A sector overview 2024

Climate change risks and adaption responses for UK electricity generation

About Energy UK, RenewableUK, Solar Energy UK

Energy UK

Energy UK is the trade association for the energy industry with over 100 members – from established FTSE 100 companies right through to new, growing suppliers, generators and service providers across energy, transport, heat and technology. Our members deliver nearly 80% of the UK's power generation and over 95% of the energy supply for 28 million UK homes as well as businesses. The sector invests £13bn annually and delivers nearly £30bn in gross value – on top of the nearly £100bn in economic activity through its supply chain and interaction with other sectors. The energy industry is key to delivering growth and plans to invest £100bn over the course of this decade in new energy sources. The energy sector supports 700,000 jobs in every corner of the country. Energy UK plays a key role in ensuring we attract and retain a diverse workforce.

RenewableUK

RenewableUK members are building our future energy system, powered by clean electricity. We bring them together to deliver that future faster; a future which is better for industry, bill payers, and the environment. We support over 450 member companies to ensure increasing amounts of renewable electricity are deployed across the UK and access markets to export all over the world. Our members are business leaders, technology innovators, and expert thinkers from right across industry.

Collectively our members employ over 250,000 people - from international energy companies to small companies keen to build new markets and ready to disrupt our energy market with new products and services. The UK has some of the best natural resources in the world for these technologies. Renewables have proven their ability to deliver, and alongside gas and nuclear will be central to keeping the lights on and powering our economy. Our role is to maximise this opportunity and create the conditions that will see the renewable sector continue to thrive here.

Solar Energy UK

Solar Energy UK is an established trade association working for and representing the entire solar and energy storage value chain. We are funded largely by our membership and represent a thriving member-led community of over 400+ businesses and associates. Our members range from ambitious and innovative SMEs to global brands. We are a non-profit organisation working on an exciting agenda to catalyse the collective strengths of our members to build a clean energy system for everyone's benefit.

Acronyms and abbreviations

ARP	Adaptation Reporting Power	GHG	Greenhouse Gas/Gases
AEP	Association of Electricity Producers	GW	Gigawatt
BECCS	Bioenergy Carbon Capture and Storage	IEMA	Institute of Environmental Management and Assessment
BESS	Battery Energy Storage System	IFRS	International Financial Reporting Standards
BS	British Standard	IOAF	Infrastructure Operators Adaptation Forum
BS EN ISO	British Standard, European, and International Organisation for Standardisation standard	IPCC	Intergovernmental Panel on Climate Change
CCC	Climate Change Committee	ISO	International Organisation for Standardisation standard
CCGT	Combined Cycle Gas Turbine	kW	Kilowatt
CCR	Climate Change Resilience assessment	MCCIP	Marine Climate Change Impacts Partnership
CCUS	Carbon Capture Utilisation and Storage	MW	Megawatt
CHP	Combined Heat and Power	NAP	National Adaptation Programme
CNI	Critical National Infrastructure	NIC	National Infrastructure Commission
CDP	Carbon Disclosure Project	NPS	National Policy Statement
CCRA	Climate Change Risk Assessment	OCGT	Open Cycle Gas Turbine
CSRD	Corporate Sustainability Reporting Directive	RCP	Representative Concentration Pathways
Defra	Department for Environment, Food, and Rural Affairs	TCFD	Task Force on Climate-Related Financial Disclosures
E3C	Energy Emergencies Executive Committee	TNFD	Taskforce on Nature-related Financial Disclosures
EMS	Environmental Management Systems	TPT	Transition Plan Taskforce
ESG	Environmental and Social Governance	UKCP	UK Climate Projection

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Executive summary

Energy UK, Solar Energy UK and RenewableUK have jointly collated information on the progress made in the electricity generation sector in adapting since the third Climate Change Adaptation Report (CCAR3) was delivered in 2021 by Energy UK. In previous years, Energy UK responded to the Adaptation Repowering Power rounds, focussing on small and large combustion plants and, for the first time in 2021, on wind. As a result of the solar sector's growing importance and role in reducing greenhouse gas emissions, the scope of this report has also been broadened to include solar farms in this reporting round. In response to a request from the Department for Environment Food and Rural Affairs (Defra) under the fourth round of Adaptation Reporting Power (ARP4), Solar Energy UK and RenewableUK contributed to this report – focussing on solar and wind respectively.

This joint report serves as an update and expansion to existing positions in Energy UK's ARP3 report. Similar to previous reporting rounds, the report has been undertaken at sector level within Great Britain on a voluntary basis. The four main areas of focus for this report include climate change governance within organisations, risk assessments, reviews of action plans, and interdependencies across sectors, which are in line with Defra's guidance and building on Energy UK's submission to ARP3.

Climate governance within organisations with regard to preparedness for future climate risks was a key focus for ARP4. Overall, research demonstrated a good level of engagement with reporting frameworks as well as engagement at management level across all reporting organisations. Additional reporting regimes, such as TCFD and CPD, were furthermore common.

A key aspect of the reporting cycle is to better understand which climate risks either have or could impact an organisation at a project or operational level. Risks to energy from high and low temperatures, high winds, and lightning were a concern for most responding organisations. Flooding was also a widespread risk identified across most technologies, including flooding of site or access routes to site. It should, however, also be noted that risks are factored in other reporting routes. The review of reporting organisations' action plans primarily builds upon the progress demonstrated in the previous report and, overall, demonstrates progress against goals outlined in ARP3.

Energy UK's submission to ARP3 in 2021 already addressed the issue of interdependencies, and an overall lack of a comprehensive understanding of those was addressed, for example, by the Climate Change Committee. Building on the ARP3 submission, engagement in this round of reporting demonstrated that electricity generation companies continue to consider interdependencies with other sectors.

ARP4 has demonstrated that the UK's electricity generation industries continue to recognise that it is vital for the UK Government to understand the climate change preparedness of critical energy infrastructure. However, to ensure Climate Change Adaptation Reporting continues to collect necessary information while remaining proportionate, we recommend that climate adaptation reporting should remain voluntary during the fifth round and beyond of adaptation reporting power and be supported by an easier-to-use template for future reporting. Finally, Defra should provide a clear plan for coordinating and aligning different reporting regimes, which this report also outlines.

1.Introduction

1.1 History of reporting

The generation of electricity is a key component of the UK energy sector, alongside vital parts of the system such as transmission and distribution level infrastructure, oil and gas production and transportation, and other energy services. This report outlines the risks and actions for electricity generation in a changing climate, under the fourth round of the Adaptation Reporting Power (ARP4).

The first round of the Adaptation Repowering Power (ARP1) (2009-11) had nine electricity generation companies reporting into the framework.[1] Energy UK's predecessor, the Association of Electricity Producers (AEP), coordinated these responses through a Resilience and Adaptation Working Group it set up and provided a sector summary of positions. Energy UK produced a full report for ARP2 in 2015[2] and again for ARP3 in 2021,[3] with its wide array of members feeding in at various stages through working groups and internal submissions. In preparation for ARP4, it was decided that the Energy UK report would be co-authored by other trade associations for the first time, with RenewableUK and Solar Energy UK writing a shared response alongside Energy UK.

1.2 Sector profile

This report covers the main electricity generation assets in Great Britain. These include solar farms, wind turbine arrays over 100MWe, larger thermal and hydroelectric power plants over 100MWe, and smaller thermal and hydroelectric power plants of 50MWe – 100MWe. The three trade associations combined represent hundreds of individual members, including those across all generation technologies represented in this report.

Electricity generation is in a period of rapid change. Coal power has now been totally phased out, and the new government's ambition for Clean Power by 2030 sets a clear trajectory away from unabated fossil fuels in the power system.[4] The trajectory for the future power sector has a number of key trends. Firstly, variable renewables, especially offshore wind, will form the bulk of the future power generation mix. Secondly, as a consequence of this, the grid will need to be more flexible. This is both in terms of demand through demand side response services, storage, and interconnection, but it will also require new forms of dispatchable low-carbon power, which

[1] Adaptation Reporting Power: received reports, (Department for Environment, Food & Rural Affairs, 2012).
[2] Climate change adaptation reporting: second round reports, (Department for Environment, Food & Rural Affairs, 2015).
[3] *Climate change adaptation reporting: third round reports,* (Department for Environment, Food & Rural Affairs, 2022).
[4] Make Britain a Clean Energy Superpower, (Prime Minister's Office 10 Downing Street, 2024).

will likely include dispatchable hydrogen gas turbines and gas turbines with CCUS. Thirdly, demand will increase by an estimated 50% by 2035 as the electrification of the economy through the transportation, industrial, and heating sectors continues.[5] This demand will be difficult to predict due to changing consumer patterns in these areas. Finally, the overall costs of power will likely reduce, with higher network costs not outpacing the deeper reductions in wholesale costs from renewables. These factors are causing rapid change, with much of the future power generation infrastructure being built at once. Therefore, these bring substantial risks and opportunities to adapt to future climate change.

Energy UK, RenewableUK, and Solar Energy UK are key stakeholders in the above, representing all the generation technologies involved as well as parts of the associated infrastructure and supply chains.

All three organisations support Clean Power 2030 and embrace the transition to Net Zero. This also means that resilience needs to be incorporated into the new power system the UK is rapidly building, and which will also require navigating the various risks to electricity generation infrastructure and the assets and services.

This report addresses seventeen core climate risks to electricity generation infrastructure, including flooding and heatwaves, and provides an overview of some of the three organisation's member action plans on dealing with these risks, measuring the level of preparedness since ARP3.

1.3 Scope of assessment

In agreement with the Department for Environment Food and Rural Affairs (Defra), this report is co-written by Energy UK, RenewableUK, and Solar Energy UK. The focus is on electricity generation assets found amongst the respective memberships of the three trade associations. As with previous Energy UK reports, the focus is on power generation, although the remit of the associations also crosses over with networks and other forms of energy.

As with the ARP3 report, the report covers both small and large combustion plants, but with an additional focus on wind power, covered by RenewableUK, and the inclusion of solar power through Solar Energy UK for the first time. This is a necessity given the focus of RenewableUK and Solar Energy UK and highlights the rapidly increasing role of variable renewables in the short time frame since ARP3. A slight additional focus has also been paid to alternative combustion technologies such as hydrogen and CCUS to reflect their increasing importance in the generation sector.

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[5] Delivering for 2035: Upgrading the grid for a secure, clean and affordable energy future, (National Grid, 2023).

Given the relatively short timeframes between ARP3 and ARP4, this report will serve as an update and expansion to existing positions in Energy UK's ARP3 report.

As trade bodies, climate change adaptation is not governed by the three organisations but directly by members, which is reflected in the feedback responses from contributing companies in subsequent chapters. A commitment to focus on climate adaptation is included in Energy UK's workstream priorities and Mission Possible, and recommendations for early steps for the government.[6]

[6] The steps to make Britain a clean energy superpower, (Energy UK, 2024).

2.Generation assets

This chapter summarises the electricity generation assets covered by this report and the trade associations' respective memberships. Solar farms are a new addition to this ARP4 report, with updated information on the other areas since the ARP3 report. These assets face climate risk exposure, which is expanded upon in subsequent sections of this report.

2.1 Solar farms

Solar farms are a new addition to the sector's ARP reporting process. Given the role of solar in achieving Clean Power 2030, and the fact it generated 5% of UK electricity in 2023,[7] solar is of rapidly growing significance in the generation mix. Solar farms use arrays of solar Photo Voltaic (PV) panels to convert light directly into electricity. Ground-mounted solar is currently the cheapest source of new electricity generation, reducing the overall cost of energy.

Solar surveyed in this report examines solar farms at a utility scale, and not individual solar on rooftops. Solar farms are designed to operate in temperatures from -40ºC to 85ºC, and across a wide array of climatic conditions.[8] In the early years of the industry UK solar farms were designed to have an operational lifespan of at least 25 years, limited by the subsidy period granted. Since subsidies were removed, 35 years or longer is typical.[9] Many projects in the UK are still in the early stages of their operational life. However, over the next decade, the first generation of solar farms – which were typically granted planning consent for 25 years - will either need to be decommissioned or repowered.

According to market intelligence held by Solar Energy UK there is just under 12GW total capacity of installed ground mounted, utility scale solar in the UK, of which roughly 10% by total capacity represents projects over 50MW, the remaining projects are smaller ranging between 5-50MW.

Solar co-located with Battery Energy Storage Systems (BESS)
The intermittent nature of solar energy means that it doesn't adjust to consumer demand. To maximise the usefulness of energy produced from the sun which is greatest in the middle of the day and in the sunnier summer months, BESS are often now co-located with solar. BESS co-located with solar shares a grid connection and can store energy when it is produced and deliver it at times of peak demand. The most common type of BESS deployed with solar is lithium-ion and today commonly able to do two cycles per day (fully charge and then discharge), with 10,000 cycles per lifetime (typically 15 years).[10]

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[7] Britain's Electricity Explained: 2023 Review, (National Energy System Operator, 2024).
[8] Do solar panels break in heatwaves?, (NXT Gen Energy Ltd, 2023).
[9] *Written evidence submitted by Solar Energy UK,* (Environmental Audit Committee, 2022).
[10] Degradation: The impact on battery energy storage in 2024, (Modo Energy, 2024).

2.2 Wind turbine arrays (>100 MWe)

Large wind turbine arrays (>100 MWe) were covered in the last round of reporting (ARP3) due to a growing contribution to the UK's electricity production.

Onshore and offshore wind generation is the result of the conversion of kinetic energy in wind using wind turbines. In 2023, wind generated a record 28.7% of the UK's electricity needs and it remains the UK's biggest source of clean power, generating over 60% of the UK's renewable electricity last year.[11] In addition, offshore wind generated 17.3% of the UK's electricity in 2023, compared to 13.8% in 2022. Meanwhile, onshore wind provided 11.4% of electricity in 2023, up from 10.8% in 2022.[12]

As highlighted in the ARP3 report, wind turbines and assets are designed, developed, and constructed with the knowledge that all infrastructure is subject to external environmental conditions and forces over their lifetime, affecting their loading, durability, and operation.

2.3 Large thermal and other power plants (>100MWe)

Large thermal plants have traditionally been dominant in the UK's generation mix, but with a focus on greater wind and solar (see above) and smaller flexible plants (see below), this area of technology is subject to rapid change. The current government's goal of Clean Power 2030, as well as the phase out of coal power in September 2024, are key updates to the power sector since ARP3. The former policy goal is likely to see a rapid reduction in gas-fired power, with a currently uncertain level of hydrogen and CCUS plant to provide long-duration dispatchable low-carbon power to compensate for variable renewables and shorter-term flexibility.

- *Combined Cycle Gas Turbine (CCGT)*. CCGTs produced 32% of UK electricity in 2023.[13] The gas is burned in a turbine, rotating the turbine and generating power. As with other forms of fossil fuel combustion plants, CCGTs have the potential to fuel switch to hydrogen, or capture combustion emissions via Carbon Capture Utilisation and Storage (CCS). CCGTs with one or both of these technologies will be required for Clean Power 2030.
- *Biomass combustion*. Biomass produced 5% of UK electricity in 2023.[14] While biomass refers to all forms of combustible organic material (and some non-biological material burned in energy from waste plants), the predominant form of biomass generation in the

[11] Britain's Electricity Explained: 2023 Review, (National Energy System Operator, 2024).
[12] Wind generates record 28.7% of UK electricity needs in 2023 as energy consumption and production drop, (Current+ News, 2024).
[13] Britain's Electricity Explained: 2023 Review, (National Energy System Operator, 2024).
[14] Britain's Electricity Explained: 2023 Review, (National Energy System Operator, 2024).

UK is wood pellets burnt via combustion in converted coal thermal plant. This drives turbines to generate power, with the potential for waste heat to be reconverted for other energy and industrial purposes. Adding biomass combustion with CCUS can result in theoretically negative emissions from biomass plant, known as BioEnergy Carbon Capture and Storage (BECCS).

- *Combined Heat and Power (CHP)*. A CHP plant is a more efficient thermal plant, which utilises the waste heat from combustion for electricity into usage heat for domestic or non-domestic use. 66% of existing CHP use gas as a fuel, with the remainder mostly using biogas.[15]
- *Nuclear*. Nuclear power produced 14.2% of UK electricity in 2023.[16] Nuclear fission created by isotopes of uranium create heat, which boils water to create superheated steam that drives a thermal turbine. Various designs of nuclear reactors are operating in the UK, with all currently scheduled to close by 2029, however lifetime extensions are being considered.[17]
- *Hydroelectric*. Hydropower produced 1.8% of UK electricity generation in 2023.[18] Hydroelectric plants use river flow concentrated at a vertical angle and via a dam to push a turbine and generate power. Variations include pumped storage, using electric pumps to push water uphill and release to power turbines at times of grid stress, and run-of-river hydro, which involves no dam and a turbine placed directly in a river. Marine technologies are a related category, but due to the nascent nature of these technologies we have not assessed them in this report.

2.4 Smaller thermal plant (50MWe to 100MWe)

The ARP3 report focused on the following area of small plants, as that are more localised and connected to regional networks. Adaptation requirements are, therefore, slightly different, and their contribution to dispatchable flexibility, as well as interconnected energy systems like heat networks, makes them a unique category for their own consideration.

- *Open Cycle Gas Turbines (OCGT)*. These operate in a similar manner to CCGTs, but can start or shut down quicker than other turbines. This makes them useful assets for grid response and flexibility. These can be fuelled by gas or diesel fuel.
- *Reciprocating Engine*. Gas or diesel-fuelled reciprocating engines combust with air to produce gases to drive pistons to generate power. These are often used for short-term and backup power generation on a smaller scale.

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[15] Digest of UK Energy Statistics (DUKES): combined heat and power, (Department for Energy Security and Net Zero, 2024).
[16] Britain's Electricity Explained: 2023 Review, (National Energy System Operator, 2024).
[17] New nuclear power in Britain: a politically attractive investment priority for the new Labour government, (Stonehaven Global, 2024).
[18] Britain's Electricity Explained: 2023 Review, (National Energy System Operator, 2024).

- *Combined Heat and Power (CHP)*. CHP is often used at smaller levels for a great variety of uses, often for local heat networks or small industrial sites.

3. Reviews of progress

As per the requirements of the ARP process, Energy UK, RenewableUK, and Solar Energy UK coordinated activities across the three trade associations in planning and assessment of the climate adaptation governance, risks and action plans across the various memberships. Cross-trade association assessments were scheduled throughout 2024, and an ARP4 Steering Group meeting was set up for members with particular expertise on climate risk. Discussion of the ARP4 report and approaches was also developed through Energy UK's Investment Committee, Environment and Planning Subcommittee, and a specific task and finish group set up by RenewableUK.

Feedback was compiled by sending two questionnaires to initially the Steering Group and then wider membership structures within the three trade associations. One questionnaire focused on questions for first-time reporting, and the other was for returning organisations that previously submitted ARP reports, either independently or through Energy UK. Questions asked reflected the three main areas highlighted in the Defra guidance for feedback, which include climate change governance within organisations, risk assessments by those organisations, and reviews of progress on their action plans and other strategies.

Each sub-chapter provides a summary of the collective responses from respondents. Where noteworthy, differences between sectors or different approaches are highlighted separately.

3.1 Climate change governance within organisations

A focus on climate governance within organisations with regard to preparedness for future climate risks was a key part of the guidance provided by Defra for ARP4. Questions that were asked among organisations concerning climate governance included;

- *How is climate change adaptation governed in your organisation, e.g. does your organisation have specific climate change adaptation objectives in its corporate plans or strategies?*
- *Which climate change adaptation standards has your organisation implemented?* Options included ISO 14090, ISO 14091, and BS 8631.
- *Which of the following additional reporting regimes is your organisation already reporting to?* This gave the examples of the Taskforce on Nature-related Financial

Disclosures (TNFD),[19] the Taskforce Climate-Related Financial Disclosures (TCFD),[20] and the Carbon Disclosure Project (CDP).[21]

This framing is designed to concentrate responses to the areas highlighted in the Defra guidance, with either direct framing of guidance questions in the questionnaire or follow-up detail setting out the positions highlighted in the guidance (such as the role of top management in climate adaptation plans). This also separates the various focuses of the reporting regimes above, with the ISOs focusing on standardising processes and products for example, with the TCFD targeting disclosure of climate related financial risks.

The results showed a wide alignment on a key variety of themes. One result that stood out was the emphasis on the level of involvement of company Boards and top management. Respondents emphasised how climate change risks and adaptation strategies were embedded into overall governance, with risk registers, environmental policies, and adaptation strategies being reviewed at Board level. The timescale of presenting climate risks to Boards varies amongst various companies, ranging from twice a year to every five years. The responsibility of climate adaptation was also set at Board level among many companies. Integrating climate adaptation into annual reports was furthermore highlighted among many respondents. As these are publicly available, many of these assessments and their contribution to overall company policy are freely available to compare. This also aligns with top-level engagement highlighted above.

Dedicated internal teams and/or committees overseeing climate risk were also common among respondents. One respondent also noted the use of external consultants to review their company's preparedness for climate risk, in addition to internal teams and analysis. Many of these internal company teams drive various adaptation, sustainability, and environmental plans and strategies published by the representative companies. These include broader company risk registers, company environmental policies, sustainability strategies, or climate transition plans. In addition, companies are also building on previous ARP reports and evidence for report submissions and work on wider alignment with a company's Environmental, Social, and Governance (ESG) strategies and goals.

Furthermore, many of the strategies inform site-level policies to prevent climate risks across a range of UK assets. These include requirements for all assets to be held to design, safety, inspection and maintenance standards. Site managers are required to implement and oversee many of these standards across the responding organisations, especially for extreme weather events and to ensure continued operability for site assets. Existing asset risk processes were in

[19] (The Taskforce on Nature-related Financial Disclosures, 2024).
[20] (The Task Force on Climate-related Financial Disclosures, 2024).
[21] (The Carbon Disclosure Project, 2024).

place across respondents, with application to individual assets across portfolios. Site-specific risk assessments were reported across a range of respondents, and one reported that upcoming development and sustainability action plans for sites include a requirement to use climate scenarios in future planning.

However, there was less alignment on certified climate adaptation standards. We described the three standards we highlighted in the questionnaire as the following;

- ISO 14090: provides organisations with a practical, structured approach for addressing and adapting to the effects of climate change over the short, medium, and long term.[22]
- ISO 14091: provides guidelines to assess climate change related risks, covering vulnerability, impacts and risk assessment.[23]
- BS 8631: provides guidance to support the business area, project, or asset managers to implement adaptation pathways.[24]

Only one respondent reported using anything other than ISO14090 in their assessments, with a majority of respondents not reporting using ISO 14090, ISO 14091, or BS 8631 in their assessments of climate risk. That company used a literature review to underpin its overall strategic approach including the development of the methodology for future climate change risk assessment and adaptation planning processes. Additional guidance the company also integrated included BS EN ISO 22301, a standard that requires a documented management system to plan and prepare for and respond to disruptive incidents for organisations when they arise. BN EN ISO 14001, a standard for Environmental Management Systems (EMS), was also used. This particular standard produces a framework for organisations to manage their environmental responsibilities systematically within an organisation to contribute to overall environmental goals. Another company in the response stated they use ISO14090, but only in relation to specific site audits, with the rest of the responses stating they used none of the above standards.

The TCFD was a common additional reporting regime amongst respondents, well represented across respondents. Companies reported adopting TCFD reporting, for example in their Corporate Sustainability Reporting Directive (CSRD). Some companies have started aligning climate-related financial disclosures in their company's annual reports.

[22] ISO 14090:2019 Adaptation to climate change — Principles, requirements and guidelines, (International Standards Organisation, 2024).
[23] Adaptation to climate change — Guidelines on vulnerability, impacts and risk assessment, (International Standards Organisation, 2024).
[24] BS 8631:2021 Adaptation to climate change. Using adaptation pathways for decision making, (British Standards Institute, 2021).

Respondents reported also using TNFD reporting, with one respondent noting they were an early adopter of TNFD, with the company's nature strategy nearing completion. The TNFD progress is furthermore integrated into another company's ESG goals.

CDP reporting was also very common, including one company applying the methodology to their wider supply chains. Respondents were also asked to provide information about other types of additional reporting regimes and policies to support them. Responses included for example, additional reporting for specific nuclear requirements to the Office for Nuclear Regulation for technology-specific requirements and potential hazards.

At this stage, it is worth noting that renewable energy developers complete Environmental Impact Assessments as part of the planning process for all new developments. These include a chapter on Climate Change, typically incorporating a Greenhouse Gas (GHG) assessment and a Climate Change Resilience (CCR) assessment. The CCR assessment identifies appropriate mitigation measures which are incorporated into the design of the Proposed Development so that it will be resilient to climate change impacts over its lifetime.

The results demonstrated a good level of engagement with reporting frameworks as well as engagement at management level across all reporting organisations. However, a lack of compliance with climate adaptation standards amongst respondents continues to be notable.

3.2 Risk Assessment

Member organisations were asked *Which of the following climate risks have impacted or could impact your organisation on a project/operational level?* Respondents were asked to choose which assets fell into which risks, with the assets including;

- Onshore wind
- Offshore wind
- Solar
- Combined Cycle Gas Turbine
- Open Cycle Gas Turbine
- Biomass combustion
- Combined Heat and Power
- Nuclear
- Hydropower

Physical risks to much of the current and future generation assets in the UK remain very low. However, as part of the sector's due diligence, climate risk assessments remain an integral part of day-to-day development, and assessment of risk to assets is deeply embedded in many organisations' management (as can be seen in Section 3.1).

The risks asked in the survey to respondents were based on Defra's Third Climate Change Risk Assessment (CCRA3), published in 2022.[25] Given this was published after the ARP3 report in 2021, the criterion for risks to generation have been adjusted accordingly, with the risks asked for by respondents now being the following:

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

Cascading risks were highlighted as a particular concern for assets with highly interconnected systems, such as thermal generation. This was also echoed for disconnection from the gas network for gas assets. Disruption to the transmission and distribution grids was presented as a large risk for all generation types. It was highlighted that site teams are at risk in these cases as they do not have control of these external assets.

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

Flooding was a widespread risk identified across most technologies. This included flooding of site (e.g. due to river, surface water or groundwater flooding), flooding of access routes to site (e.g. due to river, surface water or groundwater flooding), extreme high river water levels and other impacts from flood events. Plant and equipment damage and resultant loss in generation during flood events were identified as risks, with loss of generation highlighted by several respondents as a risk. A few respondents also noted the risk of contaminant leaks in a flood event, such as oil separators becoming overwhelmed.

3. **Risks to infrastructure services from coastal flooding and erosion.**

Several plants, including CCGTs and Nuclear, are sited on coastal areas, and plant and equipment damage from coastal flooding was identified in much the same way as option 2 above. Erosion due to rising sea levels was a long-term concern shared by many.

4. **Risks to bridges and pipelines from flooding and erosion.**

Only one respondent highlighted risks here, specifically to flooding causing exposure of underground gas pipelines and resultant risk of damage to these in a flood event.

5. **Risks to hydroelectric generation from low or high river flows.**

Only one respondent highlighted the risk to their hydroelectric assets, with either extreme high river flows or droughts causing low river flows an identified risk.

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[25] UK Climate Change Risk Assessment 2022, (Department for Environment, Food and Rural Affairs, 2022).

6. **Risks to subterranean and surface infrastructure from subsidence.**

A majority respondents raised this risk across most technology types. Damaged infrastructure due to subsidence affecting generation output was the cause for concern.

7. **Risks to energy generation from reduced water availability.**

Drought and low river flow leading to reduced water availability for thermal plants was the predominant concern, although there was some overlap with reduced flow for hydroelectric plants identified in option 5 above, with most respondents highlighting this as an issue. A particular concern was highlighted for multiple CCGTs abstracting water for the same source, with future resource a potential constraint on operation.

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

The largest number of responses and additional detail was laid out for this category of risks, highlighting the breadth of issues and particular concerns in this area. High temperature risks impacting the physical properties of infrastructure such as wind turbines, as well as the efficiency of steam turbines in higher temperatures and the efficiency of solar PV panels were all identified. One respondent noted that an inability to discharge cooling water at one of their thermal sites due to high air temperatures had already been experienced by them, as well as affecting the cooling system for the plant.

Colder temperatures had fewer identified risks, but icing of wind turbines, heavy snowfall, and freezing of assets such as water tanks in thermal plants are all risks that were put forward. Less identified were risks of wildfires and lighting, although concerns over wildfires spreading to sites was raised.

Other risks raised included changes to wind patterns in different climates leading to changes in power output. Change in wind patterns leading to changes in power output. High winds can also lead to debris on solar PV panels, blocking power production, as can changes in cloud cover patterns. Changes in precipitation are also likely to affect solar power production in the same way.

9. **Risks to offshore infrastructure from storms and high waves.**

Offshore wind was the only technology highlighted in this category, with relatively few risks identified. However, as with onshore wind, changes in wind patterns in a future climate and the resultant power output for turbines was a concern. Low wind speeds affecting output was identified, but so were extreme winds in future climate patterns. Storms and high waves are an asset risk to offshore infrastructure, particularly in extreme weather events.

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

Few risks in this category were identified by respondents, with only one respondent noting a requirement to be more flexible and efficient running at peak times may affect their emissions, air quality and water usage at plant in more unpredictable ways.

Other risks highlighted included areas not covered by the above guidance, but risks emerging in the transition to the low carbon economy. These included legal challenges, including potential restrictions on water or land use, shifts in demand driven by technological advancement and market evolution, as well as reputation risks to customers during the transition.

It was also notable that for many organisations they were identifying risks they had never actually experienced at their sites. They emphasised preparedness and changing future conditions. It was noted that both wind and solar are adaptable and resilient. Being light, robust, easy to dismantle, and with approximately 25-30 years of operation, it was noted that wind and solar assets are well suited to adaptability in a changing climate. Given the nature of nuclear plants, it was also noted that these were built to strict risk standards, which overlapped significantly with climate risks. A full range of risks across asset types have clearly been considered at a broad level, including for near term, present risks to assets, as well as longer-term and less likely impacts, ensuring a wide scope of potential resilience.

3.3 Reviews of action plans

Actions to mitigate the risks highlighted by members above tended to be managed between newer assets under development and construction and older assets currently in long-term operation.

Most respondents reported that new assets have climate risk based on the four IPCC RCP scenarios (ranging from 2080-2100 timescales) built into their assessments during the development and construction phases. Managing these risks sits with the site operators and includes a path to escalate to fleet and higher levels within companies. This clearly demonstrates that there is a clustering of technology types, with newer onshore wind, offshore wind, solar, hydrogen, CCUS, and nuclear projects having climate risk built into asset design.

Existing thermal plant, hydropower, and retrofits to existing plants (such as fuel switching CCGTs to hydrogen) have climate risk mitigated by site managers on a more site-by-site basis. Site-level policies include site managers that create mitigation policies which are added to Business Impact Assessments, crisis management and incident response, large capital project governance and internal/external assurance, and Continuity Plans, as well as wider corporate asset risk plans. Examples given included site emergency procedures to mitigate flooding, such as locating vulnerable areas of a plant away from specific areas of risk. Mitigations for local climate and regional variations were another example, including for areas of winter working. From the data we received, nuclear should be able to demonstrate a strong focus on less frequent events. Organisations managing these assets include plans to mitigate all risks with a 1 in 10,000-year probability of occurrence, as well as a systemic review of the entire safety case for sites.

One respondent noted using Integrated Management Systems for risks, with specific company processes specified in internal documents. This involves senior management engagement as part of this process. Evaluations of this system are taken at various levels, including via external auditors. Climate change adaptation specifically has a range of dedicated actions under this respondent's system, which are linked to other business continuity plans and parts of the supply chain.

An issue that was singled out by a couple of respondents was adapting to risk around changing weather patterns caused by climate change and their effect on wind and solar production in future decades. Given the reliance of the future grid on these generation technologies, any potential risk to the security of supply under the range of future climate scenarios was a concern. However, assessment of future climate pathways only found marginal drops in potential production across the worst-case scenarios. Mitigation in place included a continued review of climate scenarios and pathways, with the Met Office UK Climate Projection (UKCP18) being cited by one member as an area of focus. Meteorological monitoring (over both short and long term), while integrating responses into the crisis management and business continuity from other climate risk strategies.

Cascading risks relating to water and gas networks were a concern, but in particular, connecting to the distribution and transmission grid during climate impacts such as extreme weather events was raised. Mitigating actions were communication with and crisis management systems to distribution and transmission operators. Given the focus of this report on generation adaptation plans, some of the links on networks are out of scope. However, it highlights the reliance on a successful adaptation plan in the electricity generation and electricity networks space. For generation assets using water and gas, this extends to successful adaptation plans on gas networks and water infrastructure.

Industry confidence in its plans to manage with future climate risks was notably high in the responses received. Many organisations felt that all risks had been well identified and prepared for, the critical issue was merely the level of risk that would need to be prepared for. Confidence in renewables being adaptable, as well as confidence in existing adaptation plans for thermal plants, demonstrated the sector's confidence in preparing for future risks. However, interdependencies can reduce some of this, as the above point on electricity, gas, and water networks incorporates risks outside many respondents' control (more details on interdependencies are featured in Chapter 4).

Respondents also provided additional examples of site-specific responses to specific risks. These included black start protocols in response to cascading risks. Flood risk assessments with recommendations on drainage systems, vegetation removal, reserves of chemicals or other resources in case of transport blockage, and other systems for flood prevention were also cited. The identification of underground gas pipelines, surveying ground conditions, and monitoring of cooling and extraction systems, where also listed.

Progress against these goals in ARP3 was already significantly advanced. As this report primarily updates the previous one, and the criteria for risks have changed in the CCRA3, it builds upon the progress demonstrated in the earlier report. The seventeen risk criteria in previous CCARs have been condensed down to ten to align with the Defra guidance. All seventeen are collectively covered by all the respondents, as demonstrated in Section 3.2 above. It is clear from the responses that while work is ongoing to update and streamline much of risk reporting, areas of risk are already well covered amongst responding organisations.

4. Addressing interdependencies (across sectors)

Energy UK's submission to ARP3 in 2021 addressed the issue of interdependencies, noting the need to understand and work to mitigate interdependencies, referencing WSP's work on interdependencies and the National Infrastructure Commission's study on the resilience of the nation's economic infrastructure. Interdependencies can include disruptions to electricity, telecoms or transport networks but can also go as far as implications for supply chains.

Since ARP3, the lack of a comprehensive understanding of interdependencies was addressed by the Climate Change Committee, the National Infrastructure Commission, and the UK Parliament Joint Committee on the National Security Strategy.

The Joint Committee on the National Security Strategy highlighted in their report *Readiness for storms ahead? Critical national infrastructure (CNI) in an age of climate change*[26] that "the UK's critical national infrastructure is "fundamental to the smooth running of the economy and society" and that it is "increasingly interconnected". The Joint Committee found "very little join-up between CNI sectors, with no formal mechanism for collaboration or information-sharing on interdependencies."

The Climate Change Committee's 2023 report *Delivering a reliable decarbonised power system*[27] also highlighted the risk of cascading impacts of extreme weather events and concluded that more action is needed to "understand the scale of interdependency risk between the energy system and other key infrastructure". In addition, and in collaboration with the National Infrastructure Commission, the Climate Change Committee also wrote to ministers, urging them to take steps to improve the resilience of key infrastructure services.[28]

Engagement with members as part of ARP4 research, we found that electricity generation companies continue to consider interdependencies with other sectors. These include but are not limited to the approaches outlined below, which address both internal processes as well as engagement with other key stakeholders:

- Interdependencies are considered in companies' climate change adaptation programmes. Regarding internal processes, companies have risk controls in place at the site level to identify and manage risks and interdependencies. Additionally, companies have continuity management procedures to immediately respond to extreme and unexpected weather events.

[26] Readiness for storms ahead? Critical national infrastructure in an age of climate change, (The Joint Committee on the National Security Strategy, 2022).
[27] Delivering a reliable decarbonised power system, (Climate Change Committee, 2023).
[28] NIC and CCC call for urgent action to protect infrastructure from climate risks, (National Infrastructure Commission, 2023).

- Companies are furthermore engaged in a number of forums that address the need for collaboration on interdependencies, which include infrastructure forums and industry groups, such as the Infrastructure Operators Adaptation Forum (IOAF). In addition, companies have previously worked with the Energy Emergencies Executive Committee (E3C) and other regulators to better understand specific scenarios. Finally, companies that are part of the Transition Plan Taskforce (TPT)[29] are furthermore required to identify interdependencies.
- The sector has also done more to make progress on regional, multi-level water resource use planning, as energy and water are key interdependencies. The role of water usage for low carbon technologies such as hydrogen and CCUS has come under increasing analysis since ARP3, and further work in this sector is likely to continue.

Due to the increased electrification of the economy, interconnectivity between industries will inevitably increase, and simultaneously, the need for a better understanding of risks associated with it. While trade associations have a vital role to play in supporting coordination, there is a greater need for coordination and oversight roles within government that will ensure a systematic approach is taken.

4.1 New initiatives since ARP3 (2021)

Timeline since ARP3:

- UK Government:
  - January 2022: CCRA3 (Climate Change Risk Assessment)[30]
  - January 2022: ARP3 reports published[31]
  - February 2023: Joint Committee on the National Security Strategy: *Readiness for storms ahead? Critical national infrastructure in an age of climate change. First report of session 2022-23*[32]
  - July 2023: 3rd NAP report published[33]
  - November 2023: *Overarching National Policy Statement for energy (EN-1)*[34]
- National Infrastructure Commission (NIC):
  - April 2023: *Delivering net zero, climate resilience and growth: Improving nationally significant infrastructure planning*[35]

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[29] TPT legacy, (International Transition Plan Network, 2024).
[30] UK Climate Change Risk Assessment 2022, (Department for Environment, Food and Rural Affairs, 2022).
[31] Climate change adaptation reporting: third round reports, (Department for Environment, Food & Rural Affairs, 2022).
[32] Readiness for storms ahead? Critical national infrastructure in an age of climate change, (The Joint Committee on the National Security Strategy, 2022).
[33] Third National Adaptation Programme (NAP3), (Department for Environment, Food & Rural Affairs, 2023).
[34] Overarching National Policy Statement for energy (EN-1), (Department for Energy Security and Net Zero, 2023).
[35] Delivering net zero, climate resilience and growth, (National Infrastructure Commission, 2023).

- Climate Change Committee (CCC):
    - June 2022: *2022 Progress Report to Parliament*[36]
    - March 2023: *Progress in adapting to climate change – 2023 Report to Parliament*[37]
    - June 2023: *2023 Progress Report to Parliament*[38]

Climate Change Committee 2023 Report to Parliament: Progress in adapting to climate change

The Climate Change Committee's last annual assessment of England's progress in adapting to climate change was published in March 2023[39]. The assessment found that the second National Adaptation Programme "has not adequately prepared the UK for climate change, highlighting the "limited evidence of the implementation of adaptation at the scale needed to fully prepare for climate risks facing the UK."[40]

In their summary on the energy sector, the Climate Change Committee highlighted mixed progress on efforts to reduce the vulnerability of energy assets to extreme weather and to create a system-level security of supply. Due to a lack of policies and plans, the Climate Change Committee could not evaluate interdependencies. Interdependencies were addressed in chapter four of this report.

The Climate Change Committee's report highlighted the change in weather and climate, including higher summer temperatures, increased risks and severity of summer drought, as well as increased winter rainfall and flooding.[41] The report furthermore highlighted the risks around the electrification and diversification of the generation mix required to reach Net Zero.

Since 2021, a number of severe weather events have impacted energy generation, as well as unusually weather patterns in particular years. For example, 2022 was less windy than average.[42]

Timeline of notable severe weather events (2022 – 2024)

2022
- Unprecedented July heatwave
- Drought (early spring to autumn)

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[36] 2022 Progress Report to Parliament, (Climate Change Committee, 2022).
[37] Progress in adapting to climate change – 2023 Report to Parliament, (Climate Change Committee, 2023).
[38] 2023 Progress Report to Parliament, (Climate Change Committee, 2023).
[39] Progress in adapting to climate change – 2023 Report to Parliament, (Climate Change Committee, 2023).
[40] Ibid
[41] Ibid
[42] Offshore Wind Report, 2022, (The Crown Estate, 2023).

- Storms Dudley, Eunice and Franklin

2023

- Storms Otto, Babet and Ciarán
- September heatwave
- Exceptional rainfall in Scotland
- Second-warmest year on record for the UK (after 2022)

2024

- Storms Isha and Jocelyn

5. Future reporting and uncertainties

The UK's electricity generation industries recognise the importance of climate change resilience and preparedness. This is particularly pertinent in the context of recent weather events. As highlighted by The Crown Estate, the UK experienced one of the worst heat waves in decades in 2022.[43]

It was noted by a respondent that future revision of approaches to climate risk would be based on published standards and regulator guidance. This would update previous assessment and shape responses to future ARP rounds. Some ongoing work in this space includes onshore wind flooding resilience.

The UK's electricity generation industries recognise that it is vital for the UK Government to understand the climate change preparedness of critical energy infrastructure and is therefore committed to engage with government on a voluntary basis going forward.

To ensure Climate Change Adaptation Reporting continues to collect necessary information while remaining proportionate, Energy UK, RenewableUK and Solar Energy UK have put forward a set of recommendations that should inform the next adaptation reporting round.

Reporting as part of Defra's Adaptation Reporting Power remains voluntary for the UK's electricity generation industries; however, our understanding is that it is expected to be mandatory from ARP5 onwards.

The industry is concerned that mandating climate change adaptation reporting is at risk of duplicating existing reporting requirements already performed by developers. Industry sees an opportunity to better align reporting regimes, reducing the risk of duplication or burden on industry.

List of reporting frameworks include[44]:

- Task Force on Climate-related Financial Disclosures (TCFD)
- Taskforce on Nature-related Financial Disclosures (TNFD)
- Corporate Sustainability Reporting Directive (CSRD)
- Carbon Disclosure Project (CDP) reporting
- IFRS Sustainability Disclosure Standards
- Global Reporting Initiative (GRI) Standards
- European Sustainability Reporting Standards

[43] Ibid
[44] Understanding the Global Reporting Frameworks, (Beyond the Balance Sheet, 2024).

With the above in mind, for future reporting requirements, we would recommend the following;

Recommendation 1: Climate adaptation reporting should remain voluntary during the fifth round and beyond of adaptation reporting power, with the continued communication of timescales and expectations from the fourth round to assist reporting organisations. Climate Change Adaptation reporting should continue through a cross-sector level response, facilitated through the trade associations and Defra producing a standardised set of questions.

Recommendation 2: Provide a clear plan for coordinating and aligning different reporting regimes. This will have to simplify and streamline the existing range of regimes to maximise efficiency.

Recommendation 3: Design an easy-to-use template for future reporting and standardised set of questions, including greater detail on submitting progress on interdependencies.

6. Conclusions

Since ARP3, many trends have either continued or accelerated in the electricity generation space. Rapid decarbonisation, especially significant with the incumbent government's focus on Clean Power by 2030, now makes wind and solar the emerging backbone of electricity generation. With this, however, comes the need for low-carbon dispatchable power, and therefore, the role of retrofitting existing thermal sites to new technologies continues to put their adaptation procedures in the spotlight. To this end, there is a clear level of confidence in the feedback that the sector has identified the depth and breadth of climate risks to their businesses, and these are understood at a high level within organisations. The sector has a good level of preparedness, despite concerns over cascading risks from the electricity network, gas supply, and water supply sectors. Alignment with standardisation may be an issue, which is why we also recommend streamlining climate adaptation standards where possible. Given the shorter timescales, there have been relatively few large changes since ARP3; however, on behalf of the sector, we hope this report can play a meaningful and constructive role in climate change adaptation policy.

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