

Climate Resilient Infrastructure: Preparing for a Changing Climate





Climate Resilient Infrastructure: Preparing for a Changing Climate

Presented to Parliament
by the Secretary of State for Environment, Food and Rural Affairs by Command of Her Majesty

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Ministerial Foreword



To help our economy grow this Government has rightly focused on how effective and reliable infrastructure can enable economic growth.

Our economy must be sustainable and adapt to the challenges we face – from the global banking crisis to the Icelandic volcano cloud. Just as important, the infrastructure that enables our economy to grow and which our businesses and communities rely on must also be sustainable. It must be able to face up to the near and long-term challenges and opportunities of population change, new technology, the transition to a low carbon economy and the impacts of climate change.

Our current and future climate presents a major challenge – globally and for the UK. Over the next 50 years we will experience higher temperatures, changing rainfall patterns, rising sea levels and more frequent extreme weather events ranging from droughts, floods and freezing winters. We need to plan for this today and consider now what steps are needed to ensure our infrastructure, and the crucial services it provides, can meet the challenges that lie ahead.

The case for adapting infrastructure to climate change is compelling. Our infrastructure is an increasingly interconnected network of high-value assets with long operational lifetimes. Our existing stock of bridges, roads and power stations is already vulnerable to today's extreme weather. Climate change will increase these vulnerabilities. It will affect supply, access to resources, operations and patterns of demand. This winter we experienced disruption from snow on our transport networks which cost the country over £600 million a day. For a future with a more challenging climate we need to be well prepared.

The challenge of building climate resilient infrastructure is set within a wider challenge of securing sufficient investment to build a low carbon society. The Government is planning for UK infrastructure investment to be some £200 billion over the next five years. To ensure best value from this investment, adaptation and long-term sustainability must be built-in from the start as a core consideration. This is key for our new power stations, water and transport infrastructure. It will support our transition to a low carbon economy, resilient to climate change, create jobs and benefit the nation as a whole.

Government has a role to play in this and adaptation is already an important element of our National Policy Statements and the country's first ever National Infrastructure Plan. But we and others – owners, operators, investors and professional bodies – all need to do better and do more.

That is why the Government has pushed ahead with this project – drawing in hundreds of experts in the field – to provide a thorough analysis of the challenges and of the potential solutions for adapting infrastructure to climate change impacts.

This document shows that renewed ambition, new approaches and a determined effort to consider the impacts of climate change on both new and existing infrastructure can pay dividends – for our economy, our environment and the current generation and next.

But it is not just about minimising risk. It is also about maximising opportunities to grow a greener, more modern economy.

Taking action now will contribute to moving the economy to a low carbon, resource efficient path, which maintains UK competitiveness, increases its resilience and lays the foundations for strong and sustainable growth in the future. Government will shortly publish its *Roadmap to a Green Economy* setting out its vision for achieving this.

Adapting infrastructure to the impacts of climate change will present opportunities. Our leading infrastructure operators, consultancies and investors already operate on the global stage. They are well placed to focus on the skills and capabilities necessary to invest in, design, build and maintain infrastructure for a new global climate. In doing so, they can capitalise on global adaptation opportunities to gain a competitive edge in domestic and world markets.

This document emphasises the importance of early action to adapt the country's infrastructure to the impacts of climate change. Without a determined effort our economy and future growth will be at risk – that is the challenge, we need to work together to meet it.



Caroline Spelman
Secretary of State for Environment,
Food and Rural Affairs
Defra

Summary

Alongside the transition to a low carbon society, increasing infrastructure's resilience to climate change impacts is a high priority for this Government, to help protect the economy and its future growth.

This document has been produced as a response to calls from industry – infrastructure owners, investors and insurers – for a Government vision and policy on adapting infrastructure to climate change. It is designed to catalyse action to adapt infrastructure in the energy, ICT, transport and water sectors (infrastructure networks).

It makes the case for action, identifies who needs to act, the challenges to acting and the opportunities available. Recognising that infrastructure is largely private sector funded and operated, it sets out how Government can assist others in realising an infrastructure network able to adapt to the impacts of climate change.

The document highlights important themes such as: the risk climate change presents to infrastructure interdependencies; adaptation investment; and potential economic opportunities. The document is linked to wider Government work on infrastructure, in particular the Government's National Infrastructure Plan. In addition, the UK Government's first Adaptation Programme in 2012 will report on progress made and what further actions might be required to increase the climate resilience of infrastructure.

Government Vision

The Government's vision is for:

An infrastructure network that is resilient to today's natural hazards and prepared for the future changing climate.

Preparing Infrastructure for a Changing Climate

The Cabinet Office's *Guide to Natural Hazards & Infrastructure*¹ provides advice on building resilience to today's natural hazard events. *Climate Resilient Infrastructure* looks at addressing the challenges and potential opportunities to preparing infrastructure for a changing climate and how Government will assist.

Ahead of the UK Government's first Adaptation Programme, Government will work with industry to take forward the report and the actions set out in it.

¹ <http://www.cabinetoffice.gov.uk/infrastructure-resilience>

Headline challenges of preparing infrastructure for a changing climate

1. *How Government can facilitate progress in adapting national infrastructure to the impacts of climate change.*
2. *How to set out the challenge of adapting to climate change in economic regulatory models.*
3. *How the planning system for nationally significant infrastructure can guide applicants on the need to adapt new infrastructure to the impacts of climate change.*
4. *How to reduce the risk that climate change impacts present to infrastructure interdependencies, increasing the vulnerability of infrastructure sectors.*
5. *How to increase the adaptive capacity in infrastructure companies and others (e.g. investors) to enable robust and cost effective climate change adaptation decisions to be made.*
6. *How to improve the way investment decisions incorporate the impacts of climate change.*
7. *How to improve access by industry to specific climate information and research through better information sharing, disclosure of risk and evidence.*
8. *How to monitor progress made in adapting national infrastructure to climate change.*
9. *How to realise the potential economic opportunities that adapting national infrastructure to climate change presents.*

Purpose & Structure

The document is designed to:

- Communicate:** The Government's aims and objectives for the delivery of national infrastructure which is able to adapt to climate change.
- Facilitate progress by:** Describing the case for action and setting out how different players can support adaptation action.
- Address challenges including:** Interdependencies between sectors that climate change can intensify; uncertainty about the scale and timing of climate impacts; issues of skills and capacity; and the relatively low profile of adaptation at board level.
- Explain:** How adapting infrastructure to climate change fits with wider Government activity on infrastructure and resilience.

The document's structure is:

- Section 1:** Highlights how the UK's climate might change, the risks this presents to infrastructure and the need for climate resilient infrastructure.
- Section 2:** Sets out the infrastructure sectors examined by the study.
- Section 3:** Focuses on the need to adapt infrastructure to the impacts of climate change within the wider context of Government activity on infrastructure.

- Section 4:** Identifies the potential opportunities through taking early action and developing expertise in adapting national infrastructure to the impacts of climate change.
- Section 5:** Sets out the Government's vision and aims for adapting national infrastructure to climate change and the roles of Government and the private sector in making it happen.
- Section 6:** Highlights how successful adaptation approaches can improve the long-term resilience of infrastructure.
- Section 7:** Pulls together the main challenges and barriers preventing action.
- Section 8:** Focuses on the increasing risk from climate change to infrastructure interdependencies.
- Section 9:** Sets out the headline challenges, the opportunities for others to act and how Government can assist.

As climate change adaptation, and some aspects of infrastructure policy (e.g. water and transport), is a devolved issue, this document covers UK Government policy in England and in the UK for reserved matters. It does not cover the work of the national authorities in Wales, Scotland or Northern Ireland in regard to their devolved functions.



Climate Change Adaptation

1.1 The Adaptation Challenge

Climate change is one of the biggest challenges the world faces. Tackling climate change is a top priority for this Government – at home and internationally. The UK Climate Projections² (UKCP09) show that past, current and future greenhouse gas emissions will influence the climate for decades. So alongside efforts to reduce emissions, we need to prepare for the climate change that we cannot avoid.

The scientific evidence is overwhelming. Since the 1970s, average temperatures for Central England have risen by nearly 1°C and the last decade was the warmest on record. The climate will continue to change with higher temperatures, changing rainfall patterns, rising sea levels and more unpredictable extreme weather ranging from floods, droughts and freezing winters.

Unpredictable extreme weather already presents a challenge to infrastructure. Snow in November and December 2010 affected transport. Water resources may be affected by the warm and dry March and April this year with provisional Met Office climate figures for April 2011³ indicating that the month is the warmest on record with many parts of the UK seeing temperatures 3 to 5 degrees Celsius warmer than normal (these records go back more than 100 years, to 1910). The current weather is already affecting infrastructure's resilience, climate change will increase this risk.

Weather vs Climate

- *Weather* is what we experience over a short period of time (e.g. over an hour or a day).
- *Climate* is the average weather and its variability over a long period of time (e.g. 30 years).

It is important not to:

- Confuse short-term weather events (e.g. snow in November and December 2010) with long-term trends in the climate (e.g. winters warming by over 2°C by the mid-century).
- Presume extreme cold spells will end. Despite a warming climate, cold spells will still occur but with reduced likelihood.

The scale of impacts from climate change will vary across the country. UKCP09 provide information about the potential changes to the climate throughout this century, projecting regional differences in future climate conditions.

Some regions of the UK will be affected more by climate change than others, and certain areas within regions such as floodplains, estuaries and large urban areas may face more pronounced changes and challenges. For example, London and the South East are vulnerable to water scarcity and large urban areas are more vulnerable to extremely hot summer days and nights due to the urban heat island effect.

2 <http://ukclimateprojections.defra.gov.uk/>

3 <http://www.metoffice.gov.uk/news/release/archive/2011/dry-april>

**Changes in Winter and Summer Mean Temperature for the 2080s
(from 1961-1990 baseline under medium emissions scenario)**

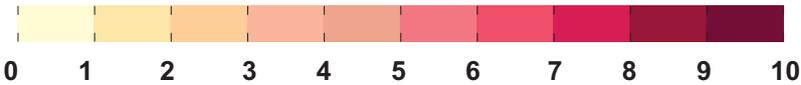
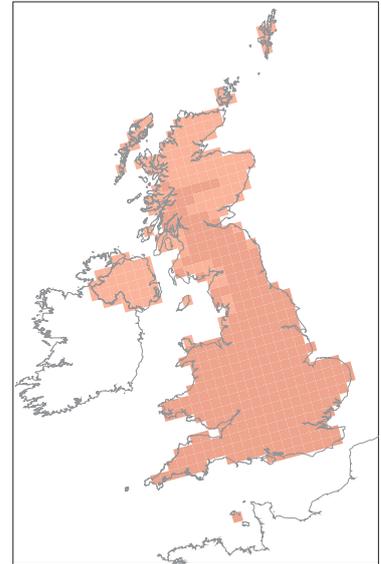
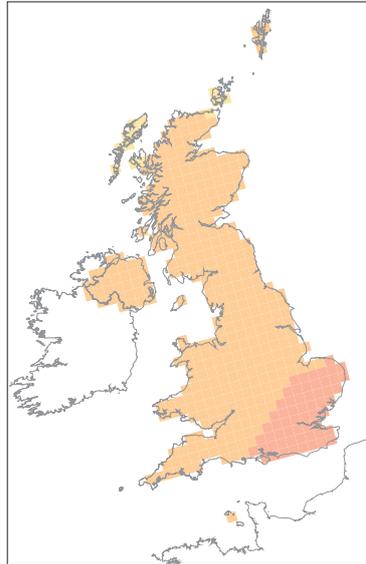
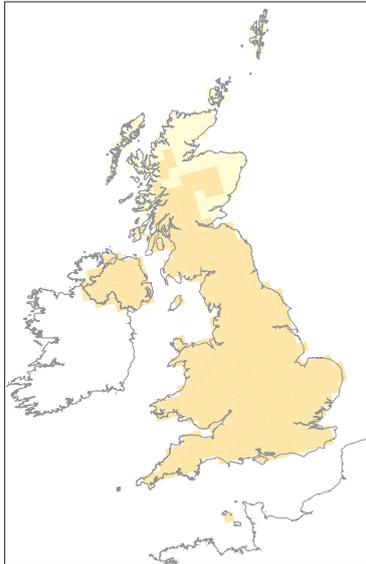
Change in winter mean temperature (°C) for the 2080s, Medium emissions scenario

10% probability level
Very unlikely to be
less than

50% probability level
Central estimate

90% probability level
Very unlikely to be
greater than

Winter



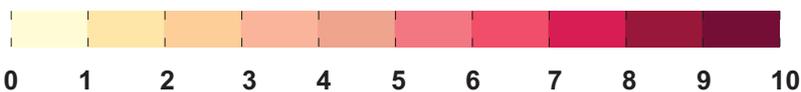
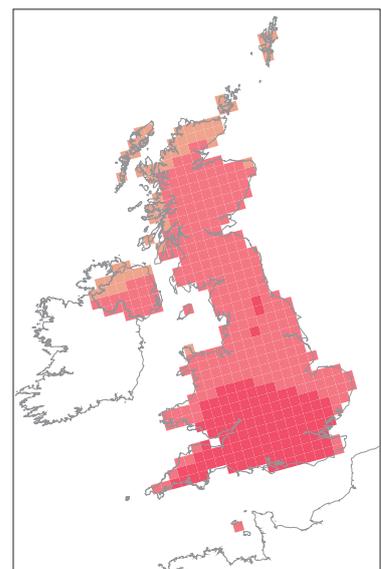
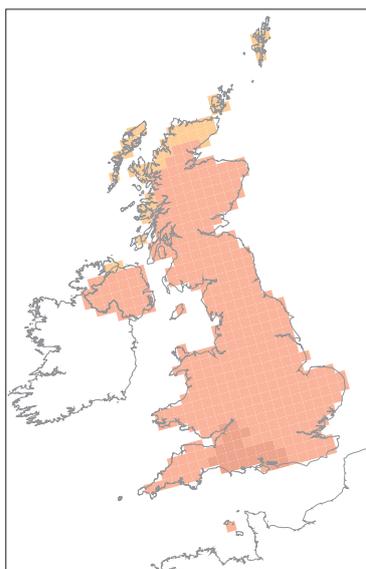
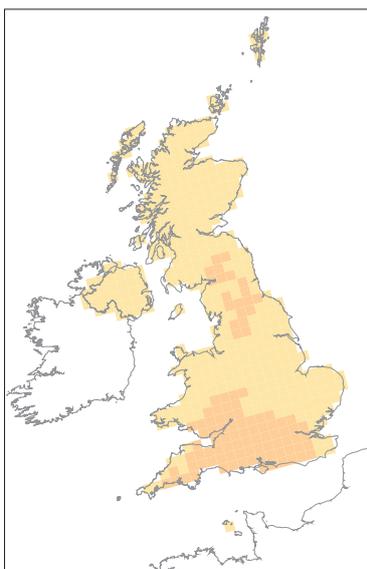
Change in summer mean temperature (°C) for the 2080s, Medium emissions scenario

10% probability level
Very unlikely to be
less than

50% probability level
Central estimate

90% probability level
Very unlikely to be
greater than

Summer



Responding to climate change requires two kinds of action:

1. We need to **mitigate climate change** by reducing greenhouse gases to 80% below 1990 levels by 2050 as required by the Climate Change Act (2008).
2. We need to plan ahead and **adapt to climate change** due to past, current and future greenhouse gas emissions.

Both require the UK to develop a strong and sustainable green, low carbon economy, resilient to climate change.

It is important for mitigation and adaptation action to be taken forward together. For example, creating a new low carbon infrastructure network is vital to reduce greenhouse gas emissions, but it is also vital that it is able to adapt to the impacts of climate change to ensure it can operate under a different climate from today.

1.2 Action to Adapt to Climate Change

The Climate Change Act (2008) sets out a framework for dealing with adaptation, recognising that the country needs to be prepared to deal with the changes to the climate that we are already starting to face, alongside wider economic and demographic trends.

Climate Change Act (2008) and climate change adaptation

The Act includes:

- The requirement to undertake a UK-wide Climate Change Risk Assessment (CCRA) and report on it by January 2012.
- The requirement to set out a statutory Adaptation Programme following the CCRA.
- An Adaptation Reporting Power allowing the Government to direct certain infrastructure companies and regulators⁴ to prepare reports on how they are assessing and acting on the risks and opportunities from a changing climate.
- Establishing the Adaptation Sub-Committee of the Committee on Climate Change⁵ to provide expert independent advice to Government on climate change adaptation.

The cross-government Adapting to Climate Change Programme (ACC)⁶ drives forward work in Government and is currently undertaking the groundwork for the UK Government's first Adaptation Programme, to be put in place by 2012.

1.3 Climate Change Adaptation Priorities

The Adaptation Sub-Committee (ASC) suggests that the priorities for planning and implementing climate change adaptation now are: assets or institutions that are sensitive to current climate risks; decisions that have long-lasting consequences; and decisions that may have systemic and far-reaching effects. This criteria has led the ASC to identify five priority areas for immediate action in preparing for climate change: taking a strategic approach to land-use planning; **providing national infrastructure**; designing and renovating buildings; managing natural resources sustainably; and effective emergency planning.

⁴ Reporting Authorities: companies with functions of a public nature and statutory undertakers. This includes infrastructure organisations in the energy, transport and water sectors.

⁵ <http://www.theccc.org.uk/about-the-ccc/adaptation-sub-committee>

⁶ <http://www.defra.gov.uk/environment/climate/government/>

In all these areas, by planning ahead and taking timely adaptation action, the UK can reduce costs and damages and take advantage of any opportunities that arise. In relation to infrastructure, early action is needed to ensure it can cope with:

- Rising temperatures, changing rainfall patterns and rising sea levels.
- Potential increases in extreme weather events, such as storms, floods and droughts.
- Possible changing patterns of consumer demand.

1.4 Prioritising Adapting National Infrastructure

The Government has prioritised the need to address the risks climate change presents to infrastructure. In 2009, a two-year Government project was set-up to examine the risks and potential solutions to improve the long-term resilience of new and existing infrastructure in the energy, ICT, transport and water sectors (infrastructure networks). The project is aligned with the Cabinet Office's work to address contingency planning and risks from today's natural hazards to infrastructure⁷.

The Government's Infrastructure & Adaptation project

The project, involving senior representatives of key Government infrastructure departments⁸, commissioned, and published, four independent studies⁹ to examine a range of key issues:

1. *Adapting Energy, Transport and Water Infrastructure to the Long-term Impacts of Climate Change* by URS Corporation Limited – examining the technical risks and operational implications for infrastructure in these sectors.
2. *Adapting the ICT Sector to the Impacts of Climate Change* by AEA – exploring the impacts of climate change on the ICT sector and the potential for adaptation.
3. *Adapting to Climate Change in the Infrastructure Sectors* by PwC – exploring the implications of climate change impacts, both for existing infrastructure and for future investment in these sectors. This report also examined the role of Government, regulators and others in encouraging adaptation action to maintain robust and resilient infrastructure systems.
4. *Infrastructure, Engineering and Climate Change – Ensuring Services in an Uncertain Future* by the Engineering the Future Group – setting out the engineering profession's views on how to adapt the infrastructure system to the long-term effects of climate change and the short-term shocks of extreme weather.

A separate Defra synthesis document summarising each independent study has been produced alongside this document.

Through this programme of work, the Infrastructure & Adaptation project and its independent studies have engaged a wide range of infrastructure and engineering organisations and experts, ensuring a robust analysis and evidence base has informed this document (Annex B lists the organisations that the project engaged with).

By working this way, the project has been able to produce a summary of the climate risks to energy, ICT, transport and water infrastructure to inform infrastructure organisations.

⁷ <http://www.cabinetoffice.gov.uk/infrastructure-resilience>

⁸ The Cabinet Office, DfT, DECC, BIS, CLG and Defra as well as the Highways Agency and Environment Agency

⁹ See <http://www.defra.gov.uk/environment/climate/sectors/infrastructure-companies/>

Summary of climate risks to energy, ICT, transport & water infrastructure gathered from the Infrastructure & Adaptation project

Sector	Climate Impact	Possible Implication for Infrastructure (based on no adaptation action)
Energy		
Fossil fuel and nuclear generation	<ul style="list-style-type: none"> Increased/more intense precipitation and/or sea level rise/storm surges. Shoreline erosion. Higher temperatures. Reduced summer rainfall. 	<ul style="list-style-type: none"> Flood risk to fossil fuel and nuclear power plants, decommissioned nuclear sites and nuclear waste reprocessing and storage facilities. Reduced efficiency. Reduced available water for cooling (for inland power stations¹⁰).
Renewable wind energy	<ul style="list-style-type: none"> Increased risk of storminess and/or reduced wind. 	<ul style="list-style-type: none"> Reduced efficiency and increased storm damage.
Electricity transmission and distribution	<ul style="list-style-type: none"> Higher temperatures. Increased/more intense precipitation. Surface water, tidal and fluvial flooding. High winds. 	<ul style="list-style-type: none"> Reduced capacity of network. Flood risk to substations. Storm damage to overhead power lines.
Fuel processing and storage	<ul style="list-style-type: none"> Sea level rise/storm surges. 	<ul style="list-style-type: none"> Flood risk to storage and fuel processing facilities.
ICT		
Wireless infrastructure	<ul style="list-style-type: none"> Higher temperatures. Increased risk of subsidence. Increased risk of storminess. Increased/more intense precipitation. 	<ul style="list-style-type: none"> Location/density of wireless masts may become sub-optimal as wireless transmission is dependent on temperature. Reduced stability of foundations and tower structures. Increased damage to above ground transmission infrastructure. Possible reduced quality of wireless service.
Copper and fibre optic cables	<ul style="list-style-type: none"> Increased risk of flooding. Increased erosion and/or flooding. 	<ul style="list-style-type: none"> Low-lying infrastructure, access holes and underground facilities at risk. Transport infrastructure (roads/bridges) affected exposing cables and trunk routes.

¹⁰ All current UK operating nuclear power stations are coastal or estuarine. Stations at Calder Hall in Cumbria and Chapelcross in Dumfries did use river water but these are now shut-down and in the process of being decommissioned.

Summary of climate risks to energy, ICT, transport & water infrastructure gathered from the Infrastructure & Adaptation project (Continued)

Sector	Climate Impact	Possible Implication for Infrastructure (based on no adaptation action)
Transport		
Road	<ul style="list-style-type: none"> • Increased/more intense precipitation. • Wetter winters and drier summers. • Higher temperatures. 	<ul style="list-style-type: none"> • Flood risk to roads. • Increased scour of bridges. • Increased instability of embankments. • Increased damage to road surfaces.
Rail	<ul style="list-style-type: none"> • Increased/more intense precipitation. • Wetter winters and drier summers. • Higher temperatures. 	<ul style="list-style-type: none"> • Flood risk to rail lines. • Increased scour of bridges. • Increased instability of embankments. • Increased rail buckling. • Passenger comfort, e.g. on the London Underground.
Ports	<ul style="list-style-type: none"> • Sea level rise. • Increased storminess and higher winds. 	<ul style="list-style-type: none"> • Flood risk to ports. • Increased disruption to operations.
Airports	<ul style="list-style-type: none"> • Increased/more intense precipitation. • Higher temperatures. 	<ul style="list-style-type: none"> • Flood risk to airports. • Lift of aircraft reduced (affecting fuel use and take-off slots).
Water		
Water supply, treatment and infrastructure	<ul style="list-style-type: none"> • Changing precipitation patterns and drought. • Increased/more intense precipitation. • Higher temperatures. 	<ul style="list-style-type: none"> • Reduced security of supply. • Increased risk of fluvial flooding to water supply/treatment infrastructure. • Water treatment processes affected.
Wastewater collection, treatment and disposal	<ul style="list-style-type: none"> • Increased/more intense precipitation. • Changing precipitation patterns and drought. 	<ul style="list-style-type: none"> • Increased risk of sewer flooding. • Increased pollution incidents. • Increased risk of fluvial flooding to wastewater infrastructure.

1.5 Climate Resilient Infrastructure

Climate change could have significant implications for infrastructure. As infrastructure assets have long operational lifetimes they are sensitive not only to the existing climate at the time of their construction, but also to climate variations over the decades of their use. For example, a substantial proportion of infrastructure built in the next five years, will still be in use long after 2030.

To increase the resilience of both new and existing infrastructure, we must be prepared to plan ahead and manage the impacts of climate change. This is an important part of the transition to a green economy.

Climate resilient infrastructure

New infrastructure can be climate resilient by ensuring that an asset is located, designed, built and operated with the current and future climate in mind.

Existing infrastructure can be climate resilient by ensuring that maintenance regimes incorporate resilience to the impacts of climate change over an asset's lifetime.

To achieve this, possible adaptation measures include:

- Ensuring infrastructure is resilient to potential increases in extreme weather events such as storms, floods and heatwaves as well as extreme cold weather.
- Ensuring investment decisions take account of changing patterns of consumer demand as a result of climate change.
- Building in flexibility so infrastructure assets can be modified in the future without incurring excessive cost.
- Ensuring that infrastructure organisations and professionals have the right skills and capacity to implement adaptation measures.

The result will be a more resilient and robust infrastructure network able to cope with projected climate impacts e.g. increased flexibility to cope with uncertainty without massive failure and economic cost.

Achieving more climate resilient infrastructure requires the impacts of climate change to be a key consideration in the way that significant pieces of infrastructure in the energy, ICT, transport and water sectors are planned and commissioned, designed, built and maintained. This includes the design of roads, railways and power lines and management of the supply/demand balance through water infrastructure.



Infrastructure

2.1 Infrastructure Examined

The Government defines national infrastructure¹¹ as nine sectors comprising the facilities, systems, sites and networks necessary for the delivery of the essential services upon which daily life in the UK depends. These sectors are:

Communications	Emergency services	Energy
Finance	Food	Government
Health	Transport	Water

In the National Infrastructure Plan 2010, the Government focuses on economic infrastructure defined as *'the networks and systems in energy, transport, digital communication, flood protection, water and waste management'*. These are all critical to supporting economic growth through the expansion of private sector businesses across all regions and industries, enabling competitiveness and improving the quality of life of everyone in the UK.

The UK's Infrastructure Networks¹²

- There are over 245,000 miles of roads. The road infrastructure accommodates on average over 600 trips per person per year by car and two-thirds of freight is moved by road.
- The railways are some of the busiest in Europe with approximately 24,000 trains per weekday, more than Spain, Switzerland, The Netherlands, Portugal and Norway combined.
- There are over 15,500 miles of high voltage overhead lines (the national grid) and almost 500,000 miles of overhead lines and underground cables (the regional distribution networks) in the UK.
- There are 18.6 million residential broadband connections in the UK with an average speed of 5.2 megabits per second.

The *Infrastructure & Adaptation* project, and this document, focus on only four sectors of national infrastructure – energy, ICT, transport and water – as these are vital in their own right and are a set of interconnected networks on which other infrastructure sectors and parts of the economy and society rely on to function. They are central in the drive to support the transition to a low carbon, climate resilient economy.

For the purposes of this document **only, national infrastructure** means energy, ICT, transport and water infrastructure (i.e. the infrastructure networks) rather than all of the nine sectors.

The *Infrastructure & Adaptation* project focused on the strategic infrastructure in the four sectors, e.g. the strategic road and rail networks rather than local roads. The project did not examine:

- The impacts of climate change on 'social' infrastructure such as schools, hospitals and prisons.
- The impact of a changing climate on customer behaviour.
- How the impact of climate change globally might affect domestic infrastructure¹³.

¹¹ As defined by the Government's Centre for the Protection of National Infrastructure.

¹² From National Infrastructure Plan 2010

¹³ Although a forthcoming Foresight project, the International Dimensions of Climate Change does consider this and future Government work on adapting infrastructure will look at this in more detail (see section 9).

The four sectors range from unregulated competitive markets (ports and power generation), to regulated private sector monopolies (energy networks and water), to state-procured public goods (motorways). The private sector is deeply involved in these sectors – as investor, owner, operator, lender, insurer and major user of infrastructure services.

The private sector, assisted by Government and its regulatory frameworks (where appropriate), has the key role in addressing the risks of climate change to infrastructure and contributing to creating a climate resilient national infrastructure network.

Infrastructure considered within the Infrastructure & Adaptation project

Energy	ICT	Transport	Water
Fossil fuel and nuclear generation; renewable energy; energy distribution; and fuel processing and storage.	Fixed and mobile communications network; internet and broadband; wireless networks; and other communication media.	Road; rail; ports; and airports.	Water supply and treatment infrastructure; and wastewater collection, treatment and disposal infrastructure.

2.2 Operational lifetimes

National infrastructure assets generally have long operational lifetimes and large parts of the UK’s existing infrastructure stock were originally built in the 19th century.

Long operational lifetimes

- London’s sewerage system was developed during the late 19th century and the system designed and built by Joseph Bazalgette remains critical to the functioning of today’s overall sewerage system.
- More than 150 years after its creation, the Great Western Railway still uses many of the original bridges, such as the Royal Albert Bridge over the River Tamar built in 1859.

This means that some of the country’s key infrastructure assets need to be maintained with the future climate in mind to secure its long-term sustainability. While new assets must be designed and built to be able to adapt to a changing climate.





Why Focus on Adapting National Infrastructure to the Impacts of Climate Change?

3.1 Adapting National Infrastructure

This document is designed to support action to adapt the country's new and existing infrastructure to the impacts of climate change. It sets out how adaptation action can be achieved across the national infrastructure sectors.

In doing this, it identifies who needs to act alongside Government, including:

1. Investors in infrastructure, e.g. infrastructure investment funds and pension funds.
2. Infrastructure owners, e.g. owners of ports and energy infrastructure.
3. Infrastructure operators, e.g. organisations that operate airports and those that are contracted to build new infrastructure and run maintenance contracts.
4. Economic regulators.
5. Professional bodies such as engineers.

As adaptation to climate change, and some aspects of infrastructure policy (e.g. water and transport), is a devolved issue, this document covers UK Government policy in England and in the UK for reserved matters. It does not cover the work of the national authorities in Wales, Scotland or Northern Ireland in regard to their devolved functions.

3.2 Context of Document

The impact of climate change on infrastructure is an important economic, environmental and social issue. Failure by Government and the private sector to be proactive and consider the impacts of climate change on new and existing infrastructure raises the possibility of increased service disruption and adverse economic impacts.

Infrastructure is already sensitive to current climate variability and the future climate is likely to be considerably more challenging and disruptive. That is why Defra's Business Plan¹⁴ has a priority *to support a strong and sustainable green economy resilient to climate change*; adapting national infrastructure forms a key part to realising this.

This document encourages a much stronger focus on adapting national infrastructure to the impacts of climate change as part of a green economy. It is a Government-wide document, recognising that adaptation is an issue:

- For all Government departments with infrastructure responsibilities¹⁵ as it potentially affects their policies and relationships with regulators, industry and the academic community.
- For the Government's wider work on infrastructure, led by Infrastructure UK in the Treasury, and the Cabinet Office-led resilience work.

Consequently, the document will influence:

- The work of **Infrastructure UK¹⁶ and the development of the National Infrastructure Plan 2011**. Infrastructure UK has a remit to provide a stronger focus on the UK's long-term infrastructure priorities and meet the challenge of facilitating significant private sector investment over the longer-term. The National Infrastructure Plan 2010 recognised climate change mitigation and adaptation as one of five major drivers that will have a long-term impact on the country's infrastructure. This document will be a valuable input to the updated Plan in autumn 2011.

¹⁴ <http://archive.defra.gov.uk/corporate/about/what/documents/defra-businessplan-101108.pdf>

¹⁵ This includes Defra, CLG, BIS, DECC, HMT, DfT and Cabinet Office

¹⁶ http://www.hm-treasury.gov.uk/ppp_infrastructureuk.htm

- The UK's **National Security Strategy**¹⁷ which outlines an appraisal of Britain's role in the world, the risks to our security and their implications for the UK. The Strategy recognises that natural hazards present a risk of significant disruption to infrastructure and this will increase as climate change continues.
- The **UK Government's first Adaptation Programme**. The UK Government will produce an Adaptation Programme, to be laid before Parliament, by the end of 2012 and infrastructure will be an integral theme. This document is an early input into the development of the Programme, to catalyse early action to adapt infrastructure. Government will use the Programme to report on progress made in meeting the aim of adapting infrastructure, for instance, the actions outlined in Section 9 of the document as well as the findings from the Climate Change Risk Assessment.

3.3 Importance of Adapting National Infrastructure to Climate Change

Effective, reliable infrastructure underpins economic activity. Recent impacts from flooding and severe weather events emphasise the risks that national infrastructure could face and the significant economic damage these types of events bring. If today's extreme weather events become both more frequent and extreme, so too will the level of disruption that they cause. This is unless appropriate adaptation action is taken.

Vulnerability of infrastructure to weather

Recent extreme weather events illustrate the vulnerability of infrastructure systems:

- The snow in November and December 2010 affected transport infrastructure – rail and airports in particular – which had knock-on impacts for other sectors such as retail.
- The severe flooding in Cumbria in November 2009 resulted in a number of road bridges collapsing.
- The Mythe water treatment works in Gloucestershire flooded in 2007 cutting off the water supply to 350,000 people in the area for 17 days. This shows how the failure of a single piece of infrastructure can have widespread repercussions.

It is also important to consider the implications of climate change in terms of the transition to a low carbon economy. Although not covered in detail here, the impacts of climate change will affect patterns of supply and demand:

- Hotter summers may lead to increased summer energy demand (e.g. increased air conditioning use).
- Higher summer temperatures may increase demand for additional road and rail infrastructure to tourist destinations such as the South West.
- Increased severe weather in other countries may affect the supply chains and resources that infrastructure companies rely on. It could also have implications for day-to-day operations, e.g. delays in supplies arriving at ports and flights arriving/leaving from UK airports.

¹⁷ http://www.direct.gov.uk/prod_consum_dg/groups/dg_digitalassets/@dg/@en/documents/digitalasset/dg_191639.pdf?CID=PDF&PLA=furl&CRE=nationalsecuritystrategy

The risks of failed or inefficient infrastructure from climate change

Infrastructure operators risk economic losses from poorly adapted assets – loss of revenue, damaged or inefficient assets.



Users (other infrastructure sectors, the wider economy and domestic users) are exposed to risks of service failure and dangers.



Investors bear investment risks from economic losses of infrastructure operators and from other investments reliant on infrastructure.



Insurers bear increased risks/losses (both insurance and re-insurance industry) as potential losses (e.g. for infrastructure owners) are reduced through insurance.



And ultimately **Government** may act as a risk bearer of last resort, stepping in to assist with losses suffered in extreme circumstances.



To reduce the risk infrastructure faces from climate change planned, but flexible, adaptation responses are required. It is not about eliminating all risks from climate change or extreme weather.

It is about putting in place measures that enable the cost effective management of climate impacts to reduce the risk that climate change presents to infrastructure and owners, investors, users, insurers and Government. This includes integrating the impacts of climate change into decision making for new infrastructure and maintenance of existing infrastructure.

This approach will be beneficial to Government, the economy and infrastructure owners and investors. Modelling by the Organisation for Economic Co-operation and Development (OECD)¹⁸ has suggested that each £1 spent on climate change adaptation delivers four times its value in terms of potential damage avoided.

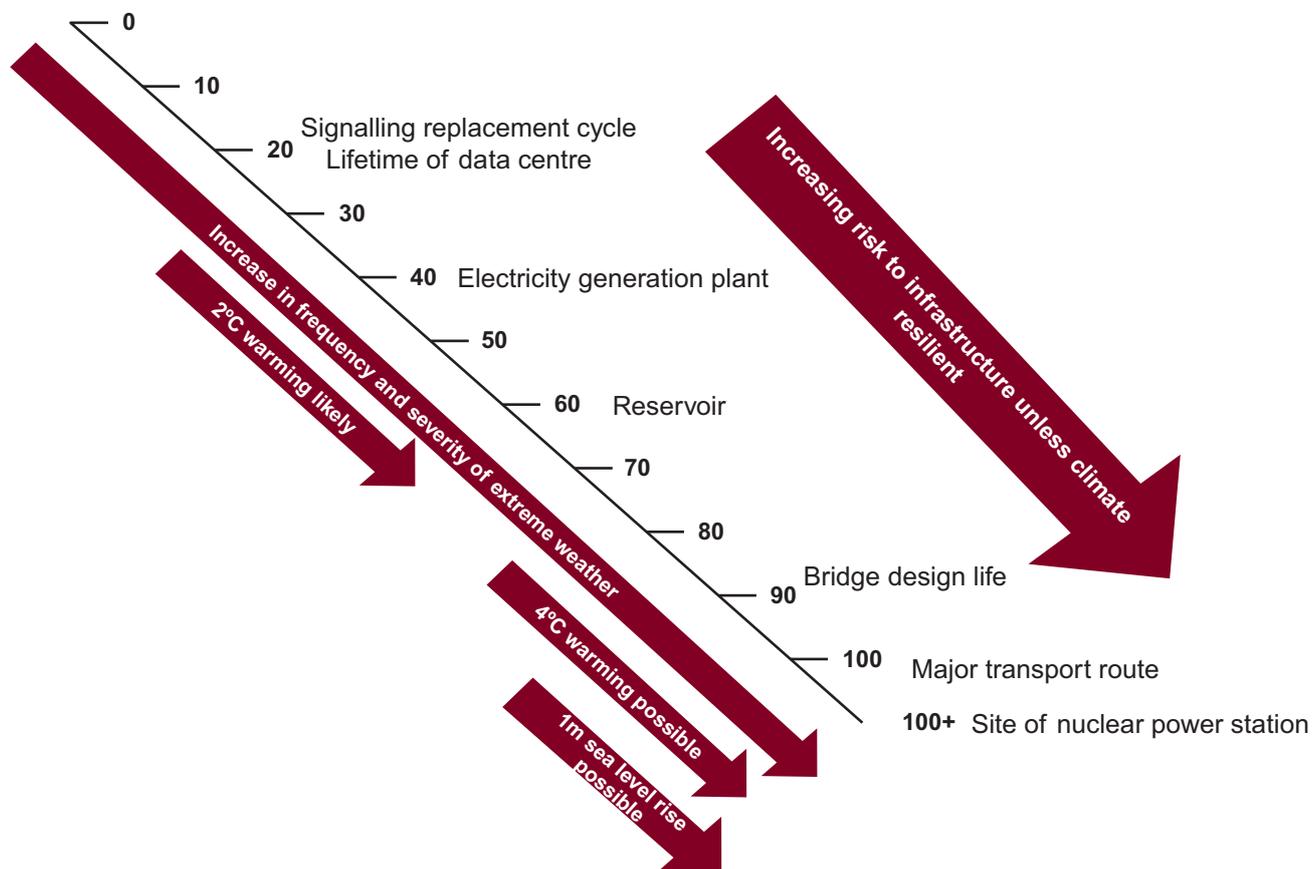
3.4 The Need for Action to Adapt National Infrastructure to Climate Change

Climate change and its impacts may seem a long-term challenge. However, the scale of investment in infrastructure, and the increasing exposure to climate risk, means that action to improve the climate resilience of infrastructure is needed as:

- **Existing infrastructure** has been engineered and built for a past or current climate and may not be resilient to the future climate.
- **New infrastructure** will often have a life of 50 to 100 years (or more). To ensure its viability over its lifetime, it needs to be resilient to a climate that could be significantly different.

When making decisions about the provision of national infrastructure it will therefore be important to allow for future climate change and avoid closing off options, making it harder and costlier to adapt infrastructure in the future.

Lifetime of infrastructure with illustrative climate change timescales for the UK



Adapted from AEA, 'Adapting the ICT Sector to the Impacts of Climate Change', 2010

18 de Bruin, K., R. Dellink and S. Agrawala (2009), "Economic Aspects of Adaptation to Climate Change: Integrated Assessment Modelling of Adaptation Costs and Benefits", OECD Environment Working Papers, No. 6, OECD publishing, © OECD.





Potential Opportunities

In a low carbon, climate resilient world, investment in climate resilient infrastructure will help enhance the attractiveness of the UK for inward investment, benefitting the country, economy, business, users and Government. And a stable long-term policy framework for climate change mitigation and adaptation can set the UK apart from other countries left more vulnerable to climate-related risks.

Commercial opportunities

*Adapting to an Uncertain Climate: A World of Commercial Opportunities*¹⁹ is a UK Trade & Investment report seeking to examine the potential business opportunities and risks involved in adapting to anticipated changes in the global climate. It examines four key sectors: financial services; **infrastructure and construction**; professional services and consulting; and agriculture and life sciences.

Adapting infrastructure to climate change impacts presents opportunities if early action is taken and expertise developed. This includes new skills and technologies as well as additional adaptation capacity to enable infrastructure to be adapted such as new engineering practices or IT-based technology.

Exporting adapting infrastructure expertise

Climate change is increasingly putting at risk the value of many existing and future investments, as well as generating demand for new adaptation specific investments. The estimated amount of investment and financial flows for adaptation is projected to represent between 0.2% and 0.8% of global investment flows by 2030²⁰ in five key sectors: water; human health; agriculture, forestry and fisheries; coastal resources; and **infrastructure**.

The main opportunities for firms to develop adaptation solutions are likely to be concentrated in sectors where substantial investments are being made, both as part of the UK's low carbon transition and in response to long-term economic and social need. These include new energy and water infrastructure and transport and ICT networks.

Using ICT to improve climate resilience

The ICT industry has an opportunity to play a leading role in increasing climate resilience by developing new technologies.

For example, the University of Cambridge and Imperial College London²¹ are assessing the performance and condition of infrastructure.

Using sensors and data management a detailed picture of the state of infrastructure assets and their resilience can be developed.

Under a changing climate, all countries will need to increase their investment in, and renew, their infrastructure to adjust to a more challenging climate. It is important that UK businesses are able to meet this opportunity. So by developing adaptation expertise now, the country should be well-placed to build on its position as a leader on infrastructure, enabling business to capitalise on an area of competitive advantage to create opportunities in domestic and global markets.

¹⁹ <http://www.ukti.gov.uk/uktihome/item/128100.html>

²⁰ From Investment and Financial Flows to Address Climate Change, UNFCCC, 2007.

²¹ Through a joint EPSRC/TSB funded project <http://gow.epsrc.ac.uk/ViewGrant.aspx?GrantRef=EP/D076870/1>

The potential economic opportunities to adapting infrastructure to climate change

- New technologies and skills can be developed to adapt infrastructure which can be used domestically and exported.
- There are engineering and planning consultancy benefits, if UK engineering and consultancy organisations do this sooner and better than other countries, they can be market leaders.
- There are opportunities for the ICT industry to develop new technologies to aid climate resilience, e.g. providing networks of sensors and other data points to provide information in relation to weather events.
- Investment and insurance provision for domestic and global infrastructure can promote climate resilience, reducing the risk of damage and securing rates of return. This may lead to the development of innovative models on climate risk that may be marketed to other financial institutions, e.g. HSBC's Climate Change Centre of Excellence investigates the likely economic risks and opportunities of climate change for the financial markets.
- Developing expertise to exploit economic opportunities, e.g. \$50 trillion will be spent in OECD countries by 2030 on infrastructure²².
- Organisations can also transfer their expertise to provide high quality advice and support to developing countries to improve the climate resilience of their infrastructure.

²² http://macquariefunds.co.uk/uk/mfg/acrobat/infrastructure_oecd_study.pdf





Aim and Roles for Preparing Infrastructure for a Changing Climate

5.1 Aim of Climate Resilient Infrastructure: Preparing for a Changing Climate

This document responds to calls from industry – infrastructure owners, investors and insurers – for a clear Government statement on adapting infrastructure.

This document sets this out, establishing an aim for:

An infrastructure network that is resilient to today's natural hazards and prepared for the future changing climate.

The Cabinet Office's *Guide to Natural Hazards of Infrastructure* provides advice on building resilience to today's natural hazard events. Government also has an important role to play in boosting the climate resilience of infrastructure – by providing appropriate policy and regulatory frameworks, information and support.

However, it is action by others – investors, owners and operators, and the engineering and construction sectors – that will be essential to implementing adaptation action enabling climate risk to national infrastructure to be effectively managed. Potential actions include:

- Infrastructure owners considering the climate resilience of their existing infrastructure assets and adjusting maintenance regimes.
- Infrastructure owners and investors considering the impacts of climate change in the design, build and operation of all new infrastructure assets.
- Investors including climate change impacts as part of 'due diligence' as a way of reducing exposure to climate risk to new infrastructure assets.
- Regulators treating adaptation consistently across the different economic regulatory frameworks, i.e. balancing long-term challenges, such as climate change, against shorter-term concerns of efficiency.

Government policy assisting action to adapt infrastructure to climate change impacts

The Government's draft Energy National Policy Statements²³ underline the importance of ensuring new energy infrastructure is resilient to the impacts of climate change.

They set out how applicants and the decision-making body should take the effects of climate change into account when developing and consenting energy infrastructure. For example, the draft *Overarching Energy National Policy Statement* sets out that:

- Applicants for new energy infrastructure must consider the impacts of climate change in planning its location, design, build, operation and decommissioning.
- To minimise risk, any safety critical elements of proposed infrastructure (e.g. parts of nuclear power stations) should be assessed against the high impact, low probability scenarios of climate change.
- The decision-making body should satisfy itself that applicants for new energy infrastructure have identified appropriate adaptation measures over the estimated lifetime of new infrastructure.

23 http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/consents_planning/nps/nps.aspx

2030s National Infrastructure

Featuring measures designed to reduce the effects of the negative impacts of climate change and exploit the opportunities. This illustration is designed to provoke thought about what good adaptation to climate change could entail – it does not attempt to provide any definite answers or solutions, as the most appropriate adaptive action will often depend on local circumstances. To allow inclusion in the illustration some features are shown closer together than they might ideally be situated.

Increased water storage

Reservoir strengthened to prevent dam-burst after extreme rainfall, and covered in summer to minimise water loss through evaporation.

Rail

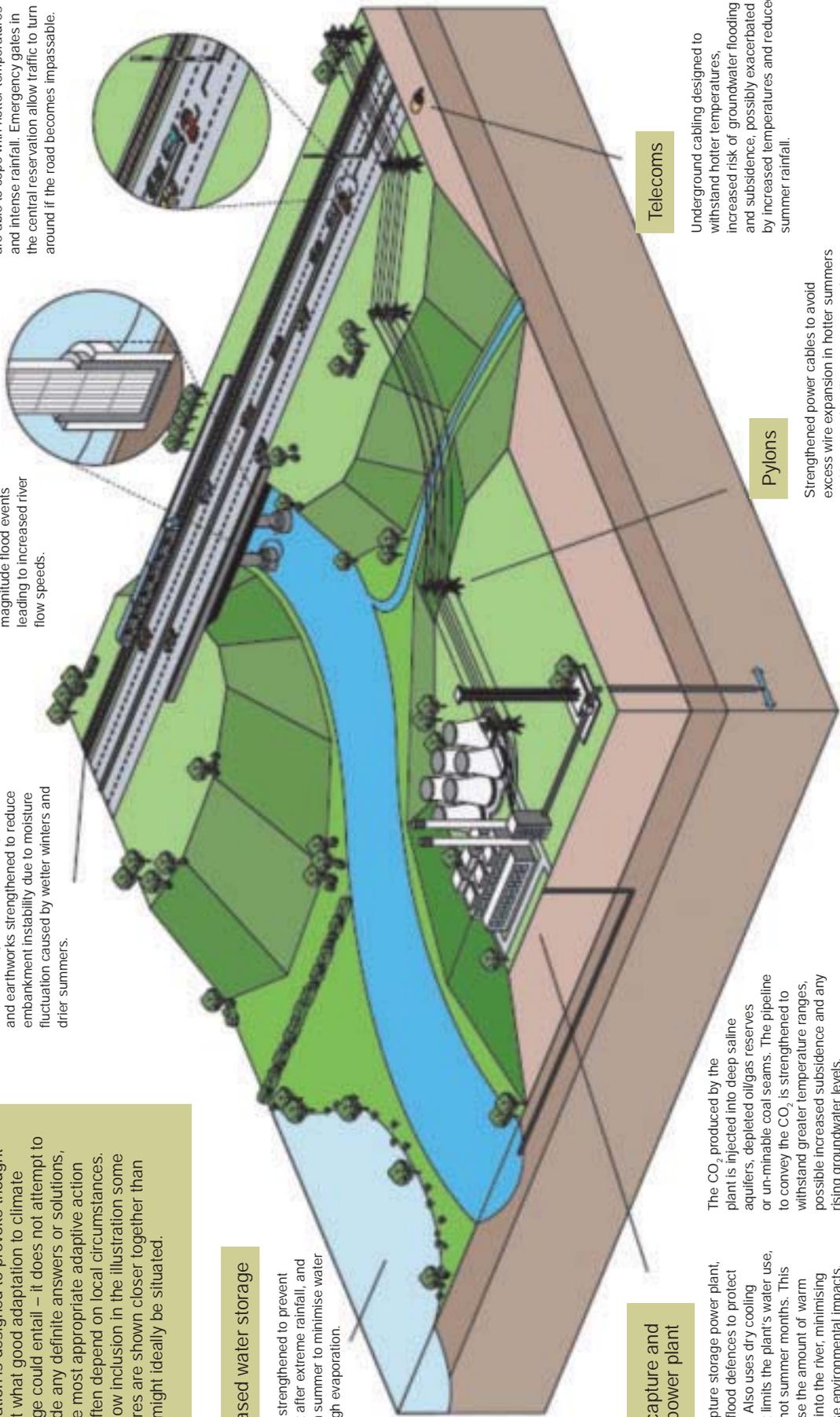
Higher standards of rail used to prevent track buckling in increased temperatures, and earthworks strengthened to reduce embankment instability due to moisture fluctuation caused by wetter winters and drier summers.

Stronger bridges

Bridges built higher than currently required to accommodate larger tidal ranges due to sea level rise over their lifespan, and foundations reinforced to cope with higher magnitude flood events leading to increased river flow speeds.

Motorway

Road Surface is made from materials that are able to cope with hotter temperatures and intense rainfall. Emergency gates in the central reservation allow traffic to turn around if the road becomes impassable.



Carbon capture and storage power plant

New carbon capture storage power plant, with increased flood defences to protect it from the river. Also uses dry cooling technology that limits the plant's water use, in particular in hot summer months. This will also minimise the amount of warm water put back into the river, minimising possible adverse environmental impacts.

The CO₂ produced by the plant is injected into deep saline aquifers, depleted oil/gas reserves or un-minable coal seams. The pipeline to convey the CO₂ is strengthened to withstand greater temperature ranges, possible increased subsidence and any rising groundwater levels.

This illustration does not necessarily depict past, present or future Government policy. The illustration concentrates on adaptation actions and does not highlight mitigation and other sustainable development measures.

Pylons

Strengthened power cables to avoid excess wire expansion in hotter summers and increased resilience to protect from increased extreme weather events.

Telecoms

Underground cabling designed to withstand hotter temperatures, increased risk of groundwater flooding and subsidence, possibly exacerbated by increased temperatures and reduced summer rainfall.

5.2 Government Role

Government has an important role in adapting national infrastructure, in particular:

- Ensuring that the policy framework for adaptation and each national infrastructure sector is conducive to adapting national infrastructure, e.g. through National Policy Statements.
- Continuing to focus the Adaptation Reporting Power on infrastructure organisations.
- Leading by example by integrating adaptation requirements when investing in and/or procuring new infrastructure projects (e.g. Crossrail) and using the Adaptation Supplement to the Green Book²⁴. This will help to stimulate the market to develop innovative and cost effective adaptation responses.
- Facilitating action by the private sector through:
 - Continued information provision.
 - Support for cross-sectoral adaptation action.
- Providing economic regulatory frameworks that are equipped sufficiently to incentivise adaptation.
- Addressing market failures and barriers to actions to adapt infrastructure where relevant.

The Government also has a specific role to play, via the DECC sponsored Nuclear Decommissioning Authority (NDA), on nuclear energy. The UK has some significant facilities including existing operational and decommissioning nuclear reactor sites, nuclear waste and spent fuel storage facilities, spent fuel reprocessing facilities, fuel production facilities and radioactive waste disposal facilities. The NDA has undertaken an assessment of both climate, and landscape, change for its sites.

Within the revised draft *Nuclear National Policy Statement*²⁵, Government has also assessed potential sites for new nuclear power stations against flood risk. The assessment, using advice from the Environment Agency, looked at flood risk to 2100.

Government has also asked the UK Chief Nuclear Inspector²⁶ to provide a report to Government on the implications of the unprecedented events at Japan's Fukushima Daichi nuclear plant following the earthquake and tsunami in March 2011 and the lessons to be learnt for the UK nuclear industry.

Addressing adaptation barriers

The rationale for Government intervention to support climate change adaptation lies in the need to address a number of barriers, which in the absence of Government intervention, would prevent achievement of an economically efficient outcome, e.g.:

- Behavioural barriers may delay complex decisions. This is an issue in particular for adaptation due to the uncertainty over the exact impacts of climate change.
- Market failure because of a lack of specific climate information.
- Institutional, financial and regulatory barriers can constrain action.
- The infrastructure owner is not exposed to the full costs to society of infrastructure failure, e.g. is not exposed to losses incurred by individuals and companies. This may lead to underinvestment in adaptation measures for infrastructure as the full costs to society are not considered.

²⁴ <http://archive.defra.gov.uk/environment/climate/documents/adaptation-guidance.pdf>

²⁵ http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/consents_planning/nps/nps.aspx

²⁶ <http://www.decc.gov.uk/assets/decc/What%20we%20do/UK%20energy%20supply/Energy%20mix/Nuclear/1437-letter-from-the-secretary-of-state-for-energy-and-.pdf>

5.3 Private Sector Led Adaptation

The private sector is the leading player across the national infrastructure sectors. Its role ranges from investor, owner, operator, lender, insurer as well as major user. It has the key role in addressing the risks of climate change.

Private sector-led approaches to adapting infrastructure to climate change impacts

- (i) **A risk-based approach to adaptation**, e.g. port operators incorporate weather variables like storminess, precipitation levels and temperature changes into the design of their ports because it is in their competitive interest to do so.
- (ii) **A business-led approach to adaptation** where competitive pressures mean that infrastructure operators that adapt more visibly and effectively than their peers emerge as leaders on climate resilience, thereby improving service resilience and reliability.

By addressing the risks of climate change, the private sector will benefit from more climate resilient infrastructure, enhanced security of supply and/or service delivery and reduced costs.

5.4 Investors

Investors in infrastructure include banks, hedge funds, insurance companies, sovereign wealth funds, investment/development banks and public and private pension funds. Time frames range from investors looking for a return within 5 to 10 years to those long-term investors looking for a continual rate of return on their investment over 20 years or more.

For long-term investors in infrastructure in particular, climate change impacts present a risk, e.g. to the continuity of rates of return. Therefore, some long-term investors can see the potential benefits of incorporating climate risk into their decision making and adapting their infrastructure assets as this will help to lower the risk to their financial returns.

The investment implications of a changing climate

Four institutional investors – Henderson Global Investors, Insight Investment, RAILPEN Investments and the Universities Superannuation Scheme – initiated a project²⁷ to identify how companies and their investors are likely to be affected by the physical impacts of climate change. Amongst its recommendations were:

- Investors should be integrating climate change related risks and opportunities into their investment analysis and decision-making processes.
- Investors should ensure that companies have appropriate governance and management systems in place.

The four institutional investors encourage **all** investors to examine adaptation related risks in their portfolios and use their influence to encourage companies to manage these risks more effectively.

Investors have an important role in adapting national infrastructure by:

- Demanding greater disclosure of climate risks and adaptation actions by companies to increase awareness, understanding and action.

²⁷ <http://www.uss.co.uk/Documents/Managing%20the%20Unavoidable%20Investment%20implications%20of%20a%20changing%20climate%20Nov%202009.pdf>

- Incorporating within their own 'due diligence' processes an assessment of vulnerability to climate change and how this is planned to be addressed over an asset's proposed lifetime.
- Developing financial models to incentivise infrastructure to be planned, designed, built and operated with both current and future climate risks in mind.

Securities & Exchange Commission, USA

Federal securities law and Securities & Exchange Commission (SEC) regulations require certain disclosure by public companies for the benefit of investors. SEC's new imperative climate change disclosure guidance²⁸ outlines the type of information that publicly traded companies facing material effects from climate change must disclose. This includes disclosing the risks that the physical impacts of climate change pose to a business.

5.5 Infrastructure Owners & Operators

Although infrastructure is often owned and operated by the same organisation, this is not always the case (e.g. London Luton Airport is publicly owned by Luton Borough Council but is operated managed and developed by a private consortium, London Luton Airport Operations Ltd). Both owner and operator will be affected by the impacts of climate change, which may:

- Have a direct impact on the value of an asset.
- Pose a risk to service disruption from weather, affect the ability to meet customers' needs and, where these exist, increase the chance of service related fines.
- Lead to higher operating costs, reduced revenues or incur costs for the restoration of services or compensation for service disruption and/or inefficiencies.
- Pose a risk to an owner's and/or operator's reputation and their ability to attract future investment or contracts.

National Grid & adapting to climate change

National Grid is an international electricity and gas company owning the high voltage electricity transmission network in England and Wales and operates the system across the UK, also owning the UK's high pressure gas transmission.

An early reporter under the Government's Adaptation Reporting Power, National Grid has developed an adaptation strategy based on scenarios developed with the Met Office that predict the energy needs and climatic constraints operating over the next 10 to 50 years.

Owners and operators of national infrastructure have an important role to play in adapting national infrastructure by:

- Embedding adaptation throughout their organisation and the organisation's decision making.
- Integrating adaptation into the maintenance regimes of existing infrastructure.
- Considering how the impacts of climate change may affect new infrastructure and implementing adaptation measures as necessary.
- Considering how operational procedures might be affected.
- Considering how their supply chains might be affected.
- Considering whether their workforce have the right skills and working practices to adapt.

²⁸ <http://www.sec.gov/rules/interp/2010/33-9106.pdf>

5.6 Economic Regulators

The *Infrastructure & Adaptation* project focused on the role of economic regulators in facilitating adaptation due to their role in establishing the terms under which investment is made. Other regulators, such as the Health & Safety Executive and the Environment Agency (e.g. for water), also have important roles to play in adapting infrastructure but were not considered by the project.

A key finding from the project is that economic regulators are well-placed to facilitate adaptation action through existing mandates, in particular the protection of short and long-term customer interest and security of supply. They are also equipped with the appropriate levers – incentives, penalties, standards and regular pricing controls – to deliver these mandates and incentivise adaptation.

However, regulating in the context of climate change is not straightforward, given uncertainty and balancing the needs of current and future customers. There is a need to avoid expensive 'gold plating' but equally to avoid storing up problems for future generations simply by aiming for the lowest bills possible today. This means that careful and balanced consideration of the impacts of climate change is needed.

To do this effectively, risk based decision making is required to balance both long-term and short-term challenges. Consideration of the impacts of climate change should be part of this process.

Climate change can also present opportunities for regulators and the organisations that they are responsible for. For example, in the water sector, the impacts of climate change can drive innovation in the development of low carbon technology and new approaches to catchment management.

Ofwat & adapting to climate change

To help set out how Ofwat will regulate in a way that takes account of climate change, Ofwat produced a climate change policy statement²⁹.

This describes how it will take account of climate change to encourage and enable companies to respond to climate change and by doing so achieve Ofwat's aim of protecting customers, promoting value and safeguarding the future.

Ofwat plan an updated version of this statement before the next price review.

In the context of adaptation, the main role of an economic regulator is:

- To balance the interests of current and future consumers by addressing long-term resilience to climate change alongside more short-term objectives of efficiency and value for money.

Economic regulators, as a group, can also play an important role in improving the links between sectors for better adaptation planning and address interdependency risks.

5.7 Insurers & Re-insurers

The insurance sector has a significant stake in timely adaptation of national infrastructure. Increased damage or interruption to insured infrastructure assets could have major cost implications for the insurance industry and affect future premiums.

²⁹ http://www.ofwat.gov.uk/sustainability/climatechange/pap_pos_climatechange.pdf

Insurance industry expertise in adapting to climate change

- Willis Research Network³⁰ is a subsidiary of Willis Group, the global insurance and reinsurance broker. Primarily focused on the key issues of climate and weather risks, including storms, floods and other extremes it supports research and development of new risk models and applications.
- Munich RE³¹, the global reinsurer, considers its expertise on climate issues to be a fundamental part of its risk management and influences its investment policy. This includes advising underwriters and clients on natural catastrophe reinsurance and being involved in research and development projects, e.g. with the London School of Economics and Political Science, to quantify the economic impacts of climate change.

Insurers have a role in:

- Working with clients to consider current and future climate resilience as a way of reducing their exposure to weather events.
- Investing in, and developing, context specific climate information to help them model climate risk and, where appropriate, share the information with investors, owners and operators to enable further planning and action. For example, RSA Group have developed systems which monitor the weather and anticipate potential incidents with expected rainfall, wind speeds and gust levels tracked daily.
- Encouraging greater disclosure of climate risks and responses by companies to increase understanding and catalyse adaptation action by both insurer and investor in infrastructure.
- As investors in their own right, ensuring their own investment portfolios factor in climate resilience.

5.8 Local Authorities and/or Local Enterprise Partnerships

This document sets out the strategic approach to adapting national infrastructure which can be replicated at the sub-regional and local level by local authorities and the new Local Enterprise Partnerships (LEPs).

Both have a potential role in encouraging and co-ordinating action to adapt infrastructure at the sub-national level to boost local resilience to climate change, minimise economic risk and maximise any economic opportunities. Other potential benefits could be:

- Facilitating localised cross-sector adaptation initiatives leading to more targeted adaptation action.
- Action locally may also lead to more action nationally.

5.9 Engineering Profession

Engineers and engineering companies have an important role to play in delivering well-adapted national infrastructure. Climate change presents engineers with a wide range of challenges, such as how:

- Existing infrastructure may need to change in order to function in a more challenging future climate.
- New infrastructure can be designed and built to function under different temperature and rainfall patterns.

³⁰ <http://www.willisresearchnetwork.com/default.aspx>

³¹ http://www.munichre.com/en/group/focus/climate_change/default.aspx

Engineering solutions to increase the climate resilience of road infrastructure

Engineers are considering the impacts of climate change on required specifications for the road network:

- New road surface specifications, similar to those applied in the south of France, have been introduced by the Highways Agency to adapt to higher temperatures.
- New drainage standards for new works and renewals have been also been introduced by the Highways Agency to improve drainage allowing for increases in rainfall intensity of 20-30%.

The engineering profession has a role in:

- Looking for engineering solutions to limit the consequences of failure from severe weather.
- Developing new ways of designing and building infrastructure e.g. to plan, design and monitor infrastructure at national and local levels to deliver climate resilience at least cost.
- Developing new engineering design practices to increase the resilience of infrastructure assets and networks.
- Developing new skills and expertise in adapting infrastructure to create marketable engineering skills and solutions, suitable for export.

5.10 Research Community

The research community can play an important role in advancing knowledge on the climate change risks to infrastructure. The Living With Environmental Change³² (LWEC) partnership helps focus nationally-funded research on the challenges of environment change and includes an infrastructure theme.

It is important that the research community, policy makers and the private sector work together to ensure that these research projects can improve our knowledge on climate risk, turning this into practical action on adapting infrastructure.

³² www.lwec.org.uk





Successful Adaptation Outcomes

Adapting national infrastructure to climate change impacts will not eliminate the risk of extreme weather adversely affecting infrastructure. It will not eliminate the need for contingency plans to be in place. Extreme weather events will continue to cause damage and disruption.

Nevertheless, timely and proportionate adaptation actions across the infrastructure sections can have a positive effect on the economic resilience of the country and, by increasing its climate resilience, contribute to creating a conducive environment for investment in infrastructure.

Does adapting infrastructure increase costs?

A World Bank study³³ found that the net cost of adapting infrastructure to climate change is no more than 1-2% of the total cost of providing that infrastructure.

And importantly, the cost of adaptation is small in relation to other factors that may influence the future costs of infrastructure.

A successful adaptation approach should be³⁴:

- **Effective:** the decision should reduce vulnerability to climate change.
- **Efficient:** the benefits of adaptation should outweigh the costs.
- **Equitable:** the distributional consequences should be taken into account.
- **Evidence-based:** the decision should be informed by latest research, data and practical experience.

While this approach will not eliminate all risk from climate change, it should enable a flexible risk-based approach to adapting national infrastructure. It will reduce the risk of delayed action, or conversely, of over-investment in adaptation.

This approach can help to ensure that:

- **Service delivery is able to adapt to meet future needs under a changing climate** e.g. demand for energy and water will increase in summer as temperatures increase.
- **Service delivery can adapt to increased risk of disruption from the weather** e.g. services are able to operate under a changing climate and, when extreme weather occurs, are able to recover quickly.
- **The viability of existing infrastructure is not compromised** e.g. maintenance and replacement regimes incorporate the future climate over their asset life to help avoid the need for costly retrofitting, re-building or even re-locating.
- **The risks associated with investment in new long-term infrastructure are reduced** by integrating consideration of the impacts of climate change in the design, build and operation of new infrastructure. This will reduce the risk of climate change impacts affecting financial returns e.g. by avoiding having to upgrade protection of an infrastructure asset.

³³ The Costs of Adapting to Climate Change for Infrastructure, 2009 – http://siteresources.worldbank.org/EXTCC/Resources/407863-1229101582229/DCCDP_2Infrastructure.pdf

³⁴ From Adapting to Climate Change: Analysing the Role of Government, 2010 – <http://archive.defra.gov.uk/environment/climate/documents/analysing-role-government.pdf>

Examples of international action to adapt infrastructure to the impacts of climate change

Country	Action to Adapt to Infrastructure to Climate Change Impacts
Australia	<ul style="list-style-type: none"> Infrastructure Australia identified adaptable and secure water supplies to cope with climate change as one of seven key objectives. Established a <i>Climate Change Adaptation Infrastructure Project</i>, which includes developing a standard 'climate change adaptation system for organisations'.
Canada	<ul style="list-style-type: none"> Infrastructure Canada considers adaptation in its funding programmes. Applicants to the Canadian Strategic Infrastructure Fund are required to demonstrate how their project addresses climate change impacts and adaptation and may be required to take certain measures to address these issues.
Denmark	<ul style="list-style-type: none"> Road regulations and railway standards are being/will be reviewed and revised with consideration of expected climate changes. The Danish Environmental Protection Agency published guidelines in 2007 in order for municipalities to take climate change into account in connection with construction and operation of sewage systems and sewer renovation.
Japan	<ul style="list-style-type: none"> Issuing a series of documents on practical guidance on strategic climate change adaptation planning.
New Zealand	<ul style="list-style-type: none"> National Infrastructure Plan (2010) identified the impacts of climate change as one of the long-term key trends that need to be addressed.
USA	<ul style="list-style-type: none"> The Council on Environmental Quality has issued Implementing Instructions to be used by the Federal Government in climate change adaptation planning. This includes Federal adaptation planning to address the effects of climate change on Federal infrastructure assets.
USA, California	<ul style="list-style-type: none"> Established infrastructure working group to analyse the impacts from climate change on its infrastructure and strategies to adapt it.





Challenges & Barriers

The independent studies commissioned by the *Infrastructure & Adaptation* project identified a number of challenges and barriers that can prevent timely planning and action to adapt national infrastructure. These include:

- **Information gaps:** improving specific climate information and research to industry.
- **Managing uncertainties:** anticipating a range of future climates as part of infrastructure decision-making.
- **Balancing priorities:** increasing the profile of adaptation.
- **Shorter-term regulatory focus:** long-term pressures, including climate change impacts, adequately set out in economic regulation.

Discounting of Capital Programmes

Long-term capital programmes tend to be heavily discounted and financing costs can mean that longer-term issues and complexities such as climate change adaptation are not addressed effectively.

HM Treasury's *The Green Book: Policy Appraisal and Evaluation in Central Government*³⁵ requires Government departments and other public bodies to examine the lifetime costs and benefits of proposed projects, and consider whether there are better ways of achieving objectives or using resources.

In response to the Stern Review on the Economics of Climate Change, HM Treasury issued, in 2008, new Green Book guidance on the discounting treatment of projects³⁶ with very long-term effects (a minimum of 50 years) and which involve substantial and irreversible wealth transfers between generations. This includes projects involving investment in infrastructure to improve its resilience to climate change impacts.

The guidance introduced a new lower discount rate to be used alongside the standard Green Book rate in project appraisals. The new rate, which is closer to the rates used in the Stern Review, requires departments to reduce by 75% the value of benefits expected in 50 years from now.

7.1 Information gaps

Government plays an important role in the provision of information on the projected future climate for the UK (e.g. UKCP09) and climate risks (e.g. through the UK Climate Change Risk Assessment). This information is provided as a public good to help public and private sector organisations understand what climate change might mean for them and how they might respond. However, the information available cannot always provide the level of detail needed by individual organisations to understand their own risks and appropriate responses, since these need to be context specific.

³⁵ http://www.hm-treasury.gov.uk/d/green_book_complete.pdf

³⁶ [http://www.hm-treasury.gov.uk/d/4\(5\).pdf](http://www.hm-treasury.gov.uk/d/4(5).pdf)

Provision of Government information on climate change and delivery

The Government has continued to invest in the evidence base for adaptation – through the UK Climate Projections 2009 and work to produce a UK Climate Change Risk Assessment.

The Government's aim is to build on previous work to provide more robust and comprehensive evidence about the risks of climate change for different regions and sectors, to help prioritise Government action on adaptation and help individuals and organisations make effective decisions on how to adapt.

Providing the information will only be effective if it is used properly and key organisations nationally, regionally and locally are aware of the need to assess climate change risks and adapt.

To help, between September 2011 and 2015, Defra will provide the Environment Agency an additional £2 million per year³⁷ to act as the Government's delivery partner in England for advice on climate change adaptation.

The Environment Agency will deliver climate change adaptation advice to help targeted sectors and businesses – including infrastructure companies, economic regulators and the engineering profession – prepare for climate change.

Work by PwC found that while there is growing awareness of climate change based on Government funded information, there remains a need for more specific climate information tailored to specific infrastructure sectors.

The need for more sector specific information on climate change impacts

Issue	Infrastructure operators		Investors	
	General awareness of climate change as an issue	Understanding of specific climate change impacts	General awareness of climate change as an issue	Understanding of specific climate change impacts
High impact events e.g. flood	• Strong for most sectors	• Strong for most sectors	• Limited to niche investors	• Limited to niche investors
Incremental changes in averages e.g. temperature	• Moderate	• Weak, growing in some sectors such as energy, roads and rail	• Weak, growing for niche investors	• Weak
Interdependency with other sectors	• Weak, although most obvious links such as cooling water for energy or role of ICT were identified	• Weak	• Weak, but growing for investors with portfolio of interlinked assets	• Weak

Source: PwC (2010)

³⁷ <http://www.defra.gov.uk/news/2011/03/22/ea-climate-change-adaptation/>

Infrastructure operators could undertake further information gathering and research to allow them to identify and model their own context specific risks, leading to detailed climate risk assessments being produced. This will enable organisations to determine more effectively what successful adaptation will look like and build a business case for action. It will also allow information gaps, such as operational thresholds, to be addressed in an effective and efficient manner.

Tailoring climate information to specific types of infrastructure

- The energy distribution companies are collaborating with the Met Office³⁸ to deepen their understanding of a range of weather and climate change impacts.
- Network Rail, the train operators and DfT with the Railway Safety & Standards Board are undertaking research, *Tomorrow's Railway & Climate Change Adaptation*. This looks at the impacts of climate change on exposed coastal tracks, embankment and bridges over the coming decades. The £750,000 investigation is expected to save £1billion over the next 30 years through safety improvements and emergency planning.

Information gathering should, ideally, be done collaboratively to minimise costs by:

- Infrastructure operators in specific sectors or sub-sectors (e.g. ports) seeking opportunities to reduce information gaps and costs. Doing this across a sector, with professional institutions and other relevant sectors, will help tackle interdependencies.
- Industry representatives working with Government (including Defra's Adapting to Climate Change Programme) to pool best available evidence and methods of adapting to climate change and sharing that across a sector.

7.2 Managing Uncertainties

While there is overwhelming evidence that the world is warming and will continue to warm further, there are uncertainties surrounding the scale, timing and nature of exactly how the climate might change. According to the Met Office Hadley Centre uncertainties arise in part from uncertainty in future emissions, and in part from the nature in which the climate system behaves, which becomes increasingly difficult to model at the regional level. These uncertainties make it difficult to know exactly what future climate to adapt to.

This presents a challenge to adapting national infrastructure – **what should our infrastructure be adapted to?**

This means that it is important that infrastructure decisions are taken by dealing effectively and efficiently with uncertainty. While there is always going to be some uncertainty about the likelihood and impact of climate change, this uncertainty is not any different to forecasting exchange rates, energy costs and R&D outcomes. Lack of certainty in these other areas does not prevent action.

³⁸ <http://www.metoffice.gov.uk/services/climate-services/case-studies/energy>

Generic climate change adaptation decision making process³⁹

A structured approach to decision making adaptation decisions should incorporate the following steps:

- Set out what the decision-maker is aiming to achieve.
- Assess the vulnerability of the objective(s) to current climate and future climate scenarios.
- Set out and evaluate possible adaptation options to address the risks.

In many cases, low-regrets options that provide immediate benefits today and are not sensitive to precise climate change predictions will be available. These can be implemented immediately without having to proceed further in the decision-making process. There are two broad categories of low-regrets options:

- 1. Measures that reduce current climate vulnerability.** These provide immediate benefits by protecting against current weather damage, while increasing resilience to future climate change. For example, setting back flood defences in sparsely populated estuaries can help to reduce current flood risk while providing room for estuaries to adapt to increased sea levels.
- 2. Measures with co-benefits or measures to manage non-climate risks.** Some measures, as well as being effective forms of adaptation, can also yield benefits with respect to other objectives. For example, water saving at home can reduce the amount of energy used in water treatment and domestic water heating.

Where investments are significant and cover a long timescale, a more formal policy appraisal should be carried out to **evaluate and compare individual adaptation options**. As a result of the uncertainty about future impacts, it is particularly important to consider:

- **Robust options** which broaden the coping range from the start. For example, where the capacity of a water storage system is increased in anticipation of drier conditions.
- **Flexible options and strategies** which allow for possible mid-lifetime adjustments as more information about climate becomes available. For example, the Thames Barrier Adaptation Plan can be modified in future to enable it to cope with sea level rise until the end of the century if required.

The decision-making process should be periodically reviewed and repeated to take into account reductions in uncertainty about climate change impacts and newly available response options.

Given the inherent uncertainties involved with adapting to climate change, there are two important aspects to an adaptation decision:

- a) What to do.
- b) When to do it.

For national infrastructure, appropriate adaptation responses will vary depending on the type and location of an asset, so these decisions are not straightforward. The different types of options and responses to adapt infrastructure can be illustrated with reference to new rail infrastructure:

³⁹ From the Adaptation Sub-Committee's How well prepared is the UK for climate change? (2010)

- The route of a railway is largely inflexible and needs to be resilient to long-term climate change (100 years+). It should be designed so that resilience can be increased cost effectively – possibly building in the option of mid-lifetime adjustments as more information about climate becomes available.
- As stations, bridges and embankments are long-life assets it is likely to be more cost effective to build in climate resilience at the outset of their design and broaden the coping range of key systems in anticipation of different climate scenarios (above and beyond normal maintenance regimes).
- For track and signalling equipment a different approach is likely to be more cost effective as these are replaced and/or upgraded more often (15-20 years). So it will be more important to ensure that track/signalling is resilient to the climate over this shorter timeframe and that this is done at every replacement cycle.

Asset type & good practice adaptation decision

Asset type	Existing asset	New asset
Long-life span (20 years+) e.g. power plants, reservoirs and water mains and transport structures.	Identify risks from climate change and appropriate responses. Incorporate adaptation measures into maintenance regime.	Identify risks from climate change and appropriate responses. Incorporate adaptation into investment decision. Adaptation measures identified and developed as part of planning application process.
Short/medium life spans (upwards of 20 years) e.g. road surfaces, data centres, overhead lines and long-life assets nearing end of life.	Identify risks from climate change and appropriate responses. Incorporate adaptation measures into maintenance regime.	Identify risks from climate change and appropriate responses. Incorporate adaptation into investment decision. Adaptation measures identified and developed as part of planning application process.

7.3 Balancing Priorities

Given the uncertainties related to the specific impacts of climate change and the long-term nature of climate change and adaptation, there is a danger that action is delayed and the focus of infrastructure companies, and investors, remains on the short-term.

This can lead to the impacts of climate change being marginalised and not receiving sufficient attention at board level. This is true for both unregulated and regulated sectors where the business case for adaptation can be constrained by lack of capital and/or management time. However, while future climate change is a long-term challenge, given the scale of infrastructure investment and the challenges of present-day climate vulnerability, proactive planning and action is required now.

So while climate resilience should be balanced against other priorities, the challenge is to increase the profile of adaptation across infrastructure companies and investors. To do this effectively, adaptation should be fully integrated into the business planning and operation of infrastructure companies.

Integrating climate resilience into infrastructure decisions

A good example of building in climate resilience into an infrastructure decision is United Utilities' West-East Pipeline project⁴⁰, which incorporates the impacts of climate change as one of three drivers for infrastructure investment.

United Utilities' are currently building a 55km pipeline to link the Prescot reservoir in Merseyside to Woodgate Hill reservoir in Bury.

At a cost of £125 million, it will increase the security of the region's water supply in the face of current risks to security of supply, EU environmental legislation and the future impact of climate change.

As climate change will have an impact on the amount of water available from Lake District sources to supply customers, in dry spells the pipeline will mean that the company can more easily move water across the region to where it is needed most.

It will increase the resilience of the region to current pressures, but also increase future climate resilience as it is expected to remain fit for purpose for the duration of its 100 year asset life.

One way to incentivise adaptation action is to encourage greater disclosure of climate risk to help raise awareness at a senior level in infrastructure companies. This will also raise awareness of investors and insurers on the risks of climate change and how companies within their portfolio understand and respond to these risks.

The Government's Adaptation Reporting Power and the independent Carbon Disclosure Project are both helping to address this issue:

- The **Adaptation Reporting Power (ARP)**⁴¹ is driving greater awareness of climate risks and adaptation responses in the energy, transport and water sectors. As each adaptation report from organisations in these sectors will be made publicly available, Government, investors and insurers as well as regulators should seek to build on the momentum from the ARP to encourage the sharing of knowledge and best practice in the infrastructure sectors.
- The **Carbon Disclosure Project (CDP)**⁴² by disclosing physical and market risks of companies to the impacts of climate change is putting climate information at the heart of financial and policy decision making.

7.4 Short-term Regulatory Focus

Although climate change adaptation is not explicitly prescribed as a statutory duty for economic regulators, the *Infrastructure & Adaptation* project found that it is embodied within economic regulators' wider mandates. In particular, the protection of short and long-term consumer interest, security of supply and service delivery.

The short-term vs long-term trade-off is partially addressed by aligning the five-yearly pricing review cycles to infrastructure companies' longer strategic aims. It is also important that economic regulators and infrastructure companies work together to plan strategically how to adapt at the right replacement cycle and the right price review. This will help reduce the risk of 'over adapting', e.g. it may be appropriate to agree some outputs between a regulator and an organisation for a longer period to enable longer-term planning in the context of five-yearly price reviews.

40 <http://www.unitedutilities.com/welm.aspx>

41 <http://www.defra.gov.uk/environment/climate/sectors/reporting-authorities/>

42 <https://www.cdproject.net>

Electricity network companies, with Ofgem, improving resilience to flooding

It is important that industry works closely with the regulator to address climate resilience. The electricity network companies have worked with Ofgem, under the auspices of the Energy Networks Association, to produce an *Engineering Technical Report*, presenting a risk-based methodology that provides guidance on how to improve the resilience of electricity substations to flooding.

For distribution companies this has meant that funding has been allowed in the five-year price control (starting April 2010) for improving resilience to flooding on the basis of completing the work programme over ten-years.

At present, there remains a strong emphasis on short-term value for money, which combined with the uncertainties around the specific impacts of climate change, mean that adaptation requirements are not yet being fully addressed by economic regulators on a systematic and consistent basis. So while in principle the economic regulatory framework is able to fund appropriate adaptation measures, in the context of securing climate resilience infrastructure for those sectors governed by economic regulation, there is a need for a longer-term focus.



Climate Risk to Infrastructure Interdependencies

A modern, efficient, networked infrastructure creates interdependencies within and between infrastructure in the energy, ICT, transport and water sectors. Each sector depends on the other sectors' resilience and it is essential that these interdependencies are both understood and managed to improve the resilience of infrastructure.

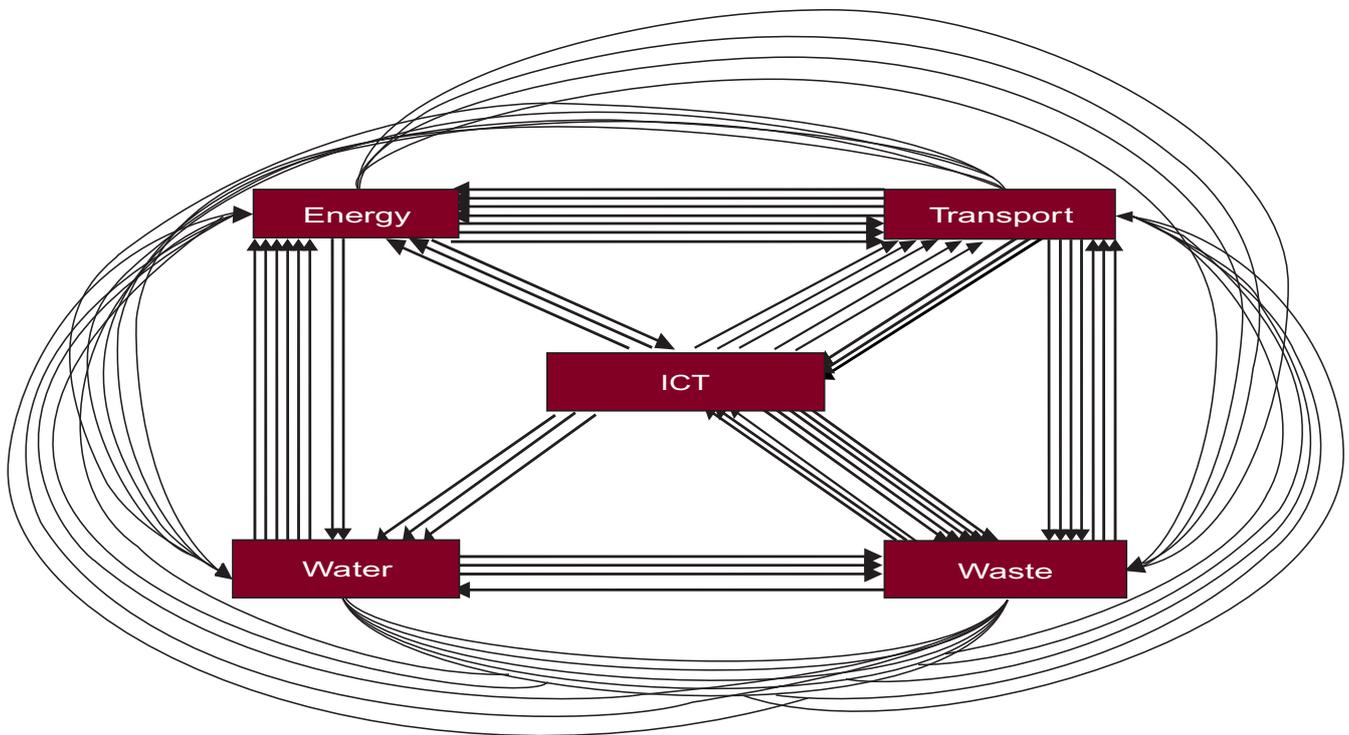
A final challenge addressed by this document is the risks that the impacts of climate change pose to interdependencies. For example, climate change may reduce the availability of cooling water for an inland power station, affecting its ability to generate electricity. Climate change risks to interdependencies merit particular attention.

Examples of interdependencies across the four sectors

Sector	Dependencies on Infrastructure	Impacts on other Sectors
Energy	<ul style="list-style-type: none"> • Water cooling in power stations and fuel refining. • ICT for control and management system of electricity and gas. • Transport for the fuel supply chain and workforce. • Gas storage and distribution relies on electricity supply. 	<ul style="list-style-type: none"> • ICT wholly dependent on energy. • Transport dependent on fuel and increasingly electricity. • Water dependent on energy for treating, pumping and processing as well as control systems.
ICT	<ul style="list-style-type: none"> • Energy for all services. • Transport for maintenance workers. 	<ul style="list-style-type: none"> • All sectors increasingly dependent on ICT for control systems, especially the smart grid. • Increasing dependence on ICT for sensing and reporting the condition of the infrastructure.
Transport	<ul style="list-style-type: none"> • Energy infrastructure for fuel and increasingly electricity. • ICT for management of services and networks. • Drainage infrastructure to prevent flooding. • Internal dependencies within and across modes (e.g. airports and roads). 	<ul style="list-style-type: none"> • All sectors dependent on transport to transport workforce to sites.
Water	<ul style="list-style-type: none"> • Energy for treating, pumping and processing. • ICT for control systems. • Transport for workforce and supplies of chemicals for processing. 	<ul style="list-style-type: none"> • All workplaces require water for staff. • Cooling water for some energy infrastructure.

Infrastructure interdependencies

A recent report on the interactions of infrastructure⁴³ stated that five sectors (energy, ICT, transport, waste and water) were all, to some extent, interdependent but that each was absolutely dependent on the provision of energy and ICT.



The National Infrastructure Plan 2010 highlighted that climate change is a growing risk to interdependencies. Climate change increases the risks of cascade failures, where a breakdown in one system has knock-on effects on others.

Scenarios demonstrating cascade failures from the impacts of climate change

- The November 2009 floods in Cumbria highlight the impact of bridge collapse on transport communications. If the bridge had been used as a connecting structure for the water mains supply though, this could have resulted in damage or complete failure to the water pipeline resulting in a loss of clean water to the local community.
- Another scenario is where a strategic transport route can be affected by an impact in the water sector. For example, during the floods in June 2007:
 - There were concerns that the Ulley reservoir might burst leading to junction 32 to 36 on the M1 near Sheffield being closed for 36 hours.
 - It was feared that, if the reservoir's dam was breached, the sudden flow of water could bring down high voltage power lines, flood the nearby M1 and a regional electricity substation, which supplies the power to the whole of Sheffield.

As the impacts of climate change are increasingly felt, interdependencies and their vulnerabilities will become more evident. This may lead to service disruption becoming more likely. Combined with a lower understanding and/or lack of co-ordination between infrastructure operators and others, it can undermine the ability to adapt national infrastructure successfully.

⁴³ AEA, An Overview of Systemic Interdependencies of the UK National Infrastructure, 2009

The difficulties in managing interdependencies mean that generally less progress has been made in addressing the risks climate change poses to infrastructure interdependencies. As a result, these can be the weakest link to achieving climate resilient infrastructure.

As climate resilience in one sector is often dependent on climate resilience in another, use of modelling and scenario planning will be essential to ensure that vulnerabilities in one sector do not compromise another.

To do this effectively, better cross-sector working will be required to improve collaboration, planning and sharing of information between sectors. Government, infrastructure sectors and regulators should all work together to do this.

Research into infrastructure interdependencies

There is a need for research into infrastructure interdependencies. A project, Infrastructure Transitions Research Consortium⁴⁴, funded by EPSRC, will:

- Develop tools for analysing interdependent infrastructure systems, taking into account risks of failure, co-evolution of infrastructure, land-use and the economy.
- Help test strategies for long-term investment in national infrastructure and understand how alternative strategies perform with respect to policy constraints such as reliability and security of supply, cost, carbon emissions and adaptability to demographic and climate change.

Tackling the risk climate change presents to interdependencies may also lead to potential opportunities for the engineering profession to:

- Develop engineering capacity and skills to engineer climate resilient infrastructure networks in a cost effective way.
- Use different techniques such as using 'dual-use infrastructure', 'smart technologies' and the natural environment to increase the climate resilience of infrastructure.

Engineers helping to increase the climate resilience of infrastructure

Engineers can play a central role in developing a climate resilient infrastructure network in a cost effective way. For example, infrastructure can be developed so that it can perform two or more functions, such as:

- Reservoirs can be used for flood control as well as water storage.
- Road and rail embankments acting as flood defences.

A specific example from overseas is Kuala Lumpur's Stormwater Management and Road Tunnel⁴⁵ which normally acts as a tunnel for road traffic but can be used to divert floodwater from tropical storms.

Taking forward the work of the engineering group that was established by the *Infrastructure and Adaptation* project, the Government set up an Engineering and Interdependency Expert Group bringing together senior expertise from industry, academia and Government. There is an opportunity to work with this group to further examine the climate risks to interdependencies.

44 UK Infrastructure Transitions Research Consortium – <http://www.ukcip-arcc.org.uk/content/view/585/542/>

45 SMART Motorway Tunnel – <http://www.smarttunnel.com.my/>



Actions to Prepare Infrastructure for a Changing Climate

This document includes actions to improve the climate resilience of infrastructure to enable the aim of *an infrastructure network that is resilient to today's natural hazards and prepared for the future changing climate* to be met.

This section sets out:

- The challenges to adapting infrastructure.
- The potential opportunities to act to meet these challenges.
- How Government can assist others, including future areas of work.

To take forward the actions within *Climate Resilient Infrastructure*, Government will work with infrastructure owners and operators, infrastructure investors and insurers, regulators, engineers and others to realise the opportunities identified.

The UK Government will publish its first Adaptation Programme in late 2012. This will include an update on progress made in taking forward the actions and meeting its aim for climate resilient infrastructure, as well as what additional actions may be required.

To inform this, Government welcomes the views of industry and others on the actions and challenges/opportunities identified in *Climate Resilient Infrastructure*.

If you wish to contribute and/or work with Government on adapting infrastructure to the impacts of climate change, please contact the infrastructure team within the Adapting to Climate Change Programme in Defra at ACCinfrastructure@defra.gsi.gov.uk.

Challenges to Adapting National Infrastructure

How Government can facilitate progress in adapting national infrastructure to the impacts of climate change.

To help overcome the challenge, Government will assist others by:

- Engaging infrastructure organisations to enable them to influence the development of the first UK Government Adaptation Programme and future adaptation policy.
- Publishing the first UK Government Adaptation Programme by the end of 2012, which will include an update on progress made in implementing the actions from *Climate Resilient Infrastructure*.
- Continuing to set out the importance of adapting to climate change, through:
 - The *Roadmap to a Green Economy*.
 - The National Infrastructure Plan 2011.
 - The Water White Paper.
 - Energy, Transport and Water National Policy Statements.
- Working in partnership with the Environment Agency, as the Government's delivery partner for advice on climate change adaptation, to engage and support infrastructure sectors to adapt to climate change.
- Influencing EU policy on climate change adaptation and specific energy, transport and water policy and regulations.
- Supporting the building of resilience to today's natural hazards, through the work of the Cabinet Office.⁴⁶

⁴⁶ <http://www.cabinetoffice.gov.uk/infrastructure-resilience>

How to set out the challenge of adapting to climate change in economic regulatory models.

The opportunity for economic regulators:

- Work as a group to consider cross-sector adaptation action to help address climate risk and interdependencies.
- Balance climate risk with efficiency and value for money considerations and planning time horizons.
- Consider (with Government) whether existing incentive and penalty structures remain fit for purpose as extreme weather events increase in frequency and severity.
- Use the adaptation reports from the Adaptation Reporting Power from the organisations they regulate to consider whether additional support and/or action is required.

To help overcome the challenge, Government will assist others by:

- Using its *Principles of Economic Regulation*⁴⁷ to inform the design of regulatory frameworks, ensuring the system remains coherent, predictable and appropriately focused.
- Applying the Principles, lead Government departments will produce detailed sector application of them later in 2011.
- Using the findings from the first round of the Adaptation Reporting Power to examine how economic regulators are currently approaching adaptation.

How the planning system for nationally significant infrastructure can guide applicants on the need to adapt new infrastructure to the impacts of climate change.

The opportunity for others:

- Clearly set out in planning applications for new nationally significant infrastructure how the impacts of climate change in the planning, designing, building, operating, and where relevant decommissioning, of infrastructure have been considered.

To help overcome the challenge, Government will assist others by:

- Including adaptation within each National Policy Statement to set out how applicants should consider the impacts of climate change in their application.

⁴⁷ <http://www.bis.gov.uk/assets/biscore/better-regulation/docs/p/11-795-principles-for-economic-regulation>

How to reduce the risk that climate change impacts presents to infrastructure interdependencies – increasing the vulnerability of infrastructure sectors.

The opportunity for others:

- Work with the new UK Infrastructure Transitions Research Consortium to improve infrastructure companies' understanding of the cross-sector risks and interdependency risks from climate change.

To help overcome the challenge, Government will assist others by:

- Using the Infrastructure UK led Engineering & Interdependencies Group to explore further how:
 - Climate risks can exacerbate interdependency vulnerabilities.
 - Engineering e.g. systems thinking and dual-use infrastructure, can reduce the risk from climate impacts.
 - Co-ordination and information sharing of cross-sectoral adaptation measures can be improved.
- Using the evidence on interdependencies from all adaptation reports received under the Adaptation Reporting Power to consider what further work is needed and could be addressed through the UK Government's first Adaptation Programme.

How to increase the adaptive capacity in infrastructure companies and others (e.g. investors) to enable robust and cost effective climate change adaptation decisions to be made.

The opportunity for others:

- Professional bodies to look at how adaptation skills can be addressed as a means of increasing adaptive capacity.
- Consider whether their workforce has the right skills and/or capacity to develop expertise on climate resilient infrastructure.

To help overcome the challenge, Government will assist others by:

- Using the results of the first round of the Adaptation Reporting Power to raise the profile of adaptation in infrastructure companies.
- Using this document to engage the investment community.

How to improve the way investment decisions incorporate the impacts of climate change.

The opportunity for others:

- Integrate adaptation into infrastructure investment decisions, in particular assets with a 20 year+ lifetime.
- Look at innovative financial approaches to incentivise adaptation in long-life assets.
- To work with infrastructure owners to increase climate resilience to reduce exposure risk.

To help overcome the challenge, Government will assist others by:

- Leading by example by integrating adaptation requirements when investing in and/or procuring new infrastructure projects and using the Adaptation Supplement to the Green Book.
- Using high profile examples (e.g. Crossrail) to demonstrate how climate change adaptation can be integrated into new infrastructure projects.
- Continuing to set out in the National Infrastructure Plan that adapting to climate change is a strategic, economic risk to the country, infrastructure operators and investors.
- Integrating adaptation into the investment decision making of the proposed Green Investment Bank.
- Increasing engagement with the investment community to raise the profile of adaptation.

How to improve access by industry to specific climate information and research through better information sharing, disclosure of risk and evidence.

The opportunity for others:

- Infrastructure operators and sectors to increase collaboration with research organisations and commission specific research on climate risks to increase understanding of technical risks, e.g. thresholds and trigger points.
- Investors and insurers to consider how greater disclosure of climate risk management would be beneficial and catalyse adaptation action.

To help overcome the challenge, Government will assist others by:

- Continuing to invest in the work of the Hadley Centre to support its world-class climate science and further develop understanding of climate impacts.
- Using the results from the first round of the Adaptation Reporting Power to share good adaptation practice and help address interdependencies.
- Using the results from the first UK Climate Change Risk Assessment to improve understanding of the risk the UK faces from climate change.
- In each lead infrastructure departments (e.g. DECC for energy infrastructure) considering with their industry partners whether their evidence base for adapting their infrastructure is sufficient.
- Raising awareness of climate resilient infrastructure to investors and insurers, e.g. through increased disclosure of risk via the Adaptation Reporting Power and Carbon Disclosure Project.
- Learning from, and sharing, adaptation experience on infrastructure from other countries, in particular G20 countries.

How to monitor progress made in adapting national infrastructure to climate change.

To help overcome the challenge, Government will assist others by:

- Asking the Adaptation Sub-Committee to include an assessment of progress on adapting infrastructure as part of their annual report on the UK's preparedness for climate change.
- The ASC will regularly assess progress across the key sectors (energy, ICT, transport and water), looking at each one in-depth periodically.

Opportunities and Future Areas of Work

How to realise the potential economic opportunities that adapting national infrastructure to climate change presents.

To take advantage of the potential opportunities, the opportunity for others:

- Seek to develop innovative approaches to adaptation, e.g. developing dual use and smart infrastructure and using the natural environment.
- Develop new technologies, skills and expertise on climate change adaptation for infrastructure to be used domestically and exported.
- Develop innovative approaches to climate risk, climate modelling and financing.

To help overcome the challenge, Government will assist others by:

- Integrating adaptation into the Government's Green Economy work.
- Considering whether further work is needed to identify the opportunities for business and professional bodies.
- Working through UKTI, with FCO and BIS, to promote and facilitate international commercial opportunities for UK infrastructure companies with adaptation expertise.

As this study did not examine the risks of climate change to waste infrastructure, a future area of work will be to examine how climate change may affect waste infrastructure. This will input into the UK Government's first Adaptation Programme, Defra Waste and Infrastructure UK.

To achieve this, Government will:

- Undertake a study on the risks waste infrastructure faces from the impacts of climate change and how the industry can adapt.

As this study did not look in detail at how the international impacts of climate change may affect infrastructure, a future area of work will be to look at how the international impacts of climate change may affect national infrastructure.

The opportunity for others:

- Examine how their international operations and supply chains might be affected by climate change globally, affecting service delivery.
- Examine their exposure to infrastructure invested or insured internationally and consider how to increase its climate resilience to reduce climate risk.
- Expand knowledge transfer so that a company's adaptation action in the UK is transferred to any overseas operations.

To help overcome the challenge, Government will assist others by:

- Considering the findings from the Foresight International Dimensions of Climate Change study and whether further work is needed to examine:
 - How climate change impacts globally may affect infrastructure service delivery.
 - How climate change impacts globally may affect infrastructure supply chains and access to resources.





Annex A: Glossary

Adaptation to climate change: Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

Adaptive capacity: The ability of a system to design or implement effective adaptation strategies to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with consequences.

Cascade failure: When one element of infrastructure fails (completely or partially) and causes failure or imposes pressure on other infrastructure simultaneously.

Centre for the Protection of National Infrastructure (CPNI): Provides integrated security advice to organisations which make up the national infrastructure.

Climate: Refers to the average weather experienced in a region over a long period, typically at least 30 years. This includes temperature, wind and rainfall patterns.

Climate change: Refers to any change in climate over time, whether due to natural variability or as a result of human activity.

Climate impact: A specific change in a system caused by its exposure to the climate. Impacts may be harmful (impact) or beneficial (opportunity).

Climate resilience: The ability of a system to absorb climate-related disturbances while retaining the same basic structure and ways of functioning.

Critical threshold: The point at which an impact to infrastructure will be observed. Beyond this point functionality may be altered, unless adaptation measures have been implemented. For example, a power plant can operate to full capacity within a certain temperature range, outside this range, reduced efficiency can be expected.

Defra: The Department for Environment, Food and Rural Affairs which has lead responsibility for domestic climate change adaptation in England. **Infrastructure:** The physical facilities that support our society such as roads, water pipes, power stations and communication systems.

Infrastructure UK: Has a remit to provide a stronger focus on the UK's long-term infrastructure priorities and meet the challenges of facilitating significant private sector investment over the longer-term.

Interdependency: Where interconnections associated with the supply or receipt of a service (e.g. water) on which the receiving sector is reliant and an impact on this supply could be critical. For example, water is essential for the cooling at power stations.

Met Office Hadley Centre: The main Government funded centre for climate change research and modelling.

Mitigation (to climate change): Action taken to reduce the impact of human activity on the climate system, primarily through reducing net greenhouse gas emissions, for example carbon dioxide.

Risk: Hazards/events that could have an impact on exposure to danger or loss. Climate risks are additional risks to investments (such as buildings and infrastructure) from potential *climate impacts*.

UKCP09: The UK Climate Projections 2009 give climate information for the UK up to the end of this century. Projections of future changes to our climate are provided, based on simulations from climate models.

Annex B: Organisations Involved in the Infrastructure & Adaptation Project

Throughout the two-year *Infrastructure & Adaptation* project, a large number of organisations and individuals inputted into the project's workstreams and their findings. This engagement benefitted not only the individual workstreams but also this document.

Organisations who participated in the project include:

Abellio	Forth Ports
Adaptation Sub Committee, Committee on Climate Change	Geode Networks Europe
Anglian Water plc	Health and Safety Executive (HSE)
Associated British Ports	Highways Agency
Association of British Insurers (ABI)	HS1 Ltd
Association of Electricity Producers	Hutchinson Ports
Association of Train Operating Companies (ATOC)	IBM
Automobile Association	Institution of Chemical Engineers (and their members)
Aviva plc	Institutions of Civil Engineers (and their members)
Birmingham International Airport	Institution of Engineering & Technology (and their members)
Bournemouth & West Hampshire Water plc	Institution of Highways & Transportation
British Airports Authority	Institution of Mechanical Engineers (and their members)
British Dam Society	Intellect
British Energy	International Power
British Ports Association	Leeds University Climate Change Centre
BP	Macquarie Group
BT Group	Manchester Airport
Carbon Disclosure Project (CDP)	National Grid
Centrica	Network Rail
Chartered Institute of Water & Environmental Management (CIWEM)	Northumbrian Water Ltd
Civil Aviation Authority	Ofcom
Consumer Council for Water	Office of Rail Regulation (ORR)
Council for Science & Technology	Office of the Gas & Electricity Markets (Ofgem)
Dorset County Council	Ontario Teachers' Pension Plan Board
Dover Harbour Board	Powerfuel
Drax Group plc	QinetiQ
East Coast Mainline Co.	
E.ON	
EDF Energy	
Eiser Infrastructure Capital Equity Fund	
Electricity North West Ltd	
Energy Networks Association	
Environment Agency	

RAC Foundation
RAILPEN Investment
Renewable Energy Association
Road Haulage Association
Royal Academy of Engineering
(and their members)
RSA Group
RWE npower

Scottish Power
Skanska
Southern Energy
Sellafield Ltd
Severn Trent plc
Society for Motor Manufacturers & Traders
Stagecoach
Surrey County Council

Thames Water Utilities Ltd
Transport for London

UKCIP
UK Energy Research Partnership
UK Major Ports Group
United Utilities plc
Universities Superannuation Scheme (USS)
Ofwat

Veolia

Water UK
Waterwise
Warwickshire County Council
Western Power Distribution plc

Yorkshire Water Services

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