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Adapting to Climate Change: helping key sectors to adapt to climate change

Government Report for the Adaptation Reporting Power

March 2012

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Contents

Introduction

The Climate Change Act 2008 provides the Secretary of State with the Adaptation Reporting Power, to encourage and influence key organisations'[1] adaptation actions.

Even though there were potentially thousands of organisations that could have been asked to report, the first strategy for using the Power targeted just 91 organisations. These organisations are largely responsible for national infrastructure in the energy, transport and water sectors which are sectors of strategic importance to the country.

In addition 12 organisations responded to our invitation to report. These organisations were invited to report rather than directed because either:

- They did not sit within the legal definition of a reporting authority but their adaptation was considered crucial to the ongoing functioning of daily life in the UK.

  OR

- They expressed their willingness to be involved in the process and to be seen as exemplars in adaptation.

The Adaptation Reporting Power entitles the Secretary of State to require organisations to provide reports containing:

- *"an assessment of the current and predicted impacts of climate change in relation to the organisations' functions; and*
- *a statement of the organisation's proposals and policies for adapting to climate change."*

In practice this means that organisations are required to assess the risks and opportunities to their organisation from a changing climate.

[1] The power applies to 'Reporting Authorities' which are defined within the act as either 'a person or body with functions of a public nature' or statutory undertakers under the Town and Country Planning Act 1990, the Town and Country Planning (Scotland) Act 1997 or Planning (Northern Ireland) Order 1991.

Purpose of the Adaptation Reporting Power

The first round of the Adaptation Reporting Power focussed on key organisations responsible for infrastructure and essential services that were thought to be potentially vulnerable to climate change impacts. The first round strategy aimed to be proportionate in minimising additional reporting burdens on public and private sector bodies and to avoid identifying authorities who already had requirements in regulation to report on climate change adaptation.

The primary aims of the first round of the Adaptation Reporting Power were to ensure that the organisations selected understood the risks climate change poses to their activities and were making the necessary plans to respond to climate change.

The Adaptation Reporting Power has enabled Government and others (e.g. the Adaptation Sub-Committee[2], regulators, and investors) to gain better information on:

- *Levels of preparedness in, and risks to, key infrastructure sectors.*
- *Actions that organisations are taking as a result.*
- *Areas where Government and others (e.g. regulators, research/scientific community) may need to act.*

Executive Summary

103 organisations, primarily from the energy, transport and water sectors, have provided reports under the Adaptation Reporting Power (ARP) to Defra. The reports demonstrate that these organisations are assessing their risks from climate change and in many cases are well-placed to mitigate them.

Different sectors and different organisations within these sectors are at different stages of considering climate change adaptation. The ARP has proved to be the catalyst for many organisations to begin formally considering their climate change risks and adaptation responses, some for the first time. One of the most common outcomes noted both in the Adaptation Reports and the workshops organised by Defra for each sector is that the ARP has led to greater visibility of climate change risks at the organisational and board level, and has embedded management of these risks within corporate risk management processes.

Some organisations are at an advanced stage of embedding climate change adaptation, and were either already undertaking research into the effects climate change could have on their functions, or taking adaptation actions to prepare for a future climate. Through the process of completing their report, many organisations engaged with their relevant stakeholders specifically on climate change risks, and worked collaboratively to identify interdependencies between sectors. Similarly the

[2] http://www.defra.gov.uk/environment/climate/government/risk-assessment/

reporting process has resulted in greater awareness of potential barriers to climate change adaptation and suggested ways these barriers can be overcome.

Overall the ARP process has demonstrated that reporting authorities are working to mitigate climate change risks and that the UK is building resilience to a future climate.

The Evaluation Process

The reports have been evaluated by:

- **Defra's Adapting to Climate Change Programme team** – who examined the reports and identified any barriers to action and interdependencies between risks.
- **Cranfield University** - Risk experts from the Risk Centre at Cranfield University who *independently analysed* the risk assessment methodology and results in each Adaptation Report.
- **Lead Policy Government Department** - Policy leads in relevant departments (e.g. Department for Transport for the aviation sector) and devolved administrations, where appropriate, evaluated the Adaptation Report from a policy perspective (i.e. lessons to inform future work) and identified information gaps and barriers to action.

Compendium Report

Nearly all of the 103 organisations who reported can be clustered together into nine sectors.[3] These sectors are:

- Aviation;
- Electricity Distributors;
- Electricity Generators;
- Electricity Transmitters;
- Gas Transporters;
- Ports and Lighthouses;

[3] Sector summaries on I.C.T. and Health were not prepared as it was not felt that a complete and accurate representation of these sectors could be made given their partial coverage through the first round of reporting. As a result the Ofcom and Monitor reports are not included in this document.

- Public Bodies;
- Road and Rail; and
- Water.

There is a chapter in this document for each of these sectors based on advice provided by Cranfield University, relevant policy teams in Government departments; and discussions with Reporting Authorities. These summary chapters aim to reflect the broader sector-wide results that have come out of the Adaptation Reporting Power. Workshops were held with all sectors to discuss each of these chapters, and in several cases further follow-up meetings and discussions with reporting authorities were also held.

It is important to note that the risks mentioned in these reports are **risks identified by the Reporting Authorities** to their own functions and are not Defra's assessment of climate change risks, which can be found in the UK's National Climate Change Risk Assessment.[4] Future editions of the UK's National Climate Change Risk Assessment[5] will utilise the information within the ARP reports to build a baseline of UK climate resilience against which risks can be assessed.

Both Defra's National Climate Change Risk Assessment and the reports submitted under the Adaptation Reporting Power will be used as part of the evidence base to develop the National Adaptation Programme, where Government will out its adaptation policies and actions.

Each chapter is structured by the following headings:

- Executive summary;
- Key climate change risks (as identified by Reporting Authorities);
- Areas of strength;
- Areas for further research (note these are not necessarily areas for the Reporting Authorities themselves to research);
- Emerging trends;
- Barriers (to adaptation as identified by reporting authorities);
- Interdependencies; and

[4] http://www.defra.gov.uk/environment/climate/government/risk-assessment/
[5] Which will be produced on a regular five year cycle.

- Annex listing the relevant Reporting Authorities for the sector.[6]

[6] Note that regulators are placed with the sector(s) they regulate, meaning that Ofgem are present in all energy sector summaries.

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Aviation Chapter for the Adaptation Reporting Power

March 2012

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INTRODUCTION

In response to directions to report under the Adaptation Reporting Power, 9 airports from England, Scotland and Wales, the Civil Aviation Authority (CAA) and National Air Traffic Services (NATS) submitted Adaptation Reports to Defra in 2011[7]. These reports were reviewed by Defra's Adapting to Climate Change team, policy teams in the Department for Transport and the Risk Centre at Cranfield University. They were published by Lord Taylor in October 2011[8].

This report summarises the findings from the reports, focusing on:

- The climate risks for the aviation sector as identified by Reporting Authorities
- Areas of strength for the industry as a whole
- Areas of good practice
- Areas for further research;
- Emerging trends and themes
- Barriers
- Interdependencies

Due to the different locations of the organisations, regional conditions bring different climate issues for the aviation sector.

[7] A full list of the airports who were directed to report can be found at Annex A.
[8] http://www.defra.gov.uk/environment/climate/sectors/reporting-authorities/reporting-authorities-reports/

SUMMARY OF FINDINGS

The evaluation of the reports by Cranfield University, DfT policy teams and Defra's Adapting to Climate Change team show that:

- Climate change risk assessments are being embedded within the aviation sector's corporate risk appraisal processes.

- For climate risk assessments the sector is making good use of climate change data (e.g. UKCP09), information, knowledge and tools

- The risk assessments have generated priorities for action and flexible adaptation responses are being developed.

- The issue of climate change uncertainties and their implications for the sector requires further examination.

KEY CLIMATE RISKS FOR THE SECTOR

This is not an exhaustive list of every risk to the aviation sector; it is an overview of the key climate risks that the aviation sector has identified. Further details about the risks faced by each organisation can be found in their individual adaptation reports.[9] Note that these risks are those identified by Reporting Authorities, not Defra.

Weather Risks

Increased frequency of extreme weather events – potential for flight diversions, delays and airport closure. Also the potential loss of business through damaged goods and pressure on air cargo storage capacity if cargo aircraft are unable to leave the airport. All of these can lead to reputational damage and financial implications.

Increased temperatures/heat waves - potential for increase in surface and subsurface damage to runways and aprons from extreme heat. Also increased risk of adhesion to aircraft tyres and ground subsidence. There is the potential for overheating of airport buildings requiring use of cooling units and cooling systems.

Heat stress to passengers, staff and particularly to vulnerable groups. May also lead to increased fire risk (in conjunction with increased drought and lightning likelihood).

Increased rainfall and flood risk- which can cause surface water flooding and exceed drainage capacity leading to reduced air traffic flow capacity and accident risk. Increased runoff from paved areas can cause standing water on runways creating hazardous conditions for landing and taxiing aircraft.

Extreme events pose the risk of de-icer contaminated surface water leading to breach of discharge consents.

Winter rainfall increases the potential for ice formation on aircraft which requires de-icing. This can disrupt surface

Managing weather risks

Gatwick Airport experienced heavy snowfall at the end of 2010. The airport was shut for two brief periods shortly before Christmas when more than 240,000 passengers were scheduled to travel.

A collaborative approach with airport partners was used, through workshops and table top exercises, to improve preparedness for future snow disruption.

In addition- Gatwick invested £600,000 in upgrading the snow clearing equipment and de-icer storage facilities during the summer of 2010. Gatwick also invested £8 million to double the size of their snow fleet, putting their snow clearing capacity on a par with Oslo airport.

[9] *http://www.defra.gov.uk/environment/climate/sectors/reporting-authorities/reporting-authorities-reports/*

transfer networks, impeding the flow of passengers, air crew and staff as well as key supplies.

Seasonal changes in fog - potential for increased disruption caused by low visibility procedures (LVPs). These can also restrict airside maintenance activities.

Increased lightning - can cause changes to flight routings and stack locations to avoid convection storms. This can lead to suspension of refuelling activities as well as disrupting control systems.

Increased freeze/thaw effect - damage of surfaces if winter temperatures become more variable, fracture risk to underground utilities and infrastructure.

General Risks

Interdependencies - particularly with the wider transport sector, water sector, energy sectors and the telecoms sector.

Global Risks - such as potential for changes in the distribution of diseases, epidemics and pandemics, resulting in travel bans or reduced demand for air travel. Risk to destination airports from climate change, as well as wider impacts to airports due to climate change mitigation efforts/behavioural change.

Subsidence - increased likelihood possible due to changes to the water table.

Specific Air Traffic Control Risks

Changes in prevailing wind conditions - affecting runway utilisation through reductions in take-off and landing rates causing backlog, delays etc. Permanent change could require realignment of runway direction although current climate projections do not suggest any likely change in the prevailing wind.

Jet stream movement - requiring changes to aircraft flow patterns and sector loading and could result in preferred transatlantic routes moving further north outside NATS's controlled airspace.

Increased low pressure storm conditions and high wind speeds - causing air traffic flow reductions, increased aircraft separation and missed approaches - leading again to delay and backlog and potentially, short-term runway closures.

Embedding Climate Change Adaptation

Climate change is included in Birmingham Airport's corporate Risk Management Register and Environmental Management System (EMS), whilst Stansted Airport's adaptation responses will be monitored through its existing Sustainability and Risk Governance Forums.

AREAS OF STRENGTH

A number of areas of strength were identified from the Adaptation Reports, illustrating that the aviation sector Reporting Authorities are beginning to take steps to assess their climate change risks. These include:

Engagement with relevant staff/departments – the majority of the Reporting Authorities engaged with key staff and departments when assessing their potential climate change risks. For example, Luton Airport held a workshop with senior departmental managers and directors to introduce the reporting process, with sub-groups based around key business functions subsequently being used to assess the risks facing their business areas.

Engaging others on adaptation

Cardiff Airport consulted a range of stakeholders, including NATS, airline operators and the Welsh Assembly and is considering holding an awareness raising seminar with airlines.

Through this Cardiff Airport have recognised opportunities for themselves for working more closely with the Welsh Assembly. Government.

Active engagement with stakeholders and interdependencies – the Adaptation Reports illustrate that a number of the aviation sector Reporting Authorities are actively engaging with a variety of stakeholders and interdependencies in relation to climate change risk management and adaptation and are aware of the need for partnership approaches to address climate change risks.

Risks assessed using existing corporate risk assessment methodologies – all of the Reporting Authorities used their existing corporate risk assessment methodology and criteria to evaluate their climate change risks. This enables climate change risks to be compared with existing risks and embedded within corporate risk management processes.

Evidence of the embedding of climate change in risk management processes – the aviation sector Reporting Authorities are actively embedding climate change risk management within their organisations.

Clear timescales and responsibilities for adaptation – a number of the Adaptation Reports outlined adaptation actions which include clear timescales for implementation and are accompanied by details of clear responsibilities. Heathrow Airport's risk management matrices provided details of the business unit risk owners and responsible directors, with 'actions' and 'prepare' tasks expected to be completed within the next 3 years.

Plans for the continued assessment and monitoring of climate change risks – the reports provided details of the sector's plans for continued assessment and monitoring of climate change risks. For example, Stansted Airport's Adaptation Report provided details of a number of proposed actions to monitor and test airport drainage infrastructure.

Evidence that the Adaptation Reporting Power has led to change – some of the Reporting Authorities in the sector note that the Adaptation Reporting Power has led to changes in the level of understanding or management of climate change risks within their organisation. NATS notes that its climate change risk assessment has led to a number of responses with, for example climate change being incorporated in its asset management, investment, strategic projects and supplier review processes amongst others.

Assessing possible adaptation responses

Manchester and East Midlands Airports held workshops with senior members of staff to identify risks and opportunities, and then ranked these on a scale of significance. An electronic voting system was used to create the ranking after discussion. This meant that the variance of workshop attendees' ratings could be analysed to assess where there was consensus or difference of opinions.

Conclusions were then classified as 'watching brief', 'investigate' or 'action'. For example the process outlined an action to increase the capacity of the surface water drainage system in response to the risk of increased winter precipitation.

AREAS FOR FURTHER RESEARCH

The review of the aviation sector reports highlighted a number of areas that might benefit from further research in future. These include:

Changes in behaviour triggered by climate change – the potential for climate change to result in changing travel demand and behaviour, with both positive and negative impacts on travel demand.

Risks to cargo flows – climate change may lead to disruptions in cargo operations and international cargo flows, and is interdependent with, for instance, the postal service. There are also potential risks to specific cargos, for instance livestock which may require existing facilities to be adapted to climate change.

Reputational and financial risks – as highlighted by the 2010 snow disruption, severe weather and climate events can disrupt air services and, possibly, lead to temporary suspension of airport operations. Reputational risks and financial risks, particularly increased insurance costs, were noted as being of concern to the sector.

Adaptation investment issues – particularly the implications of regulated capital investment, investment decision making with long timescales and uncertainties. The potential requirement to invest in equipment, infrastructure and training for highly uncertain and low frequency risks.

Overcoming climate change uncertainties – research to understand and address the challenges that climate change uncertainties represent for organisations.

Noise risk – a number of airport operators noted that climate change could increase noise risks to local communities through changes in flight patterns and increased temperatures[10]. Cardiff Airport's report noted increases in noise complaints from neighbouring residents during periods of peak temperatures.

Air quality risks – the potential for increased temperature and heat waves to result in reduced air quality and in particular the risk this poses to vulnerable groups with existing respiratory and heart conditions.

Impacts on the emergency services and safety - such as potential increases in risks, for example grass fires as temperatures increase, which may require increased fire cover and new controls. Emergency service access and increased external demands under climate change may need to be investigated and planned for.

[10] This is because aircraft need to use increased thrust on take-off to compensate for lower air densities.

Impacts on employees - issues such as employee welfare, reduced productivity and risk of heat stress, even increased disease risk, changes in staff relations and issues relating to internal expertise and knowledge.

Changes in wildlife and vegetation - such as possible effects of bird strike risk resulting from changes to migration patterns and changes in vegetation growth.

Interdependencies - with the wider transport network, water and energy sectors, planning agreements and telecoms services. The lack of awareness about how interdependencies are adapting to climate change and potential for conflicts with third parties over adaptation plans/preparedness. There were calls for integrated approaches involving local and central government to overcome interdependencies.

Airfield design standards - for some airports current airfield design standards appear to offer only a low standard of protection (no flooding for a 1 in 5 year storm and 1 in 10 years for landslide areas) which may need to change in line with expected climatic changes.

Climate change projections and information – further information is required on projections for extreme weather, storm frequency and severity, snow frequency and intensity wind speed and direction, haze conditions, air quality, fog and lightning.

Other - ground movement risks, disruption to navigation aids and potential increased maintenance costs.

EMERGING TRENDS

The review of the aviation sector's Adaptation Reports illustrates that each airport is at a different stage in the assessment of climate change risks and development of adaptation programmes. However, common issues and trends emerge across the reports that require cross-industry action.

The impact of temporary suspensions of operations at some airports during winter 2010 is clearly reflected in the Adaptation Reports and their consideration of the risks posed by adverse winter weather.

Thresholds – While a number of Reporting Authorities appear to be aware of climate change thresholds that affect their functions, others noted that they are yet to assess their potential climate change thresholds and recognise the need for further research and monitoring. The Adaptation Reports do illustrate however, that the aviation sector is clearly aware of how weather affects their operations, which is reflected in weather-related contingency plans and procedures.

Risk Assessments – In general the quality of risk assessments conducted by the sector was good, with the majority of reports containing a detailed description of the risk assessment methodology including clearly defined likelihood and consequence classifications.

A number of Reporting Authorities used supporting information such as Environment Agency flood risk maps and many used UK CP09 to test their climate change sensitivities. All assessed risks over different future timescales and a number included an assessment of the level of confidence associated with the assessment.

Further Actions proposed - in general further adaptation actions outlined focused on further research monitoring and reviewing of actions as opposed to hard infrastructure adaptation.

A number of organisations are actively designing investments that are resilient to climate change. However, others noted recent or planned investment in infrastructure but it was unclear whether climate change was considered.

Lack of Research programmes - whilst a small number of Reporting Authorities appear to have funded research into their climate change risks, unlike other sectors

there is very little, if any, evidence to suggest that the sector is engaging in research programmes.

Use of consultants - all but three of the Reporting Authorities' risk assessments were supported by external consultants.

BENEFITS AND OPPORTUNITIES

Self-generation of renewable energy - a number of airport operators highlighted the potential opportunities of renewable energy generation, for example through biomass or photovoltaics.

Reduced energy costs - warmer temperatures in future may reduce the heating season although this may be outweighed by increased cooling demand.

New management processes and policies - such as increased energy and water efficiencies, opportunities to exploit rain water harvesting from wetter winters and milder winters resulting in a longer outdoor work season.

Partnership opportunities - climate change adaptation is viewed by some as an opportunity for facilitating closer working relationships with stakeholders and interdependencies.

Changes in passenger flows and travel destinations – the UK could be seen as a better holiday location, particularly if other countries and their airports fail to adapt.

Potential reduction in the frequency of fog and snow - leading to reduction in frequency of Low Visibility Procedures (LVPs) and/or reduction in winter disruption and need for anti-icing.

BARRIERS

The review of the Adaptation Reports identified a number of barriers that were highlighted as representing a challenge to the aviation sector's ability to adapt to climate change.

Investment challenges:

- Airports have short-term timeframes for return on investment whilst climate change requires longer term investment which looks unattractive to shareholders.

- Financial uncertainties and resource constraints. Even the airports master planning timescales of 20 years is not long enough to prepare for climatic changes.

Regulatory Barriers

- Regulatory constraints on investment - airport capital investment programmes are regulated in 5 year periods by the CAA and the Airports Act with costs having to be agreed in advance. This cycle does not match the long term timescales associated with climate change.
- Future climate change regulation such as increased legislative constraints and levels of fiscal taxes may impact upon airports' ability to invest in appropriate infrastructure.
- Airfield and aviation safety regulations.
- Permitting constraints e.g. night flight quotas and noise footprints.

Information gaps

- Uncertainties around climate science and projections for the future.
- A lack of data on weather variable that are most important to the sector such as wind, fog and lightning.
- Lack of information on flooding from overland flow and drainage systems.
- Lack of policy information such as the Welsh Government has not yet published its guidance 'Building resilience into climate change' nor have some local surface water management plans and local transport plans yet been published.

Other Barriers

- Stakeholder acceptance and perception of climate change risks.
- Uncertainty, not just in climate change/scientific understanding, but also in future industry trends and developments.

- Physical constraints to adaptation, for example limited capacity to store supplies on site, space constraints posed by physical location of the airport and legacy infrastructure and runway capacity constraints.
- Skills and technical knowledge can be difficult to access which means the future impacts arising from climate change are not fully understood.

INTERDEPENDENCIES

The reports highlighted a large number of interdependent organisations and policies with many of these representing key cross-cutting interdependencies. The following broad groups were identified.

Public Sector Bodies and Regulators – UK Government, Devolved Administrations, Scottish Environmental Protection Agency, Environment Agency, Civil Aviation Authority, local authorities, Health Protection Agency, Health protection bodies (NHS etc.), Police services, local fire services, Health and Safety Executive.	**Transport/surface access –** Road network- Highways Agency/highways authorities, surface transport operators and infrastructure, Network Rail and operating companies, bus and coach operators, taxi companies, staff transport, car rental and parking.	**Aviation Sector –** Air traffic services, airlines, Airport Coordination Limited, Heathrow Airline Operators Committee, airport operators, international aviation bodies, ground handling/baggage handling agents.
Energy Supply/Utilities – Fuel supply and distriction- UK Oil Pipeline system, refineries and on-site providers, Aircraft fuel infrastructure, electricity suppliers and National	**Stakeholders-** Community groups, surrounding land users, Unions, RSPB.	**Other third party services –** offsite assets, landowners/landlords, commercial services/tenants, retail and site concessions and delivery partners, retail chains, transport/haulage

Grid, Gas supply, Water supply, ICT/telecoms provision.	and logistics companies, maintenance engineers, cleaning staff/contractors, catering, hotels, banking services, facilities management, drainage engineers, landscaping companies, cargo industry, de-icer suppliers, veterinary staff, health professionals, Met Office/meteorological data providers, University Research centres, consultancies.

ANNEX A

The full list of reporting authorities for the aviation sector that provided adaptation reports.

1. Birmingham Airport
2. Cardiff International Airport
3. East Midlands Airport (joint report with Manchester Airport)
4. Edinburgh Airport
5. Glasgow International Airport
6. London Gatwick Airport
7. London Heathrow Airport
8. London Luton Airport
9. London Stansted Airport
10. Manchester Airport (joint report with East Midlands Airport)
11. NATS (Air traffic management)
12. Civil Aviation Authority (aviation regulation)

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Energy (Electricity Distributors) Sector Summary Report for the Adaptation Reporting Power

March 2012

INTRODUCTION

In response to directions to report under the Adaptation Reporting Power, 14 organisations from the electricity distributors sector submitted Adaptation Reports to Defra between June and November 2011[11]. These reports were reviewed by the Government's Adapting to Climate Change team in Defra, policy teams in the Department of Energy and Climate Change and the Risk Centre at Cranfield University. They were published by Lord Taylor in December 2011[12].

This report summarises the findings from the reports focussing on:

- The climate risks for the electricity distributors sector as identified by Reporting Authorities
- Areas of strength for the industry as a whole
- Areas for further research or consideration
- Emerging trends and themes
- Benefits and opportunities
- Barriers
- Interdependencies

[11] A full list of the organisations who were directed to report can be found at Annex B.
[12] http://www.defra.gov.uk/environment/climate/sectors/reporting-authorities/reporting-authorities-reports/

SUMMARY OF FINDINGS

The evaluation of the reports by Cranfield University, DECC policy teams and Defra's Adapting to Climate Change team show that:

- Climate Change risk assessment forms a component of corporate risk assessment within the electricity distribution sector. The level of embedding and consideration of climate change in corporate planning and process is mixed across the sector, with some organisations yet to completely embed climate change risk management.

- Reporting Authorities have clearly used a range of relevant and appropriate data, information, knowledge and tools in their risk assessments reflecting not only the collaborative sector-level assessment of climate change risks, through the reporting process, but the range of in-depth studies that have been commissioned to develop a greater understanding of the risks facing the sector.

- The risk assessments have generated priorities for action, with key risks being accompanied by adaptation responses. The Reporting Authorities have highlighted a number of cases where they have already begun adaptation actions to reduce risks from climate change. Reporting Authorities' plans for monitoring and evaluating adaptation effectiveness were less clear however.

- Reporting Authorities emphasised that other changes, for instance surrounding the delivery of the government's 'Low Carbon Transition Plan', the introduction of smart grid technology and the connection and growth in the use of electric vehicles, will lead to greater changes to their operations than climate change.

KEY CLIMATE RISKS FOR THE SECTOR

This is not an exhaustive list of every risk that the electricity distribution sector has identified; it is an overview of the key climate risks which were identified by the Reporting Authorities. Further details about the risks faced by each organisation can be found in their individual adaptation reports.[13] Note that these risks are those identified by Reporting Authorities, not Defra.

The Energy Networks Association produced a core sector report which aimed to prioritise risks based on relative impact and relative likelihood. Four risks were identified which, if no adaptation measures were taken, received a 'very high' classification.

Substations affected by sea flooding due to increased sea levels and/or tidal surges. This risk was scored as having an extreme impact and a possible relative likelihood.

Substations affected by flash flooding due to increase winter rainfall. This risk was scored as having a significant impact and a possible relative likelihood.

Substations affected by river flooding due to increased winter rainfall. This risk was scored as having a significant impact and a probable relative likelihood.

Additional risks which, without adaptation measures, were given a high classification were:

- Overhead line conductors affected by temperature rise, reducing rating and ground clearance.
- Underground cable systems being affected by increase in ground temperature, reducing ratings.
- Transformers affected by urban heat islands and coincident air conditioning demand leading to overloading in summer months.

Clearly the industry believes that the greatest risks from climate change it faces are as a result of flooding, particularly to substations. Overall however the industry believes that it is capable of addressing all of these risks in a timely manner and at a cost which is estimated to be affordable.

[13] *http://www.defra.gov.uk/environment/climate/sectors/reporting-authorities/reporting-authorities-reports/*

AREAS OF STRENGTH

A number of areas of strength were identified from the Adaptation Reports that demonstrate that the electricity distribution sector is assessing and acting upon their climate change risks. These include:

Awareness of thresholds and climate change effects – the Adaptation Reports illustrate that the electricity distribution sector is developing a detailed understanding of the impact that climate change and weather events may have on electricity distribution infrastructure. This includes an awareness of the thresholds associated with different types of assets (e.g. transformer de-ratings), which are based on design standards and work with the Met Office developing network fault models.

Awareness of the geographical distribution of risks – the reports illustrate that the sector is developing an understanding of the spatial distribution of a number of risks that affect the sector, particularly at the national level, although some companies are also aware of the geographical distribution of their own risks. However, further research is required to develop a more detailed understanding of the spatial distribution of risks.

Research programmes – the reports provide details of a number of ongoing research initiatives, at both the sector and organisational level that the Reporting Authorities are participating in to investigate and assess their climate change risks and adaptation actions. Some of the studies have been funded through Ofgem's Investment Funding Initiative (IFI), which was introduced in response to the regulator's recognition of declining levels of research and development by the sector.

Research into climate change risks

Industry research including EP2, with recent work commissioned to develop a risk model that quantifies the relationship between climate and network faults and the vulnerability and exposure of the network to these faults.

UK Power Networks and Central Networks (now Western Power Distribution), have worked with the National Soil Research Institute (NSRI) at Cranfield University and the British Geological Survey (BGS) to produce an earthing mapping system which they hope to extend to account for the effects of seasonality and climate change.

In response to concerns regarding potential changes in vegetation growth as a result of climate change, a number of electricity distributors have commissioned a 4 year research project with ADAS to quantify the impact of vegetation growth around overhead lines and the manner in which utility space is degraded by vegetation growth.

Industry-level collaboration – as well as funding industry-level research, the sector is also collaborating on climate change risk management and resilience issues through the Energy Networks Association.

Stakeholder collaboration – for example, the ENA task group that produced their climate change report includes electricity transmission and distribution companies and the Department of Energy and Climate Change (DECC), with inputs from Ofgem, Defra, the Environment Agency, the Met Office and others.
The ENA member companies propose to engage in discussions with Ofgem and DECC with a view to agreeing revised design standards for overhead line poles to take effect from the next price control review starting in 2015.

Flood resilience – in response to the 2005 Carlisle flood and 2007 floods, the sector developed an Engineering Technical Report (ETR 138) that sets out a common approach to the assessment of flood risk and the development of target mitigation levels that are subject to cost benefit analysis. Furthermore, the electricity distribution companies have begun a circa 10 year programme of work to improve substation resilience to flooding, with Ofgem setting allowances of £110m which has been agreed as part of Distribution Price Control Review 5, that runs between 2010 and 2015.

Awareness of potential adaptation costs – the electricity distribution sector, through the ENA, outline the rough costs associated with adapting the electricity distribution network to climate change and the costs of replacing specific assets. Such information has not commonly been provided by other sectors/Reporting Authorities and represents best practice.

Emergency preparedness - the sector has well established emergency plans, which are reviewed and managed through the Energy Emergencies Executive (E3). Network companies are all members of the North East West South Area (NEWSAC) mutual aid consortium. This was used during the 2007 floods when CE Electric received assistance from Scottish Power and Central Networks.

Evidence that the Adaptation Reporting Power has led to change – some of the Reporting Authorities in the sector note that the Adaptation Reporting Power has led to changes in the level of understanding or management of climate change risks within their organisation. Examples include:

- SP Energy Networks notes that it had not explicitly

Action on Flooding

Electricity North West has embarked on a prioritised investment plan to defend sites vulnerable to flooding at a total cost of over £10m. Work has been completed at 28 sites out of a total of 50 identified as requiring improvement in the first tranche. This part of the programme will be completed by 2014. A further 102 sites are to be surveyed.

Further evidence of adaptation responses

SSE Power Distribution is introducing early adaptation measures including network automation and storm management systems, enhancing its ability to respond to extreme weather events that are likely to typify climate change.

considered climate change risk to the business before receiving the Direction to Report. Indeed, the development of its Adaptation Report has led to a more formal consideration of climate change risks within the company.

- Ofgem has met with other economic regulators to set out a framework for coordinating cross-sector work on interdependencies.

AREAS FOR FURTHER INVESTIGATION OR CONSIDERATION

Regulatory Environment

A number of issues relating to the regulated nature of the electricity distribution sector, and its management of climate change risks and ability to adapt to climate change may warrant further investigation. Amongst the possible issues identified from the reports are:

- **Regulated Price Control Reviews** - allowed revenues for the industry are set by Ofgem in periodic price reviews and therefore any potential adaptation costs are considered in setting the allowed revenue. Reporting Authorities noted that the regulatory planning cycles require business plans to be agreed 5-8 years in advance and that there is a possibility that, as energy network assets are typically long life assets, and investments considered on a net present value, companies may favour delaying investment until the asset needs replacing rather than considering retrofitting existing equipment.

- **Competitive markets and cost versus adaptation** – Ofgem's focus is on protecting consumers by ensuring costs of the network companies are as efficient as possible and investment is encouraged where it is needed to meet future needs. Price controls representing its main contribution to adaptation, through review of business plans and setting allowed revenue for the network company for the price control period. Should adaptation costs be significant then there is the risk of tensions between adaptation, funding, and consumer willingness-to-pay for adaptation, given potential benefits are long into the future. This is recognised by Ofgem who acknowledge that its main challenge as a regulator is ensuring risk mitigation that secures sustainable energy supplies and long-term value for money for customers.

- **Indirect management of climate change –** Ofgem currently indirectly addresses climate change through licences, transmission and distribution price controls for network operators, the offshore regime and network codes, and there may be a requirement for more direct management in future.

- **Security of supply and extreme events -** overall levels of supply security are agreed by Ofgem, with the standards specifying the requirements for the availability of alternative supplies at various levels of customer load. Although the standards allow for the loss of multiple circuits they do not provide for low probability events such as multiple failures or the total failure of a grid or primary substation. Thus, as highlighted in the reports, particular attention must therefore be given to grid and primary substations when considering network resilience.

Design Standards and Industry Codes

The electricity distribution sector Adaptation Reports highlight that the sectors' assets are designed to industry design standards that are used in warmer climates and thus will be able to remain in service, with a potentially reduced capacity, allowing for predicted climate change. However, a number of possible areas for further research exist, including:

- **De-rating figures -** there appears to be uncertainty surrounding some of the de-rating figures provided in the Adaptation Reports, with variations in the percentage of de-rating under climate change being cited in different reports. For example, a number of reports quote figures of <10%, whilst others, such as SP Energy Networks, estimate that de-ratings could be as high as 25% should warmer ground temperatures coincide with droughts.
- **De-rating temperatures/thresholds –** some of the de-rating information provided in the reports suggests that some assets will be affected by relatively low temperatures (e.g. 30-35^{o}C). There is also a need for thresholds affecting specific equipment/sites to be assessed so that the potential implications for the electricity transmission network can be determined. This is recognised by some Reporting Authorities.
- **Industry codes and standards** – there may be a need to adjust existing industry codes and standards in future to facilitate adaptation to climate change. For example, the reports note that there may be a requirement to revise the maximum design temperatures for equipment and that the risk profile of transformers will be affected as design temperature thresholds are exceeded, with changes needed in national electricity industry standards.

Infrastructure and Network Vulnerability to Climate Change

The review of the Adaptation Reports suggests that further research investigating the risk that climate change poses to electricity distribution infrastructure and the network as a whole may be beneficial. Possible areas for further research that were identified in the reports include:

- **Risks posed by new types of event -** the potential risk posed by new types of event that have not been previously encountered, but could arise under climate change, such as the impact of solar gain on urban assets.
- **Resilience of specific infrastructure -** the resilience of grid and primary substations and particularly their potential vulnerability to major flood incidents.

- **Urban heat risks –** solar heat faults requires further research as the future fault distribution from solar heat faults has not been estimated because their rare occurrence makes it difficult to determine a relationship between fault numbers and weather events. Reporting Authorities are also concerned about the risks posed to basement substations, located in urban environments.
- **Thresholds –** whilst there is an awareness of the equipment thresholds associated with the electricity distribution network equipment, based on design standards, further research regarding thresholds, and site-specific thresholds is required to gain a clearer understanding of the risk that climate change poses to the sector.

Future Demand

The Adaptation Reports highlight the potentially significant challenges facing the electricity distribution sector that arise from forecast increases in electricity demand. A number of areas for further research, relating to future changes in demand were identified by the Reporting Authorities, including:

- **Climate change and future demand -** further research is required to fully understand how climate change may affect electricity demand, capacity and supply arrangements. In particular, the potential of increased air conditioning loads during the summer, which together with reduced winter peak demands, as a result of warmer winters, will lead to a flatter seasonal demand curve. This potentially has implications for network flexibility and will make it harder to take circuits out of service at lightly loaded times for maintenance, requiring enhanced capacity or service standards.
- **Distributed generation/smart grids -** the shift towards distributed and low carbon forms of generation, together with smart grids could potentially lead to a significant change to the daily demand profile in future. However, the shift to smart grids will enable climate change adaptation to be addressed.

Vegetation Management

The Reporting Authorities identify future changes in vegetation growth as a result of future climate change as being a particular concern, with increases in the number of days over 5.6^{o}C impacting on the growing season. The sector highlights that there has been a significant increase in tree related faults on the UK electricity network between 1990 and 2006 and that it represents a significant cost to network operators.

Earthing Risks

Changes in earth potential as a result of climate change was identified as a key risk by the sector, with increases in earth resistance resulting in protective equipment, such as lightning arresters, taking longer to operate. Whilst this risk is being investigated by the industry, further research may be required into the impact of climate change and localised effects (e.g. groundwater levels, agricultural practice and land surface/drainage), especially as it is noted that substation earthing risk may require increased inspection regime which could potentially be expensive due to the large number of network assets.

Combined Events

The analysis of the electricity distribution sector risks, indicates that the sector is concerned about the risk posed by combined events that may become more prevalent under future climate change, and are deemed to represent challenges for the sector. Amongst the combined risks, that were outlined earlier, the sector highlights that the most challenging conditions for overhead line ratings occurs under high ambient temperatures, high solar radiation and low wind speeds.

Interdependencies

A number of issues relating to interdependencies were highlighted that may require further research, including:

- **Third-party risks -** such as transport, supply chain and logistics risks, particularly as equipment is sourced from overseas. In some instances it is assumed that third-parties are identifying and managing their climate change risks.
- **Risks to IT/communication and control infrastructure –** it was noted that IT and communication and control infrastructure risks have the potential to impact upon the management and control of the electricity transmission network and are of particular concern to some Reporting Authorities.
- **Flood and coastal defence -** SP Energy Networks notes that a very small number of sites are potentially at increased risk from sea level rise and coastal erosion if the current level of protection is not maintained or improved.
- **Smart networks –** the shift towards smart networks, renewable distributed generation and low carbon loads will result in more significant changes to the network than those required for adaptation. This is reflected in Reporting Authorities recognising the need to consider climate change and the low carbon agenda together rather than in isolation as is the current situation.

Adaptation Strategies

Whilst it is apparent that the electricity distribution sector is actively adapting to climate change, for example through the Ofgem funded 10 year programme of work to improve substation resilience to flooding, a number of areas relating to its future ability to adapt to climate change warrant further research. Particular issues identified in the Adaptation Reports include:

- **Price controls and adaptation** – Ofgem's RIIO price control will include incentives under categories such as reliability and availability and customer satisfaction. Ofgem believes adaptation is therefore indirectly covered through these incentives (there is currently no specifically targeted incentives on adaptation). Whether this may need to change in the future is unclear at present.

- **Switch to low-carbon networks –** the reports highlight that the future shift to low carbon networks and smart grids will potentially represent a larger challenge to the industry than climate change. They also emphasise that this shift provides an opportunity for adaptation to be built into the future electricity network.

Climate Change Knowledge, Expertise and Data/Information Issues

A number of issues related to climate change knowledge and data issues were raised in the Adaptation Reports that may require further research. These include:

- **Information asymmetry** – Ofgem's Adaptation Report notes that it is reliant on information provided by the sector and that it is aware that this risks information asymmetry. It also raises issues of transparency and information reliability and suggests that as a regulator, it may wish to consider undertaking independent research to evaluate the risks facing the sector as it would help to identify the adaptation needs of the sector and the potential costs when setting price control revenues.

- **Use of EA/SEPA flood maps –** a number of Reporting Authorities utilised the EA/SEPA flood maps to evaluate their flood risks, which have a number of limitations in relation to their use in climate change risk assessment.

- **Information gaps –** a wide range of information gaps were highlighted by the Reporting Authorities that limit their ability to fully assess their climate change risks.
    - Wind storms – inconclusive evidence that climate change will lead to an increase in severity of high winds that can cause extensive damage to overhead electricity networks.
    - Projected changes in wind speed, storms and gusts.

- Future predictions of wind and gale network faults are uncertain.
- Future changes in the frequency and intensity of ice storms and accretion.
- Potential impact of increased temperatures on cables laid in urban areas.
- Impact of climate change on air condition load and the timing relationship between peak ambient temperature and peak demand.
- Future changes in lightning.
- UKCP09 projections for precipitation have not been translated into impacts on river levels.
- Pathways of flood water from dam bursts.

EMERGING TRENDS

The review of the electricity distribution sector Adaptation Reports identified a number of common issues emerging across a number of the reports which are outlined below.

Functions Impacted by Climate Change

Thresholds – the evaluation of the Adaptation Reports suggests that the sector is developing a good awareness of the climate change thresholds associated with different types of electricity distribution equipment. For example, temperature thresholds that are associated with rating reductions are known for transformers, and organisations are also using equipment specifications, design standards and regulatory requirements as thresholds. However, many Reporting Authorities highlighted the need for further research to investigate other risk thresholds, such as those associated with future changes in vegetation growth and earth potential, and site-specific thresholds.

Impact of climate on the organisational functions – the Adaptation Reports indicate that the electricity distribution companies are beginning to develop an understanding of how climate change may impact upon different asset types and demand for example. However, it is difficult to determine the level of risk to the individual companies because whilst some of the potential risks to generic types of equipment have been identified, their implications for companies' sites and individual assets are yet to be assessed by some organisations.

This may reflect the fact that Reporting Authorities emphasised that other changes, for instance surrounding the delivery of the government's 'Low Carbon Transition Plan', the introduction of smart grid technology and the connection and growth in the use of electric vehicles will lead to major changes.

Varying quality risk classifications – in many cases the risk assessments could have been improved if they provided clearer, more precisely defined risk likelihood and impact classifications. This affected the assessment of a number of the Evaluation Framework sub-attributes relating to the risk assessment methodology and risk appetite.

Awareness of information gaps – many of the Adaptation Reports contained details of information gaps that currently affect Reporting Authorities' ability to assess their climate change risks. To address such issues, a number of Reporting Authorities are planning continued engagement with organisations such as the Met Office and the Environment Agency on such issues, and plan to reassess their risks when new information becomes available.

The ENA report recognises the need for the sector to reassess flood risks when updated flood risk information, including future risks and pluvial flooding, together with the second generation of Shoreline Management Plans, which include projections for coastal erosion, are published.

Cost Benefit Analysis and Sustainability Appraisal – the Adaptation Reports illustrate that the electricity distribution sector is aware of the potential long-term costs associated with adapting the electricity network to future climate change. This is evident in both the ENA report, that for example includes details of the sector-level costs associated with work to increase substation flood resilience, and in a number of the individual Adaptation Reports that provide details of the level of funding allowed by Ofgem for such works. The ENA report also outlines the indicative costs associated with adapting the electricity distribution network to a worse case climate de-rating impact.

Summary of Risks

Risk matrices – the quality of the risk matrices provided in the electricity distribution sector Adaptation Reports was variable. Some of the Reports could have been improved by providing greater detail on the definition of likelihood and impact classifications for their risk matrices which would have made it easier to interpret and compare the results. For instance, the ENA Core Report provided clear definitions of what its scoring on different impact levels meant, e.g. 'minor' impact means "small town off supply for a 24 hour period OR significant increase in cost of network maintenance requirements" which made it much easier to interpret the results.

Temporal changes in climate change risks – the analysis of the Adaptation Reports suggests that the electricity distribution sector is developing an understanding of the timescales associated with a number of its climate change risks, although the level of understanding at the individual organisation level is less clear and more variable in some cases.

Opportunities – the review of the Adaptation Reports suggests that climate change may provide opportunities for the electricity transmission sector. These particularly relate to the shift towards smart networks, low carbon electricity generation, and reduced design standards for overhead lines as a result of milder winters.

Actions Proposed to Address Risks

Clear links between priority risks and adaptation actions – the majority of reports from the sector clearly prioritised the climate change risks, with clear links to adaptation responses.

Mixed adaptation responses/targets – the Adaptation Reports provide a mixed picture of the adaptation responses proposed by the Reporting Authorities to address their climate change risks. Whilst in some cases, Reporting Authorities have clear adaptation plans, with timescales and clear risk reduction targets, others only appear to aim to reduce risks.

Barriers to Adaptation and Interdependencies

Awareness of barriers – it is evident that the electricity distribution sector Reporting Authorities are clearly aware of a number of barriers that have the potential to affect their ability to adapt to climate change. This is reflected in the majority of Reporting Authorities providing detailed descriptions of their barriers that are accompanied by plans to overcome them in future.

The ENA report notes that network operators will seek to resolve the potential barriers by jointly examining with Ofgem the current assessment of impacts and adaptation options, with the aim of agreeing a way forward that will be considered as part of the next round of price control reviews starting in 2015.

Monitoring and Evaluation

Mixed plans for monitoring and evaluating climate change risks and adaptation plans –the analysis of the Adaptation Reports has identified a mixed picture of plans for the electricity distribution sector Reporting Authorities to monitor and evaluate their climate change risks and adaptation responses. Whilst a number of organisations have clear plans to for monitoring and assessment that are linked to existing processes, many Reporting Authorities only provided indicative plans.

General Issues Identified from the Reports

Site specific risks – whilst the sector is developing an awareness of the effect that climate change will have on specific types of infrastructure, there is a clear need to translate this into individual organisation-level assessments of risk.

Flood risk – like many other sectors, flood risk assessment and adaptation appears to have been a key focus for the sector to date.

BENEFITS AND OPPORTUNITIES

A number of potential benefits or opportunities arising from future climate change were identified by the electricity distribution sector. These include:

- Potential increase in the daytime rating of overhead lines due to longer drier summers which may be accompanied by higher wind speeds that provide line cooling.
- Milder winter climates will reduce the frequency of ice accretion and loading, which cause asset failures, potentially enabling a reduction in design standard for ice loadings (e.g. for overhead lines) with subsequent cost savings.
- Reduced snowfall improving access to assets and extending the construction window for new grid connections.
- Peak loads moving to summer would enable maintenance programmes to be moved into spring and autumn, taking advantage of milder weather.
- Smart networks and climate change adaptation could be considered simultaneously thus reducing costs.
- Carbon reduction through increased renewables generation connections.
- Opportunities for further collaboration, experience sharing and learning, which will lead to increased resilience.
- Increased resilience of the power sector as a result of new technologies (e.g. distributed generation), that will increase efficiency, reliability and diversity of generation sources.
- Provision of opportunities and incentives for the energy sector to adapt to climate change.
- Opportunities for environmental benefits or low carbon futures.
- Energy efficiency may reduce the costs and challenges associated with adapting to climate change by reducing the need to build new generation or network capacity and the need for associated adaptation measures. It could also reduce the energy demands related to cooling in summer in domestic, commercial and industrial premises.

BARRIERS

A number of potential barriers to adaptation were identified in the reports including:

Ofgem price control reviews – have a strong influence on capital investment programmes and operational expenditure and there is the potential for conflict of drivers between cost reduction and the early pursuit of adaptation measures given the long lifetimes of electricity network assets.

Financial and Economic – adaptation measures may not pass current net present value investment tests. Similarly there are challenges associated with consumer willingness to pay. However some Reporting Authorities expressed confidence in Ofgem's 'RIIO' price control framework as an effective mechanism for disclosing, justifying and discussing the cost of adaptation with the regulator and customers.

Long asset life spans - the long lifetime (50y or more) of assets makes it important for key stakeholders to accept that actions required to mitigate issues that may only materialise as a result of future climate projections (e.g. 2050) may need investment in the near future.

Systematic rather than piecemeal adaptation is required - Electricity networks are complex interconnected systems that can only be modified or up-rated through systematic processes that are likely to require a considerable period of time. Piecemeal upgrades are unlikely to be cost effective or successful.

Uncertainties – make forming robust adaptation plans and investment plans challenging. There are both climactic uncertainties around projections- but also longer term industry uncertainties associated for instance with the move towards smart networks.

Physical barriers to adaptation - Physical barriers to putting new connections and infrastructure in place – e.g. lack of space in urban areas.

Planning timescales - gaining planning permission for schemes can be lengthy.

Interdependencies - dependency on 3rd party suppliers, especially for communications infrastructure.

INTERDEPENDENCIES

The reports highlighted a large number of interdependent organisations and policies, with many of these representing key cross-cutting interdependencies. The following broad groups were evident.

Regulators/ regulations and legislation – UK Government, EU, Council of European Energy Regulators, Agency for the Cooperation of European regulators, Defra, DECC, Environmental Agency, SEPA,other regulated sectors and regulators	**External expertise/data** – Universities, Research organisations, Met Office/Hadley Centre, UKCIP, External review groups/expertise, UKCP09, Flood risk data, Institute of Engineering and Technology.	**Other –** Utilities e.g. water sector, Shoreline Management Plans/coastal flood defence.
Energy sector– Energy Networks Strategy Group, E3 Committee, European electricity and gas markets, Low carbon futures/smart networks and electric vehicles.	**Transport –** Railway sector, Network Rail, London Underground.	**Suppliers –** Third party communications/ICT infrastructure, fuel supply chains.

ANNEX B

The electricity distributor sector organisations that provided adaptation reports.

1. Central Networks East Plc
2. Central Networks West Plc
3. EDF Energy Networks (Eastern)
4. EDF Energy Networks (London)
5. EDF Energy Networks (Seaboard)
6. Electricity North West Limited
7. Northern Electric Distribution Plc
8. Scottish Hydro Electric Power Distribution Plc
9. Southern Electric Power Distribution Plc
10. SP Distribution Plc
11. Western Power Distribution (South Wales) Plc
12. Western Power Distribution (South West) Plc
13. Yorkshire Electric Distribution Plc
14. Office of the Gas and Electricity Markets (Ofgem)

As a result in changes in within the electricity distribution sector and the submission of joint reports, the following Adaptation Reports were reviewed and form the basis for the analysis outlined in this report:

1. CE Electric UK – covering Northern Electric Distribution Limited and Yorkshire Electricity Distribution Plc
2. Electricity North West Limited
3. SSE Power Distribution – including Scottish Hydro Electric Transmission.
4. SP Energy Networks – covering SP Distribution Limited and SP Manweb Plc
5. UK Power Networks – covering Eastern Power Networks Plc, London Power Networks Plc and South Eastern Power Networks Plc
6. Western Power Distribution
7. Ofgem

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Adapting to Climate Change: helping key sectors to adapt to climate change

Energy (Electricity Generators) Sector Summary Report for the Adaptation Reporting Power

March 2012

defra
Department for Environment Food and Rural Affairs

INTRODUCTION

In response to directions to report under the Adaptation Reporting Power, 10 organisations from the electricity generation sector in England and Wales submitted Adaptation Reports to Defra between July and November 2011[14]. These reports were reviewed by the Government's Adapting to Climate Change team in Defra, policy teams in the Department of Energy and Climate Change and the Risk Centre at Cranfield University. They were published by Lord Taylor in December 2011.

Under the 2009 Strategy for using the Adaptation Reporting Power, reporting authorities were deemed to be electricity generating companies who produced an annual output in excess of 10 TWh. In discussions with industry, it was agreed that the scope of the reporting in the individual climate change adaptation reports would encompass each company's generating plant over 100MWe capacity, on the grounds of proportionality. It was also agreed that the reports should consider only existing power stations, and that power stations 'opted-out' of the Large Combustion Plant Directive would be excluded, on the grounds that they will close by the end of 2015 at the latest. Similarly it was agreed that the timescale for assessments would be for the 30 year period 2010-2039 as this represents a realistic timescale for continued operation of existing plants (and those under construction). This timescale is valid as current regulations require that climate change is factored into new power station projects at the design and planning stage.

This report summarises the findings from the reports, focussing on:

- The climate risks for the electricity generation sector
- Areas of strength for the sector
- Areas for further research
- Emerging trends and themes
- Benefits and opportunities
- Barriers
- Interdependencies.

[14] A full list of the organisations who were directed to report can be found at Annex C.

SUMMARY OF FINDINGS

The evaluation of the reports by Cranfield University, DECC policy teams and Defra's Adapting to Climate Change team show that:

- Climate change risk assessments are embedded, or plans are in place to do so, within the electricity generation sector's corporate risk appraisal processes.
- Reporting Authorities have made evidence-based decisions on adapting to climate change, supported by the use of relevant and appropriate data, information and tools such as the UKCP09 Weather Generator and Threshold Detector.
- Using a semi-quantitative risk assessment the sector has identified the most relevant hazards as:
    - Flooding
    - Extreme high temperatures
    - Drought
- In the vast majority of cases, the hazards assessed were considered "low risk" or "very low risk"; only in a few instances were they classed as "medium risk".
- Climate change is expected to increase the probability of existing risks occurring, and in some cases their severity, but it will not introduce any fundamentally new sources of risk.
- Adaptive capacity across the sector as a whole is ensured currently by the combination of a generating plant capacity margin, geographical diversity of generating plant (together with a national transmission network) and diversity in generation technology.
- As a result of this, the electricity supply system is robust against individual plant failure and, in the last decades, electricity generation has demonstrated a consistently high level of resilience to potential disruptions from extreme events. Provided that these key factors are maintained over the next 20 years, this intrinsic robustness is not expected to change.

KEY CLIMATE CHANGE RISKS FOR THE SECTOR

This is not an exhaustive list of every risk that the electricity generation sector has identified; it is an overview of the key climate risks that the sector faces. Further details about the risks faced by each organisation can be found in their individual adaptation reports.[15] It should be noted that individual power stations face different risks due, amongst other reasons, to their geographical spread around the country and the different types of plants asked to report. This geographical diversity builds resilience against climate change risks at the national level and is demonstrated in the figure 1 below[16]:

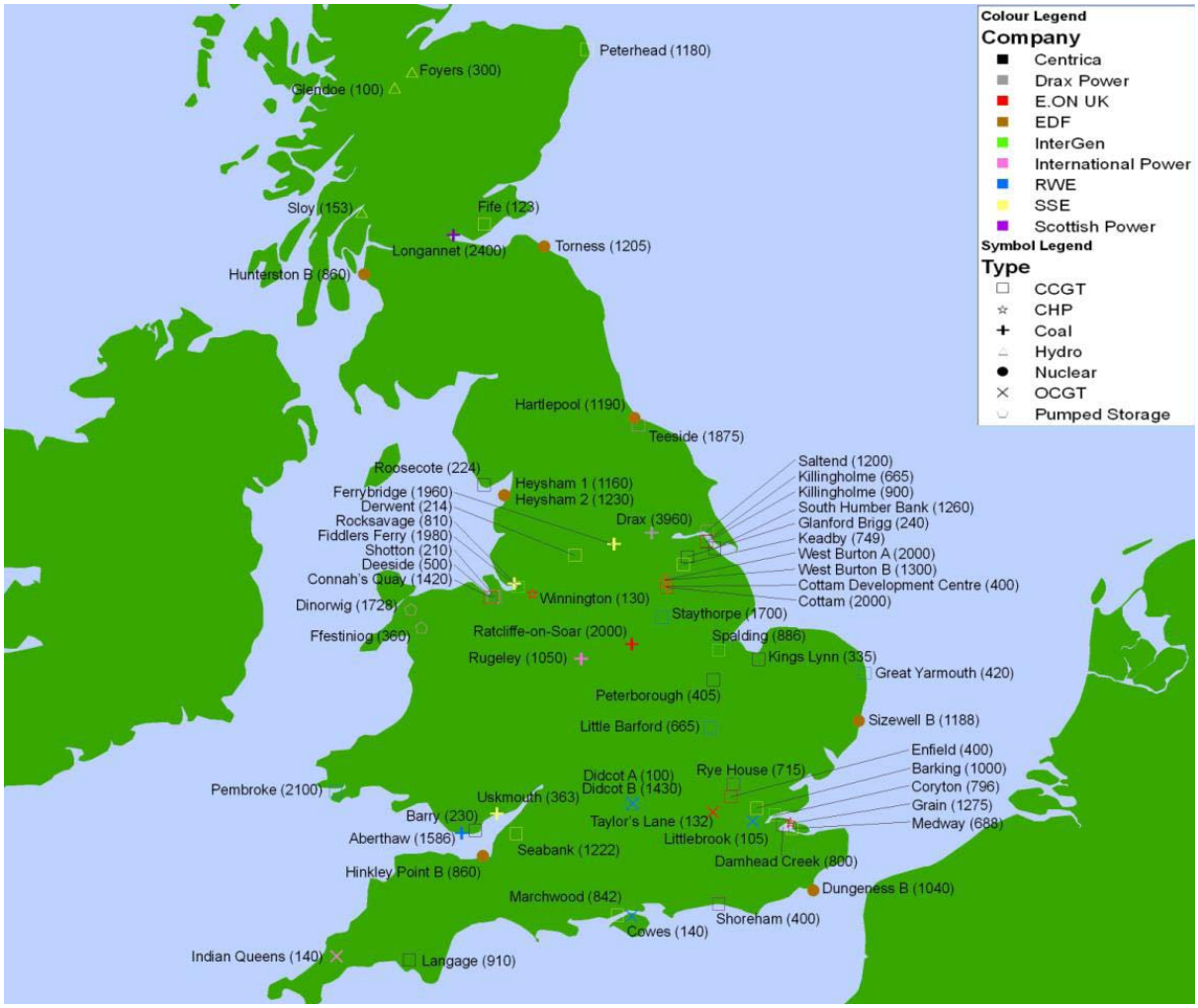

Figure 1.

[15] *http://www.defra.gov.uk/environment/climate/sectors/reporting-authorities/reporting-authorities-reports/*

[16] With thanks to Association of Electricity Producers for providing Defra with this image.

The generating companies directed to report agreed a common approach under the AEP[17]'s Working Group on Resilience and Adaptation (AEP WGREAD), and addressed 17 sources of identified hazards, collected within 4 groups. A semi-quantitative risk assessment methodology was used to identify five categories of severity of risk. No risks were assessed as being within the top two categories (very high risk and high risk) by any Reporting Authority for the agreed period: 2010 - 2039.

Evidence of embedding climate change risks

EDF Energy is adding climate change risks to the company risk log, with the process for assessing and reviewing them defined in its ISO14001 accredited Environmental Management System.

SSE Generation's report highlighted that climate change is already documented as a strategic risk within its business risk register.

Flooding and storm surge

This includes flooding to the actual site of the power station, flooding of access routes to the site, and extreme high river flow. This could lead to partial or complete shutdown of a plant, water damage to infrastructure, increased maintenance costs, increased staff shifts/staff access, disruption damage to auxiliary systems and commodity supply disruption. Flooding and heavy precipitation can also reduce water quality which is necessary where steam is used to generate electricity.

Two reporting authorities classified storm surges with a medium risk score (for coastal power plants). Otherwise the most significantly scored risk was the risk of flooding of the site of the plant.

Extreme high temperature

Extreme high temperatures could impact on gas turbine or steam turbine efficiency and net output. The impact of increased temperatures is more significant for air cooled condenser (ACC) than water cooled plants. Combined Cycle Gas Turbines (CCGTs) are potentially most affected by elevated air temperatures leading to a reduction in plant net thermal efficiency and generation output, due to reduced air density from increased ambient temperatures.

[17] Association of Electricity Producers

One reporting authority classified extreme high temperatures with a medium risk score (although this was not directly related to the effect on the steam turbine, but on other plant elements). The most common risk score for this hazard was low risk.

Climate hazards affecting water use

Drought affects water availability which could lead to insufficient water for cooling purposes leading to reductions in capacity or partial shutdowns. It also has an impact on water discharge, and could cause operational limitations in order to comply with environmental permit requirements. AEP has assessed the potential effects of a country-wide drought supposed to simultaneously affect generation output from all power plants located on rivers or estuaries. It found that generation from nearly one third of this capacity could potentially be constrained by flow-related restrictions included in the abstraction licences. Also taking into account the significant capacity of coastal power stations, unaffected by drought, the associated level of impact was not considered of national significance.

Other indirect operational limitations within this grouping are potentially related to permit constraints (e.g. linked to the temperature or the temperature rise of the discharged cooling water), which might restrict the amount of electricity generated at a power plant.

Climate hazards affecting water use received the most medium risk scores, from five different organisations, with risk of drought on water availability the most pronounced. In addition several of these risks were assessed by several authorities as likely to increase between now and the 2020s. Together these factors mean that this risk grouping was the most significant identified by the Reporting Authorities.

Other Climate hazards

This grouping contained a wide variety of risks including extreme snowfall, the effects of extreme low temperatures on cooling tower fans, external systems and cooling towers, extreme winds, subsidence/landslide and weather conditions causing plume grounding (‘ground fogging’ which can lead to hazards and complaints).

The risk of extreme winds was cited by two reporting authorities as being a medium risk, but otherwise these risks were predominantly given a ‘very low risk’ score.

AREAS OF STRENGTH

The electricity generation sector has inherent resilience through the combination of generating plant capacity margin, geographical diversity of generating plants (together with a national transmission network) and diversity in generation technology. As a result of these factors, the electricity supply system is robust against individual plant failure.

A number of areas of strength were identified from the Adaptation Reports that demonstrate that operators in the electricity generation sector are assessing and acting upon their climate change risks. These include:

Industry-level collaboration – as well as undertaking collaborative research at the industry-level, for example involving the Met Office through the EP2 study, the electricity generation sector has established an Association of Electricity Producers (AEP) Working Group on Resilience and Adaptation as a result of the Direction to Report. This has resulted in the development of a common climate change risk assessment methodology that has been used by the sector Reporting Authorities.

Stakeholder engagement – the analysis of the Adaptation Reports illustrates that the electricity generation sector Reporting Authorities are engaging with stakeholders in relation to the assessment and management of climate change risks. This includes both sector-level engagement, for example through participation in Operation Watermark, engaging with Defra on future water management policy, and company-level engagement activities with organisations such as the Environment Agency.

UKCP09 constraints- the sector appears to have a good awareness of the constraints associated with UKCP09 and tools such as the Weather Generator.

Consideration of climate change in new developments – the Reporting Authorities highlight how climate change risks are considered by the sector during planning for new power stations through existing regulatory requirements such as Environmental Permitting Regulations. Similarly, water use and supply assessments are conducted during the planning of new-build power stations and climate change is considered in National Policy Statements for energy infrastructure.

Adaptation Case Study: E.ON

Where steam is used to generate electricity, there are strict limits on the quality of the water that can be used. Flooding and heavy precipitation can reduce water quality.

After a comprehensive assessment, an increase in the frequency and magnitude of flooding in the respective river basin catchment was found to be the root cause of water quality problems at two E. ON power stations.

After monetising the impacts at each of the stations (principally, the expense of lost generation), new Reverse Osmosis (RO) water treatment plants were built at both of the stations.

Evidence of embedding – many of the Reporting Authorities have either embedded climate change risk management within existing corporate risk management processes or outline plans to take such steps as a result of the Adaptation Reporting Power. A number of organisations also outline responsibilities for the management of climate change risks.

AREAS THAT MAY REQUIRE FURTHER CONSIDERATION

Note that these are areas identified for further consideration, but not necessarily tasked to the electricity generation sector.

Climate Uncertainties

- The future availability of water for cooling, and its temperature under climate change are key issues for the electricity generation sector.
- The industry identified a need for better information on likely river flow levels in future under climate change. The industry also highlighted its desire to see national flood projections based on UKCP09 climate projections**.**
- Similarly, projections of changes in water temperature and salinity are not available for the 2020s period under UKCP09. Further information/projections on likelihood of extreme droughts were also identified as an information gap.
- The thresholds at which these climate variables become critical are also both difficult to determine and uncertain.

Water Management

- Reporting Authorities highlighted the increasing scrutiny of water demand and consumption. Future reform of water abstraction, discharge licences and permits were identified by the industry as significant current issues.
- Water management risks can be cumulative in instances where a number of power stations utilise the same river for abstraction (e.g. the River Trent).

Timescales for climate change

- Defra agreed with Reporting Authorities that the scope of the power would be restricted to the period 2010 – 2039. There is a need for continued research into climate change impacts over the longer term although it is recognised that extended timescales are not relevant to the majority of existing plants.
- Heat wave risks were assessed under the assumption of uniform air temperatures of 32ºC and 34^{o}C (across all of the UK), as agreed with DECC and the Met Office as part of work with Cabinet Office on heat wave vulnerability. However looking further ahead, an assessment against a ‘heat wave’ scenario consistent with UKCP09 might be appropriate.

Interdependencies

- The connections with other parts of the energy sector were noted by several Reporting Authorities. For instance in some cases, grid connections for generation plants are of concern because they may be more vulnerable to flooding than the generation plants themselves.
- The Water sector is particularly important to the electricity generation sector, and access to water is a key driver for power station location.
- Dependence on transport infrastructure for staff access, materials, fuel etc was also highlighted.

EMERGING TRENDS

The review of the electricity generation sector Adaptation Reports identified a number of common issues emerging across a number of the reports. These are outlined below using the headings from the Evaluation Framework overall appraisal comments, which are based on the issues outlined in Box 2 of the Statutory Guidance:

Functions Impacted by Climate Change

Thresholds – the evaluation of the Adaptation Reports suggests that the sector has been conducting work to assess climate change thresholds, through activities such as 'stress tests' that have been undertaken to determine the impact of droughts and high temperatures on electricity generation plants. However, the sector Reporting Authorities recognise the difficulties associated with identifying and assessing climate change thresholds, suggesting that further work in this area may prove beneficial.

Impact of climate on business functions – the Adaptation Reports indicate that the electricity generation companies are developing an understanding of how climate change may impact not only specific asset types, such as CCGTs for example, but also sector level risks posed by climate change including drought and heat waves.

Approach

Use of advanced UKCP09 tools - the Adaptation Reports provided by the electricity generators outline the use of the UKCP09 Weather Generator and Threshold Detector, and their use in 'stress tests'. Whilst this represents good practice, in many cases the reports would have benefitted from the inclusion of further details of how such tools were used together with the specific results from the stress tests, because this information was often a little unclear or not presented. This was as a result of structure of the reporting timeframes, and is something that could be addressed in future to allow a more iterative reporting process.

Poorly described risk classifications – whilst the sector developed a semi-quantitative risk assessment methodology which utilises a clear likelihood classification, the consequence classifications were based on those already used by individual Reporting Authorities. In some cases, the consequence classification descriptors were either not provided or poorly described, making it difficult to interpret the risk assessment methodology and results. A non-linear risk scoring classification was used by some Reporting Authorities (Figure 2) despite the qualitative descriptors inferring a linear classification. This was partly as a result of structure of the reporting timeframes, and is something that could be addressed in future to allow a more iterative reporting process.

Table 2: Consequences of Hazard Occurring

Consequence	Description of Generating Impact	Grade	Risk Score
Negligible	Small and brief output reduction, ancillary service loss, no significant output loss for > 1 day	1	3
Minor	Unit loss (hours), unit output reduction (days)	2	4
Moderate	Station loss (hours), unit loss (days), output reduction (weeks)	3	5
Serious	Station loss (days), unit loss (weeks), significant output reduction (months)	4	7
Major	Station loss (weeks), unit loss (<4 months)	5	9
Catastrophic	Station loss (months), unit loss (>4 months)	6	10

Figure 2 – an example of non-linear risk scoring used by a Reporting Authority.

Awareness of information gaps and UKCP09 constraints – the Adaptation Reports contained details of information gaps that currently affect Reporting Authorities' ability to assess their climate change risks as well as a number of constraints associated with UKCP09 that were encountered during the risk assessment process.

Cost Benefit Analysis and Sustainability Appraisal – only two sector Reporting Authorities provided details regarding the potential costs and benefits associated with their adaptation responses. However, this is reflective of the wider findings from the evaluation of the Adaptation Reports submitted by all sectors, and should be appreciated that such an assessment is difficult at the strategic level of the Adaptation Reporting Power.

Summary of Risks

Transparency – there were mixed levels of transparency in the presentation and discussion of risks across the sector, with some organisations providing details of site specific risks and others not providing detailed information. This may have been as a result of commercial sensitivity. Examples of areas where transparency issues were identified include:

- The results from the heat wave stress tests and use of the weather generator were not always presented in the reports.

- Whilst many reports discussed site-specific risks, some Reporting Authorities aggregated their risks or chose not to discuss the risks facing specific sites.

Geographical risks – the nature of the sector's assets meant that many of the reports provided details of the location of risks, although as noted above, it was sometimes difficult to interpret site-specific risks due to the level of information provided by Reporting Authorities.

Confidence – one of the Reporting Authorities provided an assessment of the level of confidence in their risk assessment. This is consistent with other sectors under the Adaptation Reporting Power and reflects the difficulty in establishing levels of confidence in the risk assessments.

Risk narratives – many of the Adaptation Reports contained good narratives of the risks identified by the risk assessment.

Opportunities - the review of the Adaptation Reports suggests that climate change may provide opportunities for the electricity generation sector. However, in many cases the Reporting Authorities did not report their eventual plans to exploit such opportunities although the commercial sensitivities associated with such information might explain these omissions.

Actions Proposed to Address Risks

Mixed adaptation responses/targets – whilst the majority of Adaptation reports identify priority risks that are linked to adaptation actions, adaptation responses and targets are very mixed across the sector. In particular, whilst some Reporting Authorities have clear adaptation plans, with timescales and clear risk reduction targets, others only appear to aim to reduce risks.

This may represent the observation that the Adaptation Reporting Power has resulted in some sector organisations assessing their climate change risks for the first time, and as such they may not have reached the stage of identifying specific risk reduction and adaptation targets. Alternatively it may reflect the fact that the sector considers other risks to be of greater significance than those resulting from climate change.

Focus on monitoring and review – whilst some Adaptation Reports provided details of infrastructure adaptation, the majority of adaptation actions outlined by the Reporting Authorities appear to focus on risk monitoring and reviews. This is likely due to the fact that climate change does not introduce any novel risks to the sector, and that other risks are considered of greater significance.

Stakeholder engagement - the sector is continuing to engage with stakeholders on climate change risk issues, which represents good practice. For example, the Adaptation Reports note that the electricity generators will continue to work with

organisations such as the Met Office to identify climate change thresholds that start to trigger weather conditions critical to safe plant operation.

Uncertainties and Assumptions

Awareness of uncertainties - in general, Reporting Authorities from across the sector are aware of the uncertainties associated with their climate change risks, and particularly the constraints and uncertainties associated with UKCP09. However, the level of understanding of uncertainties and their implications for the risk assessment findings and adaptation responses appears to be more mixed.

Monitoring and Evaluation

Mixed plans for monitoring and evaluating climate change risks and adaptation plans –the analysis of the Adaptation Reports has identified a mixed picture of plans for the electricity generation sector Reporting Authorities to monitor and evaluate their climate change risks and adaptation responses. Whilst a number of organisations have clear plans for monitoring and assessment that are linked to existing processes, many Reporting Authorities only provided indicative plans.

Evaluating adaptation effectiveness – in a number of reports it was difficult to identify whether the Reporting Authority had clear plans for monitoring and evaluating the effectiveness of their adaptation actions. Whilst in many reports monitoring and evaluation processes appeared to be addressed through risk review processes, such activities were not always entirely clear.

Embedding – as previously noted there is evidence of embedding in existing business risk management and power station planning processes that have clearly defined monitoring and review timescales.

BENEFITS AND OPPORTUNITIES

Given the competitive market in which power stations operate, the identification of opportunities is a potentially sensitive area for individual companies. Nevertheless a number of potential benefits or opportunities arising from future climate change were identified by the Reporting Authorities. These include:

Warmer temperatures

- Warmer winters with reduced ice accretion and loading could reduce the risk of structural failures and could lead to reduced use of anti-icing systems.
- Reduced ice damage of equipment and the cost of maintenance due to extreme low temperature.
- Increased plant availability/reduced average start-up times during the winter months.

Commercial

- Decreased peak demand in winter (decreasing use of electric heating) and increasing demand in summer (increasing use of air conditioning) could offer electricity generators the opportunity of operating under a more even spread of energy demand over the year, thus leading to a more evenly-balanced utilisation rate in power stations.
- Potential opportunities arising from higher yields of biofuel crops and therefore enhanced biomass-fuelled energy generation.

BARRIERS

A number of potential barriers to adaptation were identified in the reports including:

Commercial/financial/adaptation

- For an existing plant, the remaining station lifespan might be the main barrier to investment because it is difficult to justify physical or plant modifications on commercial grounds for power stations with limited remaining operational life.
- Legacy infrastructure which may require retrospective adaptation.

Climate Projections/Data

- Current lack of national flood projections based on UKCP09.
- National projections of river flows based on UKCP09 are still being researched.
- Catchment Abstraction Management Strategies (CAMS), which provide information on water availability for households and industry, do not consider UKCP09.
- Unavailability of data and inherent uncertainties within climate projections.

Interdependencies

- Interdependencies with other stakeholders (e.g. regulatory, infrastructure and indirect), including their climate change risks and adaptation plans.
- Incompatibility of (stakeholder) adaptation plans (e.g. differences in the treatment of risk, use of projection data etc).
- Economic barriers – challenges associated with consumer willingness to pay and companies potentially delaying adaptation.

INTERDEPENDENCIES

The reports highlighted a large number of independent organisations and policies, with many of these representing key cross cutting interdependencies. The following broad groups were evident.

Government, regulators and legislation – UK Government, Defra, DECC, Ofgem, Gas and Electricity Market Authority (GEMA), Ofwat, EA, SEPA, HSE, Office of Nuclear Regulation, European Commission, Council of European Energy Regulators.	**Public Sector –** Road networks and the Highways Agency/Local Authorities, Inland Drainage Boards, Shoreline management planning, flood and coastal defence.
Utilities – Communications networks, electricity suppliers, water infrastructure and water companies, information technology.	**Energy Sector –** Power distribution/transmission, trade associations, gas distribution, European electricity and gas markets, Global LNG markets.
Transport – Transport infrastructure for fuels, essential chemicals, raw materials and waste disposal. Also in terms of staff travel.	**External expertise/data –** Climate Change projections, EA, Met Office, UKCIP, Institute of Engineering and Technology, Academia/external review groups.
Customers – Market demand, customers for electricity and generation by-products.	

ANNEX C

The full list of electricity generation organisations that provided adaptation reports.

1. Centrica Energy
2. Drax Power
3. E. ON UK
4. EDF Energy
5. InterGen
6. International Power/GDF Suez Energy UK
7. RWE npower
8. SSE Generation
9. Scottish Power Generation
10. Office of the Gas and Electricity Markets (Ofgem)

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Adapting to Climate Change: helping key sectors to adapt to climate change

Energy (Electricity Transmitters) Sector Summary Report for the Adaptation Reporting Power

March 2012

defra
Department for Environment
Food and Rural Affairs

INTRODUCTION

In response to directions to report under the Adaptation Reporting Power, 3 organisations from the electricity transmitters sector submitted Adaptation Reports to Defra between September and October 2011 as well as Ofgem (Office of Gas and Electricity Markets)[18]. These reports were reviewed by the Adapting to Climate Change team and Policy teams in the Department of Energy and Climate Change and the Risk Centre at Cranfield University and published by Lord Taylor in November 2011.

This report summarises the findings from the reports, focussing on:

- The climate risks for the energy transmitters sector;
- Areas of strength for the industry as a whole;
- Areas of good practice;
- Areas for further research;
- Emerging trends and themes;
- Benefits and opportunities
- Barriers;
- Interdependencies

[18] A full list of the organisations who were directed to report can be found at Annex D.

SUMMARY OF FINDINGS

The sector-level results from Cranfield University's evaluation of the adaptation reports, Department of Energy and Climate Change policy teams and Defra's Adapting to Climate Change Team show that:

- Climate change risk assessment is being embedded within electricity transmission sector organisations' corporate risk appraisal processes.
- There is strong sector level engagement on climate change risks issues, including the commissioning of detailed research studies which is reflected clearly in the risk assessments.
- The sector is aware of the importance of considering climate change uncertainties both in terms of the risk assessment and the identification of robust and flexible adaptation measures.
- There is a wide variation in the adaptation plans across the sector with some organisations having detailed plans, whilst others have yet to identify adaptation responses.
- There may be limited benefits and opportunities for the sector under future climate change.

KEY CLIMATE CHANGE RISKS FOR THE SECTOR

This is not an exhaustive list of every risk that the electricity transmitter sector has identified; it is an overview of the key climate risks which were identified by the Reporting Authorities. Further details about the risks faced by each organisation can be found in their individual adaptation reports. Note that these risks are those identified by Reporting Authorities, not Defra.

Increased temperature/ heatwaves – This could have an impact on equipment ratings (e.g. switchgear, transformers and control centre equipment). This could potentially lead to a possible reduction in the flexibility of the network, increased air conditioning demand or potential health risks.

Increased rainfall/flooding (fluvial, pluvial and coastal/sea level rise) – There is a risk of flooding and inundation of tunnels, underground cable routes, overhead lines, towers, cable bridges, communications and control infrastructure which could lead to a potential loss of system resilience or in exceptional circumstances a potential loss of supply. This may also prevent safe and immediate access to assets requiring emergency repair/response.

Increased coastal erosion – Possible risk to infrastructure, including substations, overhead lines and towers, cable bridges, tunnels and underground cable routes. However, the slow nature of the risk means that sites at risk will either be protected or relocated prior to any system impacts.

Increased river erosion – towers, cable bridges and cable routes are at risk of failure if foundations are exposed or weakened, or soil stability is reduced, with routes potentially becoming non-operational. This could lead to a loss of system resilience and in exceptional circumstances a potential loss of supply.

Working with key stakeholders

The Met Office has been working closely with UK energy companies on EP2, an innovative project looking at the effects of climate change on the energy industry.

It identified that:

The transmission network is more resilient to weather related faults compared to the distribution network.

Lightning is the dominant cause of weather related faults

Wind, gale, snow storms/blizzards and ice are responsible for the remaining weather related faults.

Vegetation changes – Overhead lines are affected by interference from vegetation, with the risk potentially increasing as a result of prolonged growing season and changes in the growth of vegetation species sensitive to climate change

AREAS OF STRENGTH

A number of areas of strength were identified from the Adaptation Reports that demonstrate that the electricity transmission sector is assessing and acting upon their climate change risks. These include:

Research Programmes – the Reports provided details of a number of ongoing research initiatives to investigate and assess climate change risks and adaptation actions at both the sector and organisational level.

Engagement with relevant staff/departments – many of the risk assessments involved engagement with key staff and departments to assess potential climate change risks. For example, the ENA task group that produced their climate change report includes electricity transmission and distribution companies and the Department of Energy and Climate Change, with inputs from OFGEM, Defra, the Environment Agency and the Met office amongst others.

Industry Level Collaboration – The sector is collaborating on climate change risk management and resilience through the Energy Networks Association. For example, following the 2005 and 2007 floods, the sector developed an Engineering Technical Report setting out a common approach to the assessment of flood risk (inclusive of allowances for climate change and sea level rise) and the development of target mitigation levels that are subject to cost benefit assessment.

Emergency preparedness – The sector has well established emergency plans, which are reviewed and managed through the Energy Emergencies Executive (E3)

Examples include – SSE Power Distribution has a strategic stock of plants and cables to address emergency events such as floods.

Until work to defend its sites is complete, National Grid has emergency deployment plans to utilise a 1.7km mobile flood defence system

Evidence that the Adaptation Reporting Power has led to change – a number of the organisations noted that the Adaptation Reporting Power has led to changes in the level of understanding and management of climate change risks within their organisation. The development of the Adaptation report

Examples of research undertaken

National Grid has funded over £1m of research on weather and climate change related projects through the Innovation funding Incentive since 2007, both directly and in collaboration with other utilities and manufacturers (combined funding over £10m).

There have also been industry level research initiatives including Energy Project 1 and 2 with recent work commissioned to develop a risk model that quantifies the relationship between climate and network faults and the vulnerability/exposure of the network to these faults.

has led to a more formal consideration of climate change risks within several Reporting Authorities.

AREAS THAT MAY REQUIRE FURTHER CONSIDERATION

The review of the electricity transmission sector reports highlighted a number of areas that may require further research in future. These include:

Regulatory Environment

Competitive market cost versus adaptation – Ofgem's focus is on the protecting consumers by ensuring costs of the network companies are as efficient as possible and investment is encouraged where it is needed to meet future needs. Price controls represent Ofgem's main contribution to adaptation, through review of business plans and setting allowed revenue for the network company for the price control period. Should adaptation costs be significant then there is the risk of tensions between adaptation, funding, and consumer willingness-to-pay for adaptation, given potential benefits are long into the future. This is recognised by Ofgem who acknowledge that its main challenge as a regulator is ensuring risk mitigation that secures sustainable energy supplies and long-term value for money for customers.

Security of supply and extreme events- The overall levels of supply security are agreed by Ofgem, with the standards specifying the requirements for the availability of alternative supplies at various levels of customer load. Although the standards allow for the loss of multiple circuits they do not provide for low probability events such as multiple failures or the total failure of a grid or primary substation. Thus, as highlighted in the reports, particular attention must therefore be given to grid and primary substations when considering network resilience

Adjustments for exceptional events and climate change – exception events could become more frequent under climate change. There are potential issues surrounding the attribution of performance risk/annual revenue exposure to climate change which have already been acknowledged by Ofgem.

Infrastructure and Network Vulnerability to Climate Change

Offshore transmission network – The Adaptation reports did not discuss the potential threat that climate change poses to offshore transmission infrastructure (e.g. interconnectors) and its operation, this could be a possible area for further research.

Future Demand

- **Climate change and future demand** - further research is required to fully understand how climate change may affect electricity demand, capacity and supply arrangements. In particular, the potential of increased air conditioning loads during the summer, which together with reduced winter peak demands, as a result of warmer winters, will lead to a flatter seasonal demand curve. This potentially has implications for network flexibility and could make it harder to take circuits out of service at lightly loaded times for maintenance, requiring enhanced capacity or service standards.
- **Distributed generation/smart grids** - the shift towards distributed generation and smart grids could potentially lead to a significant change to the daily demand profile in future. However, the shift to smart grids will enable climate change adaptation to be addressed.
- **Management of balancing services** – National grid notes that to provide secure and reliable delivery of electricity it has commercial arrangements with market participants to enable electricity demand or generation output to be varied. It is unclear how such arrangements may be affected by future climate change and may warrant future research.

EMERGING TRENDS REQUIRING CROSS INDUSTRY ACTION

The review of the electricity transmitter sectors Adaptation identified a number of common issues emerging across a number of the reports, these include:

Thresholds – the evaluation of the Adaptation Reports suggests that the sector is developing a good awareness of the climate change thresholds associated with different types of electricity transmission equipment. For example, temperature thresholds that are associated with rating reductions are known for transformers. Thus, organisations are using equipment specifications, design standards and regulatory requirements as thresholds. However, some Reporting Authorities highlighted the need for further research to investigate other risk thresholds, such as those associated with future changes in vegetation growth and earth potential.

Impact of climate on the organisational functions – the Adaptation Reports indicate that the electricity transmission companies are beginning to develop an understanding of how climate change may impact upon different asset types and demand for example. However, it is difficult to determine the level of risk to the individual companies because whilst some of the potential risks to generic types of equipment have been identified, their implications for companies' sites and assets are yet to be assessed and in a number of cases the temporal nature of risks is a little unclear.

Approach

Lack of methodological detail – climate change risks – it is clear that the electricity transmission sector companies have commissioned a wide range of studies at the sector level to investigate their climate change risks, and these have been used to inform the risk assessments. However, whilst these studies are evidently comprehensive in nature, it is difficult to evaluate the methodologies employed because of the limited evidence trail. This was to some extent a common theme across different sectors and could perhaps be addressed by a more iterative reporting process in future.

Level of confidence – none of the Adaptation Reports included an assessment of the level of confidence associated with the risk assessment that had been evaluated using a sound methodology. This was a common theme across sectors in that it proved very difficult to provide a comprehensive assessment of the level of confidence associated with risk assessments.

Awareness of information gaps – many of the Adaptation Reports contained details of information gaps that currently affect Reporting Authorities' ability to assess their climate change risks. To address such issues, a number of Reporting Authorities are planning continued engagement with organisations such as the Met

Office and the Environment Agency on such issues, and plan to reassess their risks when new information becomes available.

Cost Benefit Analysis and Sustainability Appraisal – a number of the Adaptation Reports discuss the economic/environmental costs and benefits associated with adapting to climate change, with the two ENA-derived reports including details of the predicted long-term adaptation costs associated with the electricity network.

BENEFITS AND OPPORTUNITIES

A number of potential opportunities and benefits were identified in the reports from the electricity transmission sector**.** These include:

Fewer and less severe icing events: This will reduce the risk of ice accretion and loading which causes asset failures. This should allow a reduction in the design strengths for overheard line structures, with subsequent cost savings.

Peak loads moving to summer: This would enable maintenance programmes to be moved into spring and autumn, taking advantage of the milder weather.

Energy Efficiency: This may reduce the costs and challenges associated with adapting to climate change by reducing the need to build new generation or network capacity and the need for associated adaptation measures. It could also reduce the energy demands related to cooling in summer in domestic, commercial and industrial premises

BARRIERS

The review of the Adaptation Reports identified a number of barriers that were highlighted as representing a challenge to the electricity transmitter sectors' ability to adapt to climate change.

Regulatory, economic and physical barriers –There are challenges associated with consumer willingness to pay for adaptation. Balancing short term considerations against long term benefits from adaptation can be challenging. Lack of space in urban areas is a barrier to putting new connections and infrastructure in place.

Awareness of Climate Change – Better understanding of climate change projections, science and impacts by those in the planning, investment and asset management for infrastructure so that appropriate measures are incorporated in the decision making process.

Interdependencies – a number of interdependencies are perceived as posing barriers to the sectors' ability to adapt to climate change. Issues identified included:

- **Dependency on 3rd party suppliers** - especially for communications infrastructure.
- **Interdependencies including stakeholders** – the energy infrastructure system is highly interconnected both within and between the gas, electric and water sectors and are critical to resilience.
- **External agencies** – a number of National Grid's assets rely on flood defences or SMPS owned and managed by external agencies, the Environment Agency or SEPA. Dialogue is required to ensure protection is maintained.

INTERDEPENDENCIES

The reports highlighted a large number of interdependent organisations and policies, with many of these representing key cross-cutting interdependencies. The following broad groups were evident.

Regulators/ regulations and legislation – UK Government, EU, Council of European Energy Regulators, Agency for the Cooperation of European regulators, Defra, DECC, Environmental Agency, SEPA,other regulated sectors and regulators	**Policies** – Smart Networks/low carbon futures, price control mechanisms, flood defence/Shoreline management planning, Policies affecting demand, including regulations, ebergy efficiency and energy pricing	**Public Sector –** local Authorities, Emergency Services and Highways Agency
Energy sector– Transmission owners/operators, Distribution Network Operators, Energy networks Strategy Group, E3 commitee, European electricity and gas markets, Local and regional area mutual defence strategies	**Transport –** Road, air and sea transport, rail and air transport companies	**Suppliers –** Third party communications/ICT infrastructure, fuel supply chains, gas, electricity, water, emergency generator suppliers.
Utilities – Other utilities, water sector.	**External expertise/data** – Universities, Research organisations, Met Office/Hadley Centre, UKCIP, External review groups/expertise, UKCP09, Flood risk data, Institute of Engineering and Technology.	**Company –** Finance, Markets, Dams(third party ownership)

ANNEX D

The full list of organisations from the electricity transmitters sector that provided adaptation reports.

1. National Grid
2. SP Transmission
3. Scottish Hydro Electric Transmission Limited.
4. Ofgem

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Adapting to Climate Change: helping key sectors to adapt to climate change

Energy (Gas Transporters) Sector Summary Report for the Adaptation Reporting Power

March 2012

defra
Department for Environment
Food and Rural Affairs

INTRODUCTION

In response to directions to report under the Adaptation Reporting Power, 9 companies from England, Scotland and Wales submitted Adaptation Reports to Defra in June 2011[19] and Ofgem (Office of the Gas and Electricity Markets) submitted a report in September 2011. These reports were reviewed by the Adapting to Climate Change team and policy teams in Department of Energy and Climate Change, and the Risk Centre at Cranfield University and published by Lord Taylor in December 2011[20].

This report summarises the findings from the reports, focusing on:

- The climate risks for the gas transporters sector;
- Areas of strength for the industry as a whole;
- Areas of good practice;
- Areas for further research;
- Emerging trends and themes;
- Barriers;
- Interdependencies

Due to the different regional coverage of the organisations; local conditions bring different climate concerns for the gas transporters sector.

[19] A full list of reporting authorities from the gas transporters sector can be found at Annex E.
[20] http://www.defra.gov.uk/environment/climate/sectors/reporting-authorities/reporting-authorities-reports/

SUMMARY OF FINDINGS

The evaluation of the reports by Cranfield University, DECC policy teams and Defra's Adapting to Climate Change team show that:

- Climate change risk assessment is being embedded within the gas transporter sector's corporate risk appraisal processes. The Adaptation Reporting Power process has been a key driver behind this for a number of organisations.

- The sector is making good use of relevant data, information and knowledge tools, particularly through engagement at the sector level. The sector has shown good awareness of interdependencies and barriers to adapting to climate change.

- Some organisations could have benefited from the use of more robust semi-quantitative risk assessment methodologies in future that consider risks as opposed to climate impacts. Reporting Authorities are yet to identify clear risk reduction targets.

- The issue of climate change uncertainties and their implications for the sector requires further examination.

KEY CLIMATE RISKS FOR THE SECTOR

This is not an exhaustive list of every risk that the gas transporters sector faces; it is an overview of the key climate risks the sector has identified. Further details about the risks faced by each organisation can be found in their individual adaptation reports.[21] Please note that these are risks identified by the Reporting Authorities themselves rather than Defra.

Weather Risks

Flooding – in particular to critical sites and assets including pipes and Pressure Regulating Installations (PRIs). In addition several reports highlighted risks around transport disruptions affecting emergency service provision and staff access to offices depots and streetworks.

River bed and bank erosion- River bed and bank erosion risks exposing pipelines. Also high river water volumes risk damaging mains and pipelines in over-river crossings.

Wind damage- to above ground assets such as telemetry masts and PRIs.

Land Contaminants- Mobilisation and migration of land contaminants from former gas production sites due to changing patterns of precipitation, flooding, drought and high winds.

Ground movement – The risk of ground movements fracturing ageing low pressure network assets. Note that this risk is specific to National Grid who own and operate the UK Gas Transmission system.

Increased temperatures – Increased temperatures can affect transmission compressor stations and could lead to security of supply issues as without adaptation actions some compressors would not be operational at elevated temperatures. Note that this risk is specific to National Grid who own and operate the UK Gas Transmission system.

Other Risks

Investment – Investment policy could be affected by both increased temperatures and carbon reduction/energy efficiency measures reducing gas penetration in new homes impacting future company growth.

[21] *http://www.defra.gov.uk/environment/climate/sectors/reporting-authorities/reporting-authorities-reports/*

Supply chain risks- risks that key suppliers are not sufficiently climate resilient and are not adapting to climate change.

AREAS FOR FURTHER RESEARCH

The review of the gas transporters reports has highlighted a number of areas that may require further research in future, although not necessarily by the gas transporters sector themselves. These include:

Interdependencies

Interdependencies are a key issue for the gas transporter organisations because of the complexity of the sector and the large number of critical interdependencies.

- **Distributed business models -** A number of the Reporting Authorities, particularly the supplementary gas transporters, operate highly distributed business models. For instance companies do not necessarily operate transmission system supply/energy balancing control rooms or compressors, seasonal or diurnal storage systems, odorant injection equipment or emergency call centres meaning they are reliant on external providers for these facilities.
- **Interdependence on upstream gas transporters –** there are interdependencies within the gas industry, with supplementary gas transporters' gas distribution networks being reliant on National Grid's transmission system and Gas Distribution Network Operators distribution systems for example. This raises the potential for cascade effects.
- **Supply chain risks –** the reports highlight concerns regarding supply chain risks that have the potential to impact upon the sector. These include reliance on single suppliers, long lead-in times for some products, and potential overseas supply chain risks. Furthermore, some Reporting Authorities note that they only have limited stocking facilities, although some organisations have agreements in place with suppliers to address such risks.

Interdependencies

Wales and West Utilities are managing their interdependencies with their wider supply chain by ensuring that all key suppliers provide a continuity plan, and have a contingency of emergency stock.

Gas Distribution Network Operators (GDNOs) have mutual aid agreements to help mitigate the impact of large scale events which could result in a loss of service.

- **Emergency service provision –** a number of the supplementary gas transmitters are reliant on Gas Distribution Network Operators (GDNOs) and

- **Road transport –** the road network represents a key cross-cutting interdependency affecting emergency service provision for example.
- **Assumed adaptation/resilience –** a number of the Reporting Authorities' noted in their risk assessments and adaptation plans that they were assuming that key interdependencies such as road/transport networks and critical suppliers/supply chains are sufficiently adapted to climate change.
- **Risks from third party structures –** gas transmission assets, including mains and pipelines in third party structures that are susceptible to flood damage are of concern to some Reporting Authorities.
- **IT vulnerability -** vulnerability of critical IT equipment to extreme weather events and data centres near areas of high flood risk were raised as a potential concern by Reporting Authorities.

Examples of Interdependencies

Mains pipes associated with ESP Gas Group's gas distribution systems are typically located within footway or carriageway structures which are, or subsequently becomes (on new housing development sites upon completion or development), adopted public highway. The Highways Authority is responsible for these structure upon their adoption and ESP Gas Group has no jurisdiction over the likelihood of subsidence or similar failures of these structures.

Regulatory Environment

A number of issues relating to the regulatory environment associated with the gas transporter sector, its management of climate change risks and ability to adapt to climate change may warrant further investigation. These include:

- **Investment in adaptation –** all GNDOs operate regulated businesses operating under licences issued by Ofgem. Allowed revenues for the industry are currently set by Ofgem every 5 years (moving to 8 from 2013) and these reviews govern regulated activities and therefore any costs associated with adapting to climate change would be considered in setting the allowed revenue by Ofgem.
- **Competitive markets and cost versus adaptation –** Ofgem's focus is on protecting consumers by ensuring costs of transporter companies are as efficient as possible and investment encouraged where it is needed to meet

future needs. Price controls represent its main contribution to adaptation, through review of business plans and setting allowed revenue for the network company for the price control period. Should adaptation costs be significant then there is the risk of tensions between adaptation, funding, and consumer willingness-to-pay for adaptation, given potential benefits are long into the future. This is recognised by Ofgem who acknowledge that its main challenge as a regulator is ensuring risk mitigation that secures sustainable energy supplies and long-term value for money for customers.

Asset Resilience

Whilst the sector notes that its underground assets are deemed to be naturally protected from the majority of the effects of climate change, the analysis of the reports has highlighted a number of issues relating to asset resilience that may warrant further research. These include:

- **Thresholds –** the analysis of the Adaptation Reports suggests further work identifying both general and site-specific thresholds that have the potential to impact the sector represents an area for further research.
- **Geographical distribution of risks -** many of the Reporting Authorities have large numbers of assets dispersed over large geographical areas. There is a need for further research to investigate site-specific risks and the potential spatial distribution of the risks to the sectors' infrastructure. Indeed, some Reporting Authorities recognise that this is this is a key area for further research and represents a challenge.

  As noted earlier, water ingress into gas meter installations represents a potential risk affecting the sector. Identifying the number of installations at risk is potentially a large task, especially with companies, such as Wales and West Utilities having ~243,000 meter installations.

Climate Change Knowledge and Data/Information Issues

A number of issues relating to climate change knowledge and data issues were raised in the Adaptation Reports that may require further research. These include:

- **Secondary climate change impacts –** the Reporting Authorities highlighted the limited availability of information on secondary climate impacts as representing a challenge when assessing their climate change risks and developing adaptation responses. The following areas were of concern to the sector:

- Wildfire risk – this risk posed to assets from possible increases in wildfires was of concern as it can result in considerable damage to major assets and security of supply issues.
- Impacts on river crossings **–** current impacts are limited to structural damage to bridges but this may change under climate change, with more significant damage caused by increased water volumes.
- The complex relationship between precipitation forecasts, river water volumes, flow rates and impacts to river crossings is not fully understood.
- Changes in soil stability and subsidence, particularly in relation to case iron pipework.
- Vulnerability of critical IT equipment to extreme weather events.

Information asymmetry – Ofgem's Adaptation Report notes that it is reliant on information provided by the sector and that it is aware that this risks information asymmetry. It also raises issues of transparency and information reliability and suggests that as a regulator, it may wish to consider undertaking independent research to evaluate the risks facing the sector as it would help to identify the adaptation needs of the sector and the potential costs.

Information gaps –

- Current flood risk processes do not account for climate change.
- It would be helpful for UKCP to provide absolute peak temperatures rather than a relative increase.
- UKCP09 indicates changes to wind and storm patterns and intensities but does not provide sufficient detail. The sector is seeking information relating to future changes in the frequency and intensity of such events and high wind speeds.
- Information relating to future changes in the frequency/intensity of snow, sleet, blizzard, ice and freezing fog.
- Some locations are not currently covered by the Environment Agency's flood online risk maps.
- Environment Agency flood maps do not account for climate change.
- Pluvial and future flooding, and flood depths are not included in the EA/SEPA flood risk maps.
- Coastal erosion and potential storm surge risks by area.

EMERGING TRENDS

The review of the gas transporter sector Adaptation Reports identified a number of common issues emerging across the reports.

Functions Impacted by Climate Change

Impact of climate on the organisational functions – the analysis of the Adaptation Reports indicates that the gas transporter sector Reporting Authorities are developing an awareness of the potential impact that climate has upon their organisational functions and infrastructure, with a number providing specific examples of risks that have been encountered. Alongside this awareness of generic risks, a number of the Reporting Authorities are developing an understanding of site or asset-specific risks across their networks or are working towards this increased level of detail.

Thresholds – the evaluation of the Adaptation Reports suggests that whilst the gas transporter sector is aware of thresholds that relate to the design standards associated with some types of assets, further work is required by the sector to develop an understanding of climate change thresholds. In particular, there is a need for Reporting Authorities to investigate site-specific thresholds which are a key driver for the sectors' risks.

Approach

Inter-sectoral approaches to assessing risk – excluding Ofgem, two approaches to assessing risk are apparent in the reports. Those Reporting Authorities involved with the Energy Networks Association (ENA) opted to utilise their existing corporate risk assessment methodology to assess their climate change risks, whilst the Association of Independent Gas Transporters (AIGT) members used the National Grid approach. In the case of the AIGT Reporting Authorities, whilst a number of reports outline details of existing business risk assessment methodology it was not clear how they were used in practice.

Climate change risk assessments considering impacts as opposed to risks – a number of the Reporting Authorities only assessed their climate change impacts as opposed to assessing the level of risk impact and likelihood. In future these organisations may wish to consider using more robust semi-quantitative risk assessment methodologies, to assess their climate change risks.

Unclear risk classifications – whilst using existing business risk methodologies to assess climate change risks represents good practice, some of the Reporting Authorities who adopted this approach have not provided details of their likelihood and consequence classifications or their risk appetite. As such it is difficult to interpret the findings from these risk assessments. This detail may have been omitted on confidentiality grounds.

Level of confidence – few of the Adaptation Reports included an assessment of the level of confidence associated with the risk assessment that had been evaluated using a sound methodology. This was a common issue across most sectors, not only gas transporters.

Summary of Risks

Temporal changes in climate change risks – from the analysis of the reports it is difficult to determine whether the Reporting Authorities have a clear understanding of the timescales associated with their climate change risks. For example, whilst a number of reports noted that the risk assessment covered multiple time periods the results were frequently not presented.

Spatial distribution of risks – there is evidence of a number of Reporting Authorities beginning to consider the spatial distribution of their climate change risks, although further work could be useful.

Transparent discussion of risks – a number of the Reporting Authorities provide a transparent discussion of their climate change risks.

Actions Proposed to Address Risks

Priority risks linked to adaptation responses – the majority of reports from the sector contain priority risks that are linked to adaptation responses. Furthermore, the adaptation actions outlined by a number of Reporting Authorities are accompanied by timescales, resources and/or general responsibilities.

Unclear adaptation responses/targets – the Adaptation Reports suggest that on the whole, the adaptation responses outlined by the gas transporter sector Reporting Authorities currently lack clear risk reduction targets.

Embedding – the analysis of the Adaptation Reports illustrates that the gas transporter sector Reporting Authorities are actively embedding climate change risk management into their organisations. For example, organisations are incorporating climate change in their existing corporate risk registers and considering climate change in business risk processes, investment decisions and asset design.

Uncertainties and Assumptions

Awareness of uncertainties –there appears to be a mixed level of awareness of uncertainties across the sector, with a number of the Adaptation Reports only identifying the main uncertainties associated with the risk assessment as opposed to including a consideration of their implications for the risk assessment findings and adaptation responses.

Assumptions – similar to uncertainties, the reports tend to contain details of the assumptions associated with the risk assessment and adaptation plans, with the majority of reports not discussing their implications and how they can be addressed by the Reporting Authority.

Barriers to Adaptation and Interdependencies

Awareness of barriers – in general the analysis of the Adaptation Reports suggests that the gas transporter sector Reporting Authorities have a good awareness of a range of barriers that have the potential to affect their ability to adapt to climate change. This is reflected in a number of the Adaptation Reports containing detailed descriptions of their barriers that are accompanied by plans to overcome them in future

Awareness of interdependencies – the Adaptation Reports illustrate that the gas transporter Reporting Authorities are clearly aware of a number of interdependency issues, which is reflective of the structure of the sector and its reliance on third-parties. Furthermore, many of the reports provide examples of how the Reporting Authorities are engaging with their interdependencies and stakeholders to manage climate change risks.

Monitoring and Evaluation

Monitoring climate change risks through existing corporate processes – the Adaptation Reports outline details of how many of the gas transporter Reporting Authorities plan to monitor their climate change risks through existing corporate risk management processes, which commonly have clear review timescales and risk ownership responsibilities. However, it is difficult to determine whether some Reporting Authorities have plans to evaluate their adaptation plans, although this is likely to occur through corporate risk management processes.

BENEFITS AND OPPORTUNITIES

A number of potential benefits or opportunities arising from future climate change were identified by the gas transporter sector. These include:

Business/commercial opportunities

- Diversification into other energy assets and zero carbon technologies in response to carbon reduction targets.
- Potential opportunity to pioneer and develop innovative new technologies and techniques, including:
    - Alternative forms of gas production and availability – e.g. biomethane.
    - Upgrade obsolete assets and integrate climate resilience into new designs.
    - Diversify both the use of gas (e.g. for cooling as well as heating) and the use of the network (e.g. CO2 transportation for carbon capture and storage).
    - Combine adaptation and mitigation measures.

Operational opportunities

- **Increased winter temperatures:**
    - Small capacity sites may no longer require pre-heating.
    - Reduced snow and ice causing access issues – reduced interruption to the working environment.
    - Reduced snow and ice – fewer safety issues and incidents.
    - Fewer extreme cold weather conditions – reduced pipe fracture and leakage.
- **Reduced summer precipitation**
    - Drier summers – drier working conditions leading to improved excavation conditions.

Other opportunities

- Opportunities for enhanced shareholder returns based on improvements in network efficiency, reliability and consumer service.
- Increased resilience of the power sector as a result of new technologies (e.g. distributed generation), that will increase efficiency, reliability and diversity of generation sources.

BARRIERS

A number of potential barriers to adaptation were identified in the reports including:

- Ofgem price control reviews have a strong influence on capital investment programmes and operational expenditure and there is the potential for conflict of drivers between determining efficient investment cost and the early pursuit of adaptation measures given the long lifetimes of electricity network assets and uncertainties about the probability of the risk so far into the future.

- There are still considerable uncertainties around the likelihood and extent of climate change impacts. For instance there is limited available data on potential extreme weather events and locations, and there is a lack of national flood projections based on UKCP09.

- There are uncertainties around the future energy mix and what role gas may have within it which make it difficult to prioritise adaptation.

INTERDEPENDENCIES

The reports highlighted a large number of interdependent organisations and policies, with many of these representing key cross-cutting interdependencies. The following broad groups were evident.

Regulators/regulations/legislation- EU, UK Government, Welsh Government, Council of European Energy Regulators, Agency for the Cooperation of European regulators (ACER), Ofgem, Health and Safety Executive, Environment Agency, SEPA, Met Office, Other regulated sectors and regulators.	**Public Sector –** Highways Authorities, Highways Agency, Emergency Services, Local Authorities, British Waterways
Energy Sector – Upstream gas transporters/gas distribution networks, National Grid Transmission Service/National Transmission System, Gas Distribution Networks, Gas shippers and suppliers, Global LNG markets, National and industry standards and specifications, E3 Committee, European Gas markets.	**Transport –** Road network, Ports- overseas supplies, Network Rail, railway network
Utilities – Electricity supply, Water supply, Utility providers, Telecoms/broadband availability, Fuel availability/supply chain.	**Suppliers/contractors –** Regional construction/maintenance organisations, critical supplies/supply chain- odorant suppliers, manafacturers of Polyethylene pipe, call centre resilience.
External expertise/data- Met Office, UKCP09, Environment Agency, Institute of Engineering and Technology, Institution of Gas Engineers and Managers, Academia.	**Policies –** Emergency service provision, safety regulations

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ANNEX E

The full list of reporting authorities for the gas transporters sector that provided adaptation reports.

13. National Grid Gas Plc
14. ESP Connections
15. GTC Pipelines
16. Independent Pipelines- referred to as Independent Pipelines and Quadrant Pipelines (IPL/QPL) in the report.
17. Northern Gas Networks
18. Scotland Gas Networks- joint Scotia Gas Networks report
19. Southern Gas Networks- joint Scotia Gas Networks report
20. SSE Pipelines- report not received
21. Wales and West Utilities
22. Office of the Gas and Electricity Markets (Ofgem)

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Adapting to Climate Change: helping key sectors to adapt to climate change

Road and Rail Sector Summary Report for the Adaptation Reporting Power

March 2012

defra
Department for Environment
Food and Rural Affairs

INTRODUCTION

In response to directions to report under the Adaptation Reporting Power, 4 organisations from the road and rail sectors in England and Wales submitted Adaptation Reports to Defra between September 2010 and September 2011[22]. These reports were reviewed by the Government's Adapting to Climate Change team in Defra, policy teams in the Department for Transport and the Risk Centre at Cranfield University. They were published by Lord Taylor in October 2011. The fifth and final rail sector report was published in February 2012

This report summarises the findings from the reports, focussing on:

- The climate risks for the road and rail sectors as identified by Reporting Authorities
- Areas of strength for the two sectors
- Areas of good practice
- Areas for further research
- Emerging trends and themes
- Benefits and opportunities
- Barriers
- Interdependencies.

[22] A full list of the organisations who were directed to report can be found at Annex F.

SUMMARY OF FINDINGS

The evaluation of the reports by Cranfield University, DfT policy teams and Defra's Adapting to Climate Change team show that:

- Climate change risk assessments are already being embedded within the road and rail sectors' corporate risk appraisal processes.
- The reports contain details of a range of activities that these organisations are undertaking to investigate and adapt to the risks posed by climate change.
- The Reporting Authorities are at the stage of assessing their climate change risks, with some of the organisations undertaking detailed research to investigate specific risks and thresholds. Since the reports were submitted further work has been carried out by reporting authorities.

KEY CLIMATE CHANGE RISKS FOR THE SECTORS

This is not an exhaustive list of every risk to the road and rail sectors; it is an overview of the key climate risks that the Reporting Authorities identified. Further details about the risks faced by each organisation can be found in their individual adaptation reports.[23] Note that these risks are those identified by Reporting Authorities, not Defra.

Infrastructure - A number of climate change impacts could represent risks to the infrastructure of the road and rail sectors. These include increased and/or extreme temperatures causing issues such as rail buckling, increased mean winter temperatures leading to fewer problems caused by freeze/thaw, increased probability of extreme wind speed, increased fog, increased humidity, lightning risk, ground movement caused by soil wetting and drying, flooding and in coastal areas, sea level rise and storm surges.

Passengers/Travellers/Cargo – Increased or extreme changes in temperature may impact on customer and crew comfort. There is also the impact that increased flooding and increased probability of extreme wind speeds can have on infrastructure leading to delays/cancellations and reputational risks.

Operations/Maintenance – Significant changes in temperature, increased probability of extreme wind speed and precipitation (and subsequent flooding), increased fog and increase and change in vegetation could all impact on operations and may increase the frequency of maintenance and the difficulty in carrying it out.

Examples of existing policies and procedures to ensure climate change resilience

Eurotunnel have an established a Heatwave plan requiring increased shift turnover of staff between indoor and outdoor positions, possible installation of water mist equipment in loading areas and the possibility of reducing the number of vehicles loaded onto each shuttle.

TfL has previously assessed the current and future impacts of climate change through its work with Greater London Authority on the transport element of the Mayor's Climate Change Adaptation Strategy for London.

[23] *http://www.defra.gov.uk/environment/climate/sectors/reporting-authorities/reporting-authorities-reports/*

AREAS OF STRENGTH

A number of areas of strength were identified from the Adaptation Reports that demonstrate that the road and rail sectors are assessing and acting upon their climate change risks. These include:

Engagement with relevant staff/departments – Many of the risk assessments involved workshops and engagement with key staff and departments to assess potential climate change risks.

Active engagement with stakeholders and interdependencies – The reports show that the sectors are actively engaging with a variety of stakeholders and interdependencies in relation to climate change risk management and adaptation.

Evidence of detailed climate change studies and technical reviews – The reports outline details of a number of studies and technical reviews that organisations across the sectors are undertaking to explore and manage their climate change risks.

Research programmes – A number of the organisations provide details of research initiatives that they are participating in to assess and adapt to climate change risks. These include industry level research programmes and international studies.

Evidence of the embedding of climate change in risk management processes – It is clear that these organisations have begun to embed climate change risk management within their corporate processes. For example, TfL is implementing adaptation measures through existing business process such as Asset Management Plans.

Consideration of climate change in investment decisions – There are several examples throughout the reports of how climate change is being considered in investment decisions, such as the Crossrail development and the Highways Agency taking steps to modify its drainage standards to increase resilience against climate change.

Transparent discussion of risks – A number of the reports include a transparent discussion of the

Examples of engagement with stakeholder and other interdependent organisations in the Adaptation Reports

The **Highways Agency** signed a Memorandum of Understanding with the Environment Agency, which specifically includes climate change adaptation

Network Rail has been working with a number of organisations, including the Cabinet Office's Civil Contingencies Secretariat, to map natural hazard and climate change interdependencies.

Office of Rail Regulation are working closely with Network Rail, passenger and freight train operators and the industry supply chain to conduct the periodic review 'PR13' by 2013. They have specifically requested the development of a plan to increase the resilience of the railway (track and trains) to extremes of weather and the costs and benefits of doing so.

organisation’s climate change risks and how they may affect specific locations or assets.

Evidence that the Adaptation Reporting Power has led to change – There is evidence in some of the reports that the Adaptation Reporting Power has led to changes in the level of understanding or management of climate change risks within these organisations.

AREAS THAT MAY REQUIRE FURTHER CONSIDERATION

The review of the road and rail sectors' reports highlighted a number of areas that may require further research in future[24]. These include:

Flooding and drainage issues – Flooding represents a key risk to both sectors and the reports highlight a number of areas relating to flooding which may require further research. These include pluvial flooding, rain water drainage systems such as Sustainable Urban Drainage Systems (SUDS), drainage and the risk of pollution resulting from extreme events, the impacts of groundwater flooding, the need for specialist sea level monitoring and flood protection issues such as the reliance on the Environment Agency for flood protection and related information.

Interdependencies - Interdependencies were highlighted as requiring further work particularly in relation to flood defences, the need for partnership approaches to manage interdependent issues, reliance on ICT, power supply and supply chain vulnerabilities. In particular the dependence on ICT for signalling and communications was highlighted by some of the reporting authorities in the rail sector.

Slope and soil stability – Some of the specific research needs that were highlighted in the report include:

- the potential for changes in soil stability/ground movement and the relationship between climate and soil pore pressure regimes in slopes,
- future changes in slope stability and landslip risk,
- the interactions between soil, slope and climate change,
- the potential use of bioengineering (e.g. planting trees) to address slope and soil stability risks.

Engineering, infrastructure and maintenance – There were a number of issues relating to engineering, infrastructure and maintenance risks that were raised in the reports that may require further research. These include: electricity supply risks, line side equipment failure, scour, engineering and design standards, construction and maintenance activities, asset deterioration and green landscaping.

Risks to passengers – The risk to passengers from heat waves was raised in a number of reports. In particular, the need for research into a number of factors which potentially pose risks to passengers has been recognised, such as ventilation, humidity levels, the type of train failure and the impact of traction failure on air conditioning.

[24] Since the publication of the ARP reports, further research has already begun in many of these areas

Evidence that the Adaptation Reporting Power has led to change – There is evidence in some of the reports that the Adaptation Reporting Power has led to changes in the level of understanding or management of climate change risks within these organisations.

EMERGING TRENDS

The review of the road and rail sectors' reports illustrates that although organisations are at different stages in their assessment of climate change risks and the development of their adaptation programmes, there are common issues and themes that are prevalent across the range of the reports.

Thresholds - The evaluation of the Adaptation Reports suggests that there is a relatively mixed level of understanding of thresholds amongst the sectors. Whilst some Reporting Authorities exhibit a clear awareness of a number of weather related thresholds affecting their operations, other organisations have not identified or assessed their thresholds or have only identified a small number of thresholds. Research has also indicated that reassessment of thresholds may be valuable in some cases.

Impact of weather on the organisations' functions - The Adaptation Reports indicate that the sectors are aware of how weather currently affects their operations and in many cases actively consider weather and climate change risks in their business decision-making.

Risk assessments - The risk assessments commonly used an expert judgement approach to assess risks, underpinned by a range of data sources such as UKCP09. None of the reports initially included a level of confidence in their risk assessments themselves although the research cited in the reports does quantify the level of confidence in some cases (e.g. Network Rail).

The majority of the reports used qualitative approaches to assess their climate change risks. These often only provided generic estimates of impact rather than risk. Whilst the reports generally classified risks (e.g. high, medium and low), there was not always a clear definition of these classifications, making it difficult to interpret the results and compare risks. However, in some cases the research cited in the reports did provide quantitative risk assessments.

Embedding adaptation - The road and rail sectors are taking steps to incorporate climate change risks in existing business risk management, decision making and investment processes.

Uncertainties and assumptions - The reports demonstrate an awareness of the uncertainties and assumptions associated with climate change risks across both the sectors.

Barriers to adaptation and interdependencies - In general the sectors appear to be aware of a range of barriers that affect their ability to adapt to climate change, although some of the reports did not identify any barriers. It is possible that this is due to some of the organisations being at an early stage of considering their climate

change risks or that these organisations were happy with the analysis of barriers carried out by other parts of the sectors and did not want to repeat the analysis.

The reports suggest that the sectors are developing an understanding of their interdependencies with some organisations more advanced in their thinking than others. In some cases organisations are exploring these interdependencies further through working groups or studies such as *Engineering the Future*[25].

Monitoring and evaluation - The reports indicate that the organisations in these sectors plan to monitor and evaluate their climate change risks and adaptation plans in the future.

[25] http://www.raeng.org.uk/news/publications/list/reports/Engineering_the_future_2011.pdf

BENEFITS AND OPPORTUNITIES

A number of potential opportunities and benefits were identified in the reports from the road and rail sectors**.** These include:

- Potential for a reduction in weather events that affect network performance e.g. freezing temperatures and snow. However, despite predicted higher mean temperatures in winter, this does not necessarily imply less disruption from snow, as more extreme weather is also predicted.
- Warmer and wetter winters may reduce the need for winter maintenance activities and could also lead to fewer accidents (e.g. slips and falls).
- Climate change modelling will enable the prioritisation of actions to focus on cost-effective responses e.g. focus on long-term measures for long-life assets rather than short term rapid wear assets.
- Increased mean temperature leading to less salt needing to be spread on the network during winter months, this could also lead to slower degradation of infrastructure and fewer corroded vehicles.
- Potential for a change in the modes of transport that people use as a result of the impacts of climate change e.g. increased storminess could lead to more people using the Channel Tunnel instead of ferries.

BARRIERS

The review of the Adaptation Reports identified that whilst some organisations have highlighted a number of barriers that represent a challenge to the road and rail sectors' ability to adapt to climate change, others did not highlight any. The key barriers that were identified include:

Uncertainties – Relating to both climate change and business functions were cited as barriers. Regulatory uncertainties, relating not only to how the Government would respond to the rail industry's adaptation plans but also how adaptation would be funded in the long term were a concern. The future shape of the transport network was also cited as an unknown.

Balancing short-term profit and long-term adaptation – The difficulties associated with balancing short-term benefits and financial efficiencies when considering measures with long-term benefits were raised by the sectors.

Third party and external risks – Risks that are not under road and rail organisations' control or ownership were identified as posing a potential barrier to adaptation.

INTERDEPENDENCIES

The reports highlighted a large number of interdependent organisations and policies, with many of these representing key cross-cutting interdependencies. The following broad groups were evident.

1. Institutional Interdependencies

Government, regulators and legislation – Department for Transport and Transport Scotland, Transport for London, Office of Rail Regulation, Other Government Departments (e.g. Defra, Environment Agency, Cabinet Office and Business, Innovation and Skills), Local and regional government (e.g. London Boroughs) - with responsibility for local road maintenance.

Transport network – Road networks and the Highways Agency, Airports and cross-channel ports, Bordering national rail networks – e.g. Network Rail and SNCF, Train operating companies, Freight operating companies.

Customers/suppliers –Customers, Supply chain, Contractors and operators, providers of weather related information and forecasts.

2. Physical Interdependencies

Utilities - Gas and electricity supply and distribution, water supply and sewerage networks, ICT suppliers.

3. Operational Interpedendencies

Staff absence (eg train drivers unable to get to work), denial of access to adjacent site or geographical area. Local Resilience Forums and Infrastructure recovery groups have been identified as bodies that help reduce the risks from operational interdependencies.

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ANNEX F

The full list of road and rail organisations that provided adaptation reports.

15. Eurotunnel
16. Network Rail
17. Transport for London (TfL)
18. Highways Agency
19. Office for Rail Regulation

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Adapting to Climate Change: helping key sectors to adapt to climate change

Ports and Lighthouses Sector Summary Report for the Adaptation Reporting Power

March 2012

defra
Department for Environment Food and Rural Affairs

INTRODUCTION

In response to directions to report under the Adaptation Reporting Power, 16 organisations from the ports and lighthouse sectors submitted Adaptation Reports to Defra between February and May 2011[26]. These reports were reviewed by the Government's Adapting to Climate Change team in Defra, policy teams in the Department for Transport and the Risk Centre at Cranfield University. They were published by Lord Henley on 17 October 2011[27].

This report summarises the findings from the reports focussing on:

- The climate risks for the ports and lighthouse sectors as identified by Reporting Authorities
- Areas of strength for the industry as a whole
- Areas for further research or consideration
- Emerging trends and themes
- Benefits and opportunities
- Barriers
- Interdependencies

[26] A full list of the organisations who were directed to report can be found at Annex G.
[27] http://www.defra.gov.uk/environment/climate/sectors/reporting-authorities/reporting-authorities-reports/

SUMMARY OF FINDINGS

The evaluation of the reports by Cranfield University, DfT policy teams and Defra's Adapting to Climate Change team show that:

- Climate change risk assessments are being embedded within ports and lighthouse sector organisations' corporate risk appraisal processes.

- The risk assessments contain good coverage of climate change uncertainties, which is commonly reflected in accompanying plans for flexible adaptation responses and supporting plans for monitoring and evaluating adaptation effectiveness.
- Many of the organisations are in the early stages of assessing their climate change risks, having only considered them in detail, as a result of having to report under this Direction. Therefore, few of them currently have adaptation plans in place.
- There may be limited benefits and opportunities for the sector under future climate change.

KEY CLIMATE RISKS FOR THE SECTORS

This is not an exhaustive list of every risk that the ports and lighthouse sectors have identified; it is an overview of the key climate risks which were identified by the Reporting Authorities. Further details about the risks faced by each organisation can be found in their individual adaptation reports.[28] Note that these risks are those identified by Reporting Authorities, not Defra.

Statutory Duties

Navigation and Vessel Traffic Services – A number of climate change risks could have an impact on navigation and Vessel Traffic Services (VTS). These include erosion and flooding of port, radar facilities or power supply units which can lead to interruptions to services, sea level rise which could have an impact on the safety and security of essential navigation channels and increases in storms, storm surges and extreme events which creates risks to navigational safety and infrastructure.

Sea defences – Sea level rise and an increase in storms could have an adverse impact on sea defences and surrounding infrastructure.

Operational Functions

Vessel Movements – Increased wind speeds, greater incidences of fog and higher swells could create delays to shipping movements.

Cargo Operations – Sea level rise and storm surges, increased rainfall, high winds, higher temperatures and increased incidences of fog could all impact on cargo operations to varying degrees depending on their severity and scale.

Examples of Specific Climate Change Risks Identified in the Adaptation Reports

Harwich Haven

Sea level rise and/or any increase in the frequency of extreme events will potentially increase the risk of flooding of radar and radio equipment at Landguard Point, Shingle Street and Shotley. The loss of this equipment would have a major and unacceptable impact on Harwich Haven Authority's ability to fulfil its statutory functions.

ABP Humber

Spurn Point, which is the location of ABP Humber Harbour Authority's VTS and pilotage operations, currently experiences high levels of erosion and wave overtopping and is at risk from long-term sea level rise.

[28] *http://www.defra.gov.uk/environment/climate/sectors/reporting-authorities/reporting-authorities-reports/*

Passenger operations – Increases in storms, wind speed and fog will increase the likelihood of delays to passenger transportation.

Infrastructure and equipment – A number of risks have the potential to impact on infrastructure and equipment. These include landside flooding, sea level rise, tidal flooding, high water levels impacting on quays and sea defences, temperature rise leading to the degradation of assets such as roads and rail and increased precipitation overwhelming existing drainage resulting in localised flooding.

Business – Extreme events, increased wind speed and storms have the potential to impact on the ability of the business to function by increasing costs and reducing traffic. This could potentially lead to reputational risks to the business.

Interdependencies – There is a reliance on surface transport for access and onward movement of cargo as well as reliance on the shipping industry. There is further reliance on flood defences and drainage systems to protect infrastructure and equipment.

Other

Conservation sites – A small number of ports have a role in relation to designated conservation sites. Flooding, sea level rise and coastal squeeze can all create risks to these sites and can potentially increase the risk of pollution incidents.

AREAS OF STRENGTH

A number of areas of strength were identified from the Adaptation Reports that demonstrate that the ports and lighthouse sectors are assessing and acting upon their climate change risks. These include:

Consideration of risks to non-statutory functions – The majority of Reporting Authorities considered the impact of climate change risks on their wider, non-statutory functions in their risk assessment.

Engagement with relevant staff/departments – Many of the risk assessments involved workshops and engagement with key staff and departments to assess potential climate change risks.

Risks assessed using existing corporate risk assessment methodologies – A number of the organisations used their existing corporate risk assessment methodology and criteria to evaluate their climate change risks. This allows climate change risks to be compared with existing risks and embedded within corporate risk management processes.

Transparent discussion of risks – A number of the reports included a transparent discussion of the organisation's climate change risks. These not only included risks to specific locations or assets but also risks relating to potentially sensitive issues such as staff relations.

Consideration of extreme climate scenarios – The reports illustrate that a number of Reporting Authorities have considered the potential impact of different climate change scenarios and in particular the H++ sea level rise scenario on their business functions.

Evidence of embedding climate change risk management – The Adaptation Reports illustrate that a number of the organisations are taking steps to embed climate change risk management within their organisation. For example, climate change risks are being integrated in risk registers and Environmental Management Systems, with responsibilities for climate change risk management being clearly identified in some reports.

Evidence of climate-proofing – The Adaptation Reports clearly illustrate that a number of the organisations are taking steps to climate-proof new assets. Ports and lighthouses are already geared up to deal with extreme weather events and

Evidence of climate proofing in the reports

The Port of Dover notes that a climate change assessment was undertaken as part of the planning for its new Terminal 2, with berths being aligned to maintain operations during inclement weather.

Some Reporting Authorities, such as **Harwich Haven Authority** and **Milford Haven Port Authority** are requiring Marine Works Licences and consent applications to demonstrate that they have considered climate change and are future-proofed.

infrastructure is designed to deal with these issues.

Evidence that the Adaptation Reporting Power has led to change – A number of the organisations noted that the Adaptation Reporting Power has resulted in their organisation explicitly considering its climate change risks for the first time. They noted that this work has led to changes in their level of understanding or management of climate change risks within their organisation. For example, the Port of London Authority note that their report has resulted in a change of emphasis on when adaptation actions are required and that more structured management of its climate change risks is required. Indeed, many of the organisations within the sector are actively implementing or introducing processes to manage their climate change risks as a result of the Reporting Power process.

AREAS FOR FURTHER INVESTIGATION OR CONSIDERATION

The review of the ports and lighthouse sectors reports highlighted a number of areas that may require further research in future. These include:

Cargo – The harbour authority reports highlighted a number of areas relating to the handling of cargo which may require further research including sensitivity of cargoes to weather and climate change, invasive species and the knock on implications of delays to cargoes caused by extreme weather events.

Interdependencies - Interdependencies that were highlighted as requiring further work include greater co-operation and third-party infrastructure planning agreements, internal interdependencies and links with the supply chain.

Coastal and sedimentary change – A wide range of issues that relate to coastal and sedimentary change were highlighted in the reports as areas that may need further research. These include long term risks to infrastructure and assets, the impact that climate change will have on conservation sites and potential changes in sedimentary patterns which could impact on issues such as vessel handling and dredging activities.

Commercial/Business Risk – There were a number of issues relating to commercial/business risks that were raised in the reports that may require further research. These include reputational risk caused by the potential impacts of severe weather events, increased costs and liabilities arising from damage or adverse impacts and the potential for increased insurance premiums.

Combined events – The review of the reports highlighted some of the potential combined events that threaten the sector such as sea level rise combined with high tides in storm conditions and high spring tides and short duration high intensity rainfall.

Climate Data - The reports highlighted a lack of robust information and climate projection data on variables especially relevant to the sector such as fog, wind speed and direction, lightening, storms etc.

EMERGING TRENDS

The review of the ports and lighthouse sectors' reports illustrates that although organisations are at different stages in their assessment of climate change risks and the development of their adaptation programmes, there are common issues and themes that are prevalent across the range of the reports.

Thresholds - The evaluation of the Adaptation Reports suggests that there is a relatively mixed level of understanding of thresholds amongst the sector. Whilst some Reporting Authorities exhibit a clear awareness of a number of weather/climate related thresholds affecting their operations, other organisations have not attempted to identify or assess their thresholds or have only identified a small number of thresholds (e.g. sea level rise). Some Reporting Authorities noted that the general direction, rate and implications of any future change were of more value to them than identifying particular thresholds. Where thresholds were identified, often very little detail relating to whether they would be exceeded in future was provided.

Impact of weather on the organisation's functions - The Adaptation Reports demonstrate that the ports and lighthouse sectors are aware of how weather currently affects their operations and in many cases actively consider weather and climate change risks in their business decision-making.

Risk Assessments - The majority of the organisations in these sectors used their existing corporate risk assessment processes to assess their climate change risks. This allows climate change risks to be compared against wider business risks and to be embedded in existing risk management processes. Although the sectors commonly chose to classify their risks using their existing risk management methodologies, a significant number of them didn't clearly define these classifications. There was also a lack of explanation about organisational risk appetite, making it difficult to understand how significant the risks are to the organisations. There were few reports that included a level of confidence in their risk assessments, which could be addressed in the future with improved guidance and training. This was an issue common across several sectors.

A number of organisations used an expert-judgement-based approach to assess risks which was underpinned by a range of data sources, such as UKCP09 and Shoreline Management Plans (SMPs). However, it was not always clear how specific climate change variables had been assessed because of the lack of methodological detail or evidence sources provided in the reports.

Embedding adaptation - The ports and lighthouse sectors are clearly taking steps to incorporate climate change risks in existing business risk management e.g. Standard Operating Procedures (SOPs) and Business Continuity Management (BCM), environmental management and reporting processes.

Uncertainties and assumptions - There appears to be an awareness of the uncertainties associated with climate change risks across the sectors with several organisations recognising the importance of having flexible adaptation responses. There was also an outline of the assumptions which had been made in the development of the risk assessment and adaptation plans in the majority of the reports.

Barriers to adaptation - In general the ports and lighthouse reports illustrate that the organisations are aware of a range of barriers that affect their ability to adapt to climate change. However, in some cases the narrow scope of these barriers suggests that some of the organisations are at an early stage of developing their thinking on these issues. Barriers to adaptation are discussed in more detail in a later section.

Interdependencies - The reports suggest that the sectors are developing an understanding of their interdependencies with some organisations more advanced in their thinking than others. Some organisations are at a more advanced stage of thinking and outlined plans to engage with their interdependencies in future.

Monitoring and evaluation - The majority of reports outlined structured plans for evaluating adaptation actions and monitoring residual risks which are commonly linked to existing risk management review processes. A number of organisations also provided details of plans to improve how they monitor potential risks and collect data in order to enable adaptation measures to be put in place when needed.

BENEFITS AND OPPORTUNITIES

A number of potential opportunities and benefits were identified in the reports**.** However for ports these are, in some cases, difficult to expand upon because these organisations operate in a competitive market and have commercial interests to protect. **Benefits and opportunities** include:

Sea level rise

- Increased depth of navigable water enabling the safe passage of larger vessels. Also may increase access for more vessels and/or larger vessels.
- Possible reduction in dredging requirements, although some Reporting Authorities noted that surveying and dredging requirements may need to be amended.
- Potential reduction in the need for the pumped equalisation of water levels within impounded docks, reducing energy use and increasing the time when the locks can be open.

Low carbon and renewable energy

- Opportunities arising from the increased use of low carbon modes of transport e.g. rail and coastal shipping due to the rail connections at many ports.
- Increasing wind speed, frequency of high winds and increased solar radiation, opening opportunities to generate renewable energy. Enables organisations to harness their own power supplies, reducing costs and improving energy security.
- Opportunities associated with the development of the offshore renewable energy industry and low carbon fuels.

Warmer winters

- A reduction in ice and snow related incidents.
- Reduced costs from for example salting and gritting.
- Reduced delays from snow and ice events

BARRIERS

The review of the Adaptation Reports identified a number of barriers that were highlighted as representing a challenge to the ports and lighthouse sectors' ability to adapt to climate change.

Uncertainties – relating to both climate change and business functions were cited as barriers by the sectors. Improved evidence and/or confidence in climate change impacts was cited by some organisations to help make the commercial argument for investing in climate change adaptation measures.

Commercial interests and costs – A number of organisations cited challenges associated with the costs and commercial interest of adaptation. These include:

- The need for a justifiable business case and available budget to cover adaptation measures that require investment outside existing capital programmes or maintenance and review schedules. In particular, many organisations noted that it is particularly difficult to take action when there is perceived to be limited or no return on investment within a reasonable timescale.

- Lack of resources – supplier issues, conflicting operational requirements and budget restrictions.

Knowledge and information gaps – A range of specific information gaps, that pose a barrier to adaptation were identified in the reports, including a lack of predictions of future erosion, sediment movement and accretion, future changes in the frequency and intensity of lightning, probabilistic estimates of changes in fog and future changes in the frequency and intensity of wind (particularly gusts) and gales.

Internal barriers – There are a number of possible internal barriers that may affect the ability of organisations within the ports and lighthouse sectors to adapt to climate change. These include:

- **Conflicting investment timescales -** adaptation measures require long-term decisions which are sometimes incompatible with the investment decision timeframes of business.
- **Lack of engagement/support –** a number of organisations noted that the potential for lack of engagement and adaptation awareness from stakeholders could be problematic.
- **Staff relations –** it was noted that the need to adapt working practices such as shift patterns, could impact upon staff relations in some organisations.

Lack of appropriate drivers for taking action – Some of the reports identified the need for financial drivers for adaptation in order for the sector to gain a reasonable return on any future investment in adaptation measures. In a minority of cases the need for regulatory/legislative drivers was also raised.

Interdependencies – A number of interdependencies are perceived as posing barriers to the sectors' ability to adapt to climate change. Issues identified included:

- **A lack of control of a number of interdependencies -** particularly transport, infrastructure and utility providers. Concerns relating to the level of control over privately owned and operated cargo handling terminals or recreational users were also highlighted.
- **Planning constraints/consent and approval for harbour reconstruction –** Crown Estate and Marine Management Organisation.
- **Stakeholder support –** the number and diversity of stakeholders and the challenges associated with their support or resistance.
- **Coastal defence/shoreline management planning/monitoring –** the sector is highly reliant upon coastal defence and shoreline management planning. As such a key interdependency is with the Environment Agency, not only in terms of coastal defence but monitoring and detailed coastal studies.

INTERDEPENDENCIES

The reports highlighted a large number of interdependent organisations and policies, with many of these representing key cross-cutting interdependencies. The following broad groups were evident.

Government, regulators and legislation – UK and Scottish Governments, EU, LA's, Department for Transport, Defra, the Environment Agency, Natural England, Countryside Council for Wales, Cadw (Welsh Government's historic environment service), Environmental/EU directives (e.g. Habitats and Water Framework Directives), International climate change agreements, International trade bodies.	**Ports –** Commercial ports and terminals, developments e.g. operational berths, leisure or housing, other ports/harbour authorities, Trinity House, International Maritime Organization.	**Flood and coastal defence -** Flood defence policy, Shoreline Management Plan process, Coastal flood protection, Flood planning groups.
Transport– Transport infrastructure, Local Highway Authorities, Train operators	**Stakeholders/ recreational groups -** Royal Yachting Association and yacht clubs, environmental NGO's, emergency services/groups, port working groups.	**Customers –** Commerical, leisure users, tenants and organisations on adjacent land, third party users of marine facilities, license holders.
Utilities - Gas and electricity supply and distribution, water companies, pipeline network.	**Suppliers –** specialist suppliers, shipping companies contractors.	**Company –** employees, contractors, shareholders/investors
Emergency services/planning - Emergency services.		

ANNEX G

The ports and lighthouse sector organisations that provided adaptation reports.

20. Corporation of Trinity House
21. Northern Lighthouse Board
22. Maritime and Coastguard Agency
23. ABP Harbour Authority Hull[3]
24. ABP Harbour Authority Humber[3]
25. ABP Harbour Authority Immingham[3]
26. ABP Harbour Authority Southampton[29]
27. Dover Harbour Board
28. Felixstowe Dock and Harbour Company
29. Harwich Haven Authority
30. Mersey Docks and Harbour Company
31. Milford Haven Port Authority
32. PD Teesport Ltd
33. Port of London Authority
34. Port of Sheerness Ltd

[29] Combined report.

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Adapting to Climate Change: helping key sectors to adapt to climate change

Public Bodies Sector Summary Report for the Adaptation Reporting Power

March 2012

defra
Department for Environment
Food and Rural Affairs

INTRODUCTION

In response to a request to report under the Adaptation Reporting Power, The Environment Agency reported in November 2010. Other public bodies from England were invited to report and 10 voluntarily submitted Adaptation Reports to Defra between November 2010 and January 2012[30]. Nine reports were reviewed by the Adapting to Climate Change team and policy teams in Defra and the Risk Centre at Cranfield University and published by Lord Taylor in March 2012. [31]

This report provides an overview of some of the key findings from the reports, focussing on:

- Climate risks for the sector, as identified by the reporting authorities,
- Areas of strength,
- Areas of good practice;
- Areas for further research;
- Emerging trends and themes;
- Benefits and opportunities
- Barriers;
- Interdependencies

The diverse nature of the role of the public bodies' means sector wide issues are difficult to be identified, thus this document only provides an overview of some of the main risks as identified by reporting authorities.

[30] A full list of the organisations who reported can be found at Annex H.
[31] http://www.defra.gov.uk/environment/climate/sectors/reporting-authorities/reporting-authorities-reports/

SUMMARY OF FINDINGS

The evaluation of the reports by Cranfield University, policy teams from Defra and DCLG[32] and Defra's Adapting to Climate Change team show that:

- Climate change risk assessment is being embedded within the public sector corporate processes and activities and that the process of developing the reports acted as a driver to prioritise 'adapting to climate change'.

- The assessments undertaken by the reporting authorities make good use of relevant and appropriate data, information, knowledge and tools and enables the reporting authorities to make evidence based decisions on adapting to climate change.

- Plans are already underway in some areas for continued monitoring and evaluating climate change risks.

- Further research requirements were highlighted and some of this work is now already underway.

[32] Department for Communities & Local Government

KEY CLIMATE RISKS FOR THE SECTOR

This is not an exhaustive list of every risk that the public bodies sector has identified; it is an overview of the key climate risks that the sector faces. Further details about the risks faced by each organisation can be found in their individual adaptation reports.[33] Note that these risks are those identified by Reporting Authorities, not Defra.

There are a huge number of cross cutting risks, these have been classified into three weather changes and two significant effects of weather change.

Identification of risks

Using the evaluation criteria the **Environment Agency identified** their priority risks as:

- flooding and coastal erosion
- water resources and quality
- the impacts of climate change on wildlife and habitats.

Hotter drier summers

The increase in temperatures will impact biodiversity with changes in water body temperatures changing life composition of marine ecosystems where some species will be unable to track their changing climate space, and also impact upon terrestrial biodiversity where suitable climate space may be fragmented.

Whilst hotter temperatures may increase tourism in some areas it will decrease it in others and threaten utilities and services.

Extreme events

Whilst extreme events will have immediate effects during the course of the event, decreasing the ability to carry out day to day activities of the public body, they will also have longer term impacts.

Increase in intensity and frequency of storm events could cause more erosion and damage to habitats. Fish species distribution would be affected and changes in migration patterns could have a negative impact on marine diversity.

In woodlands, trees will experience stress conditions many species are not adapted to, and some will not prove resilient. Historic buildings would also be affected by extreme events.

[33] *http://www.defra.gov.uk/environment/climate/sectors/reporting-authorities/reporting-authorities-reports/*

Warmer, wetter winters

Warmer damp conditions make increases in pests and diseases leading to damage to woodlands more likely as well as damage to buildings. Wetter winters may lead to an increase in erosion.

Increased erosion

Whilst erosion also damages the landscape it erodes, thus putting important natural features at risk e.g. the Nordic Erratics; it also increases siltation in areas where the material ends up. This could change river landscapes and increase risk to marine environments as increased material could bring with it increased pollutants.

Sea Level rise and flooding

Sea level rise will risk those within the reach of the coast of greater likelihood of flooding but will also impact the surrounding biodiversity and farming land quality with changing salinity of water. Flooding will affect rights of way and the composition of native woodlands as some species are less tolerant to water logging.

AREAS OF STRENGTH

A number of areas of strength were identified from the Adaptation Reports that demonstrate that the public bodies are assessing and acting upon their climate change risks. These include:

Engagement with relevant staff/departments – many of the Reporting Authorities utilised both internal and external experts when conducting their climate change risk assessments.

Active engagement with stakeholders and interdependencies – Public bodies are actively engaged with their stakeholders in relation to the assessment and management of their climate change risks.

Partnership approaches – The adaptation reports illustrate a clear awareness of the need for partnership based responses to climate change.

Research studies and programmes – Many organisations across the sector are conducting further research to gain more detailed local understanding of their risks. This is including spatial distribution of risks.

Awareness of the need for a flexible adaptation – Many of the reporting authorities are aware of the need for flexible responses, such as adaptative management responses, that enable adaptation measures to respond to climate change uncertainties.

Evidence of the embedding of climate change – Public bodies are taking steps to embed climate change risk management within their organisations into their national plans, thus ensuring it is considered on a more permanent basis.

Partnership working

A partnership of agencies and organisations are working on Cheviot Futures, a local scale project in North Northumberland, working with land managers and farmers to increase awareness of adaptation.

Example of flexible adaptation

The Broads Authority highlighted that its Adaptation Plan will need to be a dynamic document which is reviewed and modified according to improving understanding and data, and its recognition of the need for flexible adaptivemanagement responses to account for future uncertainties.

Example of embedding climate change

Natural England is embedding adapting to a changing climate within their organisation, from strategic actions of including it in their objectives to developing training for staff and

AREAS OF FURTHER RESEARCH

The review of the public bodies' reports highlighted a number of areas that might benefit from further research. These range from the impacts of potential adaptive methods but also include specific local risks where the impacts are as yet unclear.[34]

Species relocation – may need to consider how species would be affected by relocations, such as which would be more resilient e.g. particularly those in uplands where as the climate becomes hotter and the cooler climate space of the uplands is squeezed.

Invasive species – the introduction of non-native species are of concern to the reporting power authorities, their effects on specific areas are less well researched.

Changing species composition and the impact on landscape character – for example new types of species will alter the appearance of forests and woodlands.

Ecological responses to water abstraction – further research is required to understand the impact of water abstraction and related pressures on ecology.

Identification of vulnerable critical infrastructure and communities to flooding – critical infrastructure including ecosystems services needs to be identified and interdependencies between them understood.

Landscape-scale approaches – the sector highlights the need for further research exploring landscape scale and transformative approaches to adaptation that provide resilient multifunctional landscapes and balance socio-economic interests alongside the environmental and adaptation benefits.

Conservation choices under climate change – a number of reporting authorities recognise that designated features may not remain valid under climate change. Understanding needs to be gained on the 'value' of certain features and when would it be considered not valuable enough to continue to manage.

Assessment of heatwave and overheating risk – further research on mapping and assessing heatwave/overheating risk, this is particularly by the Greater London Authority covering the urban area.

Risk to spring-fed properties – the potential risk that climate change poses to rural properties with spring-fed water supplies was highlighted.

Community preparedness – why there is low level of community awareness and capacity to respond to high risks including a lessons learnt exercise from awareness raising campaigns such as uptake of Floodline Warnings Direct.

[34] Since the publication of the ARP reports, further research has already begun on some of the areas highlighted.

EMERGING TRENDS REQUIRING CROSS INDUSTRY ACTION

The review of the public bodies' sector Adaptation Reports identified a number of common themes and issues emerging across a number of the reports. These are mainly actions that the industry should consider taking.

Expert advice – public bodies appear to have used a range of additional supporting information, including expert input to underpin their risk assessment; however they have continued to use UKCP02, where they may benefit from using the more updated UKCP09.

Thresholds – in some cases there is not a clear picture on how weather and climate change is currently affecting their organisational objectives therefore it is difficult to calculate future effects. The affects of climate change thresholds that may affect functionality could be further looked into.

Embedding adaptation – the reports include steps to embed climate change within their existing organisational processes.

Uncertainties and assumptions – there appears to be an awareness of the uncertainties and assumptions associated with climate change risks across the sector, more work could be done on how these uncertainties will affect specific implications for the sector.

Evidence of change – a number of the reports detailed how this process has already led to changes to the organisations management of climate change risks.

Time – great awareness was shown for understanding the risks on the three different timescales, thus showing understanding of a flexible approach.

Assumptions – the sector varied in its use of assumptions. Some clearly identified assumptions, where others went further and highlighted the implications of the assumptions.

BENEFITS AND OPPORTUNITIES

A number of potential opportunities and benefits were identified in the reports from the natural environment and public bodies sector**.** These include opportunities resulting from actions to adapt to or mitigate against climate change.

Archaeological Assets – Previously unknown or unidentified archaeological sites could be exposed by drought, erosion and new areas being prone to flooding.

Biodiversity – Improved conditions for some species, may result in species immigration, whilst some priority species and habitats may thrive by gaining an increased competitive advantage.

Communities – There may be more of an interest in natural environmental solutions across communities.

Energy – Potential increase in more sustainable energy production, via solar, offshore wind generation etc.

Environmental Benefits – With more carbon dioxide in the atmosphere, photosynthesis and plant growth will increase.

Farming and land management – Increased temperatures may lead to a longer growing season for some crops, which may lead to increased crop yields (with the availability of rainfall).

Fisheries – Fish species that flourish in warmer climates may increase in numbers potentially benefitting coarse fisheries.

Flood Risk Management – Sustainable management of flood risk, such as creation of more wetland and coastal habitats and reconnection of floodplains.

Transport – The waterways could be used more effectively to provide more sustainable transport.

Visitors, Recreation and Access – Increased number of visitors as a result of hotter, drier summers bringing in more money to the area.

Water quality and resources - Climate change may raise the profile of the water environment and the need for sustainable water management.

Woodland and Forestry – Opportunities may arise from declining productivity and tighter controls on sustainability management practices in some other global timber producing regions.

Potential increased decrease in atmospheric carbon dioxide resulting in increased woodland productivity (only in non-water stressed areas).

There are a number of cross-cutting benefits that will be felt across all sectors including those to the organisations workforce health wellbeing and ability to get to the office, as well as the upkeep of property and assets.

The Greater London Authority identified a number of potential benefits and opportunities from climate change and additional benefits that adaptive action can have. For example the increase in urban greening to provide shade against the increase in the heat will also improve the physical and aesthetic environment for people in London.

BARRIERS

The review of the Adaptation Reports identified a number of potential barriers that were highlighted as representing a challenge to the public bodies' ability to adapt to a changing climate. As the sector is so diverse these barriers are relatively organisation specific.

Timescales

Some sectors, for instance the forestry sector, plan over long term timescales, thus it is not necessarily easy to bring in changes.

Keeping pace with the continued changing nature of the landscape may make it increasingly difficult to manage. In the forestry sector so far there has been little demand for alternative minor species thus there is little planting stock in the nurseries.

There are challenges to getting funding for working across partners and organisations. Some sectors may find some potential costly adaptation measures are not economically viable due to long pay back periods. It may be difficult to get buy-in from communities, land managers etc for measures that are perceived as long term threats.

Space

Adaptation measures may need to be put in place in a different location to the area benefitting thus it may be difficult to gain agreement to the action.

The size and scale of land areas and the cross-cutting nature of adaption required in some approaches can present physical challenges.

Some adaptation measures are agreed internationally, which may not be viable to all local situations.

Incentives

Agri-environmental schemes are key levers, however some are on a short term basis making it difficult to rely on the scheme for long term change.

Knowledge, Understanding and Expertise

Working on a larger scale may require a range of expertise and skills which may have resource implications.

Monitoring

Monitoring requires resources, where funding is usually found for pressure based monitoring and where opportunities for direct observations may be limited.

Regulatory

Some barriers are linked to restrictive legislation created when climate change was not such a prominent issue, potentially limiting available adaptation action.

Technological

Some of the technical demands may be beyond the capability or capacity of organisations at the moment.

INTERDEPENDENCIES

The reports highlighted a large number of interdependent organisations and policies, with many of these representing key cross-cutting interdependencies. The following broad groups were evident.

International Agreements – Global trade agreements, UN Framework Convention on Climate Change, Common Agricultural Policy (CAP) reform	**Legislation and policy –** EU Directives, e.g. Water Framework Directive, Habitats Directives, Renewable Energy Directive, Changes in forestry regulation, protected areas, spatial planning, non-native invasive species
Technical – Technical guidance on adaptation, Approach to genetic modification on forestry, development of biosecurity solutions	**Strategies and plans –** England Biodiversity strategy, coastal flood defence, catchment flood management plans
Incentives – Environmental Stewardship, Catchment Sensitive farming schemes, National Park Authority historic buildings grants, Rural development programme	**Science / Research –** Met office, UK climate projections, marine climate change impact programme, scientists, specialists, practitioners, Advisory groups, studies and expertise, training and education
Regulators – Ofwat, Ofgem, Nuclear Regulators, Environment Agency	**Economics and Markets –** Biodiversity offsets, agricultural pressures, food security, fossil fuel prices, market demand (timber), carbon markets
Partnerships and initiatives – Delivery partners, local service boards, partnerships and	**Other groups –** Landowners e.g. National Farmers union, Conservation reserve managers, Environmental and conservation bodies, emergency series and planning, Transports sector, waste management operators,

ANNEX H

The full list of organisations that provided adaptation reports that are incorporated into this summary are:

35. Broads Authority
36. Environment Agency
37. Forestry Commission England
38. Greater London Authority
39. Natural England
40. Northumberland National Parks Authority
41. North York Moors National Parks Authority
42. Peak District National Parks Authority
43. Yorkshire Dales National Parks Authority

The following authorities also provided reports, however are not included in this summary:

1. Lake District National Parks Authority
2. Dartmoor National Parks Authority
3. Exmoor National Parks Authority

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Adapting to Climate Change: helping key sectors to adapt to climate change

Water Sector Summary Report for the Adaptation Reporting Power

March 2012

defra
Department for Environment
Food and Rural Affairs

INTRODUCTION

In response to directions to report under the Adaptation Reporting Power, 22 water companies from England and Wales submitted Adaptation Reports to Defra in January 2011[35] . Ofwat submitted its Adaptation Report to Defra in June 2011. These reports were reviewed by the Adapting to Climate Change team and Water Policy teams in Defra, and the Risk Centre at Cranfield University and published by Lord Henley in May 2011[36].

This report summarises the findings from the reports, focussing on:

- The climate risks for the water sector;
- Areas of strength for the industry as a whole;
- Areas of good practice;
- Areas for further research;
- Emerging trends and themes;
- Barriers; and
- Interdependencies

Due to the different regional coverage, size and responsibilities of the organisations; local conditions bring different climate concerns for water companies. For example, companies located by the coast have risks associated with sea level rise and salination while individual assets can be affected by issues such as local topography that would make them more or less vulnerable to flooding.

[35] A full list of the water companies who were directed to report can be found at Annex I.
[36] *http://www.defra.gov.uk/news/2011/05/20/water-companies-drier-climate/*

SUMMARY OF FINDINGS

- Climate change risk assessment is being embedded within water companies' corporate risk appraisal processes, particularly as a result of regulatory requirements.
- For climate risk assessments the sector is making good use of climate change data (e.g. UKCP09), information, knowledge and tools
- Further work may be needed to improve risk assessment methodologies to enable water companies to make more evidence-based decisions on adapting to climate change.
- The issue of climate change uncertainties and their implications for the sector requires further examination.

There are two emerging issues reflected in the evaluation of the reports:

1. The impact of the regulated nature of the water sector on the water companies' risk assessment and adaptation processes. In particular, the embedding of climate change risk assessment and adaptation within the water companies, as a result of regulatory processes such as Water Resource Management Planning (WRMP), and their requirements for monitoring and evaluation. In addition, the regulated nature of the industry has influenced the generation of adaptation priorities from the risk assessment results, with the water companies focusing their detailed planning on adaptation actions that have received regulatory approval.

2. The analysis suggests that either, there are limited opportunities for the sector under future climate change, or that these need further exploration.

KEY CLIMATE RISKS FOR THE SECTOR

This is not an exhaustive list of every risk that the water sector has identified; it is an overview of the key climate risks that the water sector in England faces. Further details about the risks faced by each organisation can be found in their individual adaptation reports.[37]

Overarching Risks

Compliance – a number of impacts could result in compliance failure or changes to compliance measures. This includes: asset loss or failure (e.g. treatment works); poorer raw water quality derived from low flows requiring additional treatments; and poorer quality receiving waters derived from low flows leading to tighter discharge conditions.

Interdependencies - interdependencies were identified as an area of high risk, in particular threats to power supplies and telecommunication links to key assets.

Reputational risk - companies are aware of the reputational risk of supply failure, customer flooding and supply restrictions (e.g. hosepipe bans).

Water Supply/Resources

Flooding of assets risking failure of service (e.g. pumping station stops working), compliance failure (e.g. unable to treat raw water, contamination of water supply) or loss of asset function for a time. Salination of freshwater resources was a concern of companies located on the coast.

Networks (pipes) – concern tended to focus on increasing leakage or burst frequency associated with more severe drying/wetting cycles. There was also concern that peak demand would put a strain on the capacity of the distribution system. However, there may be fewer incidents associated with freeze-thaw.

Examples of Specific Climate Change Risks Identified in the Adaptation Reports

Bristol Water

The public water supply intake from the Sharpness canal at Purton represents a critical asset at risk from combined coastal flooding and sea level rise, and accounts for 45% of Bristol Water's resources. Whilst it is protected up to 2035 levels, flooding could impact upon two major water treatment works and the water supply to more than 200,000 people.

Veolia Water Central

70% of Veolia Water Central's network is made up of old iron piping that is at the end of its economic life, and situated in an area that is prone to shrinkage and expansion as a result in changes in temperature. This is likely to increase as the climate changes making the network even more highly vulnerable to bursting.

[37] *http://www.defra.gov.uk/environment/climate/sectors/reporting-authorities/reporting-authorities-reports/*

Sources of supply – this is a major concern for the majority of companies that demand will outstrip, or put a strain, on supply derived from a combination of warmer weather (increased demand, evapotranspiration, competition from other water users) and reduced availability of the resource (less rainfall). This risk is multiplied by the concern that climate change could affect silting of reservoirs in heavy rainfall, increased incidence of algeal blooms on reservoirs in warm weather and heavy rainfall contributing to more pollutants finding their way into aquifers.

Wastewater

Flooding of assets risking failure of service (e.g. pumping station stops working), compliance failure (e.g. unable to treat raw water, inundation leading to wastewater overflows, contamination of water supply) or loss of asset function for a time.

Network – the major risk is from increases in rainfall (intensity and duration) and the flood risk that will result from this.

Other issues include reduced rainfall leading to sedimentation and contributing to blockages and possible flooding, increased odour from treatment works, and greater septicity.

Treatment – lower base flows in water bodies receiving discharges leading to tighter discharge consent conditions.

Sludge –issues include risks to disposal, storage, and increasing odours.

AREAS OF STRENGTH

A number of areas of strength were identified from the Adaptation Reports that demonstrate that water companies are assessing and acting upon their climate change risks. These include:

In-house risk assessment/report production – the vast majority of reports submitted by the water sector were produced in-house, suggesting that internal climate change expertise has been developed within many water companies.

Climate change and corporate planning - the Adaptation Reports indicate that water companies are mindful of the risk that weather and climate change pose and that climate change is being actively considered alongside other business risks.

Evidence of the embedding of climate change within water companies – climate change is being embedded throughout the water industry both through regulatory processes, such as Water Resource Management Plans (WRMP), and through inclusion in company risk registers.

Use of UKCP09

Companies, such as **Severn Trent** and **Anglian Water**, are beginning to use the more advanced UKCP09 Weather Generator and Threshold Detector tools to assess their climate change risks.

Thames Water have been developing a risk-based case for climate change driven investment by predicting supply using bespoke modelling based on information derived from UKCP09.

Linking monitoring and review with regulatory timescales – many water companies are linking their risk assessment and monitoring and evaluation processes with existing regulatory reporting requirements. This was reflected in the plans for monitoring and review, presented in a number of reports, which included review timescales.

Awareness of barriers to adaptation – the wide range of barriers that were highlighted in the Adaptation Reports, which were frequently accompanied by plans and recommendations for addressing them, illustrate that the water industry is developing a good awareness of the barriers to adaptation that it faces.

Awareness of climate change uncertainties – the review of the reports suggests that the water sector has developed an awareness of the uncertainties associated with climate change, although the understanding of their impact upon adaptation planning is less well developed.

Active implementation of adaptation plans – the Adaptation Reports illustrate that the industry is actively implementing climate change adaptation plans, through the Asset Management Plan (AMP) process, and have existing policies and procedures in place to finance, manage and adapt to their climate change risks.

Evidence of detailed climate change studies – the Adaptation Reports outline previous climate change risk studies, particularly investigating flood risk, with a number of Reporting Authorities outline future plans to commission further studies to explore specific climate risks.

Research programmes – water companies are participating in research initiatives to assess and adapt to their climate change risks. These include individual organisations commissioning research as well as cross-industry level research programmes and international studies.

Use of the UK Climate Projections – the water sector is actively using the UK Climate Projections, with some water companies beginning to develop a good understanding of their use.

Plans for internal awareness raising – there is evidence that a number of water companies are taking steps to raise internal awareness of the risks associated with climate change and the need for adaptation.

Awareness of the limitations associated with current risk assessment methodologies and climate change studies – the reports indicate that water companies are generally aware of the limitations with current climate change risk assessment methodologies and studies (e.g. qualitative approaches), and plan to address them in future.

Evidence that the Adaptation Reporting Power has led to change – the Adaptation Reporting Power has led to positive changes in the level of understanding or management of climate change risks within their organisation. For example, Anglian Water outlined how their Reporting Power work has resulted in the formation of a Climate Change Steering Group and the development of a new risk assessment tool.

Commissioning Climate Change Research

The water sector is proactively engaging with a range of organisations in the assessment of their climate change risks, with many companies commissioning detailed studies to investigate risks that are of particular concern. Companies such as **Anglian Water**, **Thames Water** and **Yorkshire Water** are collaborating with organisations including UK Water Industry Research (UKWIR), UK Climate Impacts Programme (UKCIP), universities and academic research centres.

AREAS FOR FURTHER RESEARCH

The review of the water sector reports highlighted a number of areas that requires further research in future. These include:

Sea Level Rise and Flood Risk – where issues such as low levels of protection/resilience, pluvial flooding and Sustainable Drainage Systems (SUDs) are combined with events such as flooding from sea level rise, fluvial events and extreme rainfall.

Biosolids/Sludge Disposal - the potential challenges that climate change poses to traditional sludge disposal routes, treatment operations and transportation.

Managing Water Quality and Pollutants - how water quality and pollution may be exacerbated by climate change (such as algal blooms and bacterial growth, catchment management and treatment processes).

Risks Posed by Extreme Events – lack of knowledge/data on systems and/or infrastructure failure. There is also a limited understanding of how the frequency of extreme events may change.

The Impact of Future Housing Growth and Socioeconomic Issues - further work on the impact of population and housing growth combined with climate change impacts and the resulting impact on water supply and water efficiency.

Demand and Demand Management – the impact of climate change on changes in demand and demand management.

Multi year drought frequency – there is currently very little understanding about the likelihood of increases in the frequency and/or length of multi year droughts.

Asset Lifespan under Climate Change - climate change has the potential to impact upon the lifespan of water infrastructure and assets, particular issues include the vulnerability of pipe crossings of rivers and dam structural stability/safety.

Water Transfer/Sharing - climate change may require investment in more strategic water transfer and storage between neighbouring water companies in future, particularly in areas that have low potential to develop new water resources. There are existing precedents for doing this and sharing and transfer agreements already exist in some areas.

Interdependencies - interdependencies were highlighted that requires further work including greater co-operation and third-party infrastructure planning agreements.

EMERGING TRENDS REQUIRING CROSS INDUSTRY ACTION

The review of the water companies' Adaptation Reports illustrates that each water company is at a different stages in the assessment of climate change risks and development of adaptation programmes. However, common issues and trends emerge across the reports that require cross-industry action.

Thresholds - While water companies are aware of flood risk thresholds and are monitoring and evaluating potential climate change risks, more work is required to understand vulnerability to climate thresholds. For example, water companies noted a current lack of knowledge of thresholds, questioned their usefulness, or were yet to determine them, whilst others recognised thresholds as representing a key uncertainty or difficult to assess due to the site-specific nature of their assets.

Risk Assessments - There were a number of themes around risks and risk assessments in the reports. These included classification of risks (e.g. high, medium and low), where a number of the reports failed to clearly define these classifications, making it difficult to interpret the results of the risk assessment and compare risks. There were very few reports that included a level of confidence in their risk assessments, which could be addressed in the future with improved guidance and training. The focus in the reports on the period up to 2035 could potentially mean that longer-term risks affecting infrastructure are not being fully considered.

Whilst a number of water companies provided details of the costs associated with specific adaptation actions that have been approved by Ofwat, or provided a narrative of the costs and benefits associated with their adaptation plans, the Statutory Guidance's requirement for cost benefit and analysis and sustainability appraisal appeared to be difficult for the water sector to address.

A number of the water companies utilised the MHW/WaterUK study - A Climate Change Adaptation Approach for Asset Management - to support their risk assessment. This outlines the risks and impacts associated with climate change for the water sector. However, it focuses on assets and does not address wider operational issues that could be affected by

Assessing possible adaptation responses

South East Water used a qualitative options appraisal process to assess its possible adaptation responses. This considered the barriers, costs and benefits, timescales, environmental, economic, and social sustainability, carbon impact and potential level of regret associated with each adaptation option.

Managing Climate Risks

Water companies, such as **Sutton and East Surrey Water** are developing resilience-based approaches to manage their climate change risks and are also recognising the need for flexible adaptation.

climate change. As such, many of the water company reports did not appear to consider wider operational risks in detail.

A number of water companies recognised the limitations associated with their current climate change risk assessment approaches – particularly the reliance on expert judgement. This, together with the other issues identified in relation to the risk assessments, suggests that there may be a need for additional support and training to develop greater risk literacy across the sector in future. This may need to be accompanied by the development of new approaches for assessing climate change risks.

Opportunities - The reports suggest that there are limited opportunities associated with the impacts of climate but there are opportunities associated with the water sector might respond to a changing climate. . Whilst some water companies did indentify potential opportunities for the sector, many of which may well be exploitable in the future with more work/research, others identified none. Where opportunities were identified by some water companies very few currently have any plans to exploit them at the moment.

Impact of regulatory processes on adaptation actions - The regulated nature of the water sector was particularly evident in the discussion of the water companies' adaptation actions. Here, the Adaptation Reports primarily focussed on adaptation actions that had been approved under the five yearly price review (AMP) process, which were accompanied by clear targets, resources and timescales. As such, longer-term and wider adaptation actions tended to receive less attention, with very little detail provided in the majority of reports. In particular, those adaptation actions that were yet to be funded tended to focus on non-infrastructure adaptation, such as awareness raising, capacity building, embedding, monitoring and research.

Embedding adaptation - The water sector is clearly embedding climate change both through regulatory processes and its incorporation in business risk management processes and business plans.

Focus on demand reduction - In several cases the adaptation actions of the water companies appeared to focus on demand reduction measures (e.g. metering and variable tariff structures) as opposed to twin-track approaches that consider both demand reduction and long-term infrastructure needs.

Designing for Climate Change

Companies are changing their design standards to accommodate future climate change. For example, **Wessex Water** is reviewing its design standards for sewerage to account for future increases in peak flows using UKCP09.

Infrastructure adaptation focuses on flood risk protection measures - The review of the adaptation reports indicates that investment in flood protection represents the main focus of water company adaptation to-date.

Barriers to Adaptation and Interdependencies - In general the water reports illustrate that the water companies are aware of a range of barriers that affect their ability to adapt to climate change. Some water companies suggested plans for overcoming barriers in future.

There appeared to be a mixed level of awareness of interdependencies amongst the water companies. In particular, whilst there was evidence of a number of companies actively engaging with interdependencies, some appeared to be at an earlier stage of identifying them, with others not currently having plans to address them in future.

Varying levels of knowledge and preparedness across the sector - The evaluation of the reports illustrates that there is a wide variation in the level of understanding and preparedness for climate change across the sector. In particular, whilst some water companies are undertaking detailed studies, engaging with a range of organisations, participating in research studies and actively implementing adaptation actions, others are only beginning to identify potential risks. This suggests that there may be a need for additional support in future to help individual companies and the sector as a whole assess their climate change risks and identify effective adaptation actions.

BARRIERS

The review of the Adaptation Reports identified a number of barriers that were highlighted as representing a challenge to the water sectors' ability to adapt to climate change. Most of the barriers identified tend to be on the supply side, rather than demand management issues.

Education/behavioural change – there is a strong emphasis that customers and staff need to be educated on the importance of adaptation.

Regulator – most of the companies identified the framework of economic regulation that OFWAT operates in and the five yearly price review process as a barrier to longer-term investment for adaptation.

Regulation/legislation – the reports convey a strong sense that regulation and legislation constrain company planning, sometimes conflicting with adaptation objectives (conservation/sustainability/security of supply). Some regulatory and reporting cycles are unhelpfully aligned and UKCP09 was launched too late for most companies to incorporate in the 2009 Price Review process.

Data and dealing with uncertainty – there is difficulty in using uncertain data (including UKCP09) to justify action/investment and there are several areas such as windspeed and extreme rainfall where there are information gaps. Many of the reports noted that the translation of climate change projections, such as rainfall and temperature, into effects, such as flooding or drought at the catchment scale, is currently limited and requires further research in future. Whilst ongoing work with Defra and the Environment Agency on the use of UKCP09 in water resource planning was noted, many water companies felt that there was a general lack of industry-wide interpretation of UKCP09.

Decisions/actions by other parties - there are a number of barriers that are outside the control of water companies, for example; third-party flood defences, interdependencies such as power suppliers, communications and transport; housing and population growth; planning decisions; and supply chains. This highlights the need for the companies and the sector as a whole to ensure that they have good relationships with these interdependencies and contingency plans in place.

Cost - the potentially high costs associated with adapting to climate change were raised across the sector. This not only includes discussions about how much the customer is willing and/or able to pay, but also includes issues such as insurance

Engaging Others on Adaptation

Water companies, such as **Severn Trent Water**, are actively engaging with their stakeholders and interdependencies, with the company conducting workshops to explore its interdependencies in detail.

and the difficulty of obtaining investment given the levels of uncertainty, timescales and affordability.

Increased energy usage - the reports highlight the potential conflict between climate change adaptation and increased energy usage and carbon footprint. In particular, treatment processes and improvements required under the Water Framework Directive, together with adapting to climate change may result in increased energy use and high embedded carbon for water companies. As such, the need to develop sustainable adaptation paths was and warrants further research.

INTERDEPENDENCIES

The reports highlighted a large number of interdependencies, with many of these representing key cross-cutting interdependencies. The following broad groups of interdependencies were evident.

Government, regulators and legislation - UK Government, Drinking Water Inspectorate, Ofwat, Environment Agency, Natural England, Consumer Council for Water, Environmental/EU Directives (Habitats and Water Framework Directives).	**Science/research -** Research and modelling community, Research councils and research centres (Tyndall Centre, Met Office/Hadley Centre, Walker Institute, Grantham Institute), Local climate change partnerships (London Climate Change Partnership). UK Climate Impacts Programme, Consultancies, UK Water Industry Research (UKWIR).	**Emergency services/planning -** Emergency services, Health service/hospitals, Local resilience forums, Mutual aid agreements, Emergency equipment stores, Bottled water stocks, Logistics contracts and multi-agency assistance.
Agriculture/landuse – Farmers, Land managers, National Farmers Union (NFU), Forestry Commission and forestry organisations (National Forest, Wildlife Trusts, Crown Estate, National Parks).	**Water companies -** Other water companies – e.g. water transfer or sewerage provision, WaterUK (WaterUK Climate Change Group).	**Flood and coastal defence -** Flood defence policy, Shoreline Management Plan process, Coastal flood protection, Flood planning groups/land drainage bodies (Inland Drainage Boards).
Utilities - Gas and electricity supply and distribution, Standby power, Liquid fuel, ICT - particularly mobile communications,	**Surface water management -** Organisations involved in surface water management (local authorities, internal drainage boards and the	**Customers –** Domestic, Commercial, Industrial (manufacturing and food production).

Telemetry.	Highways Agency).	
Transport - Highways authorities, Rail	**Company –** employees, contractors, shareholders/investors.	**Owners and operators of third-party assets -** British Waterways.
Suppliers – Chemicals, Emergency bottled water, Consumables.	**Others –** Developers, White goods manufacturers, Media, Tourist organisations.	

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ANNEX I

The full list of organisations from the water sector that provided adaptation reports.

44. Anglian Water
45. Bournemouth and West Hampshire Water
46. Bristol Water
47. Cambridge Water Company
48. Dee Valley Water
49. Essex and Suffolk Water (joint report with Northumbrian Water)
50. Northumbrian Water
51. Ofwat
52. Portsmouth Water
53. Severn Trent Water
54. Southern Water
55. South East Water
56. South Staffordshire Water
57. South West Water
58. Sutton and East Surrey Water
59. Thames Water
60. United Utilities
61. Veolia Water Central
62. Veolia Water East
63. Veolia Water Southeast
64. Welsh Water
65. Wessex Water
66. Yorkshire Water