UK Power Networks

Business plan (2015 to 2023)

Annex 8: Climate Change Adaptation

March 2014

"A reliable... an innovative... and the lowest price electricity distribution group."

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Delivering your electricity

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This annex has been updated to reflect UK Power Networks' March 2014 business plan. We have a tracked change version for the purpose of informing Ofgem of all revisions to the July 2013 business plan, should this be required.

1 Executive summary

This report describes UK Power Networks' strategy and impact assessment of the effects of climate change. This document was originally drafted in response to the Department for the Environment, Food and Rural Affairs (DEFRA) on the risks and opportunities represented by unavoidable climate change and our preparedness to adapt to and manage those risks and opportunities. UK Power Networks owns three subsidiaries Eastern Power Networks plc, London Power Networks plc, and South Eastern Power Networks plc which are the licensees for three of the fourteen distribution licences in the UK. Our role involves the transport of electricity from the transmission network operated by National Grid to electricity customers situated in our licence areas in the London, South-East and East Anglia.

This report outlines our functions as a distribution network operator (DNO) and which of these functions have the potential to be impacted by climate change. It explains the approach that we have used to recognise potential climate impacts on our business functions, and how impacts have been quantified. It then demonstrates the risk assessment process which UK Power Networks has carried out, short-listing high priority risks for further study from within the overall list of climate impacts. The high priority risks are quantified on a probability/likelihood scale and a range of proposed responses are outlined. Finally the report discusses any barriers to adaptation and demonstrates how UK Power Networks will track these risks and action plans going forward.

UK Power Networks' core function is to provide safe, reliable and efficient electricity supplies to existing customers and timely, cost-effective connections to new customers. As such, this report will address risks brought about by climate change which, if not addressed, would tend to compromise either of these two functions.

UK Power Networks has experienced long-run growth in maximum demand over the last decade of 0.5-1.0% per year, and would expect this to continue in future as a result of natural expansion in the economy driven by new buildings and business activity. The report finds that the majority of climate effects are unlikely to be distinguishable from other pressures on our business plan such as this level of natural load growth for the years up until the 2050s.

We do envisage a number of noticeable impacts by 2080. These are shown in the likelihood/impact matrix on page 6, for each licence area. The matrix illustrates the impact by the 2080s if UK Power Networks were simply to 'stand still'. In these circumstances, climate change effects would impact on the reliability of customer supplies. The consequence of each risk is colour-coded. Very high consequence risks are likely to need to be treated by replacing assets or re-locating sites, potentially ahead of their reaching the end of their natural life. High and medium consequence risks are likely to need to be treated by adding resilience to existing sites or 'up-rating' existing equipment. Finally, low consequence risks are likely to be treated with only minor modifications to the specification of new equipment at the next natural replacement cycle and relying in the short term on the inherent resilience in existing equipment on the network.

In practice, UK Power Networks' existing investment programme averaging around £275m per annum in recent years provides many opportunities to mitigate climate change impacts. The progression of the risks over the period 2020 through to 2080 is also demonstrated in Section 2.3 of the report and confirms that in many cases there is an opportunity for a natural asset replacement cycle to take place before the worst of the effects are felt.

In response to the risks identified, UK Power Networks has built an action plan comprising: widening awareness within the company; continuing efforts to quantify high risks; collecting information on the sites where impacts will expected to be felt first; and co-ordinating with other DNOs to review and potentially upgrade the standards for new-build. These are summarised in Section 2.4 of the report and are supported by detailed action plans tracked within our corporate risk management process.

UK Power Networks is well placed to carry out these actions within its existing organisation structure, and is confident that trends can be monitored in order to identify the correct points at which to initiate investment, recognising our stakeholders' interests. In some cases, UK Power Networks believes that the incremental investment in the short-term is justified, where it represents a small marginal cost and is in proportion to the uncertainty that remains in the climate predictions. We are also confident that the regulatory framework, that limits our revenue, will allow us to make the case for and where appropriate recover the cost of climate change adaptation actions.

Finally, it is important to recognise that our business as a DNO is changing. There is a pressing need not only to adapt to climate change which is now unavoidable, but to mitigate further climate change. It is widely recognised that a number of the plans set out within the Governments' Low Carbon Transition Plan[1], such as sourcing 10% of UK transport energy from sustainable renewable sources by 2020, will drive a growth in usage of electricity far in excess of natural load growth as electric vehicles are adopted. The effect of these initiatives is expected to be many times larger than the impacts on our existing infrastructure identified in this report as a result of unavoidable climate change. UK Power Networks is heavily involved in trials to prepare the smart infrastructure and smart control required for the future, and we expect the technologies being trialled may also contribute to managing the issues raised in this report.

[1] 'The UK Low Carbon Transition Plan: National strategy for climate and energy', Department for Energy and Climate Change, July 2009


EGHAM
STAINES
KINGSTON
CROYDON
WEYBRIDGE
WALTON
ESHER
NORTH SURREY
EPSOM
BANSTEAD
WOKING
LEATHERHEAD
CATERHAM
GUILDFORD
DORKING
REIGATE
REDHILL
GODALMING
CRAWLEY/
GUILDFORD
HORLEY
LINGFIELD
CRANLEIGH
HASLEMERE
EAST
GRINSTEAD
CRAWLEY
HORSHAM
BILLINGSHURST
PETWORTH
CUCKFIELD
HAYWARDS
HEATH
BURGESS
HILL
PULBOROUGH
ARUNDEL
STEYNING
SHOREHAM
BRIGHTON
HOVE
WORTHING
LITTLEHAMPTON
BOGNOR
REGIS
ROTTINGDEAN
SEAFORD
EASTBOURNE
POLEGATE
NEWHAVEN
LEWES
HAILSHAM
HASTINGS
ST. LEONARDS
BEXHILL
BATTLE
RYE
NORTHIAM
UCKFIELD
HEATHFIELD
SUSSEX COAST
GRAVESEND
SWANLEY
ROCHESTER
CHATHAM
SHEERNESS
ISLE OF
SHEPPEY
SITTINGBOURNE
WEST KENT
SEVENOAKS
MAIDSTONE
LENHAM
FAVERSHAM
WHITSTABLE
HERNE BAY
MARGATE
ISLE OF THANET
BROADSTAIRS
RAMSGATE
CANTERBURY
SANDWICH
DEAL
CHARING
ASHFORD
EAST KENT
WHITFIELD
DOVER
TONBRIDGE
SOUTHBOROUGH
TUNBRIDGE
WELLS
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STAPLEHURST
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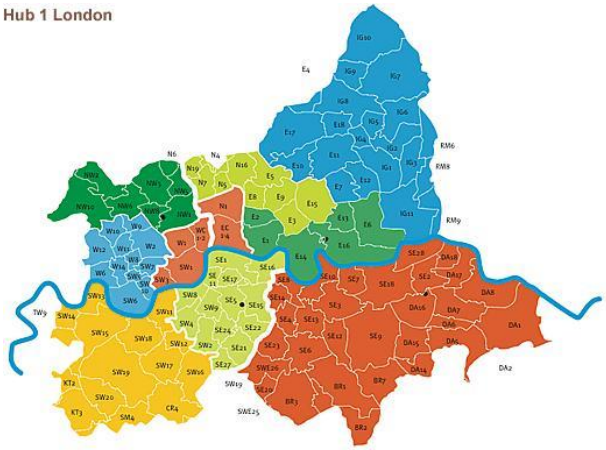
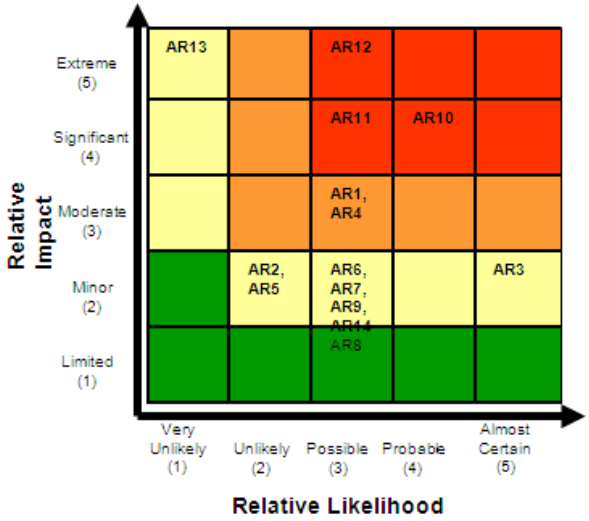
TENTERDEN
FOLKSTONE
HYTHE
DYMCHURCH
NEW
ROMNEY

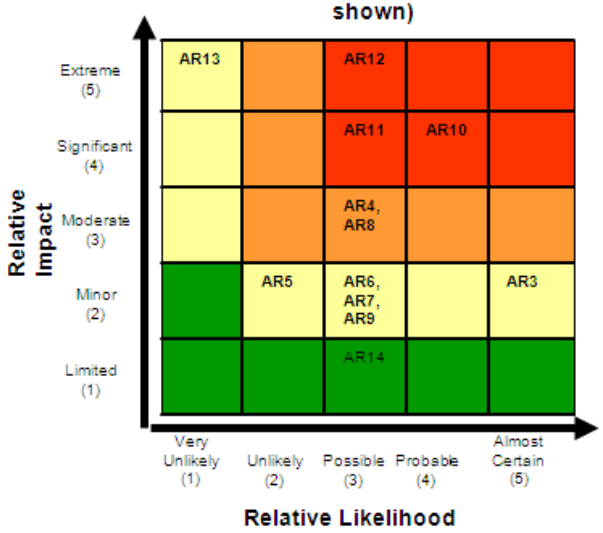

Hub 1 London

EPN

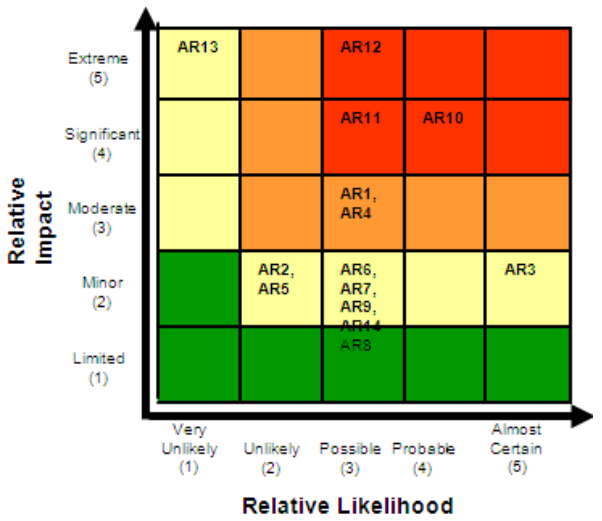


LPN

(Risks AR1, AR2 are negligible for the London network and are not shown)



SPN



Key:

- **Very High**: specific replacements
- **High**: major up-rating
- **Medium:** minor up-rating
- **Low**: updated specification of assets

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 flash flooding due to increased winter rainfall.
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.

2 Adapting to climate change - our strategy

UK Power Networks manage climate change adaptation risks through our risk management policies and procedures. Our approach to risk management is to:

- proactively identify risks to its strategy, objectives, business developments and processes and implements internal controls to mitigate these;
- explore the effectiveness of those controls in mitigating the risks through internal audit and other monitoring mechanisms;
- reactively monitor incidents, errors and breaches to identify control failures and determine areas for improvement
- develop contingency arrangements for business continuity and emergency incidents.

The remainder of this report will provide further detail of our risk analysis and mitigation measures.

2.1 Our functions and key stakeholders

2.1.1 UK Power Networks' functions

UK Power Networks is the licensee for three of the fourteen electricity distribution licences in the UK through its subsidiaries Eastern Power Networks plc, London Power Networks plc and South Eastern Power Networks plc.

Our function within our licence areas is to provide safe, reliable and efficient supplies to domestic and commercial customers and to provide timely and cost-effective access for new electricity connections. As such, our role involves the procurement of distribution equipment; design, quotation and construction; commissioning of new plant; whole life-cycle maintenance typically over 40-60 year periods; decommissioning and waste disposal. Day-to-day performance of the network is supported by operational planning which commences 3 years ahead and culminates in a detailed programme covering the current 8-week window. A single control room monitors the network across all of our three licence areas and dispatches resources for fault investigation and follow-up.

UK Power Networks also functions to support the efforts of UK government in transitioning to a low carbon future and which is likely to lead to a net increase in electricity usage due, for example, to the increased use of plug-in electric vehicles. These also present challenges and opportunities, but are distinct since they are not directly due to climate change, requiring 'adaptation', but are the consequences of actions and policy decisions taken to reduce or 'mitigate' climate change. Our performance in these areas is closely monitored by our economic regulator Ofgem and UK Power Networks has played key roles in a number of initiatives led by the Department for Energy and Climate Change (DECC) such as the Energy Networks Strategy Group (ENSG).

UK Power Networks carries out separate unregulated activities, and also operates the electricity distribution infrastructure required for the Olympic Park and Stratford City developments. These are not covered by this report.

2.1.2 Functions which will be impacted by climate change

Weather has a clear impact on our ability to carry out scheduled construction work, and extreme weather has an impact on our volume of faults and ability to mobilise staff to fault locations, and our main exposure is to the performance of existing distribution equipment. As the report will show, this may be a direct consequence of a traditional climate variable such as the force of wind or ambient temperature, or a secondary consequence such as flooding as a result of increased rainfall or soil properties changing in response to climate variations.

UK Power Networks does not currently foresee significant impacts on its supply chain. UK Power Networks operates a strict multi-vendor policy in the interests of customer value-for-money and which helps to manage our exposure in this area. A full list of our functions and a qualitative assessment of their impact can be found in the Appendix, and is discussed in Section 2.3.

2.1.3 Thresholds above which climate change and weather events will impact our organisation

The thresholds can be separated into categories: the threshold at which instances of extreme weather will prevent us from delivering our core functions; and the threshold at which a gradual change in the climate will require us to review and revise our policies and investment plans.

The extreme weather events of most interest are flooding; lightning storms; extremes of heat and cold; and extreme wind events. Appendix 5 of the Energy Networks Association (ENA) report attached as a Technical Annex to this document helpfully gives an overview of the design standards to which the distribution network operators specify equipment currently, and the standards to which they have specified equipment in the past. Analysis of the data from the Met Office's UKCP09 predictions demonstrates that it is very unlikely that temperatures will exceed 40°C on more than a handful of days per year in the 2080s, even in a high emissions scenario. This threshold of 40°C is the rated maximum daily temperature commonly used in specifications.

Similarly, there are no likely situations predicted by the UKCP09 data that minimum design temperatures would be exceeded. On this basis, we can be confident that the historic sharing of design standards across the UK and global markets with hotter climates has stood us in good stead to withstand the extremes of temperature. There may be a requirement to review maximum design temperatures, but there is plenty of time in which to enact the change. In the shorter term, we may need to pay particular attention to basement substation sites, particularly in urban areas such as London; and to plant which is sited outdoors but in 'sun traps' - particularly where the plant has been encased in a lightweight housing to mitigate rain ingress.

Thresholds to flood events have to be analysed on a site-by-site basis and the report outlines the process by which this is carried out in Sections 2 and 3. UK Power Networks also has recent experience of responding to severe weather events, including storms in the UK in 2013, 2007 and 2002, the threat of coastal flooding in 2007 and supporting EDF in France in 2009 and 2010.

The threshold at which gradual change will require us to review our investment plans must be set in the context of the natural increase in demand which UK Power Networks currently supports. Whilst demand in certain areas may decrease and in other areas accelerate above the average, UK Power Networks has seen 0.5-1.0% annualised growth in maximum demand either from existing consumers or new connections to the network over the last 10 years.

In this context, the effects of a gradual temperature increase become noticeable only once 90% of all model variations from UKCP09 are taken into account. The central 50% of predicted ambient temperatures would not have any meaningful impact on the performance of assets. It will be important, therefore, to see whether improvements in climate modelling lead to a reduced variation in the predictions, since in this case it would give confidence that our assets and current design policies are fit for purpose.

2.1.4 Our stakeholders and the impacts of climate change which they will feel

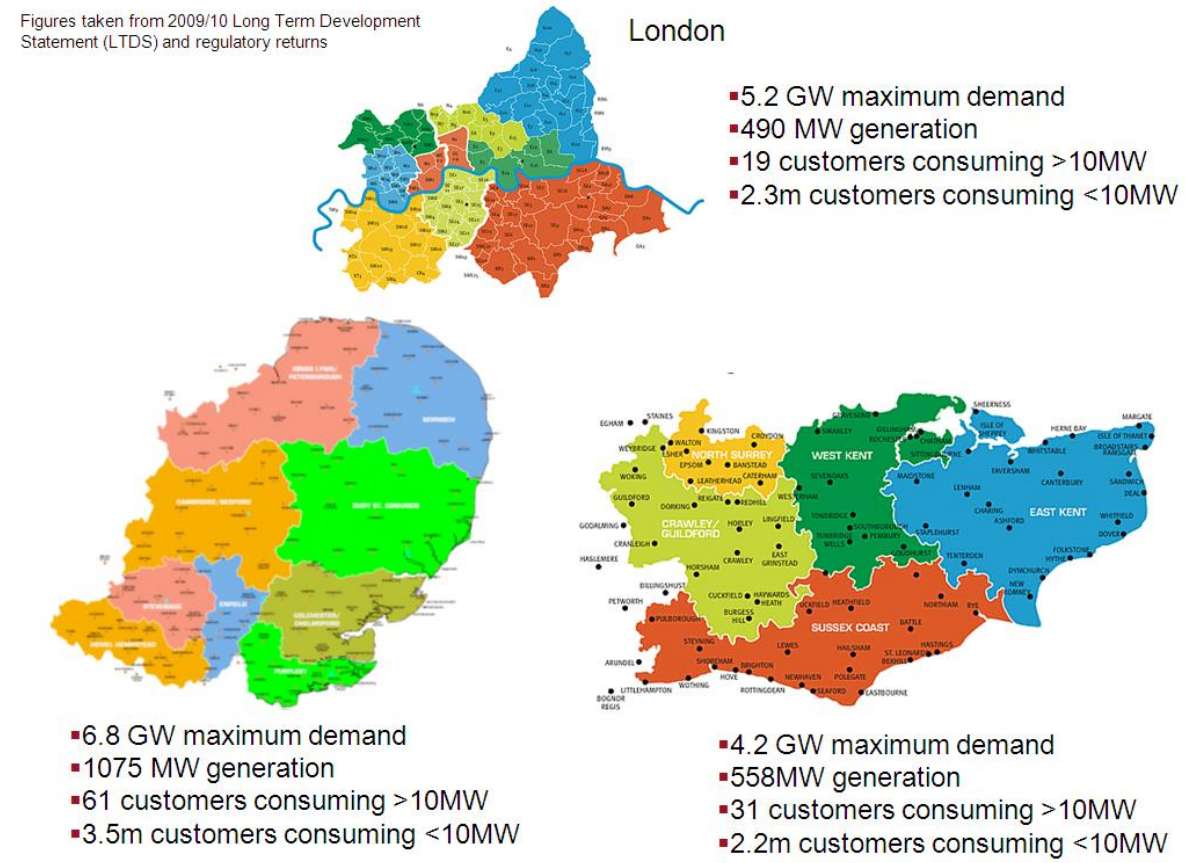
UK Power Networks' stakeholders are its:

- Domestic and commercial customers, both demand and generation customers
- Employees
- Financial owners
- Regulators (economic regulator Ofgem, quality regulator DECC, safety regulator the Health and Safety Executive (HSE), environmental regulator the Environment Agency)
- National Grid as the transmission system operator and owner of the transmission assets in our areas
- Suppliers and contracting partners

UK Power Networks serves a number of key infrastructures in particular London's central business district; the supply to London Underground; Network Rail; and the water utilities. A number of these are reporting authorities under the Climate Change Act 2008 and are submitting similar risk assessments to this one.

These infrastructure customers are shown in context in the diagram below. In the context of overall maximum demand in the gigawatt (GW) range, the adaptation actions being taken by individual large customers consuming more than 10MW will not have a significant secondary impact on the network. Rather than developing specific cross-sector plans for adaptation to climate change, we would expect to manage them through our existing stakeholder engagement process and where appropriate our new connections process.

Figure 1 Our large infrastructure customers in the context of maximum demand



One issue on which we are keen to engage our stakeholders further and understand is the extent to which the trend that has established over recent years of a flatter demand profile throughout the year will expand into more areas. This trend is driven by space heating in winter and growing use of air conditioning increasing demand for electricity in the summer.

2.2 Our approach to identifying climate impacts

2.2.1 The evidence, methods and expertise which we have used

UK Power Networks has worked with other DNOs and Transmission Network Operators (TNOs) on this common issue as part of a working group hosted by the Energy Networks Association (ENA) which has drawn widely on appropriate expertise. The DNOs carried out early work with the Meteorological Office in 2008 using the Met Office's Climate Projections (UKCP02) and which has informed our first-pass list of possible climate impacts detailed in the Appendix. We have also worked with the Met Office to understand relationships between our fault volumes and correlations with weather events, exposing the underlying relationships and sensitivity rather than just relying on our experience from significant weather events. Finally we have drawn on specific expertise to understand the impact of climate change on particular issues of relevance to us: the rate of vegetation growth close to our overhead lines with the environmental consultancy ADAS, the properties of soil using Cranfield University and the British Geological Survey's data sets, and the Environment Agency's flood data.

2.2.2 The method by which we have quantified the impact and likelihood of risks

A number of the risks which have been identified have been analysed in terms of their impact on the capacity or 'rating' of distribution network equipment. Distribution network equipment often has a rating beyond which it can only be used with a significant adverse impact on the life of the equipment or risk to safety. Therefore in the case of a climate-based risk which reduces capacity, a 'do nothing' approach will eventually result in demand outstripping capacity and supply to customers having to be restricted.

This report does not in any way endorse or propose a passive approach, but this is a useful means to understand relative impact and therefore the areas in need of most attention and early intervention. In practice, UK Power Networks readily meets the 0.5-1.0% annual load growth and demand 'churn' that we see, by intervening in a timely manner to reinforce capacity or construct new capacity. These interventions will provide an opportunity to implement adaptation actions with minimal extra effort.

In other cases we are able to quantify only by understanding or estimating order of magnitude of change with respect to the current situation. This is our expectation with respect to the issues discussed in Section 3 regarding earthing and vegetation.

Where we have used UKCP09 data, we have tended to quantify likelihood in terms of the variations in results provided by the models for the same emissions scenarios and the same time period. Where the impact is only significant once 90% of all model variations are taken into account, we have denoted it 'possible'; where the impact is already predicted by the central 50% of model variations, we have denoted it 'probable'.

Flood risk assessments to identify sites in 1:100 and 1:1000 years flood plains have been undertaken using data provided by the Environment Agency including flood depth at each site and supplemented with height assessments measured using LIDAR technology at each site. For the purposes of this report, we have regarded the 1:100 events as 'possible' on the likelihood scale.

2.2.3 The method by which we have quantified the costs and benefits of proposed adaptation options

The costs and benefits of adaptation actions have been quantified using the extensive industry wide historical base of costs for equipment replacement and new connections. The effect of reduced equipment capacity, e.g. due to higher ambient temperatures, can be equated with an increase in requests for demand - in either case, new capacity would need to be built. Similarly, the industry has a historical base of replacement and repair costs that are subject to independent scrutiny through the regulatory review process that routinely assesses efficiency.

Quantified assessments have only been carried out at a licence area level. However, the monitoring actions identified in this report are in practice take place on an individual site basis and any adaptation-related investment will be carried out and approved on a site-by-site basis. The calculations have a number of limitations - they do not attempt to address the fact that remaining capacity headroom is unequally distributed, so that some substations are closer to capacity than others; that capacity and demand both have strong seasonal and perhaps daily fluctuations; and that potential new technologies and commercial solutions have not been considered.

2.3 Summary of climate risks which affect our organisation

2.3.1 Summary of all of our strategic risks posed by climate change

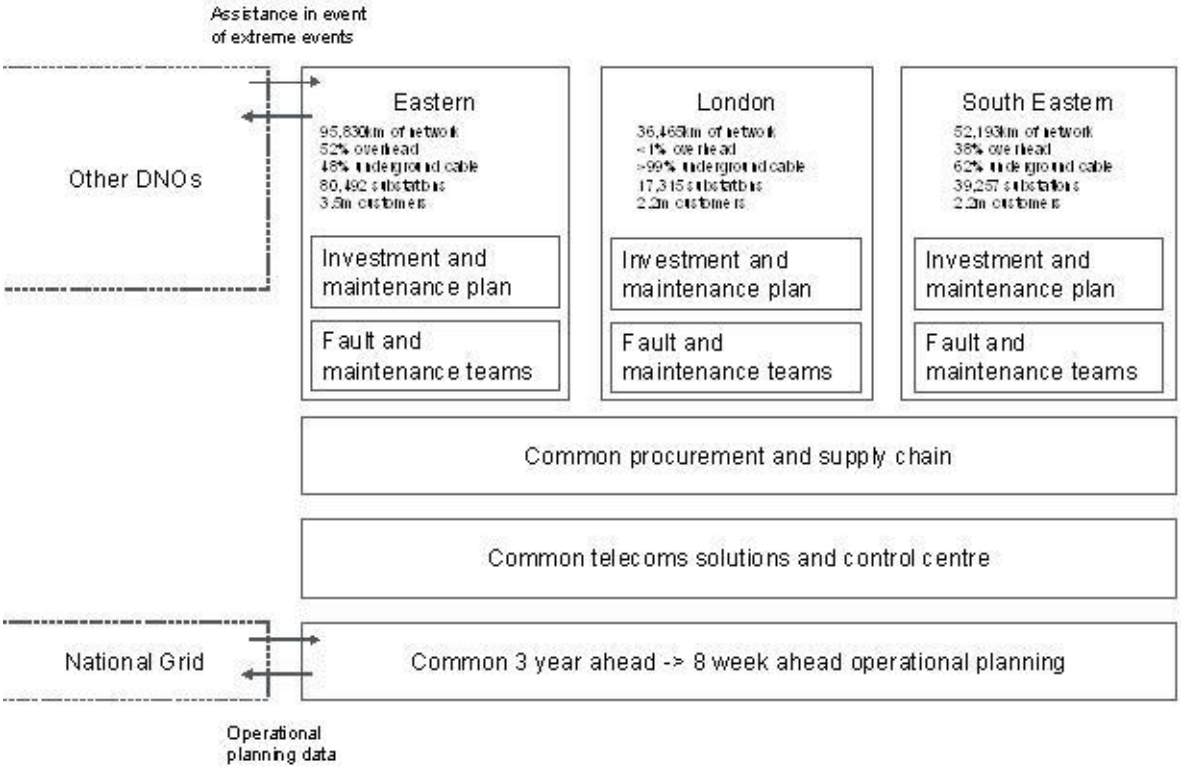
Before discussing our strategic risks, it is important to highlight similarities and differences between our licence areas. For example, our London network is the smallest in Great Britain by land area, entirely urban and dominated by underground cables, whereas our Eastern networks is the largest by land area and has a significantly higher proportion of overhead lines compared to our South Eastern network. The impact of these differences is discussed below. Whilst all of our regulated revenues are strictly managed within each licence, we clearly seek commonalities in procurement and supply chain, operational planning and our control centre. This is illustrated in Figure 2.

Our network consists of equipment sited at substations (for example transformers and switches) and the network connecting substations to customers consisting of overhead lines and underground cables that perform best under particular environmental conditions.

In general terms, the ideal environment for outdoor substation equipment is cool, dry conditions, free from pollution. This provides the maximum opportunity for natural cooling for the plant as it carries load current, ensures that the insulation associated with incoming and outgoing connections to the plant is able to perform at its optimum, and reduces risk of corrosion. Transformers in particular have an expansion tank which needs to have a source of dry air to avoid contaminating the cooling oil inside the transformer. Our main concerns with substation plant would be a future in with shorter periods where the equipment is allowed to cool naturally, i.e. periods with higher average temperatures, accompanied by warm nights and frequent consecutive days of very high temperatures.

In general terms, the ideal environment for overhead lines are cool, dry conditions, with a light breeze, free from pollution, for the same reasons outlined above. The greatest concern would be more frequent instances of high winds capable of damaging supports; more frequent instances of lightning storms; and increased instances of concurrent icy conditions and strong winds. Separately a move to hot, dry, still conditions will have a similar effect to substation plant in removing the opportunity for natural cooling. The availability of natural cooling is proportional to the square of the wind speed, so the understanding of this variable is important.

Figure 2 Overview of UK Power Networks' business structure



Finally for cables, the ideal environment consists of cool temperatures and moist soil conditions. Frequently, and especially in our London network, cables are installed in controlled environments such as ducts or with specially chosen backfill material replacing the soil near the cable and designed to lock in moisture. The greatest concern would be a move to higher average temperatures accompanied by warm nights, and in addition, dry soil conditions.

Some equipment is also sensitive to extremes of day-time/night-time temperature variation and resulting condensation. Of this equipment, a proportion is legacy equipment which will gradually be replaced in the natural renewal cycle with more advanced technology.

If climate impacts arrived equally, we might expect that our greatest financial exposure would be on the network with the largest quantity of assets, our Eastern network. Similarly, our greatest operational exposure in terms of mobilising staff would be on the largest network, Eastern.

In practice, the risk assessment demonstrated that climate impacts do not arrive equally, and that any increase in flood risk to certain key substations which serve large numbers of customers are the issue of greatest impact. This has been well recognised by the industry in response to the floods in the summer of 2007 and has led to improved, more resilient design standards being developed.

UK Power Networks worked with the other DNOs and TNOs within the auspices of the Energy Networks Association to elicit all functions which may be impacted by climate change. A summary of all the mechanisms by which climate may impact our functions is listed in the Appendix. UK Power Networks carried out a two-stage risk assessment process, an initial screening assessment of impact. Then for all of those risks which were rated as having medium or high impact a more detailed assessment where both likelihood and impact were quantified and ranked against other corporate risks on our risk register.

We should make clear that a number of risks were not analysed in further detail beyond the initial assessment. This first-pass assessment was informed by work which UK Power Networks commissioned from the Met Office with the other DNOs. The work was aimed at understanding our existing fault rates, and the extent to which they could be correlated with extremes of weather: high winds; snow, sleet and blizzards; heavy rainfall; solar heat; lightning; and freezing fog. In this case, the data set used was the Met Office's own models, rather than the fuller model set used to generate UKCP09 data and which includes alternate models from other research institutes. In particular, the work did not identify a decisive upward or downward trend predicted for wind events, although more certainty in this area would be welcome.

Table 1 Our fourteen potential impacts on our three networks by 2080

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	Sub-station and network earthing systems adversely affected by summer drought conditions reducing the effectiveness of earthing systems,
AR7	Transformers affected by temperature rise, reducing rating
AR8	Transformers affected by urban heat islands and co-incident air conditioning demand leading to overloading in summer months
AR9	Switchgear affected by temperature rise, reducing rating
AR10	Sub-stations affected by river flooding due to increased winter rainfall
AR11	Sub-stations affected by flash flooding due to increased winter rain
AR12	Sub-stations affected by sea flooding due to increased sea levels and/or tidal surges
AR13	Sub-stations affected by water flood wave from dam burst
AR14	Overhead lines and transformers affected by increasing lightning activity

2.3.2 Specific short- and long-term impacts of climate change which have been identified

The following medium and high-impact risks were analysed in greater detail:

- warmer, drier summers reducing the capacity of our equipment
- warmer, wetter winters and sea level rise leading to increased flooding
- a possible increase in lightning faults
- warmer, drier summers raising issues with earthing and vegetation management

2.3.3 Warmer, drier summers reducing the capacity of our equipment

The Met Office's UKCP09 data does predict that it is likely that the climate will trend towards warmer, drier, less humid spring and summer conditions. As discussed above, these are indeed less favourable conditions for a number of items of our plant.

UK Power Networks worked with the other DNOs and TNOs in the auspices of the Energy Networks Association to work through the implications of gradual warming on the capacity of overhead lines, transformers and cables. In particular, Sections 5.1, 5.3 and 5.5 of the Energy Networks Association (ENA) report attached as a Technical Annex describe both the mechanism by which ambient temperature impacts each of these types of plant, and the method by which a reduction in capacity or 'rating' was calculated.

Overhead lines, cables and transformers all operate at a variety of voltage levels and currents, and the impact of daytime ambient temperature on rating can differ for plant designed for different voltage levels and capacities. The table below shows the impact on our Eastern, London and South Eastern networks. The table is intended to express the worst-case planning assumptions for the effect on plant by the 2080s. In each case, the worst affected item of our plant has been chosen for study; and the 90% confidence interval on the high emissions scenario has been used for the UKCP09 data, meaning that is very unlikely that reductions in rating greater than this would materialise.

Table 2 Reduction in ratings for the worst affected equipment by the 2080s

	Eastern	London	South Eastern
Overhead lines	10%	N/A	11%
Cables	5%	5%	5%
Transformers	6%	7%	7%

The reductions in rating equate to an annualised load growth of approximately 0.15% some 3-5 times less than what our proposed business plan assumes. Even the worst-case scenario can be considered to have a low impact. These impacts are unlikely to be distinguishable until the 2050s. The progression of these risks is shown below, using the probability/likelihood matrix agreed with the other DNOs and TNOs within the Energy Networks Association. The adaptation risk AR1 is an insignificant risk on our London network, given that it is overwhelmingly a cable network.

The long-term nature of average temperatures change means that we need to model the impacts of changes needed over the long-term. We have developed a long-term modelling tool in conjunction with Imperial College that allows us to estimate investment needs out to 2050 based on a range of assumptions. This tool can be applied to support our analysis of climate change adaption requirements over the long-term. .

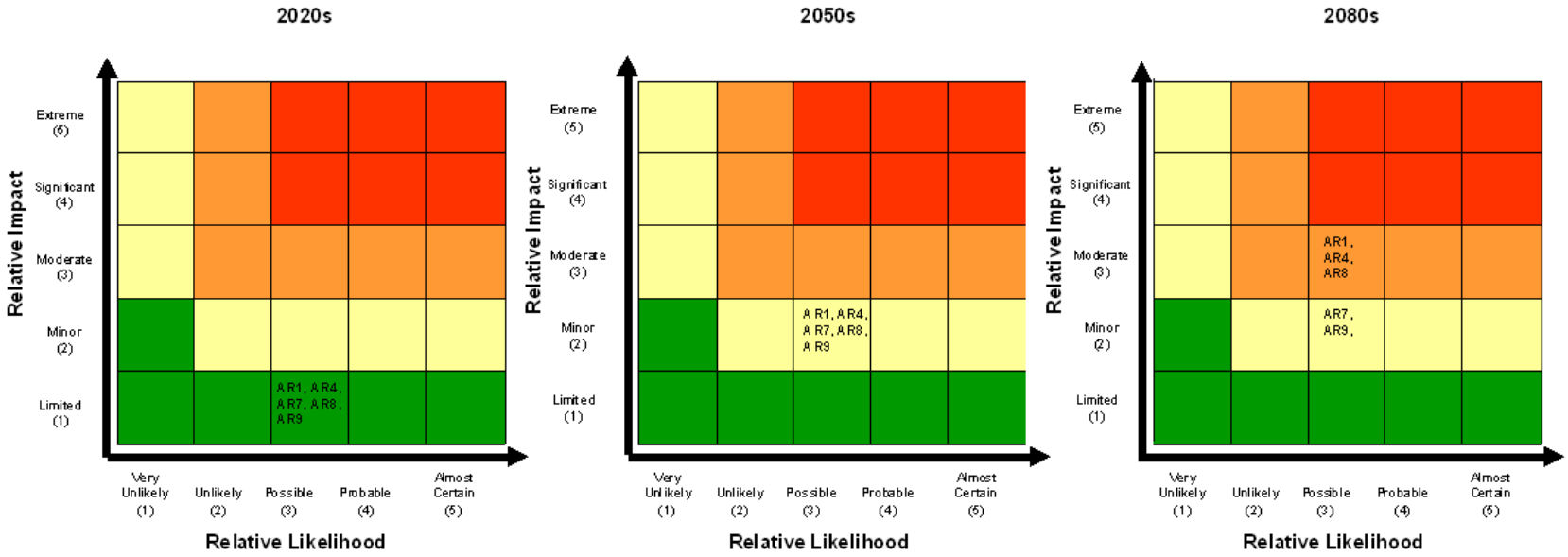
UK Power Networks is investing in innovation and smarter technologies to seek to mitigate the impacts on our networks. These include:

- The deployment of dynamic line ratings and dynamic transformer ratings will enable control engineers and planning engineers to continue to exploit the latent capacity of overhead lines and transformers at times of higher ambient temperatures.
- The deployment of predictive cooling on a number of major transformers in our London networks is enabling us to operate at an extended peak level for longer as transformer oil has been cooled prior to the peak load being experienced.
- The use of demand side response in situations where peak loads cannot be managed within existing firm capacity. This may be demand reduction, demand movement or autonomous network management that is increasingly expected to be part of the normal network planning and operational planning processes.

It is also significant that in using the UKCP09 data to forecast sample runs of daily temperatures for the 2080s, events in which the temperature exceeds 30ºC on seven consecutive days occur in only a handful of cases. This is of particular relevance to our cable and transformer systems which are more sensitive to consecutive days of high ambient temperatures with little opportunity to cool in between the peaks of each day's load. We will need to pay attention to our substations in urban areas, and particularly where these are situated in basements with restricted airflow.

In addition, to mitigate the potential of an increased number of overhead line conductors not meeting statutory clearances due to increased ambient air temperatures, alternative conductor types and overhead line insulator configurations are being deployed or are in development. For example, on the Bolney-Three Bridges 132kV tower line route, Aluminium Conductor Composite Core (ACCC) has been installed to provide increased capacity without having to change/reinforce the supporting tower structures. This type of conductor has characteristics that significantly reduced sag when in operation. In addition, the use of insulated cross-arm technology is being explored to mitigate future 132kV overhead line conductor clearance issues where full utilisation of capacity is required.

Figure 3 Adaptation risks associated with warmer, drier summers and their effect on equipment ratings



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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 flash flooding due to increased winter rainfall.
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 overhead line rating calculations in Table 1have been made using an assumption that wind speed is low (<2m/s), which is a worst-case assumption. We have participated in funding work to produce wind speed data sets to improve our understanding of wind conditions, however these studies typically are aim to understand future wind conditions by looking at the past. Predictions of future wind conditions from them must be treated with caution given the potential for a change in the climate.

Please note that the figures in Table 1represent a threshold at which the impact of climate change will become noticeable alongside existing load growth. It is important to emphasise that mitigations to climate change on transport and heat will reach these thresholds far faster and exceed them by much greater amounts unless alternative, smart, solutions can be found. For example, a penetration of 25% of electric vehicles by 2030 could lead to 50% of transformers nearest to the customer (11kV/415V distribution transformers) being overloaded, even in areas where the distribution infrastructure is built for high levels of demand in a small area[2].

2.3.4 Warmer, wetter winters and sea level rise leading to increased flooding

The risk of flooding within substations and under overhead line structures is an existing risk to electricity infrastructure, and one to which the industry has responded strongly over the last few yearsTo mitigate these risks, we have carried out an assessment of each grid (132kV in-feed) and primary (33kV in-feed) sub-station of the potential flood level using the flood maps provided by the Environment Agency (EA). This information is incorporated into the risk assessment methodology described in the Energy Networks Association Engineering Technical Report ETR138: 2009 Resilience to Flooding of Grid and Primary sub-stations to identify the sites and nature of the required protection regime.

All critical sites went through an initial assessment/screening assessment/detailed assessment as per EA advice, to the resilience levels defined in ETR138. Typically, the screening assessment is aimed at establishing whether the site is within a known flood risk area from major watercourses. This takes into account local and historical information about the site, in particular whether the site is known to be in a flood risk area, and whether the site been flooded before. As part of the screening assessment the Environment Agency website provides maps indicating areas and degree of flood risk.

Many of our sites are already built outside of flood plains. In addition, individual sites can be robust even in the case of flooding where high voltage switchgear is raised off the ground. In some cases, large transformers can sit in water. In some cases, mitigation can be limited to protecting weak points such as sub-station auxiliary supplies and protection.

All critical sites recently went through screening assessments and, where necessary, detailed assessments with a view to reaching the resilience levels defined in ETR138.

For rural areas the screening assessment is likely to investigate the surrounding area, taking into account questions such as whether the site is close to a watercourse, whether the surrounding land is higher than the site, with the potential to cause flooding from surface water run-off; whether the surrounding area is likely to be developed or redeveloped in the future, and which could impact on the degree of surface water run-off that could affect the site. Hard standing or hard landscaping in place of grassed or soft landscaped areas will reduce the time in which surface water reaches the site and is also likely to increase the volume of water affecting the site.

The detailed assessments are typically based on calculating actual flood depth at our sites using the data published by the Environment Agency, combined with local site surveys (LIDAR) commissioned by UK Power Networks to verify existing ground levels. As a result, a programme of resilience works has been developed for our three licence areas and which has had a funding allowance allocated to it by our regulator Ofgem.

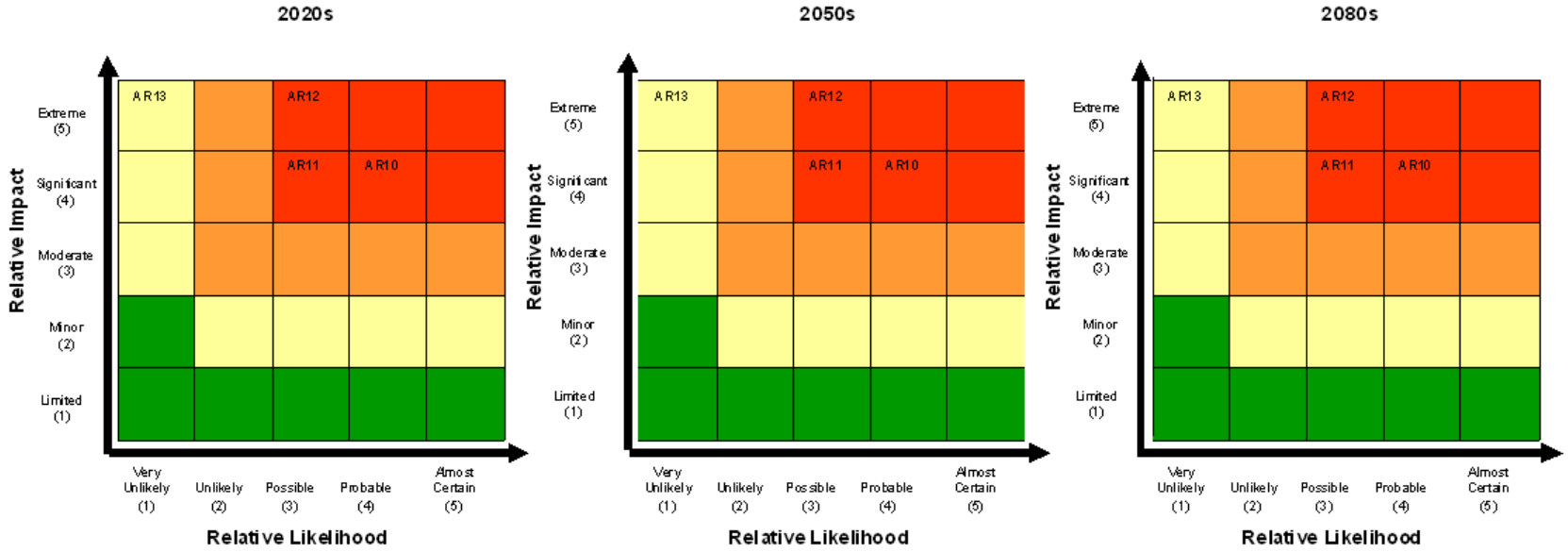
[2] 'Benefits of advanced Smart Metering for demand response based control of distribution networks', Imperial College et al, April 2010, page 24, available from www.energynetworks.org

All new proposed sites are subject to flood risk assessment with the latest available data and planning permission in which Environment Agency have right to comment. Existing sub-station sites are reviewed every three years using best available flood data and have are used UKCP09 data as soon as it has been incorporated by Environment Agency into their flood maps. Whilst new data may raise additional sites at risk as result of climate change, we feel that the 8 yearly price control is sufficiently frequent to raise these sites on a case by case basis.

The work on installing flood defences at 40 sub-stations in DPCR5 is proceeding as planned. A further 74 sites have been identified for further mitigation works in the ED1-RIIO period.

Figure 4 represents the adaptation risks associated with flooding. Please note that we have not attempted to demonstrate the progression of the risk over the century, and thus are leaving open the possibility of further flood mitigation actions needing to be taken in the 2020s. This will be reviewed as flood data associated with the future climate predictions becomes available for the areas outside of the Thames Estuary. UK Power Networks is confident that the engineering standard ETR138, and the opportunity to agree investment plans with our regulator Ofgem in 2015 and 2023, provide sufficient latitude to manage this risk. We will continue to assess any new risks on the basis of actual calculated flood depths. An important aspect is that where we find that flood plains change as a result of climate change and encroach on sites which were previously unlikely to be affected, there may still be mitigating factors if the site is on a flat area in which actual depth of the flood is not significant.

Figure 4 Adaptation risks associated with warmer, wetter winters and sea-level rise



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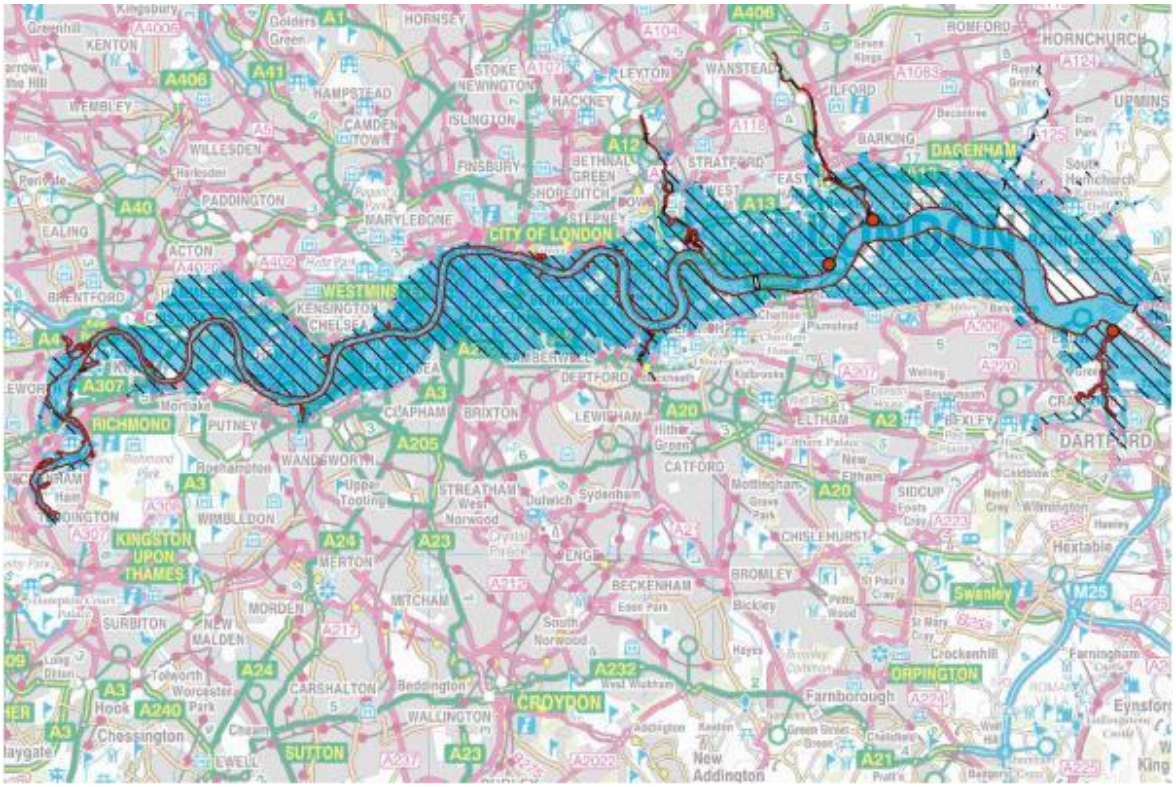
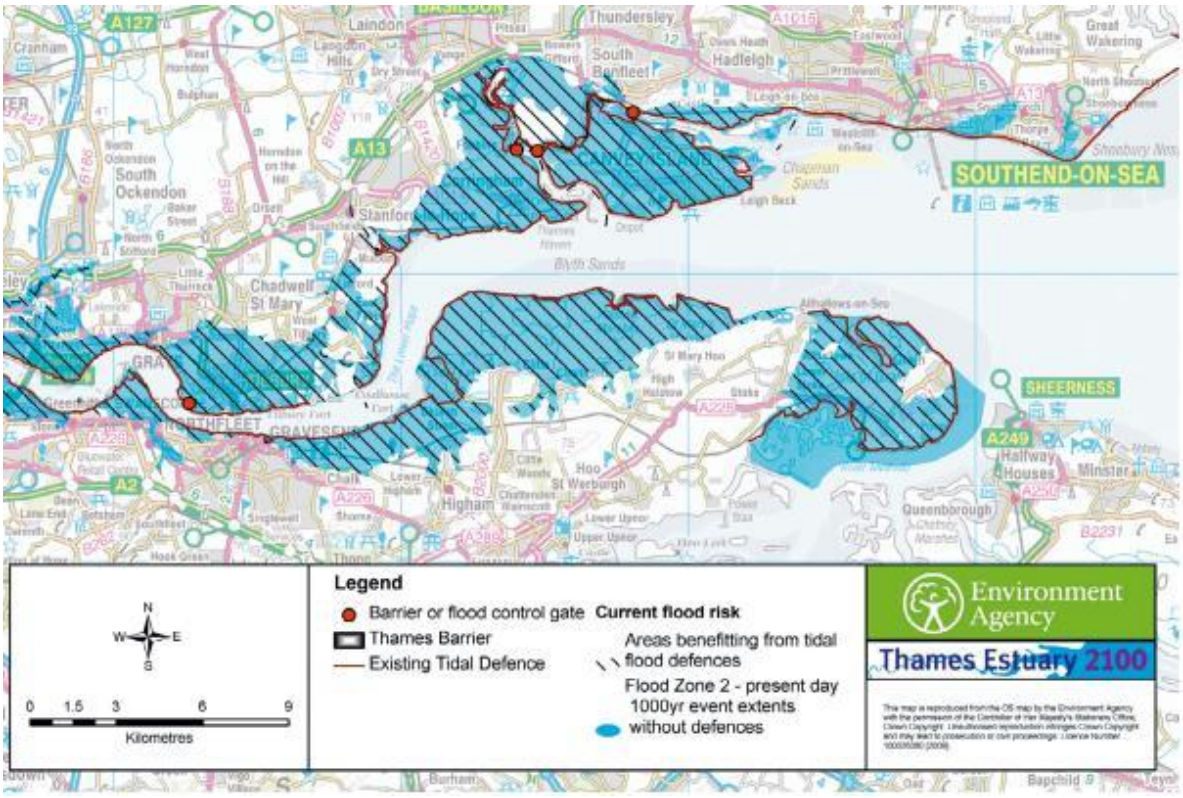
AR12 Substations affected by sea flooding due to increased sea levels and/or tidal surges.
AR13 Substations affected by water flood wave from dam burst.
AR14 Overhead lines and transformers affected by increasing lightning activity.

In Autumn 2012, the Environment Agency gave formal notice that the **Thames Estuary 2100 Flood Risk Management Plan** (TE2100) was now adopted. The Thames Estuary 2100 Flood Risk Management Plan gives an overview of tidal flood risk management recommendations in the Thames Estuary over the next 90 years.

For the first 25 years (2010 to 2034) of the plan, the Environment Agency's plan is for "maintaining confidence and planning together". The Figures below show the extent of the potential flood risk areas in the EAs plan.

Figure 5 The Thames estuary – tidal flood risk today





The plan identifies areas for priority evacuation or refuge, building resilience and building resistance.

For example, at our Littlebrook 132kV sub-station, that supplies both our London and South Eastern networks, the design of the new building housing for the replacement 132kV gas insulated switchgear containing the 132kV switchgear and control equipment is housed on the first floor with only cabling exposed to potential flood waters.

2.3.5 A possible increase in lightning faults

Insulation is a key component of both overhead lines and substation equipment, in which incoming and outgoing metallic conductors are in close proximity to metallic plant such as transformers or overhead line towers. In common with other DNOs, it is expected that lightning on occasions will find a path to earth through our infrastructure or near to our infrastructure. Our infrastructure is designed to minimise the impact of lightning and to ensure that it can cope with the voltages that arise as a result of nearby strikes.

In common with other DNOs, certain aspects of our equipment specifications are driven by the lightning insulation requirements rather than everyday operational requirements.

UK Power Networks tracks instances of faults caused by lightning, and also is a subscriber to a database of lightning strikes held by EA Technology. This provides both an early warning system and also allows us to take strategic decisions about the resilience of our network.

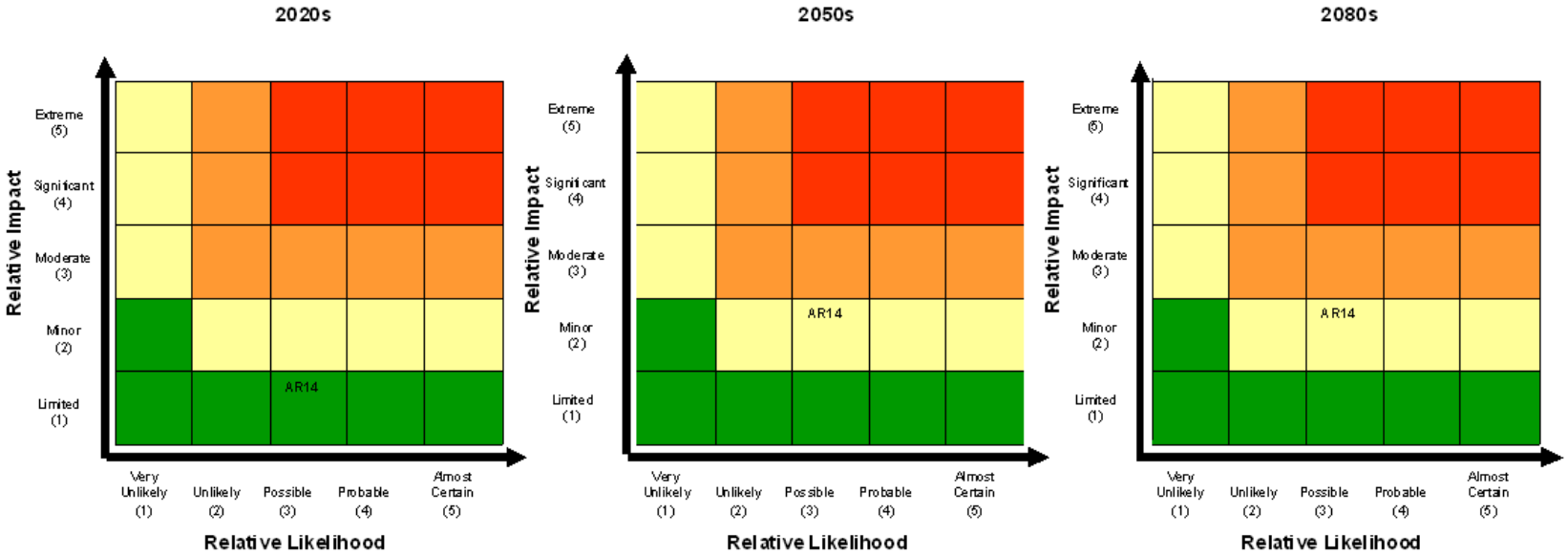
The condition of insulation forms a key part of our inspection regime on both overhead lines and substation plant.

In order to understand the potential for future impact of climate change, UK Power Networks alongside the other DNOs commissioned work with the Met Office to understand our existing fault rates, correlating them with the climate conditions which lead to lightning. In this case, the data set used was the Met Office's own models, rather than the fuller model set used to generate UKCP09 data and which includes alternate models from other research institutes.

The work looked at a wide range of extreme weather events, including high winds; snow, sleet and blizzards; rainfall; solar heat; lightning; and freezing fog. Whilst there was no decisive upward or downward trend predicted for wind events, the climate conditions associated with lightning were predicted to increase as much as 30% on our Southern and Eastern networks by the 2080s with not material risk for our London network. The modelling predicts that the effects will first become significant in the 2050's. The charts below demonstrate the progression of these risks for our network.

The report identified increased levels of lightning activity by the 2080's in our EPN and SPN networks. To improve the resilience of the overhead line networks in our Eastern and South Eastern networks to lightning activity, additional pole mounted auto-recloser circuit breakers and auto-sectionalising links will be deployed. In addition, the high voltage overhead line refurbishment programme will continue. The high voltage overhead line refurbishment specifications for our Eastern and South Eastern networks have been harmonised and now include replacement of line insulation in our Eastern network. 450 additional pole mounted auto-recloser circuit breakers are planned for the Eastern network over the period to 2023. 2,000 auto-sectionalising links for the Eastern network and 800 auto-sectionalising links for the South Eastern network are planned to improve response.

Figure 6 Adaptation risks associated with increased lightning events



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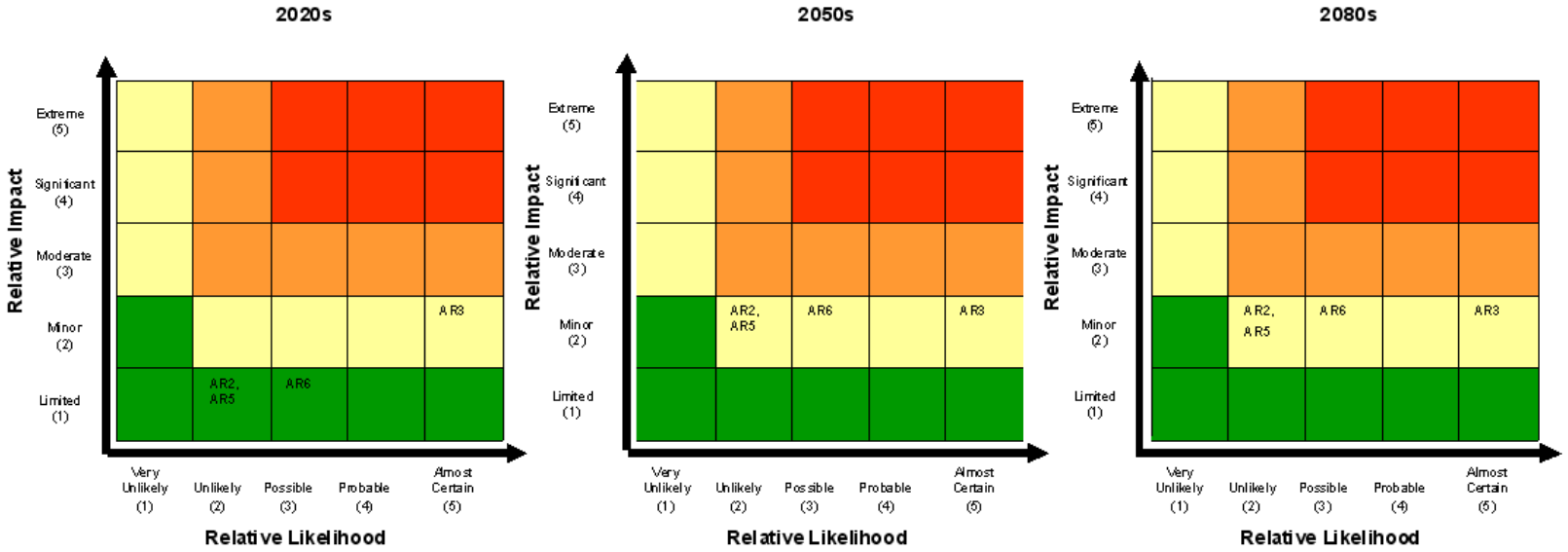
AR12	Substations affected by sea flooding due to increased sea levels and/or tidal surges.
AR13	Substations affected by water flood wave from dam burst.
AR14	**Overhead lines and transformers affected by increasing lightning activity.**

An increase in the frequency of strikes is likely to require UK Power Networks to add protection to some sites currently deemed low risk, and to revise the lifetime of lightning protection equipment. If further work were to demonstrate that there is likely to be an increase in the intensity of strikes, then UK Power Networks is confident that the equipment exists and is use in other countries to withstand these higher intensities.

2.3.6 Warmer, drier summers raising issues with earthing and vegetation management

The final areas of medium impact identified in the first-pass assessment were related to secondary aspects of climate change and are illustrated in Figure 6. In the first case, changes in patterns of precipitation and ambient temperature are likely to affect the growing patterns of vegetation. This is a critical issue for our stretches of overhead network in our Eastern and South Eastern licence areas. Part of our requirement to deliver safe, reliable supplies is to ensure that vegetation neither interferes with overhead lines nor provides climbable access to our equipment.

Figure 7 Adaptation risks associated with earthing, vegetation and ground movement



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AR14 Overhead lines and transformers affected by increasing lightning activity.

Changes in patterns of precipitation and ambient temperature may affect the effectiveness of soil to act as a conductor. In general, drier soils are more resistive and restrict the flow of current. This is related to the discussion of lightning above, since the safe path to earth for both lightning currents and other fault currents relies on good soil conditions. In less favourable soil conditions, more earthing metalwork is installed to make a greater contact area with the soil, or to make contact with deeper, damper soil. This is more expensive and less flexible on space-constrained sites. We are also seeking to understand what future soil conditions may mean for the stability of soil and potential ground movement around our assets and structures.

2.3.7 Wind impacts

Whilst our analysis does not specifically address the issue of future wind patterns and the impact of climate change on wind, there are several elements in our business plan for the period 2015 to 2023 which will address impacts from the increased possibility of larger storm events as seen in the USA in recent years.

Risks of extended interruptions to customers will be mitigated by the continued deployment of remote control and automation to the secondary distribution system. In addition, the extension of coverage of the overhead line network with additional pole mounted auto-reclosers and automatic sectionalising links will increase the speed of initial restoration and reduce interruptions on a more selective and discriminative basis. This enhanced coverage will also provide greater information to control engineers of disconnected parts of the high voltage network enabling more accurate targeting of overhead line resource dispatch.

As smart meters are rolled out, the opportunities for further improving storm response increase significantly with each passing month as the ‘last gasp’ feature of the smart meter will provide greater visibility of single premises supply failures. The provision of ‘first breath’ capability would also improve information on restored customers to assist better targeting of response resources.

2.4 Actions proposed to address risks

The preceding sections broke down the risks which are relevent to UK Power Networks business, and gave the background to the likelihood and consquence matrix shown for each of our license areas.

2.4.1 Actions which UK Power Networks will begin to undertake now

Based on the risk assessment carried out above and in particular noting the timescales at which the risks materialise and become a noticeable impact on our existing business model, UK Power Networks is taking a four-pronged approach:

- widening awareness of climate change and adaptation issues within the company
- continuing efforts to quantify high priority risks at a licence-area level
- collecting information on where impacts will first be felt at local level, in order to recognise opportunities for early interventions
- co-ordinating with other DNOs to upgrade standards for new-build, where the additional costs are a good fit to the risk and uncertainty in current climate predictions

A summary of our activities across these four areas is shown below.

	Status	On-going actions
Widen awareness	Multi-disciplinary team reporting to Director of Asset Management formed to carry out the risk assessment documented in this report.	Awareness briefings to the full team in each of the areas responsible for design standards, and to the wider management.
Quantify risk	Programme of R&D commenced in 2007 which has grown from an early study of network impacts of climate change using UKCP02 data to include a study of climate-related faults; a study of vegetation growth patterns; and a study of earthing effectiveness.	Review outcomes from the vegetation management and earthing field measurements. Review their implications for models of future vegetation growth close to our overhead lines and future performance of earthing.
		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.

Localise impacts	Remaining capacity of all primary and grid transformers[3] calculated annually, taking into account daily load and daily temperatures recorded by weather stations since 2006.	On-going review of investment plans in response to the conclusions.
	Programme of site-specific flood resilience actions in place in accordance with industry standard ETR138.	Review Environment Agency's Thames Estuary 2100 plan and review impact on our operational sites.
Co-ordinate upgrades to standards	ENA working group on Climate Change Adaptation operating since 2010. Long-standing ENA working groups in place which agree co-ordinated standards for the different asset classes (overhead lines, transformers, etc.).	Identify standards of interest and triage to the appropriate working groups.
	Programme of 'Smart Grid' trials has been underway since 2005 and was strengthened in 2010.	Identification of areas in which 'Smart Grid' solutions meet the needs not only of increased demand but also reduced ratings of assets.

2.4.2 The extent to which this will mitigate the risks identified

This report demonstrates that the effects of climate change are to amplify existing effects that our business is already dealing with. For example the reduction in capacity which is created by higher temperatures is the same as demand growth, which we manage as business as usual.

As such, we feel confident that the report has identified measures which have the potential to minimise impact on our customers. It is key that the funding of these interventions allows for flexibility to take opportunities as they arise in step with improving accuracy of climate predictions and improving certainty of the impacts.

2.4.3 Embedding the management of climate change risks in our organisation

To fulfil our strategy, UK Power Networks has existing risk management policies and procedures in place and which are well suited to managing climate change adaptation risks. Our approach to risk management is designed to provide a framework in which the business:

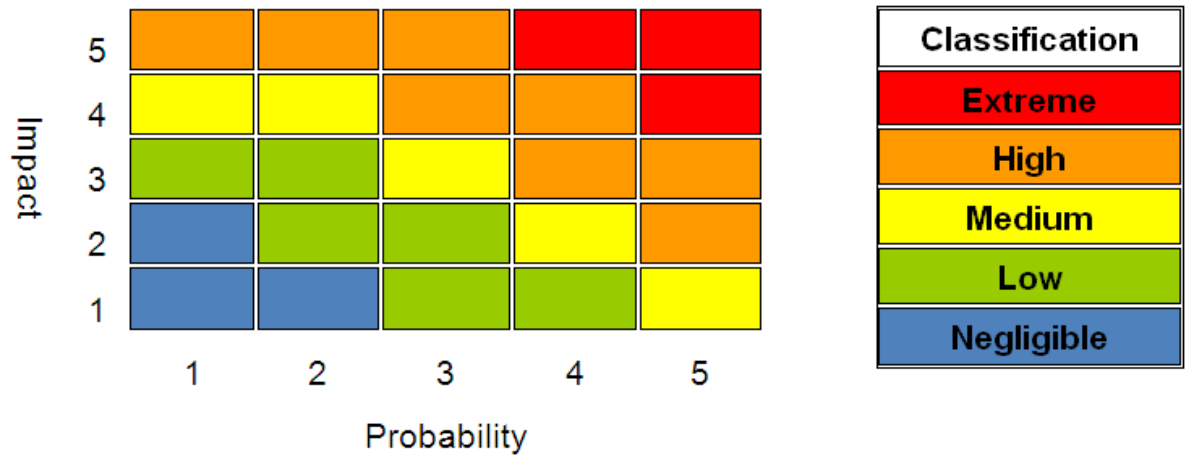
- **proactively** identifies risks to its strategy, objectives, business developments and processes and implements internal controls to mitigate these
- **explores** the efficacy of those controls in mitigating the risks through internal audit and other monitoring mechanisms
- **reactively** monitors incidents, errors and breaches to identify control failures and determine areas for improvement
- develops **contingency** arrangements for business continuity and emergency incidents

Responsibility for implementation of the risk management framework is delegated to the UK Power Networks Key Risk and Control Committee (KRC), which is supported by a Local Risk and Control Committee (LRC) within each business Directorate. All identified risks are identified and assessed by a business risk owner and escalated to the relevant LRC for authorisation to include on the risk register.

The risk assessment includes a review of probability, impact and control effectiveness. A risk mitigation strategy is defined and action plans are developed to address deficiencies. Risks are classified as extreme, high, medium, low or negligible based on a combination of impact and probability:

[3] These are typically our 132kV/33kV, 132kV/11kV and 33kV/11kV transformers, but a number of other variants exist on our network.

Figure 8 Probability and impact matrix used internally within UK Power Networks



The following climate change risks form part of the UK Power Networks risk register and are actively managed through the corresponding LRCs:

Table 3 Risks associated with unavoidable climate change captured on the UK Power Networks risk register

Risk Title	Classification
Risk of increased air conditioning load (AR8)	Low
De-rating of assets as a result of climate change (AR1,4,7,9)	Low
Degraded performance of earthing installations as a result of climate change (AR6)	Low
Increase vegetation growth due to climate change (AR3)	Low
Increased lightning as a result of climate change (AR14)	Negligible
Subsidence caused by dry soil conditions (AR2,5)	Low
Status of flood resilience programme and flood risk assessments (AR10,11,12,13)	Medium

Whilst we have outlined above the formal process by which risks are escalated through senior management, it is also useful to give an indication of where the issue of climate change adaptation sits alongside other issues facing the business. The table below shows a familiar RACI chart which explains how the adaptation issue is being managed. The table demonstrates that accountability is resting at the appropriate seniority for an issue with potential long-term impact, but mitigated by the timescales available to us in which to prepare and make interventions.

Table 4 Levels of accountability within UK Power Networks

	Manager / Senior engineer	Senior manager	Head of business unit	Director	CEO
Implementation of Health & Safety policy, reportable events			C	R	A
Lifecycle management of assets in accordance PAS 55[4]			C	R	A
Consolidated investment plan for a licence area		C	R	A	
Investment plan for an individual group of substations	R	A			
Critical national infrastructure and emergency planning		R	A		
Contingency plans for a 'black start' of the National Grid	C	R	A		
Supporting climate change mitigation through 'smart grids'		C	R	A	
Climate change adaptation plans	C	R	A		
R=responsible, A=accountable, C=consult, I=Inform					

2.5 Uncertainties and assumptions

2.5.1 Where we feel data is currently lacking

Data on the impact of UKCP09 forecasts on precipitation on river levels is limited to the work carried out by the Environment Agency and the Met Office for the Thames Estuary, and commentary within Planning Policy Statement 25. Our flood risk assessment methodology is well proven and will be able to use this data once available. Existing UK Power Networks sites at risk from flooding will be surveyed and the depth of flood water calculated based on the new data. This information will be available for each licence area as an intervention or investment plan.

There are still significant uncertainties within the UKCP09 data and the Met Office's models. For example, the range of different model predictions did not allow us to draw a firm conclusion on the impact of wind-related faults on our overhead networks. We will be keen to follow any further improvements in modelling.

2.6 Barriers to adaptation and interdependencies

2.6.1 Potential barriers to adaptation

In general, barriers to implementing adaptation are likely to be organisational, technical, or financial.

2.6.2 Organisational

UK Power Networks is confident that we are organisationally set up to manage the issue of climate change adaptation. Our accreditation to Publicly Available Specification (PAS) 55 validates that we are able to make risk-based and value-for-money-driven asset management decisions.

We recognise that effective asset management requires a disciplined approach which enables us to maximise value and deliver its strategic objectives through effective management of our assets over their whole life cycles.

[4] Publicly Available Specification (PAS) 55, discussed in further detail on page 24

This includes determination of appropriate assets to acquire or create in the first place, how best to operate and maintain them, and the adoption of optimal renewal, decommissioning and/or disposal options. Our PAS 55 accreditation requires us to have procedures in place to look at the long-term planning of our assets to provide a sustainable and risk managed approach as well as a clear audit trail for our asset management policy.

Many of our assets run on our networks for several decades, this lengthy service provides us with a challenge in managing long-term issues and in capturing accurate and timely information regarding the asset across this lengthy life cycle. PAS 55 provides us with a framework to monitor our assets across this lengthy life cycle.

We believe our existing risk management approach to corporate risks is suitable for managing the unavoidable climate change risks

2.6.3 Technical

We are confident that technical barriers can be overcome, since we are confident that any given risk can be traced back to either a well-maintained data source (such as flood data maintained by the Environment Agency) or to a physical effect which can be measured (such as ambient temperature rise). We have not identified any issue which would remain 'hidden' or hard to detect, or which rapidly deteriorates, and therefore actions can be timed in response to emerging data.

2.6.4 Financial

We do not see significant financial barriers that cannot be addressed over the time periods being discussed as we will have the opportunity to discuss our short and long term business plans with our regulator at each price control. We believe that the issues highlighted can be accommodated within the price control framework (known as 'RIIO'). The RIIO approach allows us the opportunity to put forward any incremental costs associated with adaptation actions as part our well justified business plan for the next period (2015 to 2023), and we will ensure that adaptation actions are clearly stated and separable within our plans.

2.7 Monitoring and evaluation

2.7.1 How we will monitor the outcomes of this risk assessment

As part of the UK Power Networks Risk, Control and Compliance Framework, risks are monitored monthly at Directorate Senior Manager Meetings and quarterly through the KRC and LRCs. The risk reviews include updates on the status of the risk, including any changes to the context of the risk, and progress in implementing agreed action plans. As new climate change data becomes available this will be reviewed by the risk owner and used to develop the response to the risk.

2.7.2 How we will measure thresholds and trigger points for action

The report has indicated a number of the control or monitoring measures which we currently have in place. The actions summary in Section 4 demonstrated that we assess the capacity of our grid and primary transformers on an annual basis, and can integrate outcomes into our investment plans. The discussion of flood risk in Section 3 emphasised that the new flood data available from the Environment Agency is analysed on receipt, and our policy is periodically reviewed to incorporate the new estimates and re-validate our list of prioritised sites. Lightning risk is monitored as part of our Health and Safety management plan and we would begin to view the historical record and trends in response to the risks identified.

Finally, we will periodically update our risk assessment in response to new releases of climate change predictions by the Met Office.

2.7.3 How we will monitor the residual risks

We will seek to work in a co-ordinated approach with other DNOs to manage the residual risk. In particular, where changing standards for new plant may be appropriate based on detailed analysis of the incremental cost weighed against the impact of accepting the risk of climate change.

2.8 Conclusion

The impact of climate change is an issue which UK Power Networks in common with other DNOs and TNOs have been addressing since 2008. We have built up a significant body of knowledge related to our specific industry and functions, and the issue had reached executive management attention as a potential corporate risk. This report is a culmination of our efforts to date.

UK Power Networks will actively manage the challenges presented by climate change adaptation at the same time as delivering on its key role of facilitating climate change mitigation by greater use of clean, renewably generated, electricity.

3 Appendices

A.1 Summary of all climate-related risks

(see next page)

		Identified impacts - based on predictions from UKCP09					
	Climate Related Changes	Warmer drier summers - daytime temperature increase of up to 8.1°C by 2080s compared with a 1990 baseline			Warmer, wetter winters - increased rainfall up to 67% compared with a 1990 baseline		Sea Level Rise 43cm 2080s
	Specific Risks	Temperature Increase	Drought (Soil Drying & Movement)	Prolonged High Temperature Periods	Flooding (Fluvial)	Flooding (Pluvial) / Heavy Rain	Flooding (Sea Breach including erosion risks)
Electricity Distribution Assets	Substations Transformers, Circuit Breakers, Protection & Earthing	Transformers affected by temperature rise, reducing rating. Switchgear affected by temperature rise, reducing rating. **L**	Substation and network earthing systems adversely affected by summer drought conditions, reducing the effectiveness of the earthing systems. **M**	**M**	Substations affected by river flooding due to increased winter rainfall. Serious damage to substation equipment possible (protection systems most at risk). **H**	Substations affected by pluvial (flash) flooding due to increased rain storms in summer and winter. **M**	Substations affected sea flooding due to increased sea levels and/or tidal surges (protection systems m at risk) **H**
	Network between substations Overhead Lines Applies to Eastern and South Eastern only	Overhead lines affected by interference from vegetation due to prolonged growing season. **L**	**L**	Overhead line conductors affected by temperature rise, reducing rating and ground clearance. **M**	Overhead Lines are more resilient to flooding risks providing land supporting poles does not subside. **L**	**L**	**L**
	Cables	Underground cable systems affected by increase in ground temperature, reducing ratings **L**	Underground cable systems affected by summer drought and consequent ground movement, leading to mechanical damage. **L**	Underground cable systems affected by increase in ground temperature, reducing ratings **M**	Anecdotal evidence would suggest that underground cables are less resilient to water following prolonged dry spells but the met Office reports found no direct correlation between cable faults and rainfall. **L**	**L**	**L**
Processes	Vegetation Management around Overhead Lines Applies to Eastern and South Eastern only	Changes in vegetation growth, including increased tree growth **M**	**M**	**NE**	**NE**	**NE**	**NE**
	Logistics	**NE**	**NE**	**L**	**L**	**L**	**L**
	Field Staff / Human Resources	**L**	**NE**	**M**	**L**	**L**	**L**
	Operations Centres	**NE**	**NE**	High level of resilience and redundancy already required for security and business continuity reasons **L**	**L**	**L**	**L**
	Customer Service	**NE**	**NE**	Risk of staff absence do to health/heat impacts affecting customer services **L**	Disruption to normal travel arrangements caused by flooding; staff unable to travel to normal place of work **L**	**L**	**L**

Key:
H = High Impact, M = Medium Impact, L = Low Impact, NE = None Expected
High Network component/function temporarily disabled. Function severely disrupted.
Medium Network component/function substantially reduced in capacity or damaged. Function disrupted.
Low Network component/function reduced in capacity or suffers minor damage. Function suffers minor disruption.

Identified impacts - based on the Met Office's Regional Climate Model (RCM)					Specific characteristics for UK Power Networks
Possibility of an increase in wind gusts	**Decrease in the number of days on which snow occurs in the future**	**Possible increase in lightning faults of between 8 and 32% in SE England by 2080 and between 4 and 35% in East of England.**	**Projected increase in maximum temperature.**		**Summer daytime temperature increase**
Wind and gale faults	**Snow sleet and blizzard (SSB) faults (including ice) - decrease of approx 50% to 90%**	**Lightning faults**	**Solar heat faults**		**Demand increase due to Mitigation and HVAC**
NE	**NE**	**NE**	Faults at any voltage are seldom recorded in fault reporting systems. The Met Office reports are based on a very small data set and as such the risk from increased solar heat faults is low. **L**		Transformers affected by urban heat islands and coincident air conditioning demand leading to overloading in summer months. **H** **(More likely to occur in LPN)**
Met Office studies show that on average, the number of wind related faults is likely to stay the same. There is some uncertainty in the models that shows wind gusts (biggest cause of wind related faults) may increase or decrease. **L**	Met Office studies suggest that days on which snow falls will decrease by up to 95% in the next 60 years. However, on days when it does snow there is an increased chance of 6% that a snow related fault will occur - this poses a negligible threat to the network. **NE**	Met Office studies show with confidence that frequency of lightning faults will increase by up to approximately 30% towards 2080. Overhead line networks are vulnerable to lightning strikes however existing mitigations mean that lighning can be viewed as a medium risk. **M**	Faults at any voltage are seldom recorded in fault reporting systems. The Met Office reports are based on a very small data set and as such the risk from increased solar heat faults is low. **L**		**H**
NE	**NE**	**NE**	Faults at any voltage are seldom recorded in fault reporting systems. The Met Office reports are based on a very small data set and as such the risk from increased solar heat faults is low. **L**		Urban heat island effect reduces cable rating **H**
NE	**NE**	**NE**	**NE**		**NE**
NE	**NE**	**NE**	**NE**		**NE**
NE	**NE**	**NE**	**NE**		**L**
NE	**NE**	**NE**	**NE**		**NE**
NE	**NE**	**NE**	**NE**		**NE**