CLIMATE CHANGE ADAPTATION FOR COMAH OPERATORS: A STRATEGIC FRAMEWORK

ADAPTING COMAH SAFETY SYSTEMS FOR A CHANGING CLIMATE

Arthian

EXECUTIVE SUMMARY

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Climate Change Adaptation for COMAH Operators: A Strategic Framework

Climate change is fundamentally altering the risk landscape for COMAH (Control of Major Accident Hazards) operators across the UK. Extreme weather events—from flooding and storms to heatwaves and lightning—are increasing in both frequency and severity, for major accidents and challenging established safety systems.

Natural Hazard Triggered Technological Accidents (NaTech) represent an emerging category of major accident hazards that all COMAH sites must now address. The COMAH Competent Authority expects operators of jointly regulated sites (COMAH and Environmental Permitting Regulations) to complete Climate Change Adaptation risk assessments, with regulatory scrutiny intensifying following recent guidance from CDOIF and the Environment Agency.

This white paper provides COMAH operators with a structured framework for developing a comprehensive climate change adaptation strategy, aligned with the CDOIF Guideline on Adapting to Climate Change and the management systems approach recommended by Regulators. It demonstrates how Arthian Ltd's integrated services can support operators through each stage of this journey—from initial hazard identification through to implementation of adaptive engineering and management systems.

KEY INSIGHTS

1

YESTERDAY'S DESIGNS, TODAY'S RISKS

Climate change is already impacting COMAH sites, with present-day risks potentially exceeding original design assumptions and management systems/protocols.

2

MANAGING NATECH WITH DISCIPLINE

A systematic, management-systems approach is required to identify, assess, and control NaTech hazards

3

SHAPING TOMORROW'S SAFETY

Operators must consider both present-day risks and future scenarios (+2°C by 2050 and +2 /+4°C by 2100)

4

EMBEDDING CLIMATE RESILIENCE IN OPERATIONS

Integration of climate adaptation into existing COMAH Safety Management Systems is essential

5

PROACTIVE ADAPTATION PAYS OFF

Early action reduces both compliance risk and long-term costs

INTRODUCTION: THE CLIMATE CHALLENGE FOR COMAH SITES

THE CHANGING RISK LANDSCAPE

UK COMAH operators face an unprecedented challenge. The climate has already changed measurably since most facilities were designed and constructed. Average temperatures during the hottest days have increased from 26°C (1961-1990) to 26.8°C (2008-2017), with subsequent years showing continued warming. Flood risk areas are expanding, storm intensity is increasing, and extreme weather events that were once rare are becoming more frequent.

For sites handling dangerous substances, these changes translate directly into increased major accident risk. Equipment designed to operate within specific environmental parameters may be pushed beyond safe operating envelopes. Safety barriers calibrated for historical weather patterns may prove inadequate under future conditions. Emergency response plans developed without considering concurrent extreme weather may fail when most needed.

THE BUSINESS CASE FOR ADAPTATION

Beyond regulatory compliance, there is a compelling business case for proactive climate adaptation:

REDUCED DOWNTIME

Facilities prepared for extreme weather recover faster from disruption

ASSET PROTECTION

Early adaptation measures prevent costly damage to infrastructure

INSURANCE BENEFITS

Demonstrable resilience can reduce premiums and maintain coverage

REGULATORY EXPECTATIONS

THE COMAH COMPETENT AUTHORITY HAS MADE CLEAR THAT OPERATORS MUST ASSESS AND MANAGE CLIMATE-RELATED RISKS TO MAJOR ACCIDENT HAZARDS.

1

COMAH REGULATIONS

Requirement to take "All Measures Necessary" to prevent major accidents, which now explicitly includes consideration of natural hazards.

2

ENVIRONMENTAL PERMITTING REGULATIONS

Requirements for climate adaptation to be embedded in Environmental Management Systems.

3

CDOIF GUIDELINE - ADAPTING TO CLIMATE CHANGE

Industry best practice framework establishing expectations for NaTech risk assessment.

4

OPERATIONAL DELIVERY GUIDE: NATECH AND CLIMATE CHANGE ADAPTATION

Regulatory inspection benchmarking criteria

SITES THAT FAIL TO ADEQUATELY ASSESS AND CONTROL NATECH RISKS FACE POTENTIAL ENFORCEMENT ACTION, INCREASED INSURANCE COSTS, OPERATIONAL DISRUPTION, AND—MOST CRITICALLY—ELEVATED RISK OF CATASTROPHIC ACCIDENTS.

OPERATIONAL CONTINUITY

Understanding climate risks enables better business planning

REPUTATION PROTECTION

Proactive adaptation demonstrates responsible operation

COMPETITIVE ADVANTAGE

Sites that adapt early gain operational advantages over competitors

UNDERSTANDING NATECH HAZARDS

WHAT ARE NATECHS?

Natural Hazard Triggered Technological Accidents (NaTech) occur when natural events initiate, escalate, or exacerbate industrial accidents. For COMAH sites, these can include:

INITIATING EVENTS

Natural hazards that directly trigger loss of containment, fires, or explosions.

BARRIER DEGRADATION

Natural events that weaken or disable safety systems, increasing vulnerability to accidents.

ESCALATION FACTORS

Natural events that worsen consequences of an ongoing incident

CLIMATE-RELATED THREATS TO COMAH SITES

NATURAL HAZARD	POTENTIAL MAJOR ACCIDENT PATHWAY	CLIMATE CHANGE IMPACT
Flooding	Equipment inundation, loss of utilities, foundation damage, contaminated firewater, loss of access	Increasing frequency and severity; areas previously considered low-risk becoming vulnerable
Lightning/ Thunderstorms	Ignition source, control system failure, electrical fires	More frequent intense storms; increased lightning activity
High Winds/ Storms	Structural damage to tanks/buildings, flying debris, power line damage	Increasing storm intensity; higher peak wind speeds
Extreme Heat/ Heatwaves	Overpressure of vessels, cooling system failure, material degradation, auto-ignition	More frequent heatwaves; higher peak temperatures
Extreme Cold/Ice	Material embrittlement, frozen valves/ instrumentation, delayed emergency response	Potential for more severe cold snaps despite overall warming
Heavy Snowfall	Roof collapse, floating roof failure, access disruption	Increased precipitation extremes
Drought/Water Scarcity	Cooling water shortage, firefighting water unavailability, increased fire risk	More frequent and prolonged droughts

COMMON MISCONCEPTIONS

"Our site has never flooded, so flooding isn't a risk"

Reality: Historical experience does not predict future risk. Flood patterns are changing, and sites previously considered safe may become vulnerable.

"We've considered extreme weather in our safety report"

Reality: Many existing assessments are based on historical data and may not reflect present-day risks, let alone future climate scenarios.

"Climate change is a long-term issue—we'll address it later"

Reality: Climate impacts are occurring now. Waiting increases both risk and adaptation costs.

"Our emergency plans cover natural disasters"

Reality: Generic emergency plans may not address the specific challenges of major accident response during extreme weather events.

THE CDOIF ADAPTIVE MANAGEMENT FRAMEWORK

PRE-PLANNING & LEADERSHIP	RISK ASSESSMENT PROCEDURE	IDENTIFY POTENTIAL IMPACTS (SCREENING)	RISK ASSESSMENT PART A – DETAILED NATECH ANALYSIS
Objective	**Objective**	**Objective**	**Objective**
Establish organisational commitment and adaptive capacity	Embed NaTech hazards into COMAH Major Accident Hazard identification and evaluation processes	Conduct initial screening to identify credible NaTech scenarios under present-day and +2 and +4°C warming conditions	Evaluate risk against present-day, +2°C (2050), and +2 and +4°C (2100) scenarios
Key Activities	**Key Activities**	**Key Activities**	**Key Activities**
» Senior leadership commitment to climate adaptation » Resource allocation (budget, personnel, expertise) » Competency assessment and development » Policy development integrating adaptation into corporate strategy	» Review and update procedures for MAH identification to include natural hazards » Establish criteria for climate scenario assessment » Define review and revision triggers » Link to corporate risk tolerability criteria	» Compile screening data (readily availabe data) » Review full range of potential natural hazards » Identify how hazards could initiate/escalate major accidents » Screen for potential environmental permit non-compliance » Consider off-site factors (loss of utilities, access routes, emergency services)	» Establish baseline assessment of present-day risks » Assess equipment vulnerability to climate-related threats » Evaluate barrier effectiveness under extreme weather conditions » Consider common cause failures and simultaneous impacts » Link to vulnerability of equipment design specifications
How we support	**How we support**	**How we support**	**How we support**
» Executive briefings on climate risk and strategic implications » ISO 14090-based adaptive capacity assessment » Climate adaptation policy development aligned with ESG strategy	» Process Safety Consultancy: Enhance HAZID/ENVID procedures to include NaTech screening » Procedure development aligned with CDOIF standards » Integration into COMAH Safety Management Systems	» Major Accident ID: Screen NaTech scenarios with HAZID/ HAZOP » GIS analysis of site hazard vulnerability	» NaTech Safety Report sections with scenario analysis » Physical Climate Check Report » Environmental Risk Assessment: CDOIF-compliant MATTE evaluation » Quantitative/ semi-quantitative risk analysis (LOPA/QRA)

CDOIF integrates climate adaptation into COMAH systems using ISO 14090 and a continuous improvement cycle

RISK ASSESSMENT PART B – SENSITIVITY ANALYSIS & RISK TRENDING	IDENTIFY & APPRAISE RISK REDUCTION MEASURES (ALARP DEMONSTRATION)	PLAN & IMPLEMENT ADAPTATION MEASURES	MONITOR, RECORD & REVIEW
Objective	**Objective**	**Objective**	**Objective**
Understand how risks change over time and under different climate scenarios	Identify reasonably practicable measures to maintain major accident risk ALARP	Develop and execute adaptation plan ensuring timely implementation of risk controls	Continuous monitoring of adaptation effectiveness and emerging risks
Key Activities	**Key Activities**	**Key Activities**	**Key Activities**
» Sensitivity analysis across multiple climate projections (RCP scenarios, H++ where appropriate) » Risk attribution—understanding which climate impacts drive highest risks » Risk trending—projecting how risks evolve over asset lifetime » Comparison against corporate risk tolerability criteria	» Apply safety hierarchy (inherent → prevention → control → mitigation) » Identify immediate and future measures as risks grow » Use flexible, “no-regret” options; avoid lock-in » Conduct cost-benefit analysis of adaptation choices	» Prioritize adaptation actions by risk and timing » Establish roadmap with milestones » Apply flexible adaptation pathways » Define indicators and decision triggers » Integrate into capital planning cycles » Update Safety Report and permits	» Monitor weather-related data and climate indicators » Review adaptation plan effectiveness after extreme weather events » Periodic reassessment against updated climate projections » Management of change process for creeping climate impacts » Senior management oversight and governance
How we support	**How we support**	**How we support**	**How we support**
» Assess NaTech risks against CDOIF tolerability » Model risk evolution under warming pathways » Identify intolerable “tipping points” » Plan for long-life sites beyond 2035	» COMAH: AMN/ALARP demonstrations for NaTech controls » Engineering solutions: flood defenses, bund upgrades, process modifications, drainage improvements » Containment strategy review with bund modeling	» Adaptation planning with BS 8631 pathways » Project management for engineering controls » Develop performance indicators and monitoring triggers » Integrate with wider infrastructure and sustainability	» Monitor regulatory and climate policy » Integrate climate into ISO systems » Develop KPIs and reporting » Reassess with COMAH cycles » Train staff on climate procedures

CASE STUDY

ADAPTIVE APPROACH TO FLOOD RISK

LOCATION: ENGLAND

CLIENT: CONFIDENTIAL

HIGHLIGHTS

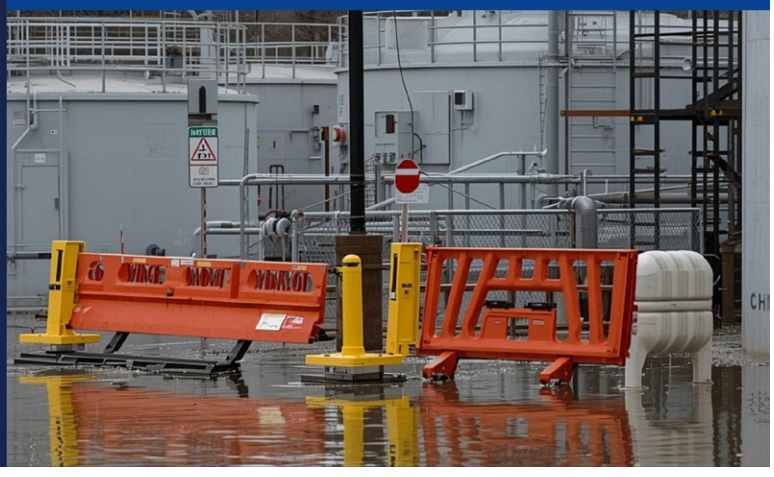
- Flood risk screening and baseline assessment
- NaTech scenario screening under flood conditions
- Regulatory-aligned reporting and engagement

THE CHALLENGE

A lower-tier COMAH chemical storage facility in Yorkshire faced increasing flood risk. Original site design assumed protection from a 1-in-100-year flood event based on historical data. Updated Environment Agency mapping indicated the site now falls within 1-in-30-year flood extent under present-day conditions, with projections showing 1-in-10-year flooding by 2050 under a +2°C scenario.

Initial screening identified potential for:

- Inundation of primary containment systems
- Loss of electrical power affecting pumps and instrumentation
- Contaminated firewater release to adjacent watercourse (designated SSSI)
- Access constraints for emergency responders



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THE SOLUTION

PHASE 1 - SCREENING & BASELINE ASSESSMENT

- Compiled flood data from EA long-term flood risk maps and local SFRA
- Reviewed UKCP18 projections for river flow increases
- Conducted site walkover to identify vulnerable assets
- Screened for MATTE scenarios under flood conditions

FUTURE WORKS WHICH COULD BE UNDERTAKEN

PHASE 2:

- Developed flood inundation modelling for present-day, +2°C and +4°C scenarios
- Assessed barrier effectiveness (bunds, drainage, electrical systems) under flood conditions
- Evaluated environmental receptor vulnerability (SSSI downstream)
- Conducted CDOIF environmental risk tolerability assessment
- Identified risk trending—present-day risk approaching ALARP limit; projected to exceed by 2035

PHASE 3:

Immediate measures (0-2 years)

- Enhanced flood warning subscription and response procedures
- Relocation of critical electrical equipment above flood level
- Installation of flood-resistant barriers at key access points
- Emergency response plan updates

Medium-term measures (2-10 years)

- Raising of bund walls and installation of flood gates
- Surface water drainage improvements
- Installation of backup power systems above flood level

Long-term consideration (10+ years)

- Evaluation of site relocation if flood risk continues to escalate
- Potential for local flood defence improvements in collaboration with EA

Outcomes

- ALARP demonstrated for present-day and +2°C scenarios
- Clear triggers defined for further measures
- Adaptation pathway maintained safety while avoiding premature costly works
- Safety Report updated with NaTech assessment
- Positive regulatory engagement showing proactive compliance

REGULATORY LANDSCAPE & FUTURE OUTLOOK

The COMAH Competent Authority's position on climate adaptation is clear on strengthening:

COMAH INSPECTION PROGRAMS

NaTech and climate change adaptation are strategic inspection topics, with delivery guides establishing benchmarking criteria any pollution incidents as part of compliance site visits.

ENVIRONMENTAL PERMITTING

Climate risk assessment and adaptation plans must have been embedded in EMS by April 2024 (England) for all permitted sites. The EA refer directly to COMAH for best practice. The EA is actively auditing documentation and any pollution incidents as part of compliance site visits.

SAFETY REPORT EXPECTATIONS

Climate-related MAH scenarios must be addressed in updated Safety Reports

ALL MEASURES NECESSARY

Operators must demonstrate they have taken All Measures Necessary to prevent and mitigate NaTech risks.

CLIMATE ADAPTATION FOR COMAH SITES WILL TRANSITION FROM EMERGING EXPECTATION TO STANDARD PRACTICE. OPERATORS WHO ACT EARLY WILL BENEFIT

EMERGING DEVELOPMENTS

STANDARDS EVOLUTION

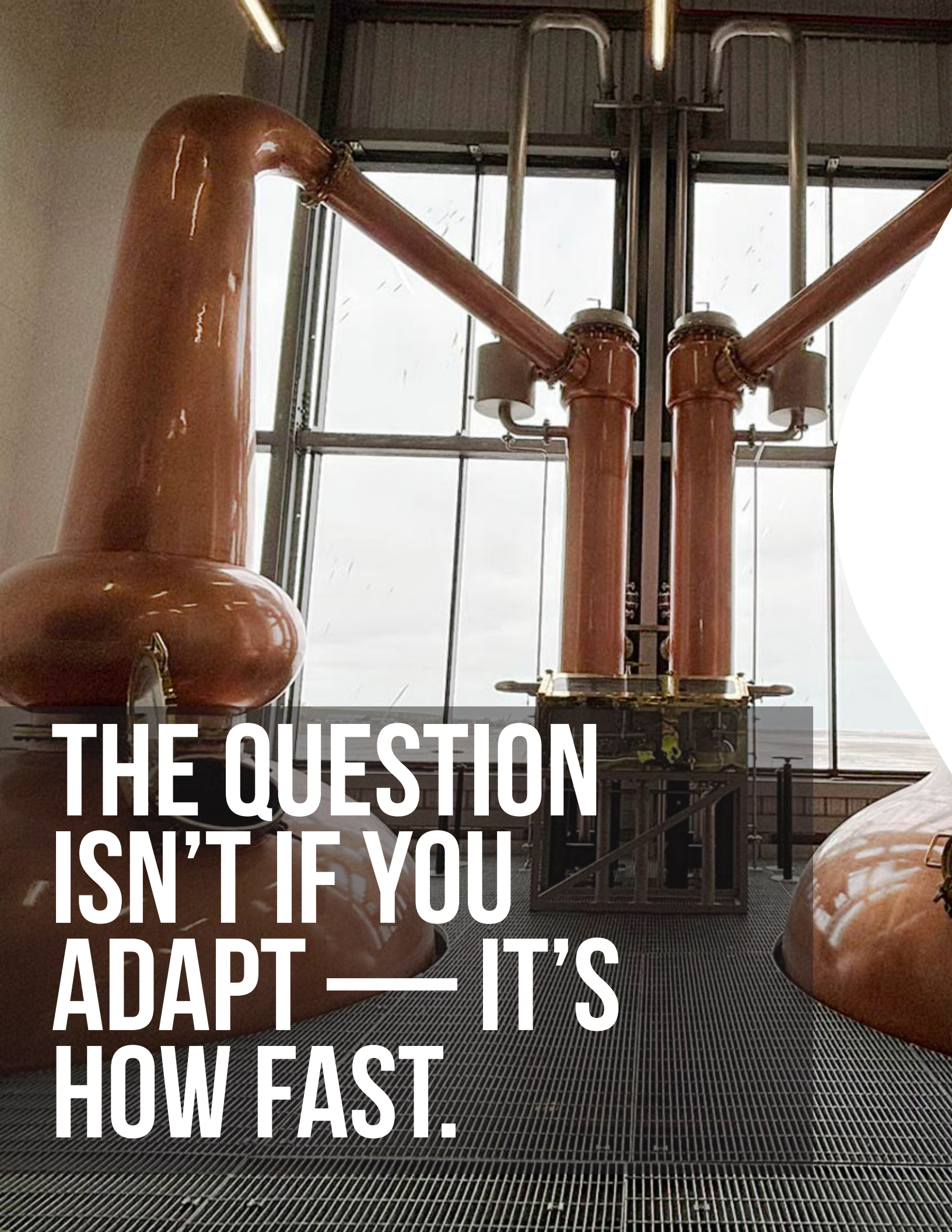
- Engineering standards now incorporate climate scenarios, not just historical data
- CEN/CENELEC embedding adaptation in infrastructure standards
- ISO 14090/14091 gaining traction• ISO 14090 (Adaptation), ISO 14091 (Risk Assessment) gaining traction

POLICY INTEGRATION

- Stronger alignment of adaptation reporting (Climate Change Act), TCFD, and safety requirements
- Government's Environmental Improvement Plan highlights +4°C preparation
- National Adaptation Programme driving sectoral action

BEST PRACTICE DISSEMINATION

- CDOIF developing sector-specific guidance
- Adaptation Forum sharing lessons learned
- OECD principles revised to emphasize adaptation



THE QUESTION ISN'T IF YOU ADAPT — IT'S HOW FAST.

ADAPTATION BECOMES STANDARD PRACTICE

Climate adaptation for COMAH sites is shifting from expectation to requirement. Acting early delivers:

- Lower costs through timely measures
- Smooth integration with asset cycles
- Stronger regulator relationships
- Reduced disruption
- Maintained insurability

Delayed action risks:

- Costly emergency fixes
- Enforcement penalties
- Operational downtime
- Insurance loss or premium hikes
- Higher accident risk

SITES DESIGNED FOR THE PAST MUST BE SAFE IN THE FUTURE.

EARLY ACTION COSTS LESS THAN EMERGENCY FIXES.

The CDOIF framework provides a robust, management-systems-based approach to achieving this transformation. By systematically identifying NaTech hazards, assessing risks under multiple climate scenarios, and implementing adaptive management, operators can maintain major accident risk ALARP while building long-term operational resilience.

The question is no longer whether climate adaptation is necessary for COMAH sites, but how quickly and effectively it can be implemented. Sites that act now will be better prepared, more resilient, and better positioned to operate safely and sustainably in an uncertain climate future.

ARTHIAN'S INTEGRATED SERVICE OFFERING

LIFECYCLE SUPPORT SOLUTIONS

Our multi-disciplinary team integrates safety, environmental, engineering, and regulatory expertise to deliver comprehensive solutions.

COMAH COMPLIANCE & PROCESS SAFETY SERVICES

Service Lead: Aaron McMillan

- Safety Report updates with NaTech sections
- MAH identification (HAZID/HAZOP incl. climate hazards)
- ALARP / All Measures Necessary demonstrations
- Emergency planning for extreme weather
- Regulator liaison and inspection support
- Training on NaTech and adaptation

ENVIRONMENTAL RISK TOLERABILITY ASSESSMENT/CDOIF

Service Lead: Liz Copland

- CDOIF-compliant environmental risk assessment for NaTech scenarios
- Source-Pathway-Receptor analysis under climate change conditions
- MATTE screening and categorisation
- Assessment of receptor vulnerability to climate-stressed environments
- Environmental permit applications, and variations and surrenders reflecting adaptation in the event of any changes to regulated activities
- Integration with EPR Environmental Management Systems

PHYSICAL CLIMATE HAZARD IDENTIFICATION

Service Lead: Josh Rigby

- Site-specific risk screening (UKCP18, local data)
- Multi-hazard assessment (flood, wind, heat, lightning)
- Scenario analysis (+2°C, +4°C)
- GIS vulnerability mapping
- Link to financial climate reporting (TCFD, IFRS S2)

PLANNING & REGULATORY SUPPORT

Service Lead: Josh Parsons

- Hazardous Substances Consent applications
- Environmental Permitting applications and variations
- Planning applications for adaptation infrastructure
- Stakeholder engagement with HSE, EA/SEPA/NRW
- Liaison with Local Planning Authorities

INTEGRATED ENGINEERING TEAMS

Service Lead: James Forbes

- **Civil & Structural Engineering**: Flood defences, drainage systems, structural resilience assessment
- **Process Engineering:** Process modifications, cooling system design, safety system upgrades
- **Environmental Engineering**: Water management, containment design, drainage modelling
- **Geotechnical Engineering**: Foundation assessment, subsidence risk, coastal erosion

CLIMATE ADAPTATION GOVERNANCE, POLICY & MANAGEMENT SYSTEM IMPLEMENTATION

Service Lead: Peter Schofield

- ISO 14090 (Climate Change Adaptation Framework) Implementation
- ISO 14091 (Vulnerability, Impacts & Risk Assessment) Implementation
- Climate Adaptation Policy, Leadership, Governance, Roles & Responsibilities (incl. Training)
- Climate Risks & Resilience Integration with Management System (ISO 9001, 14001, 45001, 50001)
- Climate Risk & Resilience for ESG Strategy and Disclosure
- Integrated Net Zero Carbon (Mitigation) and Climate Risk (adaptation) Strategy Alignment

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17 Locations across the UK & Ireland