

ICE Green Paper: How can the UK's infrastructure be made more climate resilient?

November 2022

Executive summary

Climate-related disasters across the world have focused attention on the need for climate-adaptive and resilient infrastructure.

Civil engineers are used to designing infrastructure for extremes, not averages, but the definition of 'extreme' has shifted in recent years.

As the world increasingly faces unparalleled extremes of temperature, wetter winters, drier summers, and higher wind speeds resulting from climate change, is our infrastructure ready?

What has become clear is that we will need to adapt no matter what. Even with progress towards net zero, climate change is happening and will continue to develop: in the most optimistic scenario with all COP26 pledges implemented, the world would be on a path to at least 1.5 degrees Celsius warming by the end of the century.

As a result, our infrastructure will need to be designed and operated in a way that copes better with today's extremes and is resilient to the more 'extreme extremes' of the future.

Most infrastructure that supports national resilience already exists and will do so for many years, though not all of it is built to modern engineering standards. Climate-related risks require changes to how our legacy infrastructure is monitored and maintained, as well as if and how it is retrofitted.

Otherwise, we risk increased repair bills, poorly performing infrastructure, and even a series of failures – with potentially devastating consequences.

In addition, new infrastructure – including infrastructure enabling the transition to net zero – will need to be constructed as climate adaptive.

In October 2022, the UK parliamentary Joint Committee on the National Security Strategy produced a report highlighting that the UK's national security is being jeopardised because of a failure to prepare for the increasing risks of extreme weather events due to the climate crisis.

The economic benefits of climate change adaptation are likely to be considerably higher than its costs. It is therefore clear that decisions based on best value rather than lowest cost are needed when considering infrastructure resilience and adaptation.

Most climate finance is being channelled into mitigation rather than adaptation and where funding for adaptation and resilience is available, this mainly comes from public sources.

Those currently seeking to drive forward the infrastructure climate resilience and adaptation agenda must convince public funders of its value at a time when there are many other competing demands.

This ICE Green Paper focuses on how the climate resilience and adaptation of the UK's critical economic infrastructure, including water, energy, transport and digital, can be improved. This is particularly important as the UK Government develops its third National Adaptation Strategy for climate change, due in 2023.

The paper also balances longer-term perspectives with realism about short- and medium- term policy and funding constraints.

We must ensure that we have the frameworks in place to create infrastructure that will not only reduce our impact on the environment, but also help us to cope with the changes in climate that we know are coming.

This ICE Green Paper consultation seeks to gather evidence and views from infrastructure professionals, civil engineers, civil society groups and other interested stakeholders across a short number of key questions on priorities for infrastructure climate resilience and adaptation.

The questions include:

Question 1: Do we understand the current condition of critical infrastructure assets, their structural integrity, and the maintenance and retrofit measures needed to improve their climate resilience and adaptation?

Question 2: What evidence is there that new infrastructure is being designed and constructed to be climate adaptive?

Question 3: How can we ensure that infrastructure climate resilience and adaptation are considered by asset owners and policymakers at a systems-wide level?

Question 4: How do we enable accountability within the governance system for climate resilience and adaptation?

Question 5: How do we encourage the development of the following to support resilience and climate-adaptive infrastructure, both new build and legacy? What other aspects in these areas do we need to consider?

- Regulatory system
- The planning system
- Data-driven technologies
- What works in terms of physical adaptations at ground level

Question 6: How can senior leaders in the public and private sectors build up investment in resilience and adaptation measures as well as focusing on new infrastructure?

Question 7: How can increased attention and funding for infrastructure climate resilience and adaptation beyond the water sector be encouraged?

Responses should be sent to policy@ice.org.uk

The consultation will close on 27th January 2023.

The findings from responses to this paper, alongside further evidence gathering, will be formed into an ICE policy paper later in 2023 with a series of options and solutions for policymakers in relation to improving infrastructure climate resilience and adaptation.

The global picture

Earlier this year, the Intergovernmental Panel on Climate Change (IPCC) produced the latest findings from available data and research on climate risks to infrastructure.¹ These include, but are not limited to:

- Increased frequency of flooding, with coastal infrastructure and infrastructure networks near rivers particularly at risk.
- Projected changes in temperature and rainfall will place additional pressures on the rail, road, water, and energy sectors. High temperatures create a risk of buckling on the rail network, cause cables to sag, and road tarmac to soften and rut. Digital equipment that these sectors rely on could overheat and fail.
- Changes in rainfall, coupled with population growth, are projected to increase drought risks.
- Projected extended periods of rainfall will increase the risk of slope and embankment failure, primarily affecting transport networks.
- Increases in maximum wind speeds experienced during storms would impact on overhead power lines, data network cabling, rail networks, as well as offshore infrastructure.

Global agreements and principles on resilience, climate-adaptation and sustainability are already in place. This includes the Global Goal on Adaptation and principles for resilient infrastructure developed by the United Nations Office for Disaster Risk Reduction (UNDRR).^{2,3} Adaptation and resilience were also central to the discussions at COP27, while climate-resilient infrastructure can support the efforts to achieve a number of the Sustainable Development Goals.

The economic benefits of climate change adaptation are likely to be considerably higher than its costs.⁴ Adaptation costs, however, are rising faster than adaptation finance.

The World Bank has estimated that the costs of building climate-resilient infrastructure in low- and middle-income countries will require between \$11-\$65 billion a year by 2030 and costs could rise to \$280-\$500 billion (dependent on the level of emissions) per year by 2050 for developing countries alone.^{5,6}

Although there has been no appropriate methodology to track and report private financing of climate change adaptation, it has been estimated that only 4-8% of climate finance is going into adaptation.⁷ Most climate funding has been allocated to mitigation activities, which are viewed as offering immediate cost-savings to investors.

Internationally, adaptation finance continues to predominantly come from public sources, and it has been estimated of the total \$30 billion spent on adaptation in 2017-2018, only around 1.6% (\$100 million) was estimated to come from private sources.

Water and wastewater management projects received 70% of private sector adaptation finance, with energy and other infrastructure receiving around 17%.⁸

¹ IPCC (2022) [Climate Change 2022: Impacts, Adaptation and Vulnerability](#)

² United Nations (2022) [New Elements and Dimensions of Adaptation Under the Paris Agreement](#)

³ UNDRR (2022) [Principles for Resilient Infrastructure](#)

⁴ HM Government (2022) [UK Climate Change Risk Assessment 2022](#)

⁵ World Bank Group (2019) [Lifelines: The Resilient Infrastructure Opportunity](#)

⁶ UN (2021) [Adaptation Gap Report 2021](#)

⁷ Wael Aboulmagd (2022), [Special Representative of the COP27 President-Designate during the COP26-COP27 Briefing on the IPCC Climate Change 2022 Report: Impacts, Adaptation and Vulnerability](#)

⁸ World Bank Group (2021) [Enabling Private Investment in Climate Adaptation and Resilience: Current Status, Barriers to Investment and Blueprint for Action](#)

Most of this finance has been concentrated on developed countries. Barriers to private sector investment in adaptation include uncertainty of returns on investment, high upfront costs of technology, a lack of technical and institutional capacity, and a view of adaptation as a public rather than private good.^{9 10}

The G20 are encouraging greater consistency from companies on how they report climate impacts through mandating the Task Force Climate-Related Financial Disclosures (TCFD) - a voluntary framework for assessing climate change risks and opportunities.¹¹¹² This includes a requirement for in-scope companies to disclose their analysis of the resilience of their business model and strategy - taking account of different climate-related scenarios.

This approach, however, does not automatically lead to increased private financing of climate adaptation. Governments can choose to make adaptation reporting and activities mandatory, and incentives and regulations are likely to be needed to encourage private sector reporting of climate risks to infrastructure and funding of resilience and adaptation.¹³

Adapt and thrive: New Zealand's first national adaptation plan

New Zealand's national adaptation plan responds to forty-three priority risks identified in its National Climate Change Risk Assessment 2020.¹⁴

It highlights the ten most significant risks from climate change across five domains: natural, human, economy, built and governance. These include threats to drinking water and buildings. It also warns that poor governance and unfit institutional arrangements could lead to maladaptation.

The plan identifies four priorities:

- enabling better decisions
- targeting the right places
- laying the foundations for a range of adaptation options
- embedding climate resilience across government policy

The actions outlined in the plan relate to both system-wide objectives and five 'outcome areas.' These include infrastructure, which has three objectives:

- Reduce the vulnerability of assets exposed to climate change
- Ensure all new infrastructure is fit for a changing climate
- Use renewal programmes to improve adaptive capacity

Critical actions to achieve those objectives will include developing new guidance to support infrastructure asset owners and scoping a new resilience standard for infrastructure to encourage risk reduction and resilience planning. Adaptation will be integrated into all Treasury decisions on new assets, renewals and upgrade programmes.

The plan emphasises place-based thinking to ensure future development happens in areas least vulnerable to climate impacts. Subnational government will play a key role in identifying specific risks.

The New Zealand Government will publish a new adaptation plan every six years to allow the flexibility to respond to new evidence and updated risk assessments. New Zealand's independent Climate Change Commission will also report on the adaptation plan's implementation every two years.

⁹ Timilsina, G.R (2021) [Financing Climate Change Adaptation: International Initiatives](#)

¹⁰ Khan, M.R and Munira, S (2021) [Climate Change Adaptation as a Global Public Good: Implications for Financing](#)

¹¹ OECD (2018) [Climate-Resilient Infrastructure](#)

¹² Task Force on Climate Related Financial Disclosures (2022) [TCFD Strategy](#)

¹³ Timilsina, G.R (2021) [Financing Climate Change Adaptation: International Initiatives](#)

¹⁴ Ministry for the Environment (2022) [Aotearoa New Zealand's First National Adaptation Plan](#)

The UK's existing and new infrastructure

The UK Climate Change Act includes legally binding emissions targets, a process to integrate climate risks into policy, and a central role for independent evidence-based advice and monitoring.

It includes the Adaptation Reporting Power (ARP), which can be used by the Secretary of State to direct organisations to report how they are addressing climate risks.

The Climate Change Committee (CCC) provides summaries and analysis of available data taken from reporting under the Adaptation Reporting Power and research sources. This includes the identification of specific risks to sectors, networks, and services.¹⁵

Such analysis informs national infrastructure assessments and plans across the UK and devolved administrations. Perhaps reflecting the maturity of the resilience and adaptation agenda in the water sector, much of the risk data available through the CCC technical report on adaptation relates to risk to assets through flooding or drought.

In the UK it has been estimated that by 2050, £900 million a year will need to be spent on drought resilience alone.¹⁶ The Environment Agency has suggested that annual investments of £1 billion a year will be needed to adapt flooding and coastal change infrastructure over the next 50 years.¹⁷

Heat related death could also cost the economy £323 million a year by 2050, with some estimates as high as £9.9 billion.¹⁸

Existing infrastructure

The UK's climate is changing. Our infrastructure is facing pressures that, for the most part, it was not designed to withstand. Without adaptation and improved emergency response to build in greater resilience, our infrastructure will lose its value, repairs will be costly and increasingly frequent, and infrastructure users will face high levels of disruption.

The case for maintenance and adaptation on these grounds alone is clear, but this will require investment.

The effects of climate change are becoming more evident, with more frequent extreme weather events likely to impact the infrastructure sectors that serve the public, potentially leading to cascade failure across infrastructure systems.

However, the chair of the CCC has warned that climate resilience remains 'a second-order issue,' under-resourced despite the UK having the capacity to respond effectively.¹⁹

Private sector operators are generally wary of sharing commercially sensitive data with others²⁰, and much of private sector asset management is built on traditional analogue processes²¹, even where it is digitalised.

¹⁵ CCC (2022) [Understanding Climate Risks to UK Infrastructure: Evaluation of the Third Round of the Adaptation Reporting Power](#)

¹⁶ NIC (2021) [Regulation & Resilience](#)

¹⁷ Environment Agency (2021) [Long-term Investment Scenarios \(LTIS\) 2019](#)

¹⁸ CCC (2019) [Heat and Preventable Deaths in the Health and Social Care System](#)

¹⁹ CCC (2021) [Progress in Adapting to Climate Change](#)

²⁰ ODI (2021) Case Study: The Value of Data Sharing in the Private Sector. <https://theodi.org/article/case-study-the-value-of-data-sharing-in-the-private-sector/>

²¹ Seabright, L, Renukappa, S., and Suresh, S (2022) Climate Adaptation Challenges in Infrastructure Management: Written Evidence to Parliament. <https://committees.parliament.uk/writtenevidence/106518/pdf/>

Most infrastructure that supports the UK's national resilience will continue to be used long into the future. Maintenance of infrastructure assets and systems must be further up the agenda. With much of the UK's infrastructure dating back to the post-war or even Victorian eras, this poses a growing risk as they are put under additional pressure due to climate change, such as heat stress and increased surface water run-off in urban environments.

Question 1: What is the current condition of critical infrastructure assets, their structural integrity, and the maintenance and retrofit measures needed to improve their climate resilience and adaptation?

Sub questions: Where are the weak spots in our infrastructure system, and how can we address them? Where are the biggest data gaps?

New infrastructure

Each year, governments and the private sector globally invest trillions of dollars in new infrastructure that may not withstand future impacts from climate change. The long-lived nature of infrastructure assets means that decisions made now will lock-in vulnerability if they fail to adequately consider the impacts of climate change.

There is a wider awareness from both policymakers and the public of how to meet national challenges through infrastructure interventions, including the crucial questions of which projects to promote and how to promote them. In some cases, policymakers are already shifting their requirements away from the presumption that infrastructure solutions require new assets to be built.

Lessons can be learned from the Scottish Government's Investment Hierarchy. The Investment Hierarchy 'prioritises enhancing and maintaining assets over new build' – seeking to maximise use of extant infrastructure assets in line with future need, with replacement or new build considered where upgrading existing infrastructure would be unsuitable.²²

The Joint Committee on the National Security Strategy recently highlighted that the UK is building infrastructure to meet net zero commitments without considering resilience.²³

Enormous changes are happening and will be happening to our infrastructure system, yet there is little understanding of how resilient new assets are to a changing climate.

Even if net zero targets are achieved, then the country will still be exposed to phenomena such as wind droughts if resilience is not effectively built into the power system.

Question 2: What evidence is there that new infrastructure is being designed and constructed to be climate adaptive?

²² ICE Scotland (2020) [State of the Nation Report 2020: Climate Ready Infrastructure](#)

²³ Joint Committee on the National Security Strategy (2022) [Readiness for Storms Ahead? Critical National Infrastructure in an Age of Climate Change](#)

A systems approach

The CCC has highlighted that extreme weather events can create cascading risks that spread across sectors, 'with impacts an order of magnitude higher than impacts that occur within a single sector.'²⁴

Major power outages, landslides onto roads, buckling train lines and flooding of infrastructure sites are all realistic scenarios, which can lead to cascading risks affecting other infrastructure sectors. Different infrastructure sectors are highly interdependent, so the shutdown of one operator may cause knock-on effects on multiple other sectors. In particular, the CCC has emphasised the dependence of other sectors on energy supply.²⁵

Further risk will be introduced by the development of new infrastructure and new technologies to support resilience.²⁶

One way of ensuring existing infrastructure can address this risk is to make optimal use of data and information, using them to better understand the performance of systems and assets and predicting how they will react to climate change.

Infrastructure operates as a system of systems. Infrastructure owners and operators must better understand the other networks and systems they are dependent on and interdependent with. Increasingly a failure in one sector will impact another.

The National Infrastructure Commission (NIC) has previously recommended that individual operators develop long-term resilience strategies which take these interdependencies into account.²⁷

Clear and consistent standards, alongside regular stress tests, will no doubt support this; however, the importance of resilience must be more deeply embedded in processes used by decision-makers – such as the planning system.

It has also been highlighted that there is a lack of data on interdependencies that could be used to develop more realistic models for cascades of failure across systems.

The data on climate risks to specific infrastructure and their level of resilience to these is currently very limited, although the international Task Force on Climate Related Financial Disclosures (TCFD) standard for reporting is due to become mandatory in the UK. This should increase information on risks to specific assets in the private sector, at least from the perspectives of auditors and regulators.

Currently the TCFD is focused on risk rather than adaptation. There have been calls for improved data, including on interdependencies and increased funding for climate-adaptive or resilient infrastructure for over a decade.^{28 29} Even if mandatory Adaptation Reporting Powers and TCFD reporting is in place, problems are likely to continue to impact on the gathering and analysis of private sector data for the foreseeable future.

ICE has previously identified that the lack of a systems-thinking approach within the built environment sector to resilience is an issue that must be addressed.³⁰ Individual infrastructure assets do not exist in isolation and, to a higher or lesser degree, should be considered interdependent.

²⁴ CCC (2021) [Independent Assessment of UK Climate Risk](#)

²⁵ Ibid.

²⁶ Jaroszweski, D., Wood, R., and Chapman, L. (2021) [UK Climate Risk Independent Assessment Technical Report Chapter 4: Infrastructure](#)

²⁷ NIC (2020) [Anticipate, React, Recover: Resilient Infrastructure Systems](#)

²⁸ Engineering the Future (2011) [Infrastructure, Engineering and Climate Change Adaptation](#)

²⁹ Defra (2011) [Climate Resilient Infrastructure: Preparing for a Changing Climate](#)

³⁰ ICE (2020) [ICE Response to the National Infrastructure Commission Resilience Study Scoping Report](#)

Reviews into the network response to Storm Arwen

Both Ofgem and the Energy Emergencies Executive Committee produced reports in June 2022 into the impact of Storm Arwen, the effects of which were particularly acute across large parts of Scotland and northern England in November 2021.

Several issues were highlighted in the review, including:

- The interconnectedness of green and grey infrastructure – trees and branches falling onto lines, and older wooden poles failing under strong winds.
- The need for improved, interconnected responsiveness.
- The need for improved information exchange between network providers and local resilience forums.
- Better use of technology e.g., smart meters that enable better collection of data, with data then used to quickly identify and respond to faults.
- The lack of a single resilience standard; instead there were various policies, standards, regulatory incentives, and non-mandatory technical specifications that applied to the networks.

The review recommended that the Energy Emergencies Executive Committee put forward proposals for an outcomes-focused physical network resilience standard, which represents a shift away from current standards that have an input-focused approach in the form of build standards.³¹

Interdependencies occur for two main reasons. First, because one infrastructure asset or network will place demands on another, and second, because increasing demand, due to demographic shifts and economic growth, or changes in technology, will increase one assets dependence on another, or create new demands which need to be met.

The understanding of these interconnectivities and interdependencies is less comprehensive, and current governance arrangements mean that responsibilities for assessing and managing risks from interdependencies are unclear.

Changes to governance and decision-making structures are needed which will support and entrench systems thinking in the planning, delivery, operation and recovery of infrastructure assets and systems.

First, there must be a consistent commitment by planning, advisory and decision-making bodies in considering resilience as a fundamental part of their process. The OECD believes that there are a number of barriers which can prevent climate-resilience planning, including long time horizons, uncertainty about the future, a lack of information and capacity, policy misalignments and externalities. If decisions do not benefit the economic case, are beyond the time horizons of decision makers, or incentives are distorted, resilience can be overlooked.³²

Second, planning should be conducted at multiple geographic scales, including, crucially, at a regional level. ICE has previously recommended that regional infrastructure strategies should be developed across England to ensure effective integration of networks.³³

Increasingly, responsibility for many forms of critical economic infrastructure and related flexibility over funding have been devolved to the UK's devolved national administrations, cities, and other placed-based partnerships.

³¹ BEIS (2022) [Energy Emergencies Executive Committee Storm Arwen Review](#)

³² OECD (2018) [Climate-Resilient Infrastructure](#)

³³ ICE (2019) [What Should be in the National Infrastructure Strategy?](#)

The NIC have also called for regulators to engage more with devolved administrations, Metro Mayors, local government, utility companies, consumer groups, elected representatives, and members of the public – and take their view into account in strategic decision-making, including investment.³⁴

More localised plans offer the potential to identify synergies and overlapping resilience dependencies in regional economies. Greater alignment of budgets, funding streams and programmes at the regional level for economic and social infrastructure would also contribute to greater productivity and more efficient use of resources, tying together planning and delivery.³⁵

A systems approach to resilience and adaptation is therefore crucial in order to better understand the links between infrastructure sectors, how they interact and how they can support infrastructure climate resilience.

Question 3: How can we ensure that infrastructure climate resilience and adaptation are considered by asset owners and policymakers at a systems-wide level?

Question 4: How do we enable accountability within the governance system for climate resilience and adaptation?

³⁴ NIC (2019) [Strategic Investment and Public Confidence](#)

³⁵ ICE (2019) [State of the Nation 2019: Connecting Infrastructure with Housing](#)

Resilience and adaptation across infrastructure sectors

Climate adaptation in response to flood and coastal risks is an area that is receiving increased attention and investment.

However, maintenance of infrastructure assets (including those that critical national infrastructure is reliant on such as coastal defences and transport) is typically underfunded.

With much of our infrastructure reliant on post-war or even Victorian infrastructure, this poses a growing risk as they are put under additional pressure due to climate change, such as heat stress and high surface water run-off in urban areas.

Risks found across infrastructure sectors, highlighted by the CCC, include cascading failures due to interdependencies, river, surface water and ground water flooding, coastal flooding, and erosion and subsidence.³⁶

The below sections highlight that action is underway in some sectors to improve infrastructure climate resilience, but without metrics in place, it is not possible to identify tangible results from adaptation interventions.

The CCC recently observed that there was very limited information on the effectiveness of recent and planned adaptation actions for organisations in all sectors.³⁷ It was recognised that clearer ownership, timescales, and more information on effectiveness was needed through ARP reporting.

In addition, without building direct engagement with public and consumers into policy and implementation, there is the risk that public engagement with climate change and trust could be lost. Research by the IPPR has suggested that at local level the climate crisis is often understood as a high-level, geopolitical issue discussed in Westminster and the United Nations, disconnected from local priorities.³⁸ Those participating in place-based adaptive partnerships (usually around water management) can view top-down policy and advice as counter-productive.³⁹

Water

In the UK there are already statutory duties on water suppliers to produce plans and set out what short-term operational actions a company will take during a drought to maintain supplies, and how they will increase resilience against drought and secure supply e.g., through prioritisation of public health and critical national infrastructure.

There is also a relatively mature governance structure for adaptation and resilience in the water sector. Water abstraction targets are set out in the UK Government's 25 Year Environment Plan.⁴⁰ Measures in the current Environment Bill will act as a key vehicle for the delivery of the 25 Year Environment Plan and allow for the setting of long-term targets and introduce a new statutory cycle for monitoring, planning, and reporting.⁴¹

The Environment Agency has also developed the national flood and coastal erosion risk management strategy and there has been substantial funding – running into billions of pounds – across national, regional and catchment scales to deliver this.^{42 43 44}

³⁶ Jaroszowski, D., Wood, R., and Chapman, L. (2021) [UK Climate Risk Independent Assessment Technical Report Chapter 4: Infrastructure](#)

³⁷ CCC (2022) [Understanding Climate Risks to UK Infrastructure: Evaluation of the Third Round of the Adaptation Reporting Power](#)

³⁸ IPPR (2021) [The Climate Commons](#)

³⁹ Innovate UK (2022) [Accelerating Net Zero Delivery](#)

⁴⁰ Defra (2018) [A Green Future: Our 25 Year Plan to Improve the Environment](#)

⁴¹ Defra (2022) [Environmental Bill: Environmental Targets](#)

⁴² Defra (2020) [Multi-Billion-Pound Investments as Government Unveils New Long-Term Plan to Tackle Flooding](#)

⁴³ Environment Agency (2022) [National Flood and Coastal Erosion Risk Management Strategy for England](#)

⁴⁴ Environment Agency (2022) [Review of England's Emerging Regional Water Resources Plans](#)

There is a strong place-based approach built into water sector governance, including river catchment partnerships for more than one hundred rivers⁴⁵, with plans for companies to deliver catchment-based solutions.⁴⁶

Government green funding initiatives have focused on water management⁴⁷ and some of the most cited examples of nature-based solutions and work on green-grey infrastructure are found in this sector.⁴⁸

The water sector, however, has not been immune to major regulatory failures, and around 32% of water bodies in England do not have 'good' ecological status due to continuous discharges from sewage, and 7% due to stormwater overflows.⁴⁹

The NIC have also noted that the government has yet to define long-term targets for flood resilience.⁵⁰ Until it does so, policies and investment are unlikely to fully address flood risk, while evidence suggests that there has been no comprehensive way of evaluating how better protection of infrastructure has been achieved.⁵¹

Transport

Outside the water sector, climate-adaptation statutory requirements, strategies, guidance, and interventions tend to be less well developed, although many have regional structures and quality standards that outline the level of service that network operators are expected to deliver.

Following the July 2022 heatwave in the UK, the then-Transport Secretary admitted that the nation's transport networks could not cope with extreme temperatures.⁵² He also stated that it would be decades before retrofitting could replace an ageing rail system with infrastructure that could withstand extremes temperatures.

Work on adaptation planning is taking place within the transport sector, including in the devolved administrations.^{53 54} Following the July 2022 heatwave, Network Rail announced the launch of a new taskforce focused on four workstreams including one on the performance of track and overhead line equipment.

Network Rail has also stated it may need to change its standards and engineering approaches to be more climate-resilient, but this decision has yet to be taken.⁵⁵

Energy

Energy UK, the trade association for the energy industry, recently set out a sectoral overview of climate change risks and adaptation in the sector.⁵⁶ There was, however, only a brief mention of adaptation in the UK Government's Energy White Paper.⁵⁷

⁴⁵ Catchment Based Approach (2022) [About the Catchment Based Approach](#)

⁴⁶ Ofwat (2019) [PR19 Final Determinations](#)

⁴⁷ HM Treasury (2021) [UK Government Green Financing Framework](#)

⁴⁸ Environment Agency (2021) [Delivering Benefits Through Evidence](#)

⁴⁹ NIC (2021) [The Second National Infrastructure Assessment: Baseline Report](#)

⁵⁰ NIC (2022) [Infrastructure Progress Review 2022](#)

⁵¹ Ibid.

⁵² SEC Newgate (2022) [Why Can't Britain's Railways Take the Heat?](#)

⁵³ HM Government (2022) [UK Climate Change Risk Assessment](#)

⁵⁴ Scotrail (2021) [Climate Change Adaptation Strategy](#)

⁵⁵ Network Rail (2022) [Network Rail Launches Resilience Taskforce in Wake of Record-Breaking Heatwave](#)

⁵⁶ Energy UK (2021) [Climate Change Risks and Adaptation Responses from UK Electricity Generation](#)

⁵⁷ BEIS (2020) [Energy White Paper](#)

As powers on energy are reserved, there is less drive towards decentralisation of energy infrastructure. Various projects led by BEIS, Ofgem and other national stakeholders are currently focusing on resilience and net zero, and the Energy Bill addresses the resilience of the nuclear, oil and gas sectors.^{58 59 60}

There are, however, no mentions of resilience or adaptation in the Government's proposals for heat networks across many localities.⁶¹

Recent announcements (and related documentation) of a move towards a holistic network design by National Grid ESO also made no reference to climate adaptation.⁶²

Digital

As in the case of the energy sector, there is limited evidence of climate adaptation planning and implementation in the digital infrastructure sector.

The sector emphasises that it can support infrastructure resilience, but it also creates interdependencies and related risks of cascade failures.

Activity on digital resilience is focused primarily on data centres. These have a longer lock-in period than other digital infrastructure and so are viewed as more at risk from climate change. These data centres, however, may be offshored. The CCC have given the digital and ICT sector a low confidence rating and have recommended more monitoring of climate-related events that impact on the sector and the location of UK digital infrastructure.⁶³

Data for the private sector, however, can be difficult to obtain. There are also likely to be differences in perspectives and experiences, dependent on whether resilience is considered from an urban (well-connected) or non-urban (potentially poorly connected) perspective. Much of the research on digital and resilience, for example, is focused on resilient cities.

Under proposals made by the NIC for a National Resilience Strategy and cross-sectoral standards, the ICT and digital sector may be expected to adhere to national resilience standards.⁶⁴

The NIC view high quality digital infrastructure, such as sensors and use of real time data, as offering economic opportunities and improvements in resilience across a range of infrastructure services.⁶⁵ The UK Government have proposed that data driven technologies, including cyber-physical infrastructure, AI, digital twins, robotics, augmented and virtual reality, and sensors have a significant role in supporting resilient infrastructure.⁶⁶

⁵⁸ Ofgem (2022) [Ofgem Reveals Landmark Five-Year Programme to Deliver Reliable, Sustainable Energy at the Lowest Cost to Consumers](#)

⁵⁹ BEIS (2022) [Plans to Bolster UK Energy Security Set to Become Law](#)

⁶⁰ Met Office (2020) [Exploring the Resilience of the Future Electricity System](#)

⁶¹ BEIS (2022) [Heat Networks: Proposals for Heat Network Zoning](#)

⁶² National Grid ESO (2022) [The Pathway to 2030 Holistic Network Design](#)

⁶³ Jaroszowski, D., Wood, R., and Chapman, L. (2021) [UK Climate Risk Independent Assessment Technical Report Chapter 4: Infrastructure](#)

⁶⁴ NIC (2020) [Anticipate, React, Recover: Resilient Infrastructure Systems](#)

⁶⁵ NIC (2021) [The Second National Infrastructure Assessment: Baseline Report](#)

⁶⁶ BEIS (2022) [Enabling a National Cyber-Physical Infrastructure to Catalyse Innovation](#)

Question 5: How do we encourage the development of the following to support infrastructure climate resilience and adaptation, both new build and legacy? What other aspects in these areas do we need to consider?

- Regulatory system
- The planning system
- Data-driven technologies
- What works in terms of physical adaptations at ground level

Financing and funding resilience and adaptation

Evidence suggests that most climate change finance is being channelled into mitigation rather than adaptation, with the water sector drawing in the highest level of adaptation resourcing.⁶⁷

Where funding for adaptation is available, this mainly comes from public sources, as many private investors still view adaptation as offering public value only.⁶⁸ Those currently seeking to drive forward the climate resilience agenda must, therefore, convince public funders – consumers and taxpayers – of its public benefits and argue for funding at a time when there are many other major policy demands.⁶⁹

The UK Infrastructure Bank is due to develop a ESG policy and framework incorporating resilience to climate change as an additional pillar to form an Environmental, Social, Resilience and Governance framework.⁷⁰ It was intended that the Bank would cover resilience, adaptation, and nature-based solutions, but it has been noted that its consultation on investment priorities did not mention adaptation.⁷¹

Attempts are being made to strengthen resilience and adaptation finance at national level, and the CCC is due to publish a report on adaptation finance later in 2022.

The gathering of additional data from the private sector and changes to cost-benefit analysis are viewed as vital by those advocating increased funding for adaptation, as much of the infrastructure in the UK is privately owned. It is expected that improved data and data insights will increase public and private sector understanding of climate risks and opportunities and the need for early investment.

Financial tools are also being designed to encourage private sector investment in both climate change mitigation and adaptation. Many countries, for example, have issued green bonds for financing climate change activities, including adaptation activities. However, evidence shows that green bonds have financed resilience and adaptation (including adaptation of critical infrastructure) to a very limited extent in comparison to mitigation.⁷²

In the absence of substantial funding from private investment, climate adaptation continues to be funded through consumer payments and finite public resources, which are also subject to many other demands. Individuals will also need to increasingly contribute to the costs of climate-adapting domestic infrastructure, including homes. Whatever future conditions develop, many government authorities across the UK are already struggling to find the funds to maintain essential services, while the UK economy has also become increasingly debt laden⁷³.

This has implications for public and private investment. Realised climate risks and other crises, even if substantial mitigation and adaptation actions are undertaken, will add to economic pressures and impact on the development of innovative financial approaches.

Decisions over funding for critical economic infrastructure are already influenced by statutory duties and the concept of public value. HM Treasury provides top-down guidance on how to conduct social cost-benefit analysis of policies and projects through the Green Book. This has been updated with the government's guidance on how to value the wider benefits of a project and ensure appropriate emphasis on the analysis of place-based impact.

⁶⁷ Wael Aboulmagd (2022), [Special Representative of the COP27 President-Designate during the COP26-COP27 Briefing on the IPCC Climate Change 2022 Report: Impacts, Adaptation and Vulnerability](#)

⁶⁸ Tilsina, G.R (2021) [Financing Climate Change Adaptation: International Initiatives](#)

⁶⁹ NIC (2019) [Strategic Investment and Public Confidence](#)

⁷⁰ UK Infrastructure Bank (2022) [Strategic Plan](#)

⁷¹ UK Parliament Hansard (4 July 2022) [UK Infrastructure Bank Bill, Volume 823](#)

⁷² Stockholm Environment Institute (2020) [Green Bonds: A Mechanism for Bridging the Adaptation Gap?](#)

⁷³ OBR (2022) [Fiscal Risks and Sustainability – July 2022](#)

At an ICE roundtable in February 2022 on the topic of climate resilient infrastructure, there was support for a Treasury-commissioned review on the economics of resilience in order to gain a better understanding of the long-term value that investing in resilience can provide. 'Best value' may then be interpreted as the optimum cost that provides robust and flexible performance under a range of future scenarios.⁷⁴

The UK parliamentary Joint Committee on National Security Strategy in October also recommend that the Government undertakes a more detailed cost-benefit analysis of climate adaptation for every critical national infrastructure sector.

Regulators apply the regulatory asset base (RAB) approach, which is used to implement financial measures of the value of productive capital and spreads the costs and risks of infrastructure investment across a wide customer base.

The NIC has recently proposed that UK critical infrastructure regulation must be reconfigured to meet the challenges of net zero, adaptation and digitalisation.⁷⁵

Their recommendations also included a national long-term strategic framework and investment decisions reflecting UK priorities and encouraging longer term investment in climate resilience and adaptation. As much of UK adaptation finance will come from UK consumers and taxpayers, the NIC have argued that there needs to be regulatory system in place that protects consumer interests while providing certainty to investors.

The UK Government is currently consulting on proposals for a National Resilience Strategy.⁷⁶ This takes a whole systems approach across a range of resilience issues from climate change to cybersecurity and includes cross-sectoral standards. This is due to be published later in 2022. Details on individual risks will be dealt with by individual sector strategies, but it is currently unclear whether these will provide information on, or drivers for, specific funded programmes for climate adaptation.⁷⁷

Question 6: How can senior leaders in the public and private sectors build up investment in resilience and adaptation measures as well as focusing on new infrastructure?

Question 7: How can increased attention and funding for infrastructure climate resilience and adaptation beyond the water sector be encouraged?

About ICE

Established in 1818 and with over 96,000 members worldwide, the Institution of Civil Engineers exists to deliver insights on infrastructure for societal benefit, using the professional engineering knowledge of our global membership.

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⁷⁴ ICE (2022) [Presidential Roundtable Summary: Climate Resilience and Adaptation – What is the Size of the Challenge?](#)

⁷⁵ NIC (2020) [Anticipate, React, Recover: Resilient Infrastructure Systems](#)

⁷⁶ Cabinet Office (2021) [Government Response to the National Infrastructure Commission Report 'Anticipate, React, Recover: Resilient Infrastructure Systems'](#)

⁷⁷ Joint Committee on the National Security Strategy (2022) [Readiness for Storms Ahead? Critical National Infrastructure in an Age of Climate Change](#)