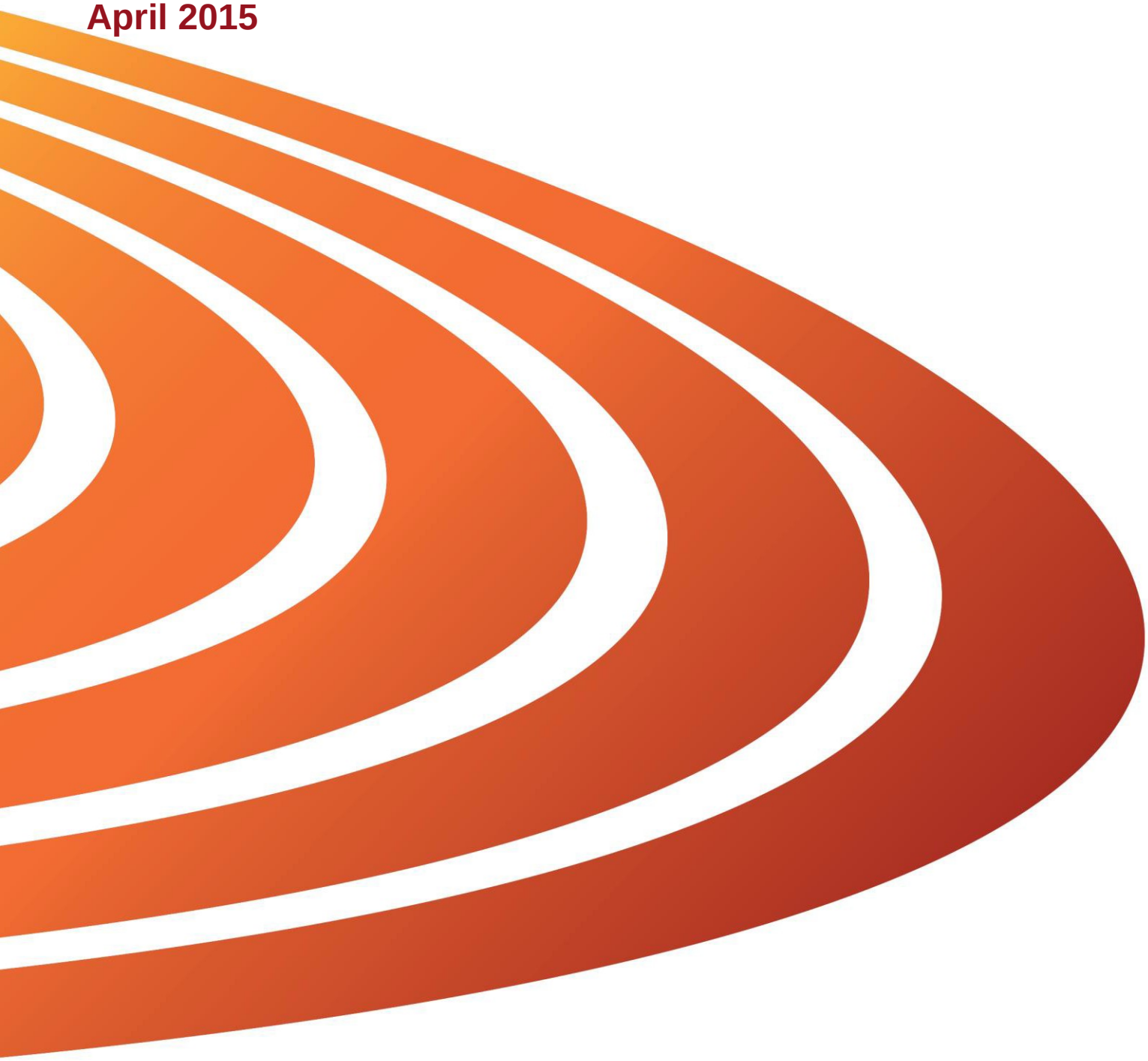
Climate Change Adaptation

Report to contribute information to the second round Climate Change Risk Assessment

April 2015



UK Power Networks
Delivering your electricity

Project Accreditations

Contents

Glossary

Primary Substation – a substation where the incoming voltage is 33kV, typical transformation 33/11kV

Grid Substation – a substation where the incoming voltage in 132kV, typical transformation 132/33kV or 132/11kV

DPCR5 – Distribution Price Control Review 5; regulatory review period 2010-2015

RIIO – Revenue = Incentives+Innovation+Outputs; basis the regulatory period (2015-2023) also known as RIIO-ED1

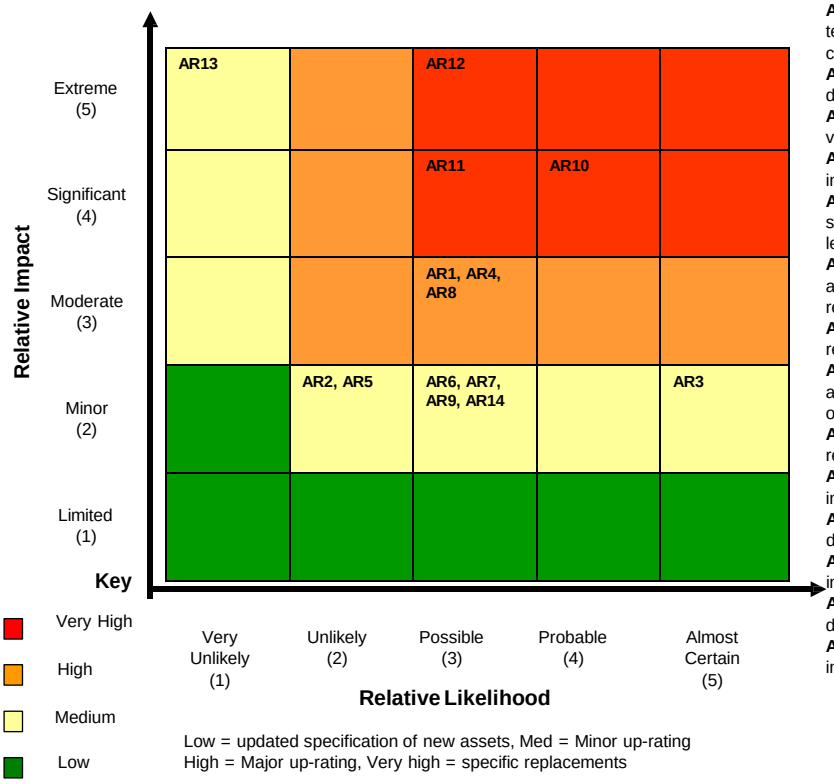
1. Introduction

UK Power Networks manage the distribution of electricity from the National Grid to 8.1million domestic and commercial customers located in London, the East and South East of England. This is done through three licensed subsidiaries Eastern Power Networks plc (EPN), London Power Networks plc (LPN), and South Eastern Power Networks plc (SPN) which are responsible for managing these networks and delivering its core function to provide safe, reliable and efficient electricity supplies to existing customers and timely, cost-effective connections to new customers.

This report represents UK Power Networks' response to the Department for the Environment, Food and Rural Affairs (DEFRA) request for information summarising progress in assessing, preparing and responding to the risks and impacts of climate change to the UK infrastructure. It is intended that this report, along with reports submitted by other individual reporting authorities, forms the basis of the DEFRA Adaptation Committee 2017 Climate Change Risk Assessment.

This report, using the template provided by DEFRA's climate change committee, outlines which of our functions as a licensed Distribution Network Operator (DNO) have the potential to be impacted by climate change and our progress to date in assessing and, where necessary, addressing them. It explains the approach that we have used to recognise potential climate impacts on our business functions, and how these impacts have been quantified. It demonstrates the risk assessment process which UK Power Networks has carried out, short-listing high priority risks for further study and action to address known climate impacts; it also highlights measures taken to support the reduction of electricity generation carbon emissions through network development to accommodate low carbon generation. The high priority risks are quantified on a probability/likelihood scale and how a range of proposed responses are chosen. Finally the report discusses any barriers to adaptation, and demonstrates how UK Power Networks has assessed and understood these risks and how we have developed plans going forward.

Figure 1 - Risk Matrix Showing Overall Impact (Refers to UKCP09 projections for the end of the century assuming a High Emissions Scenario and 90% probability level and no adaptation measures taken)



Low = updated specification of new assets, Med = Minor up-rating
High = Major up-rating, Very high = specific replacements

AR1 Overhead line conductors affected by temperature rise, reducing rating and ground clearance.
AR2 Overhead line structures affected by summer drought and consequent ground movement.
AR3 Overhead lines affected by interference from vegetation due to prolonged growing season.
AR4 Underground cable systems affected by increase in ground temperature, reducing ratings.
AR5 Underground cable systems affected by summer drought and consequent ground movement, leading to mechanical damage.
AR6 Substation and network earthing systems adversely affected by summer drought conditions, reducing the effectiveness of the earthing systems.
AR7 Transformers affected by temperature rise, reducing rating.
AR8 Transformers affected by urban heat islands and coincident air conditioning demand leading to overloading in summer months.
AR9 Switchgear affected by temperature rise, reducing rating.
AR10 Substations affected by river flooding due to increased winter rainfall.
AR11 Substations affected by pluvial (flash) flooding due to increased rain storms in summer and winter.
AR12 Substations affected by sea flooding due to increased sea levels and/or tidal surges.
AR13 Substations affected by water flood wave from dam burst.
AR14 Overhead lines and transformers affected by increasing lightning activity.

The main impacts on electricity networks from the current climate change projections are considered to be:

- Temperature - predicted increase;
- Precipitation - predicted increase in winter rainfall and summer droughts;
- Sea level rise - predicted increase;
- Storm surge – predicted increase.

As is demonstrated in the Figure 1 matrix above, flooding (AR10, AR11 and AR12) has been identified as one of the higher risk and more immediate issues and as such UK Power Networks has focused on managing this risk over other, longer term climate change risks. While works have been, and will continue to be, undertaken to understand other climate change risks and develop the network to be able to accommodate low carbon generation, as demonstrated in this report, the focus remains on protecting plant, equipment and supply from the more immediate and understood flood risk.

2. Understanding Climate Risk

2.1 How has your understanding of climate risks, impacts and their effects on your sector/organisation and stakeholders advanced since your first round report?

The potential risk from climate change impacts is understood at all management and operational levels within UK Power Networks; standards outlining the risk and detailing mitigation methods are available and are communicated to all relevant teams and individuals. The understanding developed from these documents is used to assess network development and climate change protection schemes during the approval and review processes.

It is recognised that the UKCP09 data published under the Climate Impacts Programme UKCIP is still valid and is updated with the latest data and technological information as it becomes available; issued in 2009 it was written to have a 10 year lifespan and as such is expected to still be pertinent to climate change impacts for most of RIIO ED1. While the industry understanding of climate risk and climate change is still based on UKCP09, UK Power Networks have been reviewing the mechanisms and impacts of recent national and international events including Hurricane Sandy in New York and the 2013/2014 storms throughout the South of England.

The primary climate change risk to the electricity network is considered to be flooding and since 2010 UK Power Networks have been running a flood protection programme to understand, evaluate and, where necessary, mitigate this risk. This programme will continue to run until 2023 with higher risk sites being completed early in the programme.

The 2013/14 winter floods in the UK saw no customer supply interruptions as a result of flooding at major substations operated directly by UK Power Networks.

2.2 What climate change evidence or research have you used to better understand the implications for organisational functions?

Through joint research ventures undertaken by the Energy Networks Association (ENA) and Strategic Technology Programme (STP)/EA Technology and on behalf of DNOs, UK Power Networks have improved their understanding of the impact of potential temperature increases on the load capacity of the overhead line and cable networks. Research has also recently been carried out by Newcastle University on the possible impacts of increased wind speed on overhead lines during storm conditions; although more detailed area specific research is required, early draft reports have indicated that wind speeds will not increase dramatically in the foreseeable future and that frequency of storms is likely to increase by only 5%.

UK Power Networks utilise the latest flood information available from the Environment Agency and all of our flood protection schemes are developed using the 2070 climate change factored flood level figures (plus 300mm freeboard) released in December 2013.

While considered not as accurate as current fluvial and tidal flood risk maps and still requiring improvement, UK Power Networks are using Environment Agency surface water/pluvial flood mapping information to carry out an independent

assessment of the risk of surface water/pluvial flooding to its major substations. This information will form the basis for further research and the continued development of its flood protection programme. Historical scenarios are also utilised to instigate pro-active deployment of UK Power Networks' temporary flood protection barrier, for instance during east coast tidal surge and spring-tide events.

2.3 Has your understanding of thresholds of climate impacts advanced to better pinpoint organisational vulnerability? If so, how?

Where current research provides information regarding clear potential impact, UK Power Networks have developed strategies and mechanisms to address the predicted scenarios which have assisted the understanding of risk at particular sites and ensured that appropriate protective measures are put in place. However, current climate change temperature thresholds based on the High, Medium and Low rises in greenhouse gases are currently too broad to provide meaningful assessment and develop mitigation methods. While this evidence is still inconclusive, UK Power Networks will monitor assets and use the information to ascertain the temperature rise thresholds that could have an impact on network capacity.

2.4 How have you developed your quantified assessment and analysis of risk likelihood and impacts?

Following the identification of sites vulnerable to flooding a survey was undertaken in 2009 using catchment area flood prediction calculations and LiDAR survey data to establish potential flood depth. This information was used in conjunction with known customer and critical customer numbers to develop a high level risk assessment considering physical risk to the network and societal risk. The risk assessment enabled the prioritisation of key substation sites enabling a programme of more detailed site risk assessment and feasibility studies to be developed and undertaken in order to understand what substation plant and equipment is at risk and establish effective controls and mitigation.

While third party flood defences sometimes provide flood protection to UK Power Networks substation assets, only the Environment Agency TE2100 project is considered robust enough to rely on for protection from future Thames River fluvial flood events. This reliance has allowed UK Power Networks to develop its LPN flood protection strategy , in conjunction with assessing fluvial flood risk from other sources and catchment areas (e.g. River Lee valley), to address the risks posed by surface water/pluvial flood events; an approach that is now being developed in the SPN and EPN areas.

Since 2010 UK Power Networks has collated information and attributed faults to one of 99 different direct causes; eleven of these are weather related:

- Lightning;
- Rain;
- Snow, Sleet, Blizzard;
- Ice;
- Freezing Fog and Frost;
- Wind and Gale (excluding Windborne Material);
- Solar Heat;
- Airborne Deposits (excluding Windborne Material);
- Condensation;
- Flooding;
- Windborne Materials.

Using data from the NaFIRS system, UK Power Networks can monitor network performance, identify any trends in weather related faults and respond accordingly.

As mentioned in Section 2.2, new work is being focussed on identifying risk from the possibility of higher wind gusts or more frequent storms. High velocity winds are a serious risk to overhead line networks and can uproot trees where, despite branches and boughs being cleared, can still topple onto an overhead line damaging the conductors and/or break supporting poles. During the winter of 2013/14 this was a particular issue where very strong wind storms were combined with prolonged rainfall which made trees more susceptible to uprooting.

As a result UK Power Networks has been contributing to a review to the approach to resilient tree cutting set out in Engineering Technical Report (ETR) 132 Improving Network Performance Under Abnormal Weather Conditions by Use Of A Risk Based Approach To Vegetation Management Near Electric Overhead Lines

This document was developed in conjunction with DECC and Ofgem and provides guidance for Network Operators on how to improve Network performance by enhancing the Resilience of the Network to Vegetation (mainly trees) related faults under Abnormal Weather conditions, including high winds, ice, snow and prolonged high temperatures. This is particularly important in the mitigation of the possibility of increased rainfall combined with strong winds and extended growth periods as a result of climate impacts.

3. Understanding Uncertainties

3.1 What uncertainties remain in monitoring and evaluating climate risks to your sector's/organisation's functions?

The uncertainties highlighted in UKCP09 still remain; natural climate variability, uncertainty in future emissions from developing nations combined with modelling uncertainty and potential inaccuracy caused by an incomplete understanding of earth system processes all have an impact in assessing the potential medium and longer term risks to the electricity network. As highlighted in Section 2.3, the range of predicted temperature change is currently too broad to provide meaningful assessment, develop mechanisms to mitigate the impact and ensure that asset investment is necessary timely and appropriate.

Incidents of unprecedented high intensity or prolonged rainfall and high tides still have the potential to affect the electricity network even with mitigation measures in place. The extent of the control of urban development through future planning decisions will have a consequential effect on run-off and surface water flood events as will the policies regarding maintenance of river channels and third party flood defences on the levels of protection required.

It is important to understand the risk analysis and interdependencies of other utilities and of infrastructure in order to determine their own resilience and reliance. While there is a strong reliance on a DNO to provide a reliable electricity supply, DNOs rely equally on being able to utilise the transport infrastructure to deliver and install temporary control measures (e.g. temporary flood barrier) and gain access to repair faults and on the continuing operation of the telecommunications systems for communication and SCADA control of its network.

3.2 What new uncertainties have come to light?

Following the events during winter 2013/14 there is now uncertainty whether increased storm activity will remain a low frequency event or whether it will become a more common occurrence as a result of climate change. This risk could have an impact on how the electricity network is developed and how it is managed during storm conditions.

The research undertaken by Newcastle University to date suggests that storm intensity will not increase and frequency will only increase slightly (5%) but further research utilising more widespread datasets is required in order to understand the potential profile and qualify predictions.

There is also a need to understand the impact of combinations of weather scenarios, for example high winds following flooding, a flooding event or high rainfall following period of drought.

3.3 What further implications do uncertainties have on action your sector/organisation has taken or plans to take?

As per UK Power Networks' RIIO-ED1 regulatory settlement (2015-2023) there is no allowance for an increase in climate change related activity. While investment in flood protection measures has been set, there is no allowance within the framework for further climate change adaptation studies or actions; any future works to address current uncertainties will have to be financed from business-as-usual developments of specification, approach and general works programmes.

3.4 What progress have you made to address information gaps?

UK Power Networks have actively engaged in a combination of independent and collaborative research in order to understand climate change risks and impacts. In addition, the following initiatives are being undertaken:

- Working with the Environment Agency to understand the latest fluvial, tidal and pluvial flooding information and updates of national flood protection guidance;
- Review of draft report from Newcastle University regarding the impacts of storms on the UK electricity network,
- Information on the impact of recent severe weather has been shared between electricity network companies and a large number of actions to improve emergency response have been co-ordinated internally and through the ENA and DECC;
- All electricity network faults are recorded in the NaDIR database – these incidents have been linked to the progress of storm events in order to develop an estimate of the number of customer supplies expected to be lost for a storm of a given wind-speed; this is now allowing pre-emptive planning of emergency response resources;
- Working in conjunction with other UK DNO's to revise and develop the ENA document ETR138 'Resilience to Flooding of Grid and Primary Substations' using shared experience and understanding of flood risk and flood mitigation measures and solutions.

3.5 What are the strategic business and methodological assumptions that underpin your analysis of impacts and risks?

Strategic business requirements underpinning all works undertaken by UK Power Networks include:

- Customers/public and employees safety at all times;
- The regulatory framework;
- Reliability of the network and supply and through that ensuring that Customers receive the best possible service;
- Asset life cycles.

Key assumptions made in developing the risk action models include:

- The lifespan of substation assets (40-80 years) means that the asset is likely to be impact by climate change in some way during its operational life;
- The Environment Agency TE2100 project will be developed fully and will be robust enough to protect existing LPN assets at risk from undefended River Thames flood risk;
- Climate change factors and agreed freeboard used in developing flood protection schemes are adequate to ensure long term protection of assets.

UK Power Networks are currently focusing mainly on only known risks such as flooding and the assumption here is that the risk level will not increase significantly beyond the current 2070 predicted figures. Flood protection works have now been extended to include pluvial/surface water flood risk assessment and it has been assumed that the quality and accuracy of the predicted levels will improve during the RIIO-ED1 period to allow more accurate risk/benefit analysis to support a programme of mitigation studies and works

4. Details of Actions

During the first round of adaptation reporting UK Power Networks highlighted a number of actions it proposed to undertake to prepare the company and network; as set out in the table below. These actions were to be, and have been, carried out within the existing organisational structure and, where appropriate, have been progressed to become part of the set of standard considerations taken in developing network development and reinforcement schemes.

While most actions have been developed as planned it has been decided to adopt monitoring as an approach to assessing and managing the on-going risk.

Very high consequence risks have led to replacing assets, re-locating sites or significant protection schemes, some ahead of the assets reaching the end of their natural operational life. High and medium consequence risks have been treated by adding resilience to existing sites or 'up-rating' existing equipment. Low consequence risks have been treated with only minor modifications to the specification of new equipment in the next natural replacement and monitoring the existing network assets for any increasing impacts of climate change.

Summary of Actions proposed	Timescale over which actions were planned in first round report	Progress on implementation	Assessment of extent of which actions have mitigated risk	Benefits / challenges experienced
High Level Action - Widening Awareness				
Awareness briefings to the team in each of the areas responsible for design standards, and to the wider management team	To be complete by Dec 2012	Asset Management Civil Design Standards team are now the technical point of contact for flood protection and substation development issues – flood protection standards have been reviewed and revised to ensure validity and Grid and Primary Substation standards have been reviewed and revised to include reference to considering the management of flood risk in new designs	All key section and levels of UK Power Networks have a greater awareness to flood risk and protection. Flood risk assessment and mitigation is now integral to substation design and development	Protected sites – no sites where taken out of commission during the 2013/14 storm events.
High Level Action - Quantify Risk				
Review outcomes from the vegetation management and earthing field measurements monitoring increased vegetation growth. Review their implications for models of future vegetation growth close to our overhead lines and future performance of earthing.	To be complete by Dec 2013	Review has suggested that increased vegetation growth is not currently an issue – as such the tree cutting and vegetation management programme is unchanged.	N/A	N/A
Initiate study to better understand load from air conditioning, particularly at the small premises level. Larger premises typically connect at higher voltages and the drivers for their demand are better understood.	To be complete by Dec 2013	While no specific study of the increased use of small premise air-conditioning has been undertaken increased use will contribute to an overall increase in load which is reviewed and applied to future load estimates as part of the Planning Load Estimate (PLE) process	N/A	The current regulatory framework does not permit development of the network ahead of demand and as such predicted increases in load cannot be accommodated in advance.

Summary of Actions proposed	Timescale over which actions were planned in first round report	Progress on implementation	Assessment of extent of which actions have mitigated risk	Benefits / challenges experienced
High Level Action - Localise Impacts				
Ongoing review of investment plans in response to conclusions drawn from calculated remaining capacity of Grid and Primary transformers.	Annually	Continuing to be ongoing as part of the business-as-usual network reinforcement programme and PLE process – see also Transformer Capacity below	N/A	N/A
Delivery of flood protection programme consisting of 40 sites across our three licence areas.	By end-2014	See summary below in Addressing Risk - Details	Protection of key substation sites from 1:100, 1:200 and 1:1,000 risk flood events	Protected sites – no sites where taken out of commission during the 2013/14 storm events.
Review Environment Agency's Thames Estuary 2100 plan and review impact on our operational sites.	To be complete by Dec 2012	Ongoing as it develops and incorporated in LPN flood protection strategy	Has helped focus LPN Flood Protection programme and enabled development to protect from other flood risk mechanisms	Has helped focus LPN Flood Protection programme and enabled development to protect from other flood risk mechanisms
High Level Action - Co-ordinate Upgrades to Standards				
Identify standards of interest and triage to the appropriate working groups with ENA task groups.	By Q3 2011	Engagement in developing and reviewing ENA Engineering reports continuing; EA Technology STP studies undertaken	No direct impact in mitigating risk but understanding of predicted likelihood and impact of events has contributed to the decision making process	The process has enabled the development of relationships within the industry and an agreed common approach to certain issues
Integration of new standards into proposed business plan for the 2015-2023 period (RIIO-ED1) as a clear, separable incremental cost.	By Q2 2012	Integration completed - RIIO-ED1 Flood protection programme follows on from DPCR5 programme	The development and updating of the standards supports the ongoing flood protection programme detailed in this report	Communication of information and knowledge to key areas of the business to ensure flood protection and other mitigation measures are considered in all substation development schemes.
Identification of areas in which 'Smart Grid' solutions meet the needs not only of increased demand but also reduced ratings of assets.	By Q2 2013	Further investigation and development of Smart Grid technologies to accommodate low carbon generation have been undertaken – see below in Addressing Risk - Details		A number of the projects are still being trialled and the results of the impact and benefit are still being assessed.

Risks

In addition to the Actions identified in the first round reporting, UK Power Networks are also considering the risks highlighted in the Figure 1 matrix (Section 1) as detailed below. In response to these risks UK Power Networks has built an action plan comprising widening awareness within the company through strategy, policy and standards and, where considered necessary, a platform from which to develop programmes addressing the issues raised which are tracked within the corporate risk register.

Risk reference code	Risk	Action
AR1	Overhead line conductors affected by temperature rise, reducing rating and ground clearance.	A project to establish the Dynamic Line Rating of overhead 33kV lines is ongoing – although this research is not directly linked to Climate Change research, interpretation of the results can enable an understanding of the impact increasing air temperatures on conductor temperature and capacity. Studies and reports have also been commissioned with EA Technology to understand any potential impacts.
AR2	Overhead line structures affected by summer drought and consequent ground movement.	No specific action – continuing business as usual activity
AR3	Overhead lines affected by interference from vegetation due to prolonged growing season.	Continuing business as usual strategy and in accordance with ENA ETR 132 – no current requirement to increase vegetation management visits, monitoring for any changes
AR4	Underground cable systems affected by increase in ground temperature, reducing ratings	No to limited predicted impact based on currently available information – currently monitoring situation and will revise standards accordingly to provide larger conductors if found necessary
AR5	Underground cable systems affected by summer drought and consequent ground movement, leading to mechanical damage.	No predicted impact based on currently available information
AR6	Substation and network earthing systems adversely affected by summer drought conditions, reducing the effectiveness of the earthing systems.	No specific action; EDS 06-0001 'Earthing Standard' and associated earthing guidance documents are reviewed regularly to ensure they accommodate any longer term changes soil resistivity
AR7	Transformers affected by temperature rise, reducing rating	No to limited predicted impact based on currently available information.
AR8	Transformers affected by urban heat islands and coincident air conditioning demand leading to overloading in summer months.	No specific action although transformer specifications for warmer countries have been reviewed. Where network load monitoring through PLEs suggest increasing load reinforcement is considered in to reduce overloading
AR9	Switchgear affected by temperature rise, reducing rating	No action - European rating considered adequate to accommodate for predicted UK temperature increases.
AR10	Substations affected by river flooding due to increased winter rainfall.	Robust flood assessment and protection programme – see below for details
AR11	Substations affected by flash flooding due to increased winter rainfall	Risk assessment and prioritisation programme being developed – see below for details

Risk reference code	Risk	Action
AR12	Substations affected by sea flooding due to increased sea levels and/or tidal surges.	Robust flood assessment and protection programme – see below for details
AR13	Substations affected by water flood wave from dam burst.	Current probability value considered too low to justify investment at this time.
AR14	Overhead lines and transformers affected by increasing lightning activity.	No current evidence to suggest increasing lightning storm activity

Addressing risk – details

Flooding

Since 2010 UK Power Networks have been developing and delivering a programme of works across its three licensed areas to assess and, where necessary, protect substation plant, equipment and buildings from the risk of fluvial and tidal flooding – in LPN this protection programme has also been extended to include water main failure/surface water risk. In response to increased understanding UK Power Networks have also undertaken a high level risk assessment of the risk from surface water/pluvial flooding using the recently updated Environment Agency information and our own substation location data. This risk assessment will be developed in the same way as the fluvial and tidal assessment undertaken in 2010 to prioritise sites for further study and, where necessary, mitigation works to protect critical assets.

The tables below detail the number of customers and load to be protected at the end of each regulatory period, DPCR5 (Distribution Price Control Review 5) ending in March 2015, RIIO-ED1 (which runs from April 2015 to March 2023).

Flood Protection measures at Peterborough Power Station Grid (2014) and Newhaven Grid (2013)

DPCR5 and RIIO-ED1 number of customers to be protected			
	Number of customers protected by the end of DPCR5	Number of customers protected during the RIIO-ED1 programme	Total Number of customers to be protected by end of DPCR5 & RIIO-ED1 periods
EPN	414,227	556,388	970,615
LPN	369,968	414,102	784,070
SPN	272,248	311,875	584,123
Total	1,056,443	1,282,365	2,338,808

DPCR5 and RIIO-ED1 load (MVA) to be protected			
	Load to be protected by the end of DPCR5	Load to be protected during the RIIO-ED1 programme	Total load to be protected by end of DPCR5 & RIIO-ED1 periods
EPN	763	1,048	1,811
LPN	1,585	1,206	2,791
SPN	549	540	1,089
Total	2,897	2,794	5,691

All flood UK Power Networks flood protection schemes have been developed through assessing the technical and financial viability to ensure that projects deliver the most efficient protection to the network. Where a scheme is considered unviable or a reduction in scope is required an assessment of the risk to the network is considered and communicated to others parts of the company to ensure that the residual risk is considered during emergency situations.

It should be noted that not all 8.1million of UK Power Networks' customers are served by substations at risk from flooding and the current flood protection programme has been designed and developed to address the issues at all of the high and medium priority Grid and Primary substation sites by 2023.

In addition to assessing the technical viability of protection schemes the financial viability is also assessed through a Cost/Benefit Analysis (CBA) in accordance with section 8 of ETR 138. Typically UK Power Networks operate a limit of £30 / customer as a basis for understanding the CBA.

UK Power Networks also own and operate 1000m of temporary flood barrier (deployed at Watford South in February 2014) used to protect sites awaiting permanent flood protection measures or lower priority sites. This barrier is similar to that used by the Environment Agency and has worked in combination to the benefit of both parties since it was purchased in 2010.

In conjunction with the assessment and delivery works UK Power Networks' Asset Management team regularly review and update the standards, guidance and policy supporting the flood protection programme to ensure that they reflect lessons learnt, new technologies and new risks. The requirement for flood assessment and protection is also incorporated into all other relevant standards (EDS 07-0102 'Secondary Substation Civil Design Standards', EDS 07-0105 'Grid and Primary Substation Civil Design Standards') to ensure it is considered during the design of all new substation assets and major substation reinforcement works.

Cable and Overhead Line Capacity

Collaborative research has suggested that predicted increases in temperature are expected to only have a minimal impact on cable and overhead line ratings; STP report S3173_1 'Implications of Climate Change for Cable Networks: Effect on Cable Ratings' indicates a loss of reducing summertime in-soil ratings by between 1.5 and 5% by the 2050s and between 2.5 and 8.5% by the 2080s. As current predictions are not robust enough to support a business case to invest in the replacement and upgrade of cables and overhead lines, UK Power Networks will continue to monitor and will revise specification as issues are realised although independent trials as detailed below could be used to provide clearer, real-world predictions.

As part of a project to understand Dynamic Line Rating (DLR) of overhead lines, the UK Power Networks Future Networks team are assessing sections of the 33kV overhead line network to monitor and calculate real time ampacity values to overcome an existing thermal constraint due to increased volumes of distributed generation connections. Rather than apply fixed seasonal line ratings, the purpose of the DLR trial project area is to unlock (where possible) additional capacity from existing 33kV overhead lines by adopting dynamically derived line ratings calculated using information derived from local weather measurements and automatically control interruptible generation export on the network in such a way that the dynamically calculated ampacity of the lines is not exceeded.

It is thought that capacity gains of up to 50% or more can be achieved, depending on the environmental conditions, enabling increased renewable generation to be connected onto the 33kV network; although this research is not directly linked to Climate Change, research interpretation of the results can enable an understanding of the impact increasing air temperatures on conductor temperature and capacity.

Transformer Capacity

In line with EU Directive 2009/125/EC, UK Power Networks are specifying low loss transformers, the efficiency of the liquid immersed Grid and Primary transformers utilised on the network are required to operate at an efficiency of 99.671 – 99.709% (improving to 99.712 – 99.745% by 2021). Although limited in the overall impact, more efficient transformation reduces initial source generation requirement which in turn reduces the carbon emissions generated.

Network Development and Smart Technology

The consideration of the potential impacts of climate change is becoming part of the business as usual approach and as such Smart network development includes factors for climate change resilience to ensure they support, not hinder, the existing protection to the passive network.

Although limited by Ofgem directives preventing pre-emptive development of the network, UK Power Networks are developing the network to accommodate non-fossil fuel generation as solar PV and wind farm connections are agreed and commissioned. Again it is thought that capacity gains of up to 50% or more can be achieved through utilising DLR improving the efficiency of the network to accommodate these connections.

As part of developing the network to accommodate low carbon generation, a storage facility is being constructed and commissioned at Leighton Buzzard. The scheme (run under the Low Carbon Networks Fund (LCNF) and known as SNS – Smarter Networks Storage) is expected to demonstrate how 6MW/10MWh of lithium-ion storage can be deployed on the distribution network to support security of supply.

Energy storage is a key source of flexibility that can help address some of the challenges associated with the transition to a low-carbon electricity sector. Storage, as identified by the Smart Grid Forum, is one of the key smart interventions likely to be required in the future smart grid. However, challenges in leveraging the full potential of storage on distribution networks to benefit other industry segments, and a lack of scale demonstrations are currently hampering the efficient and economic uptake of storage by the electricity sector.

The SNS project is carrying out a range of technical and commercial innovation to tackle these challenges and facilitate more efficient and economic adoption of storage. It is differentiated from other LCNF storage projects through the demonstration of storage applications across multiple parts of the electricity system, including the distribution network but also outside the boundaries of the distribution network. By demonstrating this multi-purpose application of 6MW/10MWh of energy storage at Leighton Buzzard primary substation, the project is exploring the capabilities and value in alternative revenue streams for storage, whilst deferring traditional network reinforcement.

As part of the Low Carbon London LCNF project, organisations in the capital with photovoltaic panels and combined heat and power (CHP) plants are contributing to finding smart ways to integrate low carbon generation on our network, without overloading cables and substations.

The UK's Low Carbon Transition Plan sets out how the UK will achieve targets to produce 30% of electricity from renewable sources by 2020. Increasingly, wider use of local, intermittent generation will result in less predictable two-way power flows on our electricity network.

Currently, electricity mainly flows downstream through our substations and cables from a centralised power station to consumers. In the future more electricity may be generated and used locally and exported on to our network when there is a surplus.

This decentralised energy trial is investigating new Active Network Management (ANM) automation and control techniques can be used to develop a smarter electricity network that helps residents and businesses generate their own low-carbon electricity in a cost-effective way.

In order to provide clearer guidance regarding photovoltaic (PV) generation connection to the network, UK Power Networks plans to implement clear policy guidelines advising planners when further investigations might be necessary before connecting large clusters of solar panels to our electricity network. Having studied requests for photovoltaic (PV) connections in concentrated areas, like housing estates, we developed a draft policy. We are now in the process of validating those guidelines.

Emergency Response

As a result of the 2013/14 storm events, UK Power Networks have been working to develop and improve its response to emergencies and extreme weather events impacting on the electricity network. Past storm events have been studied and a model to estimate the number of customer supplies expected to be lost for a storm of a given wind-speed has been developed; this model allows pre-emptive planning of emergency response resources and operational teams from Met Office forecasts and warnings. Links to the Environment Agency provide warnings of flood risk and dates of predicted tidal surges allowing defences to be deployed at critical, unprotected sites prior to the event, protect plant, equipment and supply.

Temporary flood barrier deployed at Watford South Switching Station (February 2014)

Wind speed v Customer interruptions

EPN	60mph	65mph	70mph	75mph	80mph
HV	49	119	178	332	547
LV	136	333	485	916	1518
SP	65	122	166	291	465
Customers	42837	98502	141468	263203	433396
Calls	11000	25000	36200	67500	111000
24hrs	50	125	150	290	500
48hrs	25	62.5	82.5	150	250
72hrs	17	37.5	56	100	175
96hrs	12.5	30	42.5	75	125

5. Addressing Barriers and Understanding Interdependencies

5.1 Where you've identified interdependencies, how have these assisted or hindered actions to address climate risk?

There are clear interdependencies with local resilience forums when developing flood protection and recovery plans and it is important that these are linked with the development of other utilities' and infrastructure plans although local schemes are often developed out of sync with individual utility schemes, an example is the Coastal Communities 2150 project at Newhaven/Lower Ouse where extensive flood protection of the Newhaven Grid and Newhaven Primary substation sites has already been completed. These sites were completed early in the UK Power Networks flood protection programme as they were considered high risk following the survey and prioritisation assessments completed in 2010

With the exception of National Grid, flood protection schemes where there are common goals and assets, UK Power Networks prefer not to collaborate on joint schemes as the strategy is not to rely on third party managed and maintained flood protection schemes. This is because the level of maintenance and effectiveness of the protection cannot be guaranteed in the longer term and as a result substation specific schemes continue to be developed.

While all UK electricity DNO's are working together through the ENA it is felt that there is an "islanded" approach between different utilities and infrastructure to mitigating the risks of climate change impacts such as flooding even where improvements in the protection of one will have a positive impact on others.

Support of low carbon renewable generation initiatives such as PV and wind farms has had an impact on network development; Smart networks are being designed to accommodate these loads at present without completely rebuilding existing systems, however, there will still be a need for conventional network reinforcement and this will need to be designed to accommodate climate impacts where robust information is made available.

5.2 What were the main barriers to implementing adaption actions and why?

It has been confirmed that UKCP09 continues to provide a valid assessment of climate change and that it is reviewed and updated at regular intervals to ensure that it accommodates the latest available data and research results. There is, however, a need for stronger links between the forecasts and the actual projected impact at the local, regional and national environment level including the level of rainfall, frequency of severe events, change in wind levels, the degree, extent and depth of flooding, increased rates of erosion and the exacerbation of land movement and so on that will impact on all sectors.

UK Power Networks' focus of implementation action has been on flooding resilience where climate impacts, where agreement of the flood protection programme over the DPCR5 and RIIO-ED1 regulatory periods has allowed the resilience works to continue until 2023.

5.3 Have new barriers been identified? Are these being addressed? If so, how?

No new barriers have been identified.

6. Monitoring and Evaluating

6.1 How effectively has consideration of climate change risks been embedded within your sector or organisation?

Consideration of flood risk is now incorporated in UK Power Networks' substation design standards EDS 07-0105 'Grid and Primary Substation Civil Standards' and EDS 07-0102 'Secondary Substation Civil Standards'; these design guidance documents are supported by a specific flood protection document EDS 07-0106 'Substation Flood Protection' which details the assessment and design processes and provides guidance on technical mitigation solutions. All of these documents are developed, supported and communicated by the Asset Management directorate and are available internally via UK Power Networks' intranet and to developers and customers through an external portal.

6.2 How effective have organisational monitoring and evaluation processes been to ensure adaptation responses are implemented and on track? If these have not been effective, what barriers prevented this?

Key risks are recorded on a risk action log which is updated and reported on a monthly basis, there is also a high level monthly dashboard report on key projects indicating progress against a pre-determined target. In order to ensure progress, project progress meeting are undertaken. Status maps of the flood protection programme for each licensed area are updated quarterly to provide a visual representation of which sites are protected, assessed resilient and which are still unassessed or vulnerable. Combining these reports and meetings ensures that information is available at all levels of the organisation.

6.3 How effective were monitoring and evaluation processes in determining how the organisation/sector handled recent extreme weather conditions?

Updates from the Met Office and the Environment Agency are collated and communicated to all staff through text messaging and email alerts; the mapping mentioned in section 6.2 can be used to identify sites in flood risk areas and support a decision as to whether temporary flood defences are required. As a result of works to date, no UK Power Networks sites have lost supply through flooding since 2000 and it has been possible to deploy the temporary barrier within time to protect sites where flooding was predicted but no permanent protection has yet been constructed / installed.

Monitoring and evaluating new data from external sources (Environment Agency) and from internal feasibility studies meant that where flooding incidents have occurred they were, within reason, as expected. Lessons Learned information gathered from the 2013/14 storm events is being included in the protection works programme assessment criteria and in understanding how to design out risk in future network reinforcement projects.

During the exceptional winter weather of 2013/14, UK Power Networks faced an exceptionally demanding sequence of storms from November 2013 to February 2014 causing direct damage to wood pole overhead lines and impact damage from falling trees and wind-blown material. Although normally considered to be “exceptional circumstances” the impact of the storms over Christmas 2013 prompted two enquiries, led by Ofgem and DECC, into the performance of all utilities and service providers, following which UK Power Networks contributed reports as to how performance during and following a storm could be improved. The actions to be implemented by UK Power Networks as part the ongoing internal response development and national response process are summarised as:

- Improvements in customer communication through all mediums including increasing use of social media and the development of a national power outage contact number;
- Developing worst case scenarios for customer calls and ensuring that telephony systems and call agents can provide a high level of service;
- Develop systems to ensure that there is adequate emergency scouting and call taking cover available and in place before, during and after storm events;
- Liaising with contractors and staff to ensure the rapid availability of adequate resources to deliver resilience, particularly over extended holiday periods.

The actions by UK Power Networks and the electricity industry as a whole are reviewed after each winter to see where improvements need or can be made to provide a more reliable service.

6.4 Has the sector/organisation identified any financial benefits from implementing adaptation actions? Perhaps through cost benefit analysis, fewer working days lost, more efficient operations etc?

Cost benefit analysis has been undertaken for all schemes to ensure efficiency but no specific direct financial benefit has been gained from implementing actions other than from protecting our assets and minimising capital replacement costs. Ongoing and future research may provide data to help facilitate an improvement in the efficiency of the network which could reduce reinforcement costs although further investment in adaptation schemes may be required if Climate Change impacts are found to be more severe than currently predicted.

6.5 Has there been sufficient flexibility in the approach to adaptation within the sector/organisation, which allowed you to pursue alternative courses of action? If not what remedial measures could you take to ensure flexibility?

With the fixed nature of the assets and frequent unavailability of alternative areas of land for re-location it is necessary for UK Power Networks to address the impacts of climate change in place of taking alternative action.

Through the development of site specific flood risk assessments UK Power Networks has been able to tailor its approach to flood protection to achieve the most efficient solution and as such it has the ability to develop flood protection schemes to protect whole or parts of sites or individual or groups of plant/equipment depending on equipment criticality, flood depth and operational requirements.

While industry agreement on flood risk protection as set out in ETR138 sets requirements it also allows cost benefit analysis to be undertaken to allow development of most efficient scheme; UK Power Networks is also involved in a number of joint flood protection schemes with National Grid in order to ensure protection of assets extends to all levels and voltages of the electricity network.

7. Opportunities and Benefits

7.1 What action have you taken to exploit opportunities?

As highlighted inn section 5.1 the development of physical flood protection schemes remains in-house and opportunities for collaborative working have not been explored because of risk management issues. Internally UK Power Networks implements flood protection in conjunction with reinforcement and substation development programmes wherever possible in order to maximise efficiencies and, where necessary, flood protection is incorporated into new designs reducing the capital cost of improving resilience.

UK Power Networks has strengthened relations with the Met Office and Environment Agency through DNO group working groups and has developed contacts through flood protection seminars and conferences and Local Flood Resilience groups.

7.2 How effective were your efforts?

During the 2013/14 storms no supplies from ground mounted substation sites were lost due to flooding, existing schemes performed as expected and supplies where maintained even if the site and surrounding area where under water. Supply to approximately 17,000 customers was protected by the flood protection works incorporated into the redevelopment of Bushey Mill Grid substation shown below.

Bushey Mill Grid Substation (February 2014) showing elevated Switchouse and control rooms