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FOR WHAT COMES NEXT

Future-Proofing Digital Infrastructure

Climate Resilience in the Data Centre Sector

Committed to Climate Action

About techUK

techUK is the trade association which brings together people, companies and organisations to realise the positive outcomes of what digital technology can achieve. With around 1,000 members (the majority of which are SMEs) across the UK, techUK creates a network for innovation and collaboration across business, government and stakeholders to provide a better future for people, society, the economy and the planet. By providing expertise and insight, we support our members, partners and stakeholders as they prepare the UK for what comes next in a constantly changing world.

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Data Centres Programme

techUK's award-winning Data Centres Programme provides a collective voice for UK operators. We work with government to improve the business environment for our members. To date we've saved UK operators over £150M, alerted them to business risks, mitigated regulatory impacts and raised awareness. techUK is a signatory of the Carbon Neutral Data Centre Pact.

Foreword

Data centres are the backbone of the UK's economy and society, powering everything from online banking and healthcare applications to streaming services and remote working tools. They contribute over £4.bn GVA to the UK economy, employ over 40,000 well-paying jobs and have the potential to double this in the next 5 years[1]. The recent recognition of data centres as Critical National Infrastructure (CNI) by the government is a welcome step forward, highlighting the central role these facilities play in the economic prosperity, security, and resilience of the UK.

The sector has long championed resilience – not just operationally but also with regard to environmental and climate challenges. However, data centres are often misunderstood by policymakers and the public alike. Despite their proactive approach to sustainability and rigorous adherence to efficiency standards, data centres are under heightened pressure and scrutiny. This attention is warranted, but it is crucial to recognise the fine balance between climate resilience and climate mitigation. Data centres must constantly weigh these considerations to protect both the continuity and sustainability of digital services, which is a complex task.

With this recent CNI designation, we are optimistic that the sector can work more closely with government to shed light on the unique operational realities it navigates and secure the support needed to advance climate resilience, net-zero and energy security goals. Data centres now require a permanent and active role in policy discussions to ensure that efforts to combat climate change are coordinated with resilience initiatives that reinforce our infrastructure's stability and capacity.

techUK thanks the Department for Environment, Food and Rural Affairs (Defra) for the opportunity to report on behalf of the sector and remains committed to bridging the gap between government and the data centre industry. By building a foundation of shared understanding, we look forward to collaborating with policymakers to foster a sustainable, resilient and digital future for the UK.

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[1] techUK (2024) "*Foundations for the future: how data centres can boost UK economic growth"* Available at: https://www.techuk.org/resource/techuk-report-foundations-for-the-future-how-data-centres-can-supercharge-uk-economic-growth.html (Accessed: 5 November 2024)

Introduction

Executive summary

This voluntary report, submitted under the Adaptation Reporting Power, provides an overview of physical and transitional climate change risks, current resilience measures, best practices, and key gaps that data centres, government, and interconnected sectors must collaboratively address to secure the long-term sustainability, reliability, and resilience of the UK's digital infrastructure amid escalating climate challenges.

Data centres are inherently resilient due to their carefully selected sites, robust construction, and systematic risk management. Standards, including those from the International Organization for Standardization (ISO), guide resilience efforts. Collaboration across the industry is strong, with data centre operators working with organisations like the Climate Neutral Data Centre Pact to promote shared resilience strategies and best practices.

The sector demonstrates early compliance with stringent sustainability regulations, including many derived from the EU acquis. Data centres in the UK are proactively aligning with anticipated regulatory changes by developing comprehensive reporting practices and implementing operational adaptations ahead of legal requirements, demonstrating a commitment to sustainability and resilience.

The report identifies key physical climate change risks, including water stress and heatwaves as priority concerns with the highest potential to disrupt operations in the UK in the near future. To address these risks effectively and stay ahead of evolving climate challenges, the sector must overcome several critical barriers.

A significant issue facing the sector is its dependency on other sectors, especially energy. This complicates resilience efforts, as adequate power is essential for continuity, yet the grid is currently insufficient to support surging demand. In particular, the expected rise in AI applications could increase data centre electricity demand sixfold over the next decade, posing risks unless energy infrastructure modernises to meet these needs[2]. Initiatives like on-site renewable energy generation, nuclear, and green hydrogen are under exploration but are not yet sufficient to meet demand alone.

In addition to energy dependencies, the sector faces challenges from workforce shortages and the clustering of data centres in specific regions due to customer preferences, planning considerations, as well as energy and fibre availability. Clustering intensifies the risk of service disruptions from localised climate events, while skill shortages impact the sector's ability to implement resilience measures effectively.

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[2] Shankleman, J. (2024) *"AI will suck up 500% more power in UK in 10 years, Grid CEO says"* Bloomberg. Available at: https://www.bloomberg.com/news/articles/2024-03-26/ai-will-suck-up-500-more-power-in-uk-in-10-years-grid-ceo-says?embedded-checkout=true (Accessed: 20 August 2024)

Another notable barrier is the uneven application of resilience standards for on-premise data centres (where servers are kept on-site), especially within the public sector. On-premise data centres fall short of the robustness found in commercial data centres, leaving critical gaps in the broader digital infrastructure's climate preparedness.

Regulatory hurdles further complicate resilience efforts. While some policies encourage sustainability, others, like the UK Emissions Trading Scheme (UK ETS), inadvertently burden the sector, reducing its capacity to invest in resilience and meaningful sustainability initiatives. The lack of understanding of data centre operational needs among policymakers leads to regulatory misalignments and missed opportunities.

Given their designation as CNI, data centres should be closely involved in policy discussions that affect their operations or supply chains, ensuring that regulations support rather than hinder the sector's capacity to withstand climate impacts. This report serves as a call for ongoing adaptation and sector-specific regulatory support to maintain robust, sustainable digital infrastructure amidst an intensifying climate landscape.

Summary of policy recommendations

- **Industry standards**: Mandate common industry standards to level the playing field.
- **On-premise data centres spot check:** Conduct a spot check exercise to review resilience measures in a subset of on-premise data centres, ideally across both public and private sectors, to ensure that resilience measures are appropriate for the type of data that is managed by the facility.
- **Central register for public sector data centres:** Create a central register of all data centres that it operates, as recommended in the "Review of the cross-cutting functions and the operation of spend controls" conducted by Lord Horsham in 2021.
- **NSIP inclusion:** Include data centres in the Nationally Significant Infrastructure Projects (NSIP) consenting regime to provide an additional (but not exclusive) avenue for data centre development.
- **Efficient planning processes:** Expedite the approval process for both NSIPs and standard planning applications.
- **Centralised approaches to planning:** Ensure consistent handling of planning applications across local authorities.
- **Modernisation of the grid:** Accelerate the process of establishing grid connections and increase capacity as data centres scale in response to economic growth.
- **Ofgem and Environment Agency cooperation:** Ofgem and the Environment Agency must engage in continuous dialogue to address the intersecting impacts of energy and water use in data centres.
- **Renewables, nuclear and hydrogen:** Ensure long-term commitment to investment in renewables, small modular reactors, and green hydrogen.
- **Skills Toolkit improvements:** Leverage the existing Skills Toolkit to promote opportunities within the data centre sector.
- **Growth and Skills Levy:** Deliver the Growth and Skills Levy to cover intensive courses that focus on green skills.
- **UK ETS:** Reform the UK ETS to exclude data centres from the scheme.
- **Heat network zoning:** Adopt a flexible approach to data centres as heat sources and look in the direction of small-scale heat export projects, such as greenhouses and fish farms.
- **Biodiversity Net Gain:** Create a digital platform for developers in scope of Biodiversity Net Gain regulations to upload their plans and extend the regulations to the rest of the UK.
- **Sustainability disclosures:** Include public bodies in the upcoming sustainability disclosure regulations to improve the visibility of small on-premise data centres that they might run, as well as leverage the upcoming framework to encourage nature-related reporting.
- **Government working groups:** Invite data centre representatives to participate in existing government working groups, such as those focused on climate change, to ensure that the perspectives and needs of data centres are considered in policy discussions that impact the industry and its supply chains.
- **Data Infrastructure Forum:** Ensure that government departments focused on climate and the environment attend the Data Infrastructure Forum run by the Department for Science, Innovation and Technology.

Scope of the assessment

As an industry association, we provide a collective voice for commercial operators in the UK. Consequently, the scope and detail of our reporting are limited to a general summary of readiness at the sector level and do not possess the granularity of an individual corporate report, as we are not in direct control of the way risks are managed. We are not privy to, and are therefore unable to comment on, individual corporate risk plans. Moreover, much of the UK's data centre estate is owned and operated by private sector organisations, and site-specific information is generally not disclosed for reasons of operational security and resilience.

The community we represent consists predominantly of colocation data centres and cloud service providers. This does not encompass the entirety of the data centre sector in the UK, where a significant proportion of activity takes place in-house, for example dedicated purpose-built facilities, small on-premise data centres, server rooms, and distributed IT setups (including servers in cupboards and closets within office buildings) that are not obligated to disclose information about their operational resilience. Consequently, little is known about this group. While we must acknowledge their existence due to the associated risk, we cannot speak on their behalf.

This report is based on comprehensive desk research and extensive conversations with key stakeholders in the data centre industry. The findings and insights presented here reflect a thorough review of existing literature and direct input from industry experts and practitioners.

History of submissions

techUK responded to two previous rounds of climate adaptation reporting – in 2016 and 2021.

The 2016 submission explored the climate change readiness of the UK's data centre sector, alongside informal observations on interdependent core digital infrastructure such as fixed-line and mobile communications. It outlined approaches to identify, manage, and mitigate risks used by data centres at the time. The report also reviewed climate-related incidents leading to service interruptions, more specifically Hurricane Sandy, the 2015 winter flooding in York and Leeds, and the Japan Tsunami of 2021, extracting valuable lessons from these events. Finally, it identified areas warranting further examination to uncover potential vulnerabilities and suggested proactive measures.

Following the submission of the report, we actively monitored incidents within the sector through trade press, Uptime Institute surveys, and the Data Center Incident Reporting Network (DCIRN)[3]. We raised awareness regarding the nature of climate change risks and the utilisation of available information among data centre operators. Additionally, we proposed requirements for regular flood risk reviews under existing standards and advocated for systematic enhancements within availability standards. Our efforts included ongoing engagement with

[3] The Data Center Incident Reporting Network was dissolved in 2021.

external stakeholders such as government and media to advance climate change resilience. We conducted briefings with operators, developed a comprehensive library of resources, and collaborated with standards bodies to update requirements. Furthermore, we fostered productive relationships within the infrastructure community through the Infrastructure Operators Adaptation Forum (IOAF), facilitating dialogues on interdependencies across sectors. Internationally and nationally, we engaged with a diverse range of stakeholders and contributed multiple articles on climate change resilience.

Our report submitted in 2021 focused on the broader UK data centre market, assessing its preparedness for climate change risks and investigating resilience strategies such as adoption of industry standards, industry collaboration and compliance with regulation. The report also examined lessons learnt from the COVID-19 pandemic and offered recommendations for both industry stakeholders and the government.

Since 2021, the data centre industry has increasingly found itself at the core of technology-related discussions, as it forms the backbone of digital infrastructure. With sustainability now a critical focus for governments and society, we have fully committed ourselves to both digital and green transitions.

Significant strides have been made in enhancing climate resilience, with data centres embracing renewable energy sources and implementing innovative cooling technologies to reduce energy consumption and carbon emissions. Furthermore, collaborative initiatives have strengthened disaster preparedness and response strategies, ensuring operational continuity amidst climate-related challenges. In line with the recommendations made in our report, we have continued to engage with organisations such as the Coalition for Disaster Resilient Infrastructure (CDRI) and the Sustainable Digital Infrastructure Alliance (SDIA), as well as government departments and agencies, to advance discussions on climate resilience. We have advocated for policy and regulation that bolster the data centre industry's adaptation efforts, most recently the planning reform.

We are committed to further advancing these efforts following the submission of this report.

Overview of the sector

What is a data centre?

Data centres are highly resilient facilities that underpin our modern economy by processing, managing, storing, and transacting digital data.

They are specialised facilities that house computing equipment, primarily servers, offering various organisations a secure and controlled environment for their IT operations, being equipped with a guaranteed power supply and high-bandwidth connectivity. With advanced building management controls, security systems and redundant network infrastructure, they guarantee uninterrupted access to critical digital services.

There are various types of data centres, each catering to different client needs. The most common models include:

On-premise	**Colocation**	**Cloud**
		
On-premise (also known as in-house or enterprise) data centres are tailored to meet specific internal IT needs. Unlike colocation or cloud data centres, which serve large-scale operations or multiple tenants, these data centres are designed exclusively for the organisation that owns them.	Similar to hotels that rent out rooms to guests, colocation facilities rent out space to multiple organisations, allowing them to house their own servers and networking equipment within their highly secure and controlled building.	Cloud facilities are typically designed to support scalable applications and data storage requirements. These facilities provide on-demand IT resources as a service, often through virtual machines in a "multi-tenant" configuration with several customers sharing the same infrastructure. In this context, both the building and servers are managed by a third party.

However, despite the above classification, it is rare to find two data centre sites that look the same, even if they are run by the same company. This is due to factors such as geographical location, local climate, regulatory requirements, technology available at the time of construction, and the specific needs of the clients or the owning organisation, all of which necessitate unique design and operational considerations for each site.

Role in the economy

Data centres support every conceivable part of the economy. Financial transactions, healthcare records, entertainment streaming and social media interactions all depend on the reliable storage, processing, and distribution of digital data facilitated by data centres.

More recently, data centres have been playing a pivotal role in enabling the training and deployment of artificial intelligence (AI) systems. They provide the computational power and data storage necessary for training and running AI models, such as those used in advanced language models like ChatGPT.

Similarly to telecommunications, data centres are essential for the functioning of society, with the sector officially designated as CNI in September 2024 due to the crucial nature of the activities it facilitates.

On an annual basis, data centres are contributing £4.7 billion in GVA to the UK economy, 43,500 jobs, and £640 million in tax to the exchequer[4].

Case study | What the 2024 CrowdStrike incident tells us about data centres and climate change?

Data centres are often referred to as the fourth utility alongside water, gas, and electricity, due to the fact that they are essential for the functioning of modern life. A disruption in data centre or IT services that they underpin can cause widespread outages, affecting everything from personal communication and entertainment to vital business operations and emergency services. The CrowdStrike outage of 19 July 2024 serves as a stark reminder of the importance of our digital infrastructure and the need for proactive measures to ensure its resilience against a variety of different threats. The IT security failure caused major interruptions across the world, resulting in:

- **Financial losses for businesses:** The outage is estimated to have caused hundreds of millions of pounds in lost revenue globally, particularly for financial institutions, e-commerce platforms, and retailers, many of which could not process transactions for several hours.
- **Impact on individuals:** The disruption in healthcare services was particularly severe, with hospitals in multiple regions unable to access patient records. This led to delays in surgeries and medical treatments, putting lives at risk. In the aviation sector, passengers faced significant delays due to airline booking systems going offline, further straining global travel.

[4] techUK (2024) "*Foundations for the future: how data centres can boost UK economic growth"* Available at: https://www.techuk.org/resource/techuk-report-foundations-for-the-future-how-data-centres-can-supercharge-uk-economic-growth.html (Accessed: 5 November 2024)

While the root cause of the CrowdStrike incident was cybersecurity-related, it can be applied to the broader vulnerabilities faced by our digital infrastructure in the face of environmental threats. For instance, a complete flooding of a data centre could trigger widespread outages, preventing organisations from accessing vital data and disrupting communication channels, ultimately affecting thousands of people globally. Although the data centre sector has demonstrated resilience to these threats, the increasing dependence on digital services leaves no room for complacency - particularly as climate change introduces new and unpredictable risks.[5]

Number of facilities

Data centres are not specifically measured by the UK's official statistics body, and it is extremely difficult to accurately estimate the number of data centres in the UK. This is namely due to the lack of a universal definition regarding what constitutes a data centre, different ownership models, and sensitivities surrounding the disclosure of locations. The industry's rapid growth further complicates this task, as new facilities are continually being developed while existing ones may undergo expansions or modifications, making it challenging to maintain an up-to-date and comprehensive inventory.

With these limitations in mind, techUK estimates that there are approximately 450 data centres in the UK. This figure includes data centres registered under Climate Change Agreements (CCAs), along with an estimated number of enterprise data centres[6].

Geographical spread

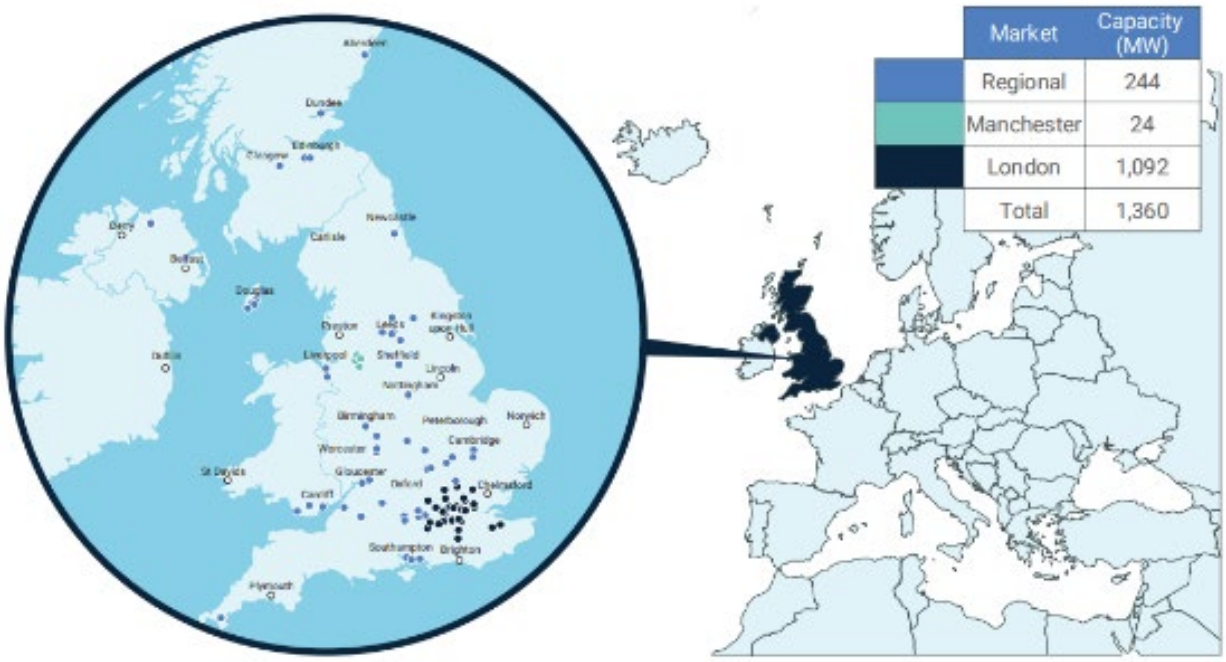
Data centres are primarily clustered near fibre optic and power infrastructure. Around 80% of the market is concentrated around the M25 surrounding Greater London, with Slough being a particularly prominent hub. The second largest cluster is in Greater Manchester, and there is growing interest among operators in exploring locations in Scotland and Wales for new facilities[7].

[5] Lawrence, A. and Smolaks, M. (2024) "*Global IT disruption highlights concentration, third-party risk*" Uptime Intelligence. Available at: https://intelligence.uptimeinstitute.com/resource/global-it-disruption-highlights-concentration-third-party-risk (Accessed: 1 November 2024)

[6] techUK (2024) "*Foundations for the future: how data centres can boost UK economic growth"* Available at: https://www.techuk.org/resource/techuk-report-foundations-for-the-future-how-data-centres-can-supercharge-uk-economic-growth.html (Accessed: 5 November 2024)

[7] techUK (2024) "*Foundations for the future: how data centres can boost UK economic growth"* Available at: https://www.techuk.org/resource/techuk-report-foundations-for-the-future-how-data-centres-can-supercharge-uk-economic-growth.html (Accessed: 5 November 2024)

Chart 1 – UK's leased data centre market by region



Climate change risks

Physical risks

If not adequately prepared and fortified, data centres are vulnerable to disruptions and damage caused by extreme weather events exacerbated by climate change. These include floods, high and rapidly increasing temperatures, fluctuating humidity levels, intensified storms, droughts, and wildfires, all of which pose significant threats to data centre operations and infrastructure integrity.

The table below provides an overview of physical risks relevant to the data centre industry, as well as likely first and second order impacts. Level of concern was determined considering existing prevention measures.

Table 1 – Overview of physical risks and first and second order impacts

Risk	First order	Second order	Level of concern
Water stress	Water supply issues for some cooling systems	Increased operational costs, potential cooling system failures	**High:** Water stress poses a significant climate change risk for data centres in areas facing water scarcity, as some facilities rely on water for cooling to reduce energy consumption and the carbon impact associated with refrigerants. To mitigate this risk, data centres are increasingly adopting innovative cooling designs and exploring water harvesting techniques, though these have physical space limitations.
High temperatures and heatwaves	Increased power usage, risk of service interruption due to overstretched cooling systems, poor working conditions for staff, equipment overheating, increased Heating, Ventilation, Air Conditioning (HVAC) and cooling	Higher energy and utilities costs, reduced equipment lifespan	**High:** Data centre facilities typically have cooling systems designed with built-in redundancy to ensure resilience. However, higher external ambient conditions can reduce the effectiveness of these systems, increasing the energy required to cool the same load and potentially

	requirements, increased water usage		placing additional strain on the power grid, especially in areas with a high concentration of data centers. Legacy sites may struggle to maintain required temperatures or avoid hot spots more than newer facilities.
Temperature variability	Higher HVAC costs, stress on components and hardware	Reduced operational efficiency, reduced equipment and hardware lifespan	**Medium:** Data centres use ASHRAE standards which define operating envelopes for servers in terms of temperature and humidity boundaries. They also use innovative cooling methods to ensure consistent temperature maintenance and protect sensitive equipment from fluctuations.
Wildfires	Direct fire damage, power outages, access issues, loss of biodiversity on site	Long-term facility downtime, high repair costs, data loss, potential need to relocate, health risks	**Low:** While data centres in the UK have not been affected by wildfires, these are becoming more common in Europe. This is concerning because many data centres are situated near forested areas, which are often susceptible to wildfires.
Smoke	Potential cooling system contamination, air quality issues affecting equipment and staff	Increased filter and ventilation system maintenance	**Low:** Data centres have sophisticated ventilation systems and are able to recirculate air. Those sites that use outside air for cooling can switch to mechanical cooling.
Coastal floods (from seawater)	Flooding of buildings and ducting, water damage to cabling or cable landing stations, interruptions or damage to the power supply system, access issues	Scour, subsidence, corrosion, erosion, material degradation, high repair costs, higher insurance premiums, potential need to relocate	**Low:** Data centres use flood maps and zones to ensure they are at low risk of flooding. They are rarely constructed in coastal areas without significant risk mitigation measures which include flood defences, elevated foundations, building

			slightly in-land, and ensuring power resilience. They also use advanced drainage and water detection systems.
Fluvial floods (from rivers and streams)	Flooding of buildings and ducting, water damage to cabling or cable landing stations, interruptions or damage to the power supply system, access issues	Scour, subsidence, corrosion, erosion, material degradation, high repair costs, higher insurance premiums	**Low:** Data centres use flood maps and zones to ensure they are at low risk of flooding. They are rarely constructed near rivers or streams without significant risk mitigation measures in the form of flood defences and elevated foundations. They also use advanced drainage and water detection systems.
Pluvial floods (from rain)	Flooding of buildings and ducting, water damage to cabling or cable landing stations, interruptions or damage to the power supply system, access issues	Scour, subsidence, corrosion, material degradation, high repair costs	**Low:** Data centres use flood maps and zones to ensure they are at low risk of flooding. They also implement various measures to protect against heavy rain. Many facilities construct attenuation ponds to manage flooding and harvest water. They also rely on national drainage systems in the area.
Increased humidity or change in humidity	Increased need for dehumidification, damage to equipment	Higher energy consumption, reduced equipment lifespan	**Low:** Humidity requirements vary depending on the specific equipment or application. However, the acceptable range of relative humidity is quite broad (between 20 and 80% according to standards).
Storms and increased severity of high winds	Damage to buildings and external infrastructure, risk of power outages, safety hazards	Extended power outages, high repair costs	**Low:** Data centres undergo regular building fabric inspections to ensure structural integrity, operational efficiency, and resilience against environmental stresses.

Landslides	Structural damage to buildings and external infrastructure, risk of power outages, safety hazards	Operational downtime, extended power outages, high repair costs, need for relocation	**Low:** Data centres mitigate landslide risks by conducting geological assessments that evaluate slope steepness, bedrock composition, and the area's history of landslides to ensure site stability.

Transitional risks

Transitional risks include regulatory changes, trend shifts in the wider market, and technological advancements. In practical terms, this typically means unforeseen costs to businesses.

Due to regulatory changes, data centres must allocate financial resources to comply with various new requirements, including emission reduction targets and water and energy-related taxes. Failure to comply could result in fines, reputational damage, and a subsequent loss of revenue and business opportunities as customer and investor sentiments turn towards more sustainable practices and responsible corporate governance.

Case study | Regulatory ripple effects: unintended cost pressures from aviation sustainability mandates on data centres

More than often, data centres are indirectly impacted by regulations meant to accelerate net zero transition in other sectors such as aviation.

The Renewable Transport Fuel Obligations (Sustainable Aviation Fuel) Order 2024 mandates that aviation fuel suppliers must raise the proportion of sustainable aviation fuel (SAF) in their jet fuel mix.

As a result, data centre operators are experiencing higher costs when purchasing Hydrotreated Vegetable Oil (HVO) for their generators, as the same suppliers often provide SAF and HVO, linking their pricing structures. If operators incur an additional charge of 30p per litre, their annual fuel expenses could rise by thousands of pounds.

While it is understandable for suppliers to pass these costs down, the data centre industry is concerned that this may deter some operators from transitioning from diesel fuel to HVO which reduces the net carbon emissions by 90%[8]. Although diesel is cheaper than HVO, it is less environmentally friendly, and higher costs could make operators reluctant to adopt this cleaner alternative.

Fluctuations in the availability of power (whether due to increased demand, supply disruptions, or regulatory shifts) can also lead to unplanned infrastructure upgrades or reliance on more expensive energy sources, compounding financial pressures.

[8] Data Center Dynamics (2023) "*Plant-powered generators: Switching data centers from diesel to HVO"* Available at: https://www.datacenterdynamics.com/en/analysis/plant-powered-generators-switching-data-centers-from-diesel-to-hvo/ (Accessed: 28 November 2024)

Strategies for building adaptive capacities

Resilience by default

Data centres, intentionally designed for resilience, possess inherent systemic traits that render them relatively robust against climate change risks. Climate change risks are handled as just one of a myriad of business risks facing data centre operators.

Risk planning for data centres happens at three stages – **site selection**, **design and build**, and **operation**.

Data centre site selection is a highly specialised process, involving thorough assessments of potential locations. Key factors considered include historical weather data, seismic activity, flood risk maps, and proximity to coastlines vulnerable to sea-level rise. Additionally, the availability and reliability of essential infrastructure, such as power grids and water supply, are thoroughly evaluated to ensure the site's suitability.

Once a location is picked and construction begins, data centre facilities are built to withstand natural disasters like hurricanes, earthquakes, and floods. This includes elevated foundations, reinforced structures, attenuation ponds and flood barriers. Industry standards play a major role in guiding these practices, and we delve into this topic in the section titled "Industry standards and best practice".

Ensuring reliable and uninterrupted operation continues to be a top priority after construction is completed. Because they compete based on their ability to provide continuity of service, data centres typically incorporate redundancy across all operational levels. These include but are not limited to:

- **External power supply:** Resilient facilities have separate and independent electricity feeds from the grid. This ensures that if one power source fails due to climate-related events such as storms or floods, the facility can continue to operate without interruption.
- **Emergency power generation:** Data centres are equipped with emergency generators, often with priority agreements for fuel replenishment to ensure sustained operation during prolonged outages. This capability is crucial during extreme weather events which can disrupt primary power supplies.
- **Communications:** Resilient sites feature dual or multiple independent connections to ensure continuous connectivity. This redundancy is vital in maintaining operations during disruptions caused by storms, physical damage to cables, or other infrastructure failures.
- **Cooling:** Cooling systems are designed to exceed maximum operational requirements, with additional redundancy to meet contractual obligations and SLAs. Effective cooling is essential to prevent overheating of servers during heatwaves or periods of high ambient temperatures, thereby maintaining operational stability.

- **Equipment lifecycle management:** Servers, switches, routers, and cooling systems are just some of the critical equipment found in data centres. A proactive replacement cycle, typically based on manufacturer recommendations and industry standards, ensures that data centres stay ahead of wear and tear, technological obsolescence, and potential damages caused by environmental stressors.
- **Ability to move workloads:** Workloads can be moved across if a site is compromised. This flexibility is critical for maintaining service continuity in the face of localised climate events, such as floods or wildfires, allowing server owners to redistribute tasks to unaffected locations efficiently.

Industry standards and best practice guidelines

Data centres often take a proactive approach to regulation, effectively self-regulating by adhering to a variety of standards and best practice guidelines. They typically adopt a combination of generic risk standards and a wide array of bespoke, data centre-specific industry standards, KPIs, metrics, and toolkits to ensure resilient design and operation.

The CEN/CENELEC/ETSI Coordination Group on Green Data Centres (CEN/CLC/ETSI CG GDC), a collaborative effort among the three European Standards Organizations (ESOs), has produced a document titled "The Standardization Landscape for the Energy Management and Environmental Viability of Data Centres". This document offers a detailed analysis of standardisation activities pertinent to the design, operation, and components of data centres.

In this section, we outline the key standards and best practice guidelines that are used by the UK data centre industry to achieve climate resilience.

ISO standards

International Organization for Standardization (ISO) standards provide guidelines for making a product, managing a process, delivering a service or supplying materials. They cover a wide range of activities and can be applied by various businesses. Accredited by the United Kingdom Accreditation Service (UKAS), ISO certification demonstrates an organisation's commitment to best practice. Although these standards are not specific to data centres, they offer a framework that helps them directly and indirectly improve their climate resilience. The sector regularly follows recommendations included in:

- **ISO 31000 – Risk management:** Provides guidelines on risk management. It helps businesses identify, assess, and manage risks, including those posed by climate change and extreme weather events.
- **ISO 14090 – Adaptation to climate change:** Outlines principles, requirements and guidelines for adaptation to climate change.
- **ISO 46001 – Water efficiency management systems:** Specifies the criteria and provides guidance for setting up, executing, and maintaining a water efficiency management

system. It facilitates the efficient use of water by applying the 'reduce, replace, or reuse' principles.

- **ISO 9001 – Quality management systems:** Provides a framework for establishing and maintaining a quality management system. This standard promotes efficient and consistent processes, which indirectly support climate resilience by enhancing the reliability and sustainability of data centres.
- **ISO 14001 – Environmental management systems:** Serves as a framework for embedding environmental considerations into business operations. It aids businesses in proactively reducing their environmental impact, adhering to regulations, and achieving their environmental goals. This standard covers multiple elements, including the use of resources, waste management, the tracking of environmental performance, and engaging stakeholders in related initiatives.
- **ISO 22301 – Business continuity management:** Focuses on maintaining the continuity of vital business operations during disruptions, such as those stemming from climate-related events. It aids businesses in understanding and prioritising potential threats to enhance their resilience.
- **ISO 27001 – Information security management systems:** Specifies the requirements for establishing, implementing, maintaining, and continually improving an information security management system (ISMS). It helps businesses protect their information assets from threats, ensuring data integrity, confidentiality, and availability, which is critical for maintaining operations during climate-related disruptions.
- **ISO 50001 – Energy management systems:** Assists organisations with incorporating energy management into their broader initiatives to improve quality and environmental management.

EN 50600 series

The EN 50600[9] series includes performance metrics and guidelines for data centers. Standards that it incorporates collectively contribute to enhancing the efficiency, sustainability, and resilience of data centers, supporting industry-wide efforts to improve performance and adapt to evolving environmental challenges.

Data centres use various standards from the series to improve their climate resilience, both directly and indirectly. Most notable examples include:

- **EN 50600-4-2 – Power Usage Effectiveness (PUE):** PUE is a key metric used to measure the energy efficiency of a data centre. It is calculated by dividing the total building energy usage by the energy used by the IT equipment alone. A lower PUE indicates better energy efficiency, as it shows that less energy is being used for non-IT systems, such as cooling, lighting, and power distribution, relative to the energy used by IT equipment.

[9] For all standards included in the EN 50600 series, please click here.

- **EN 50600-4-9 – Water Usage Effectiveness (WUE):** WUE measures the efficiency of water use within a data centre. It is calculated by dividing the total amount of water used by the data centre by the amount of energy used by IT equipment. A lower WUE indicates more efficient use of water resources, which is important for reducing environmental impact and managing water consumption effectively in areas susceptible to draught.
- **EN 50600-4-7 – Cooling Efficiency Ratio (CER):** CER is a metric used to evaluate the efficiency of cooling systems in a data centre. It is calculated by dividing the amount of energy used for cooling by the total IT equipment energy consumption. A lower CER reflects a more efficient cooling system, which helps in reducing the overall energy footprint of the data centre and enhances its ability to cope with high or varying temperatures.
- **EN 50600-2-3 – Environmental control:** Provides guidelines for managing and controlling environmental conditions within a data centre, including temperature, humidity, and air quality. Proper environmental control is essential for maintaining optimal operating conditions for IT equipment and ensuring reliable performance, which also contributes to the facility's overall climate resilience.
- **EN 50600-2-2 – Power supply and distribution:** Addresses the design and implementation of power supply and distribution systems in data centres. It includes guidelines for ensuring reliable power delivery, incorporating redundancy and backup systems to maintain continuous operation. Effective power supply and distribution are critical for preventing outages and ensuring the data centre can handle climate disruptions.
- **EN 50600-2-1 – Building construction:** Covers aspects such as site selection, architectural design, and the choice of construction materials. It emphasises the need for robust and resilient construction practices to protect against physical and environmental risks, including extreme weather and natural disasters.

Climate data for building design

Organisations that provide sources for climate data to inform design specifications for buildings such as data centres are ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers), ANSI (American National Standards Institute) and CIBSE (Chartered Institute of Building Services Engineers). Two key sources of climate data from these organisations are:

- **ANSI/ASHRAE Standard 169 – Climatic Data for Building Design Standards:** This standard provides external ambient climate data (including temperatures, enthalpy, humidity ration, wind conditions, solar irradiation, latitude, longitude, elevation) for every country and major city in the world which informs the design specifications for new data centre builds as well as upgrades or refurbishment of existing facilities. This weather

data is retrospective but updated every four years. Designers choose to base specifications on 20 years, 50 years or 100 years of data[10].

- **CIBSE Weather Data:** CIBSE supplies extensive weather data for use in building performance analysis and design. These figures, which include temperatures, atmospheric pressure, solar irradiation, cloud cover, wind speed and direction, are produced in collaboration with the UK Climate Impacts Programme, Arup and the University of Exeter, and include the latest climate change projections so that data centre design professionals and others within the construction sector can future proof buildings[11].

Green building rating systems

As sustainability becomes an increasingly critical factor in the construction and operation of data centres, two prominent rating systems, BREEAM (Building Research Establishment Environmental Assessment Method) and LEED (Leadership in Energy and Environmental Design), serve as valuable benchmarks for ensuring environmental performance and resilience. In the UK, data centre operators predominantly favour BREEAM for certification, though some facilities are required to obtain LEED certification by international shareholders. As of June 2024, there are over 1,430 LEED-certified and registered data centers across the globe[12].

BREEAM

BREEAM is a sustainability assessment method which captures a range of impacts relating to the procurement, design and construction of buildings. The BREEAM ratings range from Pass, Good, Very Good, Excellent to Outstanding. When seeking BREEAM certification, data centres are assessed against a variety of environment-related categories. This includes evaluating the building's ability to withstand and adapt to climate change, as well as energy efficiency, land use and ecological impact, water management, materials selection, and waste management[13].

The sector has previously used the BREEAM Data Centres 2010 scheme which assessed the design and construction of data centre facilities including new builds, extensions and major refurbishments, as well as building fit-outs. In 2019, a **Data Centre Criteria Appendix** was launched for use alongside the BREEAM New Construction International manual. The appendix

[10] ASHRAE *"Weather Data Center: Climatic Data"* Available at: https://www.ashrae.org/technical-resources/bookstore/weather-data-center#climaticdata (Accessed: 29 November 2024)
[11] CIBSE *"Weather Data"* Available at: https://www.cibse.org/weatherdata (Accessed: 29 November 2024)
[12] US Green Building Council (USGBC) *"Applying LEED to Data Center Projects"* Available at: https://support.usgbc.org/hc/en-us/articles/12154267763987-Applying-LEED-to-data-center-projects (Accessed: 29 November 2024)
[13] BREEAM *"How BREEAM Works"* Available at: https://breeam.com/about/how-breeam-works (Accessed: 29 November 2024)

integrates aspects of the EN 50600 series for energy efficiency with BREEAM's holistic sustainability framework[14].

LEED

LEED is a green building rating system. LEED-certified projects use less energy, water, and natural resources, and are designed to minimise their environmental impact on local, regional, and global scales.

Data centres can obtain certification through various LEED rating systems at different phases of their lifecycle using the following frameworks:

- **LEED for Building Design and Construction (BD+C):** Suitable for new data centres. To qualify, at least 60% of the project's gross floor area (GFA) must be finished and ready for its intended use by the time of certification.
- **LEED for Building and Construction: Core and Shell (BD+C: CS):** Intended for projects where the developer oversees the design and construction of the complete mechanical, electrical, plumbing, and fire protection systems, but not the design and construction of tenant fit-outs. This category applies to colocation data centres.
- **Building Design and Construction: New Construction (BD + NC):** Designed for projects that are constructing new buildings or taking on major renovations of existing buildings (including major HVAC improvements, significant building envelope modifications and major interior rehabilitation).
- **LEED for Operations and Maintenance (O+M):** Suitable for existing data centres that have been operational and occupied for at least one year. It can be applied to projects that may be undergoing improvements with minimal construction.

LEED also provides a **Climate Resilience Screening Tool** which helps operators identify climate sensitivities and prioritise opportunities to promote enhanced resilience.

Thermal guidelines for IT hardware

The primary purpose of a data centre is to provide a safe and secure environment for computer servers. Significant advancements have been made to expand the temperature and humidity ranges within which computing equipment can operate reliably. This effort has been driven by the goal of improving operational efficiency, as servers that can function at higher temperatures require less cooling and therefore electricity. However, the capability of computing hardware to endure fluctuations in temperature and humidity is also crucial for climate change resilience.

[14] BRE Group (2019) *"BREEAM Survey Report: Data Centres Sustainability Gap"* Available at: https://files.bregroup.com/breeam/surveyreport/breeam-survey-report-data-centres-sustainability-gap.pdf (Accessed: 29 November 2024)

ASHRAE's "**2021 Equipment Thermal Guidelines for Data Processing Environments**", housed in the ASHRAE TC 9.9 Datacom Encyclopedia, provides the latest operating envelopes for servers, specifying temperature and humidity boundaries within which manufacturers guarantee reliable performance. While these standards specifically pertain to the IT equipment housed within the data centre, they are crucial for adaptation and resilience as they define the operational temperature and humidity limits for the entire facility.

ASHRAE provides two temperature and humidity ranges – recommended and allowable. The recommended temperature range for data centre IT equipment is between 18°C to 27°C, with a recommended relative humidity range of 45% to 50%. Allowable ranges are broader to accommodate various equipment classes, with temperatures ranging from 10°C to 35°C and humidity levels from 20% to 80%[15].

Policy and regulation

Well-thought-out policy and regulation are essential for motivating data centres to enhance their climate resilience, and this issue is rising up the policy agenda globally. Measures that foster a culture of resilience planning, enabling data centres to better prepare for and adapt to the impacts of climate change, include:

- **Sustainability reporting:** Mandated sustainability reporting and transition planning are still in the early stages in the UK, especially when compared to jurisdictions such as the EU. The UK Sustainability Reporting Standards (UK SRS) are set to be introduced in 2025, with mandatory rules for listed and other companies expected to take effect in 2026 and 2027. However, as most of the data centre industry operates internationally, many UK-based data centres are already aligning their practices with established EU regulations that are considered among the most complex and rigorous in the world. This includes adherence to the Corporate Sustainability Reporting Directive (CSRD) and the Energy Efficiency Directive (EED), as well as voluntary frameworks such as the Science Based Targets Initiative (SBTi), Carbon Disclosure Project (CDP) or Global Reporting Initiative (GRI). Although reporting rules and practices remain imperfect, transparency through sustainability reporting fosters accountability and enhances climate resilience by motivating data centres to identify, manage, and mitigate environmental risks effectively.
- **Biodiversity enhancement:** In England, biodiversity enhancement is supported by legislation like the Environment Act 2021, which mandates Biodiversity Net Gain. This requires new developments to increase biodiversity value by at least 10% over the pre-development baseline. Data centres achieve Biodiversity Net Gain by creating green roofs and walls, establishing wildflower meadows, planting trees, developing on-site wetlands, and installing bee hives. These initiatives improve local ecosystem health and biodiversity, creating more resilient environments. By supporting diverse plant and animal species, data centres contribute to pollination, water purification, and

[15] ASHRAE *"Datacom Series"* Available at: https://www.ashrae.org/technical-resources/bookstore/datacom-series (Accessed: 29 November 2024)

temperature regulation, which are crucial for mitigating climate change effects and enhancing overall climate resilience.

Effective policy and regulation can significantly drive climate resilience, directly or indirectly, but poorly designed or ineffective measures can distort progress and undermine efforts. We explore this issue further in the section titled "Regulatory challenges”.

Industry collaboration

In recent years, international organisations and alliances focused on climate have gained increasing prominence in the data centre industry. These include the **Climate Neutral Data Centre Pact**, **Infrastructure Masons,** and the **Coalition for Disaster Resilience Infrastructure (CDRI)**. Their work either directly or indirectly impacts the resilience of data centres, but CDRI is particularly worthy of note because the scope of its activity is specifically related to disaster recovery within infrastructure sectors.

There is also an excellent level of cooperation, information sharing and best practice related discussion at European levels through industry representative bodies such as the **European Data Center Association (EUDCA),** the **Data Centre Trade Association (DCA)** and techUK’s counterpart in the EU, **DIGITALEUROPE**.

Climate resilience is a regular subject of informal peer to peer activity among national trade associations focused on data centres. techUK's Climate, Environment and Sustainability Programme has identified climate resilience as a key priority for 2024. It features prominently on the agendas of several working groups and councils (including those sitting under the Data Centres Programme) and remains a popular topic for webinars, reflecting its growing importance within the industry.

Barriers to climate resilience

How is the data centre sector assessing its own performance?

7

We asked techUK data centre members to rate their own climate resilience on a scale of 1 to 10. The average score reported was 7, reflecting a strong sense of progress, but also highlighting areas where further improvements can be made. This self-assessment demonstrates a solid commitment to resilience, with room for continued advancement as the sector adapts to the challenges posed by climate change.

When gathering feedback from the industry, it became apparent that, despite data centre operators expressing a strong commitment to innovation, many feel that financial investment in research and development (R&D) to achieve better sustainability outcomes is not evenly prioritised. The industry could also benefit from a more open-minded approach, particularly in the realm of resilience to power disruptions and outages.

Adoption of industry standards

While data centres widely adopt various standards and certifications to enhance their resilience, the level of adoption can vary significantly across the industry. For some, the process appears more like a routine formality rather than a substantive commitment.

There is considerable room for increased standardisation, particularly in developing standards tailored to the unique sustainability challenges of data centres. Ultimately, effective regulation is needed to ensure these guidelines are consistently and appropriately applied. This being said, excessive regulation or standardisation could also have adverse effects on the sector, potentially stifling innovation or imposing undue constraints. Balancing robust guidelines with flexibility is crucial to advancing the industry's climate resilience goals without hindering its progress. To achieve this, the government should take guidance from the data centre industry’s needs and feedback, focusing on areas where effective mandates could drive positive change.

On-premise data centres

While we provide a collective voice for commercial operators, telecommunications and IT services providers with significant data centre assets, and some financial institutions, these operators only represent part of the UK’s data centre estate. Commercial operators must demonstrate resilience capabilities to attract business, and this is usually confirmed contractually. As a result, they are strongly motivated to prioritise business continuity and

climate change risks are addressed as part of wider corporate risk assessment and management processes.

Outside the commercial sector, the way that a data centre is run is up to the organisation it supports. In some cases, it will be highly resilient and run as a business, but this is not guaranteed.

Case study | Guy's and St Thomas' NHS Foundation Trust IT Critical Incident

On 19 July 2022, the UK experienced an unprecedented heatwave, with temperatures reaching a record-breaking 40°C. This extreme weather event had severe implications for two data centres operated by Guy's and St Thomas' NHS Foundation Trust, located at Guy's Hospital and St Thomas' Hospital. Designed to serve as backups for each other, these facilities encountered cooling system failures that led to overheating and malfunctioning of the IT equipment.

The failures of these two data centres had severe repercussions for the Trust, affecting its ability to manage and access critical data across its 371 legacy IT systems and incurring £1.4 million in unexpected IT costs.

Key failure factors identified in a formal review of the incident included:

- **Age of technology infrastructure:** The legacy nature of the IT systems contributed to their vulnerability during the heatwave.
- **Complex estate:** The overly complex setup of the data centres made it difficult to manage and recover from the failures effectively.
- **Inadequate cooling systems:** The cooling systems in place were inadequate for handling the extreme temperatures experienced during the heatwave.[16]

In contrast to the challenges faced by Guy's and St Thomas' NHS Foundation Trust, other data centres based in Central London fared significantly better during the same heatwave. Two commercial cloud data centres, which also experienced cooling failures, managed to restore full functionality by the following day[17]. The recovery of the Trust's IT systems took much longer – while the technical team began working to resolve the issues right away, it ultimately took several weeks before near complete restoration was achieved. The critical site incident was officially stood down two months later, on 21 September. This delay was compounded by an unrelated cyber-attack that began on 4 August, affecting an external

[16] Guy's and St Thomas' NHS Foundation Trust (2023) *"IT critical incident review. London: Guy's and St Thomas' NHS Foundation Trust"* Available at: https://www.guysandstthomas.nhs.uk/sites/default/files/2023-01/IT-critical-incident-review.pdf (Accessed: 20 August 2024)

[17] BBC News (2022) *"Data centres: The huge costs of a vital industry"* Available at: https://www.bbc.co.uk/news/technology-62202125 (Accessed: 29 November 2024)

supplier. While it is unclear how much longer the recovery process would have taken without this additional complication, the difference in recovery times remains significant. The Trust's recovery was delayed by nearly two months, whereas commercial data centres managed to resume full operations within a day. This highlights the disparity between the Trust's aging on-premise infrastructure and the more resilient, scalable commercial cloud data centres.

Key concerns regarding the climate resilience of on-premise data centres include:

- **Unknown scope and vulnerabilities:** While we can estimate the number of larger enterprise data centres, it is impossible to judge the number of small on-premise data centres and server rooms. Although there are many such facilities, we do not know how widespread they are, how they are managed, and whether loss of functionality caused by climate change could have a material impact. For small on-premise data centres supporting a business, service interruptions will affect that business, its customers and its customers' customers. For a local authority data centre, the loss of functionality could impact the delivery of a wide range of public services to hundreds of thousands of individual citizens.
- **Resilience status and evidence gaps:** The resilience status of on-premise data centres and server rooms is also unknown, both in terms of power and cooling continuity, and the ability to redirect workloads to other locations. Anecdotal evidence, particularly from the public sector, is not encouraging. The only data we have relates to energy efficiency, but it suggests that operational stewardship lags well behind the commercial sector. It is likely that what is true for energy management applies to resilience planning due to the inherent overlaps between the two.
- **Lack of regulatory obligations:** Excepting regulated sectors like financial services and telecommunications, the commercial drivers and regulatory obligations requiring enterprise data centres to demonstrate resilience are often greatly reduced, or even absent. This suggests that the adoption of industry standards is likely to be lower in enterprise data centres, especially smaller ones.

The potential degree of exposure to climate change risks within on-premise data centres should be a matter of concern, especially those operating within the public sector. While this is a sectoral flaw, it is crucial that the government addresses it directly, as we do not represent this segment and public sector data centres pose the greatest risk.

We strongly recommend a spot check exercise to review resilience measures in a subset of on-premise data centres, ideally across both public and private sectors, to ensure that resilience measures are appropriate for the type of data that is managed by the facility. Following spot checks, the government could create a central register of all data centres that it operates, as recommended in the "Review of the cross-cutting functions and the operation of spend controls" conducted by Lord Horsham in 2021. We believe this would be a helpful step in improving transparency and should be extended as widely as possible across the public sector.

Clustering

The UK data centre sector is heavily clustered and a significant proportion of new development at scale is within or close to existing data centre clusters. When multiple data centres are located in the same region, the collective risk of climate-related events becomes amplified. A single extreme weather event could potentially disrupt multiple data centres simultaneously, leading to widespread service interruptions and loss of data. Clustering can also strain existing infrastructure, including power grids and water supply systems.

Ideally, data centres should establish facilities in different geographic regions to reduce the risk of simultaneous disruptions due to localised climate events. While the industry is already collaborating with other stakeholders to improve regional resilience, effective de-clustering will largely depend on government intervention. This is because data centres are typically located where fibre connectivity and power supply are optimal, limiting their ability to choose less clustered locations without substantial infrastructure changes. The government can play a crucial role by investing in infrastructure improvements to encourage data centres to expand into less congested areas.

Planning reforms also hold a significant potential to facilitate de-clustering by streamlining the development process for data centres. The government's proposed reforms to the National Planning Policy Framework (NPPF), announced in mid-2024, present significant opportunities for development. These reforms include plans to utilise "grey belt" and previously developed land for new projects, which would help free up land for development while still preserving the integrity of the Green Belt. Additionally, the reforms align with techUK's call to have data centres included in the NSIP consenting regime, which would streamline the approval process for large-scale data centre developments.

To make the new planning rules effective, the government must accelerate and improve the approval process for both NSIPs and standard planning applications. It will also be crucial to ensure consistent handling of planning applications across local authorities, allowing data centre developers to choose the most suitable regime for their needs and receive a high standard of service. This has been made more difficult in recent years by the decline in funding for planning offices. Since 2010, there has been a 16% fall in planning funding in England, 50% fall in Wales, and a 38% fall in Scotland, alongside declining numbers of lower-paid planning officers.

Ensuring that local planning applications are handled by expert and well-funded planning departments is essential for getting projects off the ground quickly and providing the consistency of service needed to support investment[18].

[18] techUK (2024) *"techUK's response to the Ministry of Housing, Communities and Local Government's consultation on the proposed changes to the National Planning Policy Framework"* Available at: https://www.techuk.org/resource/techuk-s-response-to-the-ministry-of-housing-communities-and-local-government-s-consultation-on-the-proposed-changes-to-the-national-planning-policy-framework.html (Accessed: 28 November 2024)

Stranded capacity

Stranded capacity refers to the underutilisation of resources within a data centre. One of the primary contributors to stranded capacity is the segregation that exists between the IT domain and the building services that look after mechanical and electrical equipment. This gap leads to inefficiencies in how space, power, and cooling are allocated and used.

As a result of this fragmentation, a significant portion of the originally designed capacity goes unused, with losses often exceeding 40%. In practical terms, this means that a portion of the power reserved for the data centre's operations may not be fully utilised, leading to unnecessary overhead costs and wasted resources. The term "stranded capacity" reflects the fact that these resources are effectively locked away and unavailable for productive use, even though they have been reserved and allocated in the data centre's original design.

Digital twin platforms offer a promising solution, providing a dynamic, real-time virtual replica of the physical data centre, allowing operators to closely monitor and optimise resource utilisation. By integrating IT and building services through digital twin technology, data centre operators can significantly reduce the fragmentation of space, power, and cooling, leading to better capacity utilisation and ultimately reducing the risk of stranded capacity. However, the adoption of such tools is still limited, and their use is not yet widespread across the industry.

Dependency on other sectors

Digital infrastructure is not standalone. Data centres are primarily dependent on telecommunications networks that provide connectivity and enable the flow of data. They are also heavily reliant on power – computing equipment can only tolerate interruptions in supply of a few milliseconds, so resilient networks and an uninterrupted supply of power are critical. Furthermore, data centres often depend on landlords or third parties for real estate, which can limit their influence over key factors such as resilience.

Telecoms

Data centres and telecom networks share a symbiotic relationship, with their operations deeply interwoven to sustain the digital infrastructure that underpins modern society. Telecoms operators rely significantly on data centres to store and process data near end-users, minimising latency and enhancing network performance. In return, data centre facilities depend on telecom providers to deliver reliable, high-speed connectivity, ensuring seamless access to the data they house. This mutual reliance ensures that digital services remain functional, but it also creates shared vulnerabilities, particularly in the face of climate-related risks.

The resilience of a data centre is closely tied to the robustness of the telecom networks it connects to. Even if a data centre remains operational during a climate-related event, such as a flood, damage to fibre-optic cables, compromised switching hubs, or power outages at telecom

sites, can render the data centre effectively inaccessible to its users and clients. For example, flooded telecom exchange points can lead to data bottlenecks, while damaged fibre routes can sever entire regions from critical online services.

Recognising these risks, data centres work closely with telecom operators from the earliest planning stages to ensure resilience is built into their shared infrastructure. This collaboration includes incorporating redundancy measures such as dual connectivity paths and alternative data routing capabilities. In situations where telecom networks face disruption, data centres implement contingency plans to maintain operations. These plans often involve migrating data and workloads to other facilities or leveraging satellite and wireless technologies as temporary backups. This requires substantial coordination with telecom providers and satellite operators.

Although collaboration between data centres and telecom providers is already well-established, the increasing risks posed by climate change underscore the need for ongoing dialogue and adaptive strategies. Both industries will need to continue evolving their approaches to shared vulnerabilities and ensure that resilience keeps pace with the growing complexity of digital infrastructure.

Utilities

Just like connectivity, power dependencies are accommodated in data centre risk planning. Any facilities that underpin important functions should have duplicate power feeds, robust battery storage systems, and embedded emergency generation. However, the data centre sector is growing and power supply is lagging well behind demand in development hotspots. This supply issue appears to be largely because, as a heavily regulated entity, National Grid cannot expand capacity speculatively, irrespective of how much evidence there is for growth in demand.

The rise of generative AI | Trend analysis

As AI-powered applications such as virtual assistants, image generation, and personalised recommendations become increasingly integrated into daily life, the demand for these technologies among everyday people and businesses is skyrocketing.

According to the Managing Director of National Grid, John Pettigrew, electricity demand of UK data centres is projected to increase six times over the next decade due to the surge in AI use.[19]

AI consumes so much power primarily because of its high computational demands. Training AI models involves processing enormous datasets and performing complex mathematical calculations, which require powerful graphics processing units (GPUs) and tensor processing units (TPUs). These energy-intensive processes and hardware, coupled with the need for

[19] Shankleman, J. (2024) *"AI will suck up 500% more power in UK in 10 years, Grid CEO says"* Bloomberg. Available at: https://www.bloomberg.com/news/articles/2024-03-26/ai-will-suck-up-500-more-power-in-uk-in-10-years-grid-ceo-says?embedded-checkout=true (Accessed: 20 August 2024)

continuous operation to provide real-time services, drive up the power consumption of data centres.

This being said, the integration of liquid cooling technologies that have emerged as most suitable for AI applications presents exciting opportunities for data centres to export excess heat, which has the potential to improve their own sustainability and contribute to the UK's green transition.[20]

Inadequate power supply is a significant concern – sufficient digital infrastructure capacity is not only a prerequisite for the UK to function as a digital economy but is also essential for sector resilience. For example, large cloud providers need to build out sufficient capacity within their availability zones to ensure business continuity in the event of outages or failures at single site level. Data centres of this type are location-specific and by constraining capacity, lack of power has an inevitable impact on resilience. Furthermore, in some cases, security, data protection, or compliance requirements prohibit cloud providers from using data centres outside the UK to host customer data during outages. Therefore, we must ensure we have adequate capacity and resilience to meet the demand for such use cases.

The UK requires a modernised grid that can accommodate the evolving demands of digital infrastructure, which is scaling rapidly in response to economic growth. Like other productive sectors of the economy, data centres cannot realistically be expected to reduce or independently meet their power needs. The 24hr energy consumption profile of data centres is relatively constant, with overall demand increasing slightly during the daytime due to increased cooling requirements, and to a lesser extent in accordance with the demand for compute power. While data centres can operate 'off-grid' in emergency scenarios, back-up generators rely on fossil fuels, meaning that such activities would be environmentally harmful.

Data centres are exploring a variety of options to supplement their power needs and reduce dependence on the grid, for example by generating renewable and nuclear energy on-site. However, while solar panels are increasingly being adopted, the energy produced falls short of the data centre's overall demand and is typically sufficient only for powering office operations. Small modular reactors (SMRs) offer a promising clean energy solution. However, they are costly to implement, and the lengthy regulatory approval processes, combined with construction timelines exceeding 10 years, limit their feasibility in the near term for many sites. The sector is also leveraging technology to refine operational efficiency and continuously seeks innovative methods to curtail cooling requirements, but these efforts alone are not enough and might result in a strain on other utilities, particularly water.

[20] techUK (2024) *"Warming Up to Efficiency: Understanding the Potential Benefits and Pitfalls of Data Centre Heat Export in the UK"* Available at: https://www.techuk.org/resource/warming-up-to-efficiency-understanding-the-potential-benefits-and-pitfalls-of-data-centre-heat-export-in-the-uk.html (Accessed: 1 November 2024)

Data centres face a challenging trade-off between energy and water efficiency. Liquid cooling systems, often highlighted as a more sustainable option for meeting the power demands of AI compared to air cooling, can operate using either evaporative cooling or refrigerants to bring the cooling loop back to the supply temperature required by the servers. Evaporative systems lower energy and carbon impacts but depend heavily on water, while refrigerant-based systems eliminate water use but come with increased energy consumption and higher carbon emissions.

It is important to highlight that water consumption is heavily influenced by the server supply temperature. This temperature is typically determined by the specifications set by chip manufacturers and, in the case of colocation data centres, the preferences of clients. To put things into perspective, maintaining a server supply temperature of 26°C requires twice the volume of water compared to maintaining a temperature of 35°C.

The decision on which cooling system to use thus depends on the server supply temperature, and the priorities set for energy, water, and carbon performance. Although there are clear commercial and climate benefits to using cooling systems that rely on water instead of refrigerant, this may not be sustainable in regions prone to water scarcity. In the UK, data centre operators are aware of these water stress risks and carefully select cooling solutions tailored to their location. For instance, evaporative cooling might be feasible in water-abundant areas like Cotswolds or Wales, yet unsuitable for drier regions like London or Cambridge.

In the rare instances where evaporative cooling is used in the UK (a method historically considered unsuitable due to the country's cooler climate), potable water is often the only available option, as other water sources aren't offered by providers. Water harvesting and filtration systems are being explored to avoid the use of potable water, but this is not always entirely possible due to physical space limitations. With rising concerns over water scarcity, especially in the South East of England, the data centre industry is expected to limit water use by increasingly relying on mechanical systems, but this will entail higher carbon emissions and increased costs.

As energy and water demands become more intertwined, stronger collaboration between regulators will be essential. Ofgem and the Environment Agency must engage in continuous dialogue to address the intersecting impacts of energy and water use in data centres. techUK is already working with the Environment Agency and conducting a survey to assess current data centre water usage and emerging trends, but sustained support from regulatory bodies will be necessary to drive effective, resource-conscious solutions forward.

Additionally, the government should initiate discussions with chip manufacturers to encourage server temperature specifications that optimise water and energy efficiency. These specifications play a significant role in determining cooling requirements, and greater collaboration with manufacturers could help align technological advancements with the UK's sustainability goals.

Energy pricing and the war in Ukraine | Trend analysis

Energy pricing is a major concern for data centres. The fluctuating and often high prices of energy can impact the operational budgets of data centres, as well as hinder long-term planning and investment in new technologies. This adds another layer of complexity to the already pressing issue of inadequate power supply and slow connection times, as 40% of new grid connection agreements sold feature connection times extending into the 2030s[21].

Economic and geopolitical disruptions caused by the conflict in Ukraine have directly and indirectly weakened global technology supply chains, and the impacts have been felt by the data centre sector.

The biggest concern is that the conflict has exacerbated global energy prices due to the reduction in natural gas supplies from Russia. Data centres, which are energy-intensive, have seen operational costs increase significantly.

The conflict has also forced UK companies to reduce their dependence on data and tech supplies from Eastern Europe, leading to a shift towards European and domestic suppliers. This transition may involve higher costs and require time to establish new supply chains.

As energy and other costs rise, the funds available for other priorities, such as improving climate resilience, become more limited. The long-term effects will depend on the duration of the conflict and the global economic response, but to mitigate potential impacts, the UK government must adhere to its commitment to investing in renewables, nuclear energy generation and green hydrogen.

Real estate

The real estate on which data centres operate plays a significant role in their climate resilience, yet this is not always fully within the operators' control. Many data centres are not built on freehold land but are instead leased properties, where the climate preparedness of the premises is often a shared responsibility. This arrangement can limit operators' ability to make necessary investments or modifications to improve climate resilience.

Physical space constraints further complicate climate adaptation efforts, particularly in densely populated urban areas where land availability is limited. For instance, implementing water harvesting may be impractical due to lack of space. Similarly, the installation of renewable energy systems, such as solar panels or battery storage, may be constrained by site size.

[21] Ofgem (2023) *"Open letter on future reform to electricity connections process"* Available at: https://www.ofgem.gov.uk/sites/default/files/2023-05/Open%20Letter%20Connections%20%28Final%2016.5.23%29.pdf (Accessed: 28 November 2024)

Skills shortages

The data centre sector in the UK suffers from both short-term and long-term skills shortages. These are compounded by rapid growth, intense competition for talent, Brexit imposing constraints on free movement of labour, lack of certain STEM skillsets for technical roles, the lack of STEM qualified students in education, and relative obscurity of the sector. The shortage of appropriately skilled staff is therefore a continuous resilience concern for operators, as it directly impacts their ability to implement and maintain effective climate resilience measures, manage emerging technologies, and respond swiftly to climate-related disruptions.

The data centre sector has complex skills requirements. This is because it is not a single sector, but rather a composite of different industries – construction, IT, communications, facilities management, and engineering, to name just a few. As a result, the sector needs technical skills across multiple disciplines. Data centres also need people who are multi-disciplined as these specialist technical areas have to work together, not in isolation. Furthermore, the core requirements are changing from pure mechanical and electrical engineering skills to a broader range of technical competencies covering areas like IT and connectivity.

Data centres require “T-shaped” professionals who have both broad and deep skills across both business and technical domains – the vertical stem of the T is a foundation of deep disciplinary skills, and the horizontal bar of the T adds the breadth of skill necessary to work across an organisation with the ability to influence others, collaborate across disciplines, and develop creative solutions to complex business problems.

In order to retain talent, data centre operators have a number of choices. They can increase salaries (and risk a bidding war), develop their own staff (and risk poaching), relax recruitment criteria (and increase training costs), outsource (and risk losing control) or ask existing staff to cover the gap (and risk losing them). Many are investing in staff development with larger operators implementing bespoke training schemes, and others are working more proactively with training providers, industry associations, and suppliers.

At the sector level, a number of collaborative initiatives are underway. techUK has started a Skills Group which aims to demonstrate that the data centre sector is a career destination of choice, facilitate professional development within the sector (in conjunction with the Institution of Engineering and Technology), tackle some of the policy and organisational barriers that are restricting the skills pipeline, and provide a forum for information exchange.

The National Data Centre Academy (NDCA) is an evolving initiative designed to provide a comprehensive training environment for the data centre industry. The NDCA's curriculum ranges from introductory courses for career starters to hands-on workshops focused on optimising data centre performance, reducing energy consumption, and implementing best practices.

Operators also participate in UTC Heathrow’s Digital Futures Programme which aims to equip young people with mechanical and engineering skills, knowledge of IoT devices and cabling infrastructure, as well as project management.

Despite the acute skills shortages and candidate scarcity, the sector has continued to drive growth. techUK members are making significant investments in lifelong learning strategies and helping people to navigate changing nature of jobs. Nevertheless, technical skills shortages are a critical issue in terms of competitiveness, resilience and growth, and comprise a continued threat that has the potential to undermine other resilience efforts. To address this, the government should leverage the existing Skills Toolkit to promote opportunities within the data centre sector. Delivering the new Growth and Skills Levy and work with the tech sector to cover short, modular courses that focus on green skills will also be essential.

Regulatory challenges

Data centres are poorly understood by policymakers, which can lead to a disconnect between regulatory frameworks and the specific needs of the sector. This lack of understanding means that regulations are frequently created without a comprehensive grasp of the intricacies involved in data centre operations. These regulations may not account for the unique challenges and requirements of data centres, such as their energy consumption, cooling needs, and the critical role they play in supporting digital infrastructure. As a result, the sector is sometimes required to comply with regulations that were originally designed for different industries or with broader objectives in mind, or implement self-regulatory measures in areas where policy lags behind.

Regulations and policy proposals that the sector considers to be unhelpful in the context of climate resilience or in need of improvement include:

- **UK Emissions Trading Scheme:** The UK Emissions Trading Scheme (ETS) is an example of how regulations can unintentionally impact data centres and indirectly affect resilience budgets. Originally designed to target major Scope 1 emitters (e.g. fossil fuel power stations and heavy industries like cement, glass, and steel manufacturing), the UK ETS inadvertently includes data centres due to their use of on-site combustion plants, including back-up generators. These generators, rarely used but essential for ensuring resilience during power outages, often push data centres over the 20MW thermal input capacity threshold that triggers UK ETS permitting requirements. Operators that emit less than 2,500 tCO2e annually have the option to opt out as ultra-low emitters (under Article 27a) after acquiring three years of compliance, but this is impossible to demonstrate for new sites. This regulatory misalignment can strain the sector's ability to allocate resources towards climate resilience and sustainability initiatives. Compliance costs reduce the available budget for investing in greener technologies and more efficient operations, potentially undermining efforts to enhance overall climate resilience. Given the mismatch between the scheme’s design and the data centre industry’s operational realities, the government should reconsider the inclusion of data centres in the UK ETS.
- **Heat network zoning:** The current proposals for heat network zoning regulations in England illustrate a missed opportunity in the context of climate resilience. The

ambitious plan to require data centres to export heat to district heating networks overlooks significant practical challenges. For data centres to scale up heat export effectively, numerous conditions must be met, including costly retrofitting and overcoming complex operational hurdles. Realistically, any mandate to connect to a heat network would be more feasible if limited to new developments. The government has also failed to consider a more strategic approach that could yield substantial climate resilience benefits in the near term. Greenhouses and fish farms, for example, are sectors that could benefit immediately from heat export. By focusing first on these areas, the government could enhance climate resilience more effectively and leverage existing opportunities.

- **Biodiversity Net Gain**: The sector's positive contribution to the biodiversity landscape across the UK is evident. However, consumers currently lack accessible information to evaluate the biodiversity contributions of different sites, making it difficult to make informed and environmentally responsible procurement choices. To address this gap, the government could develop a digital platform where all biodiversity plans are easily accessible, as well as leverage the upcoming UK SRS to encourage nature-related reporting. Furthermore, the sector would be supportive of expanding Biodiversity Net Gain regulations beyond England to ensure consistent biodiversity standards across the entire UK.
- **Streamlined Energy and Carbon Reporting (SECR):** The exclusion of public bodies from the SECR overlooks a crucial chance to identify on-premise data centres and evaluate their climate change preparedness. As the government develops a new regulatory framework for mandatory sustainability disclosures, it should ensure that public bodies are included in scope, as this would enhance transparency and comprehensively address the climate resilience of small on-premise data centres that they might run.

There is a need for more informed policymaking that takes into account the specific operational and environmental dynamics of data centres. With the CNI designation, the government and regulators should actively seek input from data centre operators and consult with them on any new approaches or regulations that may impact them or their suppliers, or might benefit from their input.

To facilitate this, it would be valuable to include data centre representatives in key working groups on climate change across various government departments. Furthermore, since many relevant policy issues for the sector involve sustainability, it is important that the Department for Energy Security and Net Zero, as well as Defra, regularly attend the Department for Science, Innovation and Technology's quarterly Data Infrastructure Forum. This cross-departmental collaboration would ensure that data centres can regularly engage with policymakers and that their perspectives are considered, leading to more practical and effective policy approaches that balance operational needs with environmental goals.

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