UK CLIMATE RISK

ENERGY BRIEFING

Findings from the third UK Climate Change Risk Assessment (CCRA3) Evidence Report 2021

ENERGY

This briefing summarises how the energy system has been assessed in the latest UK Climate Change Risk Assessment (CCRA) Technical Report, and what types of action to adapt to climate change risks and opportunities would be beneficial in the next five years.

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The full assessment looks at risks and opportunities for the UK under two climate change scenarios, corresponding to approximately a 2°C or a 4°C rise in global temperature by 2100. It answers three questions, for 61 different risks or opportunities using available published evidence and analysis:

1. What is the current and future level of risk or opportunity?

2. Is the risk or opportunity being managed, taking account of government action and other adaptation?

3. Are there benefits of further adaptation action in the next five years, over and above what is already planned?

The main findings from the full assessment related to energy are summarised below, together with the adaptation actions that would be beneficial over the next five years. Each risk or opportunity has an identifier code linked to the full analysis, which is available in the CCRA3 Technical Report.

Readers are encouraged to use these briefings to locate the parts of the Technical Report of most relevance to them.

Alternatively, if you would like a summary of the analysis by UK nation, please go to the national summary documents:

• **England** • **Northern Ireland** • **Scotland** • **Wales**

This briefing is aimed primarily at the UK Government, the governments of Scotland and Wales, the Northern Ireland Assembly and their respective departments and agencies responsible for energy. However, it should also be of interest to a wider audience.

Key messages

- All energy-related infrastructure is at risk from the impacts of climate change, especially due to the changing frequency and intensity of surface water and coastal flooding.
- High and low temperatures, snow and ice, high winds and lightning can all cause disruption to the energy network. The future risks from wind and lightning are more uncertain than for other hazards.
- Energy infrastructure assets represent a key element of the UK infrastructure system and could affect, or be affected by, failures of other assets due to extreme weather such as transport, information and communications technology (ICT) and water infrastructure including reservoirs, pipelines, water treatment plants and sewage treatment plants.
- There are also risks to buried infrastructure such as gas pipelines, with damage potentially becoming more frequent in future due to flooding (affecting bridges that carry pipelines) and subsidence.
- Hydroelectric power output can be affected by high and low river flows, which may be affected to a greater extent in future due to expected changes in rainfall patterns. Impacts have been seen in recent years, including reduced generation in 2018 due to the very dry summer.
- The potential for reduced water availability in future could reduce output of thermal power generators and potentially biomass and gas power output.
- The risk of more frequent destabilisation or degradation of offshore infrastructure due to sea level rise and more extreme weather could also occur in future, though this is difficult to quantify.
- Household heating demand is very likely to decrease due to warmer winters, and cooling demand is likely to increase in hotter summers if air conditioning uptake increases. These changes may alter the pattern of peak electricity demand for energy companies.

Risks, opportunities, and benefits of further action

More action needed

Further investigation

Sustain current action

Maintain a watching brief

Average UK wide scores

I1. Risks to infrastructure networks (water, energy, transport, ICT) from cascading failures

I2. Risks to infrastructure services from river, surface water and groundwater flooding

I3. Risks to infrastructure services from coastal flooding and erosion

I4. Risks to bridges and pipelines from flooding and erosion

I6. Risks to hydroelectric generation from low or high river flows

I7. Risks to subterranean and surface infrastructure from subsidence

I9. Risks to energy generation from reduced water availability

I10. Risks to energy from high and low temperatures, high winds, lightning

I11. Risks to offshore infrastructure from storms and high waves

H6. Risks and opportunities from summer and winter household energy demand

1. Risks to infrastructure networks (water, energy, transport, ICT) from cascading failures (I1)

Vulnerabilities on one infrastructure network can cause problems on others, and energy infrastructure represents a significant part of this system. Recent research conducted to support the CCRA has indicated that the vulnerability of interconnected systems may be significantly underestimated.

The risk of network failures is already high, potentially affecting hundreds of thousands of people per year, in urban areas in particular.

There are many examples that show how energy is an integral part of this interconnectedness. Some examples in recent years have included:

- Interruptions to the supply of biomass to power stations following flooding of the Port of Immingham
- Flooding of electricity substations at Gatwick Airport resulting in the disruption of 13,000 airline travellers.
- The loss of electrical power at a major exchange in Birmingham which led to the loss of broadband connection to hundreds of thousands of UK customers
- Widespread power cuts in and around Edinburgh due to winter storms in February 2021.
- Power cuts in England and Wales due to lightning strikes in August 2019.
- Power cuts in Northern Ireland due to Storm Ciara in February 2020.

In another study, it has been estimated that the total economic loss resulting from the failure of five electricity substations to be around £27 million per day.

Power shut offs can also be a required response to climate-related incidents due to safety risks during flooding or the potential for sparking in dry weather leading to wildfires, although such risks are likely to be lower in the UK due to a strong network redundancy. However, as a result of such analysis, the overall risk of cascading failures is of high magnitude now and in future in all scenarios across the UK.

Beneficial actions in the next five years include:

- **Improving resilience to a single infrastructure sector (such as protecting electricity substations from flooding), the benefits of which can become much greater when considering the cascading impacts that are then avoided.**
- **Using common formalised standards of resilience, such as the new ISO 14091 standard, across different infrastructure sectors including the energy sector to help build systemic resilience across the whole infrastructure system.**

Further details on this risk: Infrastructure Technical Chapter, I1

2. Risks to infrastructure services from river, surface water flooding (I2)

River and surface flooding is a perennial risk to UK infrastructure, with each season adding new evidence to underpin the significant magnitude of the threat.

Risks to energy infrastructure from flooding include the flooding of facilities, damage to power lines and disruption to power stations.

Data show that 178 power stations and 575 substations are currently at significant risk from surface water flooding and 67 power stations and 234 substations are at risk from river flooding across the UK.

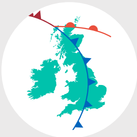
The risk increases significantly from surface water flooding in the future, potentially doubling the risk in a 4°C warming scenario.

Conversely, the risks from river flooding to energy infrastructure generally decrease in the future.

Beneficial actions in the next five years include:

- **Developing consistent indicators of resilience to flood risk across all critical national infrastructure sectors and networks, including energy. This would allow for improvements across the board to be better measured over time for different sources of flooding, building on improvement in local hazard information, such as the Cabinet Office's Resilience Direct platform which provides street-level surface water flood forecasts to authorities and category 1 and 2 responders.**
- **Bringing forward further planned adaptation work in the protection of electricity substations; for example, it is estimated that if National Grid brought forward the entirety of planned works scheduled for 2022, this would result in additional savings of £133,260,000 in avoided expected annual losses.**

Further details on this risk: Infrastructure Technical Chapter, risk I2



The UK is expected to experience **warmer, wetter winters** and **hotter, drier summers** as the climate changes. **Sea levels** will also continue rising.

3. Risks to infrastructure services from coastal flooding and erosion (I3)

Sea levels are currently rising and the rate of rise is accelerating, including around the UK. Coastal flood and erosion risk to infrastructure services, including those associated with the energy sector, will therefore increase.

The consequences of coastal flooding have been tempered over time due to improvements in flood defences, together with advances in flood forecasting, warning and emergency response and spatial planning. Despite this, notable coastal flooding incidents have still occurred that have significantly impacted infrastructure, and assets remain located in low lying coastal areas which will be threatened in the event of a defence failure.

In total, 35 power stations and 34 substations across the UK are in areas at significant risk from coastal flooding. The entire nuclear fleet of power stations is also located in the coastal zone, but they are very well protected.

The risk of coastal flooding will increase as sea level continues to rise. Current projections show the likely change to be between 0.27 and 1.12 metres by the end of the century.

Beneficial actions in the next five years include:

- **The use of adaptation pathways for the long-term planning of flood risk management, first used in developing the Thames Estuary 2100 flood risk management strategy, has been shown to be a promising technique that can be applied more widely in the UK.**
- **Given the uncertainties around sea level rise, 'what if' planning for high coastal risk scenarios can help with understanding what could be done in the event of very high rates of change.**

Further details on this risk: Infrastructure Technical Chapter, risk I3

Later this century more of the rain in summer will come from **short lived high intensity showers.**

4. Risks to bridges and pipelines from flooding and erosion (I4)

Currently, there are no quantitative projections for climate change impacts for bridges and pipelines, with results limited to the identification of weather events and environmental hazards which underlie the risk.

Plenty of case studies are available of present day impacts. For example, following Storm Desmond, Cumbria County Council had to spend around £120 million on repairs to over 270 bridges. Another well-known example is the collapse of the Tadcaster bridge due to flooding in 2015, which also ruptured the gas pipelines that spanned the bridge.

As well as high river flows, warmer temperatures could also damage bridges and pipelines due to heat-related deterioration.

Beneficial actions in the next five years include:

- **Producing future estimates of the risks to bridges and pipelines from flooding and high temperatures. Modifications can be made to bridges to reduce their vulnerability to damage from flooding including any other infrastructure they carry such as cables and pipelines.**
- **For pipelines, improving drainage in areas that regularly flood, monitoring of river and coastal erosion, and the development of flood, coastal and updated contingency defence measures.**
- **Ongoing monitoring and maintenance of both types of assets will remain crucial to spot problems in enough time to act.**

Further details on this risk: Infrastructure Technical Chapter, risk I4

The chance of **extreme maximum daily temperatures** will increase.

5. Risks to hydroelectric generation from low or high river flows (I6)

While hydroelectric power currently represents a small proportion of UK energy capacity (around 2%), there is potential for growth in the future.

Hydroelectric generation is vulnerable to both low river flows and extremely high river flows, which are dependent on rainfall amounts.

Low flows reduce power output. A reduction in hydro generation of 7% in 2018 compared to 2017 was in part attributed to lower rainfall.

Very high flows can damage generation equipment and the associated infrastructure, but conversely, moderate high flows have the potential to improve the output.

The future impact of climate change on hydro output is very much dependent on future patterns of rainfall and temperatures together with changes in the water catchment area.

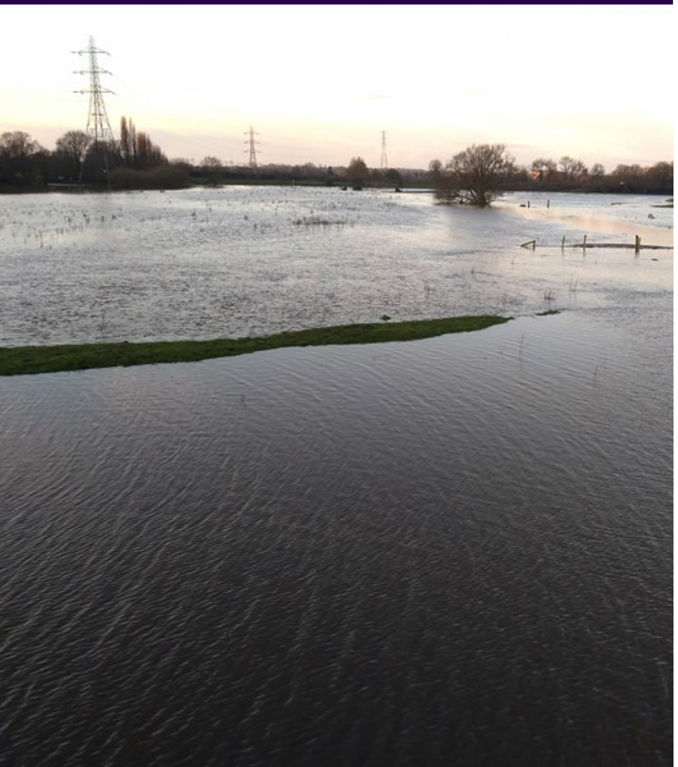
Beneficial actions in the next five years include:

- **Ensure that a range of climate scenarios are included in the planning of new schemes, including during site selection and design, and that this is set out in accompanying Environmental Statements.**
- **For existing sites, carry out site-specific climate risk assessments to advise on the necessary actions required to minimise impacts.**
- **Turbine upgrades and additional spillways and fusegates to control the water flow and alleviate the risks during high flows. There are also structural options to address changes in flood return periods and peak intensity, but these tend to be much more expensive.**

Further details on this risk: Infrastructure Technical Chapter, risk I6

A decrease in soil moisture during summers is projected, consistent with the reduction in summer rainfall

6. Risks to subterranean and surface infrastructure from subsidence (I7)



Damage to infrastructure due to subsidence often occurs as a direct result of shrinking and swelling of clay soils due to changes in soil water content. This form of subsidence is regarded as the most damaging geological hazard in Britain today.

Buried infrastructure is vulnerable to damage and disruption due to climate change driven subsidence effects. However, buried electrical cables are usually sufficiently flexible to accommodate small movements due to shrink-swell subsidence and are usually located at depths where little movement occurs hence these are considered to be at low to medium risk of damage compared to other assets such as gas pipes.

The current overall risk is deemed low rising to medium by the 2050s and beyond across the UK, and confidence in this assessment is low.

Beneficial actions in the next five years include:

- **Production of more accurate and consistent data for understanding the linkages between subterranean and other types of infrastructure, and understanding potential adaptation strategies, which is mainly limited to monitoring at present.**
- **More detailed information on sub-surface composition to predict future behaviour of buried gas pipes, although this would be costly to achieve.**
- **Quantifying the uncertainty in soil properties.**
- **Increased ground and weather monitoring and the use of real-time decision support tools as a potential method to mitigate the risks of shrink-swell subsidence.**

Further details on this risk: Infrastructure Technical Chapter, risk I7

By the end of the century, sea level in places around the UK is projected to rise between **0.29m** and **1.15m**

7. Risks to energy generation from reduced water availability (I9)

Around 60% (by capacity) of all thermal power plants in the UK are cooled with sea and tidal water, including all nuclear generation, with the remainder reliant on freshwater for cooling.

Thermal power generators that rely on freshwater for cooling, including energy from waste plants, are the main type of energy generation vulnerable to a reduced water supply as it could affect their ability to use water as a coolant.

Increasing water temperatures could affect all these assets by reducing the effectiveness of the cooling water and reducing output as a result. Analysis of future risks to the sector suggest there are areas of the UK where existing inland thermal plants source water from areas which are likely to be vulnerable to water scarcity.

However, the UK's commitment to Net Zero by 2050 will see a significant turnover in current thermal plant thus it is important to assess the suitability of locations and the water dependence of Net Zero compliant plant considering future constraints on water availability.

While the risk assessment analysis has mostly focused on risks to the UK's current energy portfolio, it also highlights that potential future energy generation technologies rely on freshwater availability and considers the risks, including to Carbon Capture and Storage (CCS), biomass and biofuel production, hydrogen, and possibly shale gas.

Beneficial actions in the next five years include:

- **For existing thermal generation sites, consider the impacts of abstraction reforms on water availability (England and Wales) and ensure that site-specific risk assessments to assess future water scarcity have been conducted (UK-wide).**
- **Evidence for the risks to the energy sector from higher water temperatures as well as reduced water availability should be kept under review.**
- **Long-term monitoring of the risks to energy generation due to reduced river flows, alongside greater consideration of the potential influence of water scarcity for the UK's Net Zero commitments, which requires regional risk assessments to assess the impact of low flows for new developments.**

Further details on this risk: Infrastructure Technical Chapter, risk I9

4°

The UK could experience an increase in annual average temperature of **up to 4°C** or more by the **end of the century**, depending on the success of global greenhouse gas reductions.

8. Risks to energy from high and low temperatures, high winds, lightning (I10)

The risks to energy infrastructure from extreme weather are already an issue in the current climate.

For example, high temperatures can affect the amount of energy generated from thermal generators and solar panels, high winds and resultant debris can cause damage to power lines, line faults can occur in cold temperatures or due to snow and ice, and lightning can lead to power cuts.

Some communications equipment supporting the national gas grid have been found to have a maximum operating temperature of 40°C (where external temperature and the load on the asset are contributing factors). Summer operation of some facilities is already being affected and this will be exacerbated by projected increases in summer temperatures.

Future modelling has been carried out especially on the impacts of temperature. For example a reduction in solar PV output of between 1 and 3% and thermoelectric generation of 5 and 14% (in scenarios up to a 3°C rise in global temperature) is possible in future due to increasing temperatures.

The ramifications of this is less certain due to the implications of the UK’s Net Zero targets and strategies on the future energy mix and the reliance on different sources such as solar. Moreover, the effects to energy infrastructure from changes in wind and lightning are more uncertain.

Beneficial actions in the next five years include:

- **Gaining a better understanding of the risks from passing specific thresholds that affect energy supply.**
- **Further investigation of the future risks of damage from falling trees due to high winds, alongside a watching brief on the evidence regarding potential changes to wind speeds in future due to climate change.**
- **Further investigation on activities being implemented to protect assets from increased lightning strikes.**
- **Scenario studies looking at the effects of different hazards (high winds and lightning, or high temperatures and lightning for example). Recent years have shown that multiple events (e.g. concurrent lightning strikes) can have severe knock-on impacts on energy supply.**

Further details on this risk: Infrastructure Technical Chapter, risk I10

We can expect increases to **extreme coastal water levels** driven mainly by increases in **sea level rise.**

9. Risks to offshore infrastructure from storms and high waves (I11)

Offshore infrastructure includes equipment used by the oil and gas industry, wind, tidal and wave energy, and gas pipelines and power cables on or under the seabed.

Their vulnerabilities as a result of storms and high waves include the destabilisation or degradation of mechanical structures, reduced energy output and operating periods, damage to cabling systems due to sediment transport and prevention of access for maintenance and inspection activities.

The current risk to offshore infrastructure is low, based on good evidence which has changed little since the previous risk assessment. From the 2050s, the risk is allocated as medium magnitude in part due to increasing offshore renewable energy infrastructure linked to the UK and devolved administration Net Zero targets; the UK's fleet of offshore wind turbines is expected to at least double by 2030 and there are currently about 3,000 offshore wind turbines installed or under construction in UK waters.

A large fleet of oil and gas platforms might also be repurposed for CCS. There is some evidence that changes to wave height, wind speed and sea level rise could exacerbate the risks to offshore infrastructure in future. Current projections show the likely rise in sea level to be between 0.27 and 1.12 metres by the end of the century.

Beneficial actions in the next five years include:

- **Changes to the accessibility of offshore infrastructure to facilitate easier maintenance and crew transfer.**
- **Further investigation into the potential changes in relevant metrics including wind speed and wave heights could better inform design and siting choices, especially given the anticipated expansion of offshore renewable energy and current uncertainties about changes in marine conditions as the climate changes.**

Further details on this risk: Infrastructure Technical Chapter, risk I11

Rainfall is expected to **decrease in summer**, but when it does rain it is projected to be **more intense**, by as much as **25%**.

10. Risks and opportunities from summer and winter household energy demand (H6)

Household heating demand dominates energy use in housing at present. Future heating demand will be reduced by climate change due to warmer winters, and cooling demand is likely to increase in summer, though this is very dependent on how much households take up mechanical cooling measures like fans and air conditioning.

Reduced heating demand may reduce winter fuel poverty, but 'summer fuel poverty,' where householders may not be able to afford cooling, could rise.

The exact level of risk or opportunity, trading off between reduced heating and increased cooling, remains hard to quantify.

In addition, changing energy policy to meet the UK and devolved administration Net Zero targets will have a high influence on this opportunity as there will be big changes in fuel types used, total electricity demand given increasing electrification of the energy grid, and the types of heating and cooling devices that will be most effective in homes given these changing demands in winter and summer. For example, smaller heat pumps may be better given the change to warmer winters.

Beneficial actions in the next five years include:

- **Policies and strategies for heating and cooling in dwellings would be more successful if they include consideration of the changing climate and its effect on energy demand in homes alongside the need to decarbonise. The size of the potential for reduced household energy costs, lower emissions and better indoor environmental quality is enormous if an integrated approach is taken that looks at adaptation and emissions reduction together.**
- **At the same time, keeping track of the UK's Net Zero policies is important. The fast pace of the development of these policies now could affect future options that do not represent the best approach if adaptation is not considered.**
- **This risk/opportunity has been highlighted in the risk assessment as particularly likely to benefit from an adaptive pathway approach. This is where various policy choices are mapped out against different future climate change and Net Zero scenarios, and these choices are narrowed down over time as uncertainty decreases. Adaptive pathways are used routinely in the flooding and water sectors, but to date have not been used widely in energy policy.**

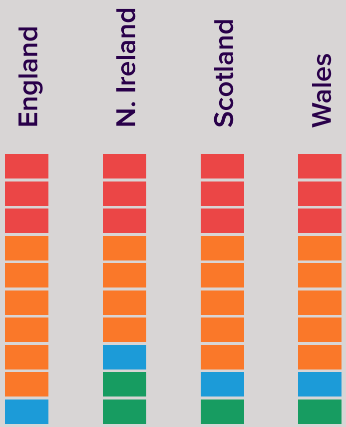
Further details on this risk and opportunity: Health, Communities and Built Environment technical chapter, risk/opportunity H6

The UK is expected to experience **warmer, wetter winters** and **hotter, drier summers** as the climate changes. **Sea levels** will also continue rising.

Variations across the UK

Key

- More action needed
- Further investigation
- Sustain current action
- Maintain a watching brief



Risk or opportunity	England	Northern Ireland	Scotland	Wales
Risks to infrastructure networks (water, energy, transport, ICT) from cascading failures **(I1)**	More action needed	More action needed	More action needed	More action needed
Risks to infrastructure services from river, surface water and groundwater flooding **(I2)**	More action needed	More action needed	More action needed	More action needed
Risks to infrastructure services from coastal flooding and erosion **(I3)**	Further investigation	Further investigation	Further investigation	Further investigation
Risks to bridges and pipelines from flooding and erosion **(I4)**	Further investigation	Further investigation	Further investigation	Further investigation
Risks to hydroelectric generation from low or high river flows **(I6)**	Further investigation	Maintain a watching brief	Further investigation	Further investigation
Risks to subterranean and surface infrastructure from subsidence **(I7)**	Further investigation	Further investigation	Further investigation	Further investigation
Risks to energy generation from reduced water availability **(I9)**	Further investigation	Maintain a watching brief	Maintain a watching brief	Maintain a watching brief
Risks to energy from high and low temperatures, high winds, lightning **(I10)**	Further investigation	Further investigation	Further investigation	Further investigation
Risks to offshore infrastructure from storms and high waves **(I11)**	Sustain current action	Sustain current action	Sustain current action	Sustain current action
Risks and opportunities from summer and winter household energy demand **(H6)**	More action needed	More action needed	More action needed	More action needed

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Background

The UK Government is required by the UK Climate Change Act 2008 to assess the risks and opportunities from climate change to the UK every five years and respond to the risks via a National Adaptation Programme, covering England. The devolved administrations also publish their own adaptation programmes in response to the risk assessment.

For this third UK Climate Change Risk Assessment, the Government's independent advisers on climate change, the Climate Change Committee (CCC), have been asked to prepare an independent risk assessment setting out the latest evidence on the risks and opportunities to the UK.

Over 450 people from more than 130 organisations have contributed to preparing the assessment. The risks have been assessed using the latest climate projections for the UK which were updated in 2018 by the Met Office. These briefings summarise some of the key topics that are assessed through the Technical Report, to enable readers to understand the key messages and where to find more detail.

Where to find more detail

Each risk or opportunity in this briefing has an identifier code linked to the full analysis, which is available in the CCRA3 Technical Report. Readers are encouraged to use these briefings to locate the parts of the Technical Report of most relevance to them.

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