closures. This may affect the possibility of emergency services accessing the site and providing an adequate response, as well as workers entering or leaving the site (flooding and snow).

- Power failures. This could compromise the availability of power supply, utilities and other services like communication channels, which would be needed to ensure a coordinated response to an emergency (flooding, prolonged cold temperatures, high winds).
- Supply chain disruptions or delays. This could affect the availability of raw materials or the distribution of final products, with subsequent impacts to businesses (flooding, prolonged cold temperatures).
- Processing disruptions. This could impact on asset-ageing and increase the risk of major accidents (flooding, extreme heat, prolonged cold temperature).
- Property damage. If the property is damaged, it may be necessary to shut down operations until reparations are completed (flooding, lightning, storms, high winds).

For some climate change hazards e.g. temperature change and high winds, there is not enough knowledge on the potential impacts, possibly because of the low number of relevant events that have occurred in the UK. In addition, those establishments that have already experienced climate change events have not shared with others how they responded to them. The creation of a platform to share knowledge and lessons learnt could be considered in order that a wider range of measures are implemented in COMAH establishments.

Current standards e.g. COMAH regulations [7] generally do not cover safety measures to adapt to climate change. The publication of new or updated standards addressing these will take time and so will their implementation in COMAH establishments. COMAH requires the demonstration by the dutyholder (operator) that risks are reduced as low as reasonably practicable (ALARP) and that all measures necessary (AMN) are provided to protect the environment. This means periodic review of the safety measures and consideration of the need to go beyond current standards. The Chemical Industries Association (CIA) Guidance "Safeguarding chemical businesses in a changing climate: How to prepare a Climate Change Adaptation Plan" [2] encourages review of current measures against climate change threats and this could feed into the ALARP/AMN demonstrations.

For some establishments, the balance of the effort required to implement any adaptation measures and the benefit gained may not be considered worthwhile. In these cases, operators may decide not to take these measures and consider other options such as moving location, change in business nature or cessation of operations.

Some of the potential measures that could be implemented in the near future to adapt to climate change and to build climate change resilience may include: changes in the utilities provisions, use of in-house services, graceful degradation of local systems, publication of industry guidance on how to identify climate change hazards and possible measures to address them, availability of multiple access routes to establishments or use of multiple supply chain strands.

Disclaimer

This paper and the work it describes were funded by the Tyndall Centre for Climate Change Research. Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy.

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Annex 1 – Table from L111 showing upper and lower tier thresholds for each hazard with impact pathways.

Column 1	**Column 2**	**Column 3**	
Hazard categories in accordance with the CLP Regulation	**Qualifying quantity in tonnes of dangerous substances for the application of:**		**Impact pathway**
	Lower tier requirements	**Upper tier requirements**	
Section 'H' – HEALTH HAZARDS			
H1 ACUTE TOXIC Category 1, all exposure routes	5	20	Flooding (from any source)
H2 ACUTE TOXIC Category 2, all exposure routes Category 3, inhalation exposure route (see note 7)	50	200	Flooding
H3 STOT SPECIFIC TARGET ORGAN TOXICITY SINGLE EXPOSURE STOT SE Category 1	50	200	Flooding
Section 'P' – PHYSICAL HAZARDS			
P1a EXPLOSIVES (see note 8) Unstable explosives, or Explosives, Division 1.1, 1.2, 1.3, 1.5 or 1.6, or Substances or mixtures which have explosive properties according to method A.14 of Regulation (EC) No. 440/2008 of 30 May 2008 laying down test methods pursuant to Regulation (EC) No. 1907/2006 of the European Parliament and of the Council on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) (see note 9) and do not belong to the hazard classes Organic peroxides or Self-reactive substances and mixtures	10	50	Seismic activity Fire Cold
P1b EXPLOSIVES (see note 8) Explosives, Division 1.4 (see note 10)	50	200	Seismic activity Fire Cold
P2 FLAMMABLE GASES Flammable gases, Category 1 or 2	10	50	Fire
P3a FLAMMABLE AEROSOLS (see note 11(1)) 'Flammable' aerosols	150 (net)	500 (net)	Fire

Category 1 or 2, containing flammable gases Category 1 or 2 or flammable liquids Category 1			
P3b FLAMMABLE AEROSOLS (see note 11(1)) 'Flammable' aerosols Category 1 or 2, not containing flammable gases Category 1 or 2 nor flammable liquids category 1 (see note 11(2))	5,000 (net)	50,000 (net)	Fire
P4 OXIDISING GASES Oxidising gases, Category 1	50	200	Fire
P5a FLAMMABLE LIQUIDS Flammable liquids, Category 1, or Flammable liquids Category 2 or 3 maintained at a temperature above their boiling point, or Other liquids with a flash point ≤ 60°C, maintained at a temperature above their boiling point (see note 12)	10	50	Fire
P5b FLAMMABLE LIQUIDS Flammable liquids Category 2 or 3 where particular processing conditions, such as high pressure or high temperature, may create major-accident hazards, or Other liquids with a flash point ≤ 60°C where particular processing conditions, such as high pressure or high temperature, may create major accident hazards (see note 12)	50	200	Fire
P5c FLAMMABLE LIQUIDS Flammable liquids, Categories 2 or 3 not covered by P5a and P5b	5,000	50,000	Fire
P6a SELF-REACTIVE SUBSTANCES AND MIXTURES and ORGANIC PEROXIDES Self-reactive substances and mixtures, Type A or B or organic peroxides, Type A or B	10	50	Fire flooding
P6b SELF-REACTIVE SUBSTANCES AND MIXTURES and ORGANIC PEROXIDES Self-reactive substances and mixtures, Type C, D, E or F or organic peroxides, Type C, D, E, or F	50	200	Fire flooding
P7 PYROPHORIC LIQUIDS AND SOLIDS Pyrophoric liquids, Category 1 Pyrophoric solids, Category 1	50	200	Fire
P8 OXIDISING LIQUIDS AND SOLIDS Oxidising Liquids, Category 1, 2 or 3, or Oxidising Solids, Category 1, 2 or 3	50	200	Fire
Section 'E' – ENVIRONMENTAL HAZARDS			

E1 Hazardous to the Aquatic Environment in Category Acute 1 or Chronic 1	100	200	Flooding
E2 Hazardous to the Aquatic Environment in Category Chronic 2	200	500	Flooding
Section 'O' – OTHER HAZARDS			
O1 Substances or mixtures with hazard statement EUH014	100	500	
O2 Substances and mixtures which in contact with water emit flammable gases, Category 1	100	500	
O3 Substances or mixtures with hazard statement EUH029	50	200	