SSEN Climate Change Adaptation Report - Third Round, December 2021

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Scottish & Southern Electricity Networks

Contents

1 Executive Summary

1.1 Management of network assets are an integral part of the Scottish and Southern Electricity Networks (SSEN) business and demand continuous review and revision to reflect changing technology, regulatory requirements, network demands and environmental impacts. These principles are reflected in a defined and integrated risk-based asset management system that provides an efficient cost-effective solution, ensures that SSEN meets its asset management objectives and continues to be certificated to BS ISO 55001:2014, Asset Management.

1.1.1 This is a combined report covering the three businesses which comprise SSEN each registered to report under the Adaption Reporting Power.

- Scottish Hydro Electric Transmission Limited
- Scottish Hydro Electric Power Distribution Plc
- Southern Electric Power Distribution Plc

1.2 It is recognised that there is a high probability of climatic change over the next 100 years but it must also be recognised that assets have a life varying from 25 to 80 years and as such, in conjunction with appropriate mitigation, the need to replace assets purely for climate change is relatively low.

1.3 When assets are replaced, SSEN aim to ensure that the replacements conform to the latest standards. In addition, where cost effective changes can assist with the mitigation of potential impacts of climate change, SSEN will adopt these practices as a matter of course.

1.4 SSEN regularly review, revise and implement internal strategies such as assessing and mitigating the effects of flooding on grid and primary substations, and a commitment to reduce SF6 emissions.

1.5 SSEN have, and will, continue to employ a flexible and diverse range of research and development work to forecast, prepare for and mitigate the effects of climate change both within SSEN and in collaboration with the rest of the sector. This approach allows the re-assessment of migration risks (as future information on climate change is realised) to be factored in to SSEN Asset Management Strategy at an early stage.

1.6 SSEN strongly believes in taking learning from weather events to help mould the understanding for development of strategies to make SSEN network more resilient.

1.7 In considering the changes of risk since the Second Round Report SSEN have conclude that there is one risk which has been reduced, switchgear affected by temperature rise, and one, and one newly emerging risk, that of wildfire.

1.8 SSEN have been early adopters of many practices that have over the years resulted in an increasingly resilient network as can be demonstrated by the dramatic improvements in network performance over the last 20 years.

Examples of these early adoptions, which are still being deployed, include:

- Use of covered conductor (termed BLX) on High Voltage (HV) overhead wood pole lines

- Use of aerial bundled conductor on Low Voltage (LV) overhead wood pole lines
- Standardisation of minimum sizes for LV and HV distributor cables, 185 mm^2 and 150 mm^2 respectively
- Increase in minimum size of three phase secondary transformers to 500 kVA for ground mounted units, and 50 kVA for pole mounted units to reduce system losses
- Installation of transformers that outperform, in terms of losses, the Commission Regulation (EU) No 548/2014 (Ecodesign – Transformers) rated at voltages of 132 kV, 66 kV and 33 kV
- Adoption of cable ploughing techniques to improve the economics and environmental impact of underground cable laying
- Network automation and storm management systems, which have enhanced the ability to respond to extreme weather events that are likely to typify climate change
- Enhanced fault location techniques to reduce impact of power cuts on LV systems

1.9 In conclusion, SSEN have a good understanding of the risks associated with climate change. The management of these risks is already embedded within SSEN Asset Management System. Should climate change accelerate then SSEN will strive to modify or re-design assets during the maintenance cycle.

2 Introduction

2.1 SSEN is the Distribution Network Operator (DNO) for both Central Southern England and the North of Scotland. In addition, in the North of Scotland SSEN are the Transmission Network Operator. SSEN Distribution is responsible for ensuring a safe and reliable supply of electricity to 3.8 million customers in communities across its network.

2.2 This document, produced by SSEN, specifically encompasses, qualifies and expands on the Third Round Climate Change Adaptation Report produced by the Energy Networks Association (ENA) for Gas and Electricity Transmission and Distribution Network Companies.

2.3 The ENA report serves as a basis for this individual SSEN report which include specific responses and considerations, these are shown adjacent to the corresponding position of the ENA response.

2.4 This document reports the progress SSEN has made since the Second Round Climate Change Adaptation Report (link – SSEN CCAR2).

2.5 The ENA Third Round Climate Change Adaptation Report can be found in full in Appendix A.

2.6 Unless otherwise stated in this document terms 'SSEN' and 'DNO' shall cover both the SSEN Transmission and Distribution businesses.

3 References

The documents detailed in Table 3.1 - Scottish and Southern Electricity Networks Documents and Table 3.2 –External Documents can be used in conjunction with this document, please note that some may have to be purchased.

Table 3.1 - Scottish and Southern Electricity Networks Documents

Reference	Title
SSEN CCAR2	SSEN Climate Change Adaptation Report Second Round July 2015

Table 3.2 –External Documents

Reference	Title
ENA ETR 132	Improving resilience of overhead networks under abnormal weather conditions using a risk-based methodology
ENA ETR 138	Resilience to flooding of Grid and Primary substations
ENA CCAR3	ENA Third Round Climate Change Adaptation Report

4 Acronyms

4.1 The acronyms shown in Table 4.1 are used throughout this document.

Table 4.1 - Acronyms

Reference	Title
AAAC	All Aluminium Alloy Conductor
AR	Adaptation Risk
ARP	Adaptation Reporting Power
BEIS	Department for Business, Energy and Industrial Strategy
BLX	Belagt Linesystem XLPE

Reference	Title
BS	British Standard
CCAR	Climate Change Adaptation Report
DEFRA	Department for Environment, Food and Rural Affairs
DFA	Distribution Fault Anticipation
DNO	Distribution Network Operator
E3C	Energy Emergencies Executive Committee
EA	Environment Agency
ENA	Energy Networks Association
HSE	Health and Safety Executive
HV	High Voltage
ISO	International Organisation for Standardisation
LIDAR	Laser Imaging Detection and Ranging
LV	Low Voltage
NRW	Natural Resources Wales
Ofgem	Office of Gas and Electricity Markets
SEPA	Scottish Environment Protection Agency
SF6	Sulphur Hexafluoride
SSEN	Scottish and Southern Electricity Networks
UK	United Kingdom
UKCP	UK Climate Projection

5 The ENA Third Round Climate Change Adaptation Report

5.1 Method of producing the report and background information

5.1.1 The ENA is the trade association representing the energy networks in the UK and Ireland, of which SSEN is a member. The group assessment report has been developed in response to the requirements placed on reporting authorities by the Climate Change Act under the Third Round of Adaptation Reporting.

5.1.2 The ENA and its members have contributed to all rounds of climate change adaptation reporting: -

- In ARP1 the group established the response as a collaborative project amongst electricity network operators and identified key risks to network assets and operation posed by climate change impacts
- In ARP2 the group built on the understanding of the risks and updated DEFRA on industry mitigation measures being put into place on the networks. The group developed a consistent reporting methodology from ARP1 and provided further evidence of actions taken in response to key climate risks
- In ARP3 the group aim is re-assessment and review of existing risks, mitigation measures and programmes, and to look to identify new risks materialising to provide

an enhanced picture of how the potential for climate change influences and affects networks.

5.1.3 The ENA report has been prepared by a task group of electricity distribution and transmission network operator members of ENA and is intended to provide a response to climate change adaptation on behalf of the Energy Networks. This SSEN report continues the progress made since the Second Round of reporting and should be read in conjunction with the SSEN Second Round Report.

5.1.4 The ENA report intentionally provides information at an industry level. SSEN have used the ENA report as the basis for its individual report and included company specific information.

5.1.5 Transmission and distribution companies in Great Britain are regulated businesses and operate under licences issued by the Ofgem, and are also subject to common statutory requirements which are overseen by the BEIS, HSE, EA, SEPA and NRW. Revenues for the industry are set by Ofgem in periodic price reviews and costs associated with adaptation to climate change have to be presented to Ofgem via well-defined and justified business cases.

5.1.6 Transmission and distribution companies are responsible for transporting electrical power from generating plants to customers over their networks. Overall levels of supply security are agreed with Ofgem and these standards specify the requirements for the availability of alternative supplies at various levels of customer load. Although these standards allow for the loss of multiple electrical circuits, they do not provide for certain low probability events including multiple failures or the total failure of the network. Particular attention must therefore be given to key sites when considering network resilience.

5.1.7 Whilst every effort is made to ensure network resilience, companies have well developed business continuity and emergency plans to ensure an effective response to a range of events that can affect both transmission and distribution networks. Under the terms of the Civil Contingencies Act, network operators are Category Two responders and work closely with other utilities, the emergency services and local authorities. They are also active participants in the BEIS E3C (Energy Emergencies Executive Committee).

5.2 Headline climate change impacts

5.2.1 The main impacts on electricity networks from the latest independent Met Office UKCP18 (link - About UKCP18 - Met Office)climate change projections remain: -

- Temperature—predicted increase
- Precipitation—predicted increase in winter rainfall and summer droughts
- Sea level rise—predicted increase
- Storm surge—predicted increase
- Increasing wet – dry cycles
- Increasing windstorm frequency (particularly when following high intensity precipitation)
- Significant cold spells – predicted decrease but more severe

- Wildfire

6 Climate Change Research and Met Office Report Outputs

6.1 In considering adaptation to climate change, electricity network companies use the Met Office UK Climate Projection (UKCP18) tool and take into account projections to the end of this century as much of the network infrastructure generally has an operational life expectancy of 30-80 years. In spring / summer 2020, on behalf of its members, the ENA commissioned the Met Office to undertake a review of the UKCP18 data and existing studies in order to understand the changes in potential impact to energy networks equipment from climate change. The report from this research has been used to assess the current risks to the energy network, and to guide future mitigation or management actions. In addition, other tools, for example the Landmark flood mapping tool (©Landmark Information Group), have been used by energy network organisations in research and risk assessment independent to the ENA Met Office research. Because of the diversity of the hazards, it was decided to prioritise those which pose the highest risk to energy network assets, and the assessment process was accordingly graded to provide an appropriate focus.

6.2 A full climate assessment was produced for the highest priority hazards: -

- Prolonged rainfall leading to flooding
- Extreme high temperatures
- Heavy rainfall/drought cycles

Since there is currently no strong signal within the climate projections for a change to future storm intensity, the risk of strong winds was assessed in the current climate only.

For the remaining lower priority hazards, a qualitative approach was undertaken: -

- Sea level rise
- Warm and wetter conditions, followed by heavy rainfall and/ or wind
- Storm surge and wave height
- Warmer and wetter conditions – longer growing/nesting seasons
- Snow and ice
- Wildfire
- Lightning
- Solar storm
- Diurnal temperature cycles

6.3 Many of the hazards identified by ENA members are projected to increase due to future climate change: increased frequency of high temperature days, prolonged rainfall events, hourly rainfall extremes, sea-level rise, extreme sea level events, increased risk of wildfire and increased extreme diurnal cycle events are all expected over the 21st century. On the other hand, the frequency of snow and ice days are expected to decrease. Hazards for which there is little evidence for a change in frequency include strong wind events, high wave heights, wetter conditions coincident with warmer temperatures and/or strong winds, lightning and to some extent, diurnal temperature cycles. Solar storms are not affected by increased greenhouse gases, so a study of historic occurrence of this hazard has been presented. The societal response to climate change has also been considered in the context of hazards to the energy network. Impacts of the weather hazards on the energy network are likely to come in the form of an altered dependency between weather and both supply and demand. Increases to the prevalence of electrified heating and electric vehicles increases the reliance on the electricity network by consumers. This increases the impact of hazards on the electricity network. Interconnections between different industry sectors is a major source of risk for the energy network, with failures from one sector frequently causing impacts. Telecommunications and road transport are thought to be the most important sources of risk. Telecommunications are already important for automated and remotely controlled equipment, and for communication with personnel in the field. Risk from telecommunications failure has the potential to increase in the future with greater reliance on smart systems (dependent on telecommunications). Road transport is often essential for restoration of supply and access to assets for routine maintenance and emergency restoration. Societal responses to climate change may also increase the risk on the road network from the electricity network, as electric vehicles become more commonplace.

7 Climate Change Adaptation Risks

This section details the adaptation risks referenced in the First and Second Round Reports and highlighted in the third-round reporting template. The climate variables and their impact on the transmission and distribution networks have been identified. The mitigation measures that have been proposed by the ENA Task Group are outlined in Section 8. Where appropriate SSEN have modified or enhanced the wording in the third round reporting template.

7.1 AR1 Temperature - Overhead line conductors affected by temperature rise

Thermal expansion of conductors throughout the year is a design consideration for overhead lines. Supporting structures are designed to account for conductor sag to ensure statutory ground to conductor clearance is maintained. Lines are currently designed using three temperature zones, Winter, Spring/Autumn and Summer. Where these lines are exposed to temperatures considered extreme by UK standards, and where the frequency and duration of these events increases, it is possible that sag will exceed the current overhead line design parameters. This could lead to an increasing number of occasions where conductor clearance limits are compromised. Increasing temperatures also reduces the capacity of the conductors and constrains the network as a consequence. Conductors are designed to operate at a maximum core temperature corresponding to a specific ambient temperature and load (current) rating. Heat produced in the core of the overhead line is due to the electric load it is carrying. As the ambient air temperature increases the core temperature increases as does the resistance within the conductor culminating in a reduction in its current (load) rating or an exceedance of its design temperature. The advent of higher usage of electricity in the Summer could result in lines needing to be upgraded to account for the higher load and ambient temperatures.

7.2 AR2 Temperature - Overhead line structures affected by Summer drought and consequent ground movement

Increasing temperatures will, without precipitation, lead to drying of the certain types of ground causing it to shrink. Any structures built on this ground could be subject to movement which, as well as being exacerbated by the height of the structure (subject to being affected by strong winds), can lead to instability of the foundations. Overhead line structures are more vulnerable to this movement, but it can also impact on ground mounted structures such as transformer bases and switch house foundations.

7.3 AR3 Temperature / precipitation - Overhead lines affected by interference from vegetation due to prolonged growing season

Increases in both temperature and precipitation will lead to increased vegetation growth. This impacts on overhead lines as increased growth of branches of trees growing adjacent to the overhead lines can reduce electrical clearances leading to faults and physical damage.

The extended growth season also results in deciduous tree retaining their leaves longer, now encroaching the tradition 'storm' seasons making them more susceptible to toppling.

7.4 AR4 Temperature - Underground cable systems affected by increase in ground temperature

Increasing ambient temperatures can increase the ground temperature in which the cables are installed. Cables are designed to operate up to a design core temperature corresponding to a specific ground temperature and load (current) rating. Heat produced in the core of the cable is due to the electric current it is carrying. As the ground temperature increases less heat can be conducted from the cable. The effect is to reduce the current (load) carrying capacity of the cable.

7.5 AR5 Temperature - Underground cable systems affected by Summer drought and consequential ground movement

Ground movement caused by drying and shrinkage can exert tensile forces on cables. Whilst cables have an inherent tensile strength, joints in the network are more vulnerable and can fail by being effectively pulled apart. Extreme wet-dry and freeze-thaw ground movements may have a similar impact.

7.6 AR6 Temperature - Substation and network earthing systems adversely affected by Summer drought conditions

As moisture in the soil reduces the soil resistivity increases reducing the effectiveness of the earthing system. Where earthing design parameters are exceeded, system and public safety issues can arise with increased touch potential voltages or failure to disconnect faulty assets in a timely manner.

7.7 AR7 Temperature - Transformers affected by temperature rise

Transformers are designed to operate within particular temperature parameters and are assigned a maximum operating temperature for a given ambient temperature and load current. As air temperature increases, for the same load current, the operating temperature can exceed the maximum operating temperature of the transformer. Such situations can causing overheating of the transformer reducing capacity and life expectancy and, in extreme cases, cause failure of the unit.

7.8 AR8 Temperature - Transformers affected by urban heat islands and coincident air conditioning demand

Localised build-up of heat, particularly in city environments, will lead to increased demand from air-conditioning and ventilation unit operation; some network operators are now seeing very little difference between Summer and Winter demand. Traditionally Summer was always the season of reduced electricity usage and could be exploited when rating a transformer, which is normally rated for Winter demands and lower ambient temperature. Increased Summer demand can overheat the transformer reducing capacity and life expectancy and, in extreme cases, cause failure of the unit.

7.9 AR9 Temperature - Switchgear affected by temperature rise

Increasing temperature impacts all plant and equipment and increases will impact on switchgear by reducing its capacity, or in extreme cases lead to the switchgear tripping resulting in loss of supply or operating incorrectly and damaging the network. Prolonged periods of hot weather will increase the temperature inside switch rooms and could exceed the maximum optimum operating parameter for the switchgear increasing the potential for faults or mal-operation of protective devices.

Switchgear is designed to international standards, however, there are recorded days where switch room ambient temperatures have exceeded the operational maximum of the switchgear. This may result in substations requiring air conditioning/chilling to be installed.

7.10 AR10 Precipitation - Substations affected by river (fluvial) flooding due to increased winter rainfall

Increasing periods of rainfall could extend the area of traditional flood plains beyond there recorded extents resulting in flooding of substations not currently protected with flood defences.

Significant increases in rainfall could result in the flood defences of existing substations being breached.

7.11 AR11 Precipitation - Substations affected by pluvial (flash) flooding due to increased rainstorms in Summer and Winter

Unpredictable flash floods of high intensity could result in substations which do not require fluvial defences being engulfed with flood water. Such situations may be of short duration but water ingress into the electrical plant could cause failures and disruption to electrical supplies.

7.12 AR12 Precipitation - Substations affected by sea flooding due to increased rainstorms and/or tidal surges

Plant and equipment is physically damaged by flood water, with water ingress causing failure within the assets leading to loss of supply to the network. Consequential repair or replacement of assets is costly and time-consuming extending restoration of supply to local areas, being exacerbated by the presence of residual flood water. SSEN will often choose to switch out plant and equipment to avoid water ingress causing a failure or uncontrolled disconnection of the network; however, this can still result in assets requiring replacement. Saline water causes more damage to electrical equipment than non-saline water which can be dried out in some circumstances restoring the asset to a usable condition.

7.13 AR13 Precipitation - Substations affected by water flood wave from dam burst

Where substations are located far enough away from dams the impact of water inundation from a dam burst is no different from “standard” pluvial, fluvial, or tidal flooding and flooding impacts can be considered similar.

Where substations are close enough to dams to be impacted by the full force of a breach, the damage to a substation would be substantial. Plant and equipment would not only be impacted by water ingress but are likely to be physically damaged or even washed away by the force of water. Where a substation site has been impacted by the full force of a dam breach, it would not be possible to re-establish supply without fully reconstructing and recommissioning the site.

7.14 AR 14 Overhead lines and transformers affected by increasing lightning activity

Increased storm frequency can lead to an increased lightning strike frequency. Where lightning strikes exposed substation plant or, more likely, overhead line assets, the resulting surge will cause circuits to trip under fault condition. In extreme cases strikes will lead to physical damage to the assets or a loss of generation, leading to loss of supplies.

7.15 AR15 Wildfire - Overhead lines and underground cables affected by extreme heat and fire smoke damage

This risk has been added for the Third Round reporting following the Saddleworth Moor wildfires in 2018. Although a consequential risk of increased temperatures and reduced precipitation, wildfire poses a significant risk to overhead line structures and conductors where they are located in susceptible areas such as open heathland.

Operational telecommunication systems, strung on overhead lines are also considered at risk from this scenario, and without operational telecoms it is impossible to remotely control and monitor the network and an extended loss of supply could occur following an unrectified fault.

8 Risk Mitigation and Management

8.1 AR1, AR2, AR4, AR5, AR6, AR7, AR8

SSEN will continue to monitor its network and asset performance to assess the physical impacts of climate change, including the increased likelihood of global temperature rise, in its Design, Installation and Operational Strategies, implementing climate adaptation plans. It should be noted that SSEN use cables and overhead conductors designed and manufactured to international standards, and consequently these assets are designed to operate safely in much greater range of temperature than those found in the UK.

8.2 AR3

SSEN treat vegetation growth as a business-as-usual activity and manage it as part of our ongoing overhead line maintenance and clearance programmes. ENA document ETR 132, Improving resilience of overhead networks under abnormal weather conditions using a risk-based methodology, provides industry guidance on the management of vegetation below and to the side of overhead line routes. This document is reviewed on a regular basis and would incorporate a suggestion of increased frequency of tree cutting and vegetation management if the business-as-usual programmes were not managing to maintain minimum clearances or in the light of increasing storm frequency.

8.3 AR9

In the main SSEN switch rooms and plant enclosures are designed to maximise the use of natural ventilation to keep internal temperatures within plant and equipment operating within their optimum parameters. Where heat build-up is perceived to be an issue forced ventilation is used and, in extreme cases or where the path to an external air inlet is problematic, air conditioning is considered.

8.4 AR10, 11 & 12

Throughout the DPCR5, RIIO ED1 and T1 price control periods, SSEN have undertaken an extensive flood protection programme to provide physical protection and network reconfiguration to minimise disruption from localised flood events. Dependent on the outcome of the next regulatory settlement, the flood protection programmes will continue into RIIO ED2 and T2 to accommodate recommendations raised in the 2016 Government National Flood Risk Review. New substation development and substation reinforcement schemes will continue to reference guidance from the ENA ETR 138 document, Resilience to flooding of grid and primary substations.

8.5 AR13

It is understood that dams are now designed to a 1:10,000 risk of failure, far exceeding the 1:1000 design risk utilised for assessing and developing flood protection measures for substations with more than 10,000 connected customers. While SSEN will try and avoid constructing new primary or grid substations within the breach zone of a dam, there is currently no programme to relocate existing substations, it being problematic to supply the existing network in these areas from remote sites.

8.6 AR14

Storm and lightning frequency are not expected to increase, and technical controls are currently employed to mitigate against lightning strikes and protect network equipment. Enhanced earthing, the installation of surge arresters on plant, and other equipment are business-as-usual for SSEN but will be re-valuated if strike frequency increases.

8.7 AR15

The impact of increasingly dry and warm summers on the frequency of wildfires has yet to be established. Once established the frequency would need to be ratified against a potential increase of risk to overhead line and operational telecommunications assets. SSEN acknowledges the possibility of this emerging wildfire risk and are maintaining a watching brief on events and event frequency in relation to its assets.

9 Risk Assessment

9.1 As part of the First and Second Round Reporting the risks AR1-14, shown in Table 9.1, were assessed and quantified in the Risk Matrix as set out in Figure 1. To provide comparison, the assessment has been repeated for the Third Round Report in Figure 2, utilising the information and predictions set out in the Met Office Report (see Section 6).

9.2 AR15 is a new risk identified during the Third Round review and therefore has only been shown in the Risk Matrix in Figure 2.

9.3 Energy Networks combined Risk Matrices can be found in the ENA Third Round Climate Change Adaptation Report.

Table 9.1 – Summary of Climate Change Adaptation Risks, Task Group and SSEN Risk Scores

Risk Code	Task Group Risk Score	Climate Variable	Impact	Task Group ARP3 Risk Considerations	SSEN Risk Score ARP2	SSEN Risk Score ARP3	SSEN ARP3 Risk Considerations
AR1	9	Temperature	Overhead line conductors affected by temperature rise	Localised increase in pole heights and age-related replacement maintains line clearances	10	10	SSEN considers that long term this risk will go up due to increased loadings (move towards more electric than gas) hence reduced clearances. Internal review has been proposed to establish whether it would be necessary to update design standards for overhead lines to specify the upsizing of capacity to meet future load demands and projected higher temperatures. For specific schemes requiring high load transfer the use of low sag conductors is being employed. This technology will also be considered to defer replacement of existing towers where these are still serviceable.

Risk Code	Task Group Risk Score	Climate Variable	Impact	Task Group ARP3 Risk Considerations	SSEN Risk Score ARP2	SSEN Risk Score ARP3	SSEN ARP3 Risk Considerations
AR2	6	Temperature	Overhead line structures affected by Summer drought and consequent ground movement	No significant changes in UKCP18 predictions over UKCP09	4	4	Tower line conductors are replaced approximately every 60 years and the opportunity can be taken at each reconductoring to access the design integrity to the latest standards. AAAC are recommended for use in the future and replacement projects to extend lifespan of conductors, although the risk will stay unchanged. Summer droughts can cause ground shrinkage which can lead to de-stabilisation of the foundations of single structures and towers. A technical review has been proposed to be carried out to ascertain the real risk of this occurring and any mitigation required.

Risk Code	Task Group Risk Score	Climate Variable	Impact	Task Group ARP3 Risk Considerations	SSEN Risk Score ARP2	SSEN Risk Score ARP3	SSEN ARP3 Risk Considerations
AR3	8	Temperature/ Precipitation	Overhead lines affected by interference from vegetation due to prolonged growing season	Emerging risk. Impact dependent on geology and topology	9	9	SSEN has reviewed and increased its tree cutting cycle frequency from 4 to 3 years to maintain current risk score in Distribution and ensure compliance with all appliable regulatory standards. Frequency remaining at 4 years for Transmission. Use of LIDAR system to aid in the management of trees is being utilised allowing a better understanding of circuit resilience to be amassed. This will allow risk-based tree management to be employed. Covered conductor will be the overhead asset replacement option, with the aim to create a more tree resilient line ensuring that the line can remain live but also safe with a tree having fallen onto it. In addition, building on the ongoing DFA technology trial of smart technology to detect where and what type of faults have occurred quicker and more efficiently on the HV network SSEN aim to make use of smart technology to reduce fault response time.

Risk Code	Task Group Risk Score	Climate Variable	Impact	Task Group ARP3 Risk Considerations	SSEN Risk Score ARP2	SSEN Risk Score ARP3	SSEN ARP3 Risk Considerations
AR4	9	Temperature	Underground cable systems affected by increase in ground temperature	Limited data on impact on cable ratings	10	10	Internal review has been proposed to determine the effects of increase in ground temperature on underground cable systems. The effects of local generation and the changes to cyclic loading at the LV level shall be considered in future network designs.
AR5	6	Temperature	Underground cable systems affected by Summer drought and consequential ground movement	Emerging risk. Impact dependent on geology and topology	4	4	SSEN have not experienced an increase in cable failings related to ground conditions and movements to this point. Internal review has been proposed to establish whether it would be necessary to update design standard for the use of ducted cable systems in urban environments to mitigate the impacts of the drying out of soils.
AR6	6	Temperature	Substation and network earthing systems adversely affected by Summer drought conditions	Limited test data available, but anecdotally Grid and Primary substations are buried deep enough to only experience minor impact in performance	6	6	SSEN have not experienced earthing system failings specifically related to summer drought conditions Internal review has been proposed to explore a risk-based approach that could be used to inspect and monitor changes in conditions of network earthing systems following extreme summer drought periods.

Risk Code	Task Group Risk Score	Climate Variable	Impact	Task Group ARP3 Risk Considerations	SSEN Risk Score ARP2	SSEN Risk Score ARP3	SSEN ARP3 Risk Considerations
AR7	6	Temperature	Transformers affected by temperature rise	Temperature rise accommodated in design.	6	6	Where transformers have radiators, internal review has been proposed to investigate the need for increasing the size of the radiators or the use of water cooling to address the concerns in relation to temperature rise. Providing the current cyclic rating is used a rise in ambient temperature will only have a slight reduction in predicted life. On sites with redundancy in transformers required for network security this situation will be less pronounced. SSEN shall explore installation of temperature monitors for monitoring temperature and humidity conditions in distribution substations and primary substations where applicable. SSEN shall ensure all newly installed equipment and where possible installed equipment is clearly labelled as to their maximum permitted temperatures. This combined with temperature monitoring infrastructure shall alert for inspection when temperatures have reached the maximum tolerable levels.

Risk Code	Task Group Risk Score	Climate Variable	Impact	Task Group ARP3 Risk Considerations	SSEN Risk Score ARP2	SSEN Risk Score ARP3	SSEN ARP3 Risk Considerations
AR8	9	Temperature	Transformers affected by urban heat islands and coincident air conditioning demand	Managed through load planning although extended high load my reduce the life expectancy of the transformer	6	6	Considerations for AR7 are applicable to this section as well.
AR9	4	Temperature	Switchgear affected by temperature rise	Temperature rise accommodated in design	10	8	SSEN design standards, where applicable, consider provision for suitable environmental conditions such as increased ventilation, air-conditioning and dehumidification that will function in line with the changing climate conditions. Provision for additional ventilation, air-conditioning and dehumidification in current substations are being considered as applicable.

Risk Code	Task Group Risk Score	Climate Variable	Impact	Task Group ARP3 Risk Considerations	SSEN Risk Score ARP2	SSEN Risk Score ARP3	SSEN ARP3 Risk Considerations
AR10	9	Precipitation	Grid and Primary Substations affected by river flooding due to increased winter rainfall	While risk of flooding has increased the asset protection measures employed have offset and reduced the risk	20	20	SSEN have assessed, mitigated and will monitor, the risk and resilience of critical substations affected by river flooding and where required develop local flood mitigation plans. Further investment in flood mitigation measures will be considered for critical substations affected by river flooding (e.g. raising individual sites above the flood level or the installation of temporary barriers). SSEN shall continue to design substations in line with ENA ETR 138 which applies to Grid and Primary sites and consider the use of flooding maps developed by EA and SEPA in future network designs.
AR11	6	Precipitation	Grid and Primary Substations affected by pluvial (flash) flooding due to increased rainstorms in Summer and Winter	While risk of flooding has increased the asset protection measures employed have offset and reduced the risk	20	20	Considerations for AR10 are applicable to this section as well. SSEN will continue to monitor the surface water flooding maps as they are evolved by the environmental agencies.

Risk Code	Task Group Risk Score	Climate Variable	Impact	Task Group ARP3 Risk Considerations	SSEN Risk Score ARP2	SSEN Risk Score ARP3	SSEN ARP3 Risk Considerations
AR12	8	Precipitation	Grid and Primary Substations affected by sea flooding due to increased rainstorms and/or tidal surges	While risk of flooding has increased the asset protection measures employed have offset and reduced the risk	20	20	SSEN have assessed, mitigated and will monitor, the risk and resilience of critical substations affected by sea flooding and where required develop local flood mitigation plans. Further investment in flood mitigation measures shall be considered for critical substations affected by sea flooding (e.g. raising individual sites above the flood level or the installation of temporary barriers). SSEN shall continue to design and protect substations in compliance with ENA ETR 138 which applies to Grid and Primary sites and consider the use of flooding maps developed by EA and SEPA in future network designs. SSEN shall explore opportunities to restore seagrass beds in the SSEN licence areas working with existing marine conservation initiatives protecting against coastal erosion in Transmission and Distribution.
AR13	5	Precipitation	Grid and Primary Substations affected by water flood wave from dam burst	Considered unviable to protect against	5	5	SSEN have a small number of primary and grid substations which could be affected and shall continue to monitor the current position regarding dam burst and ensure the required mitigation measures are in place where necessary.

Risk Code	Task Group Risk Score	Climate Variable	Impact	Task Group ARP3 Risk Considerations	SSEN Risk Score ARP2	SSEN Risk Score ARP3	SSEN ARP3 Risk Considerations
AR14	6	Lightning	Overhead lines and transformers affected by increasing lightning activity	Existing mitigation measures adequate	6	6	The installation of covered conductor in Distribution and the lightning protection enhancements in SSEN have already shown benefits in reducing lightning damage. During the ARP1 review Distribution took the option to standardise on class 2 surge arresters which give better overall protection and shall continue with this strategy to mitigate against the equipment failings related to increased lightning activity.
AR15	6	Wildfire	Overhead lines and underground cables affected by extreme heat and fire smoke damage	Based on Saddleworth Moor incidents and increased frequency of California wildfires	N/A	9	SSEN shall engage with land management industry to support wildfire prevention methodologies. Long term incidences of wildfire impact on assets shall be monitored and recorded to develop risk-based modelling for intervention planning. Further, SSEN shall explore wildfire areas and look towards prevention methods by establishing a Wildfire taskforce group.

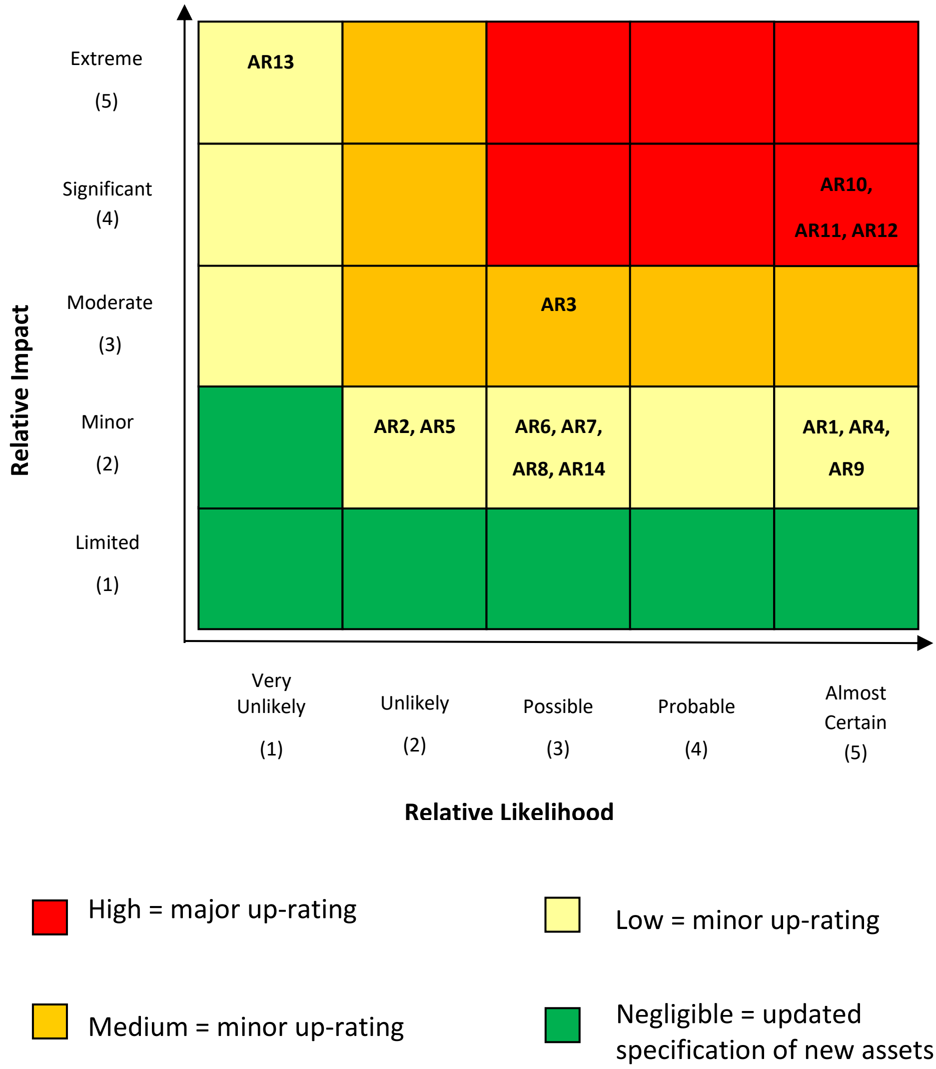

Figure 1 – SSEN First and Second Round Reporting Risk Matrix

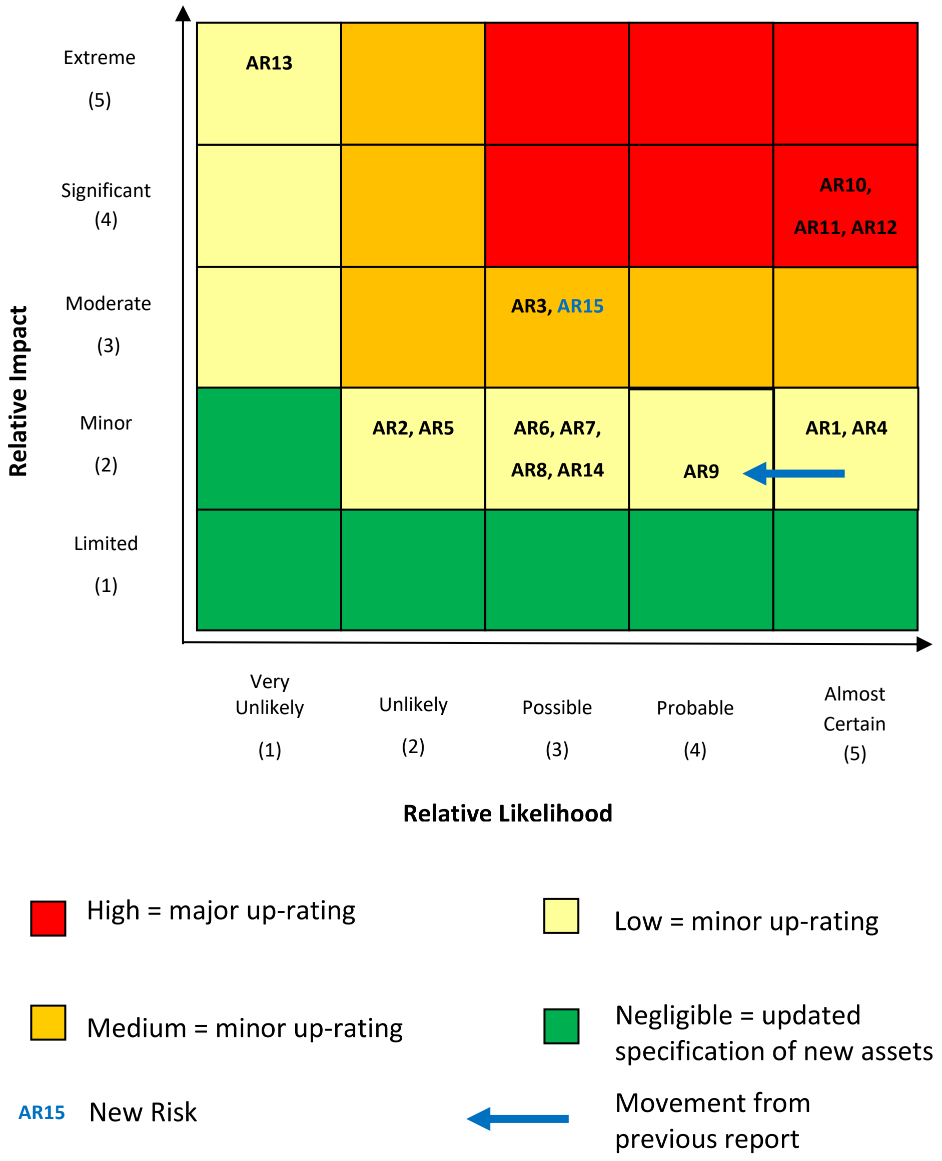

Figure 2 – SSEN Third Round Reporting Risk Matrix

10 2050 Risk Score Narrative

10.1 As part of the Task Group review, the ENA have not been able to provide a risk score for 2050 as there are too many variables that could affect the magnitude of climate change impacts. The ENA will, however, continue to monitor the impacts of Net Zero strategies, review climate change impacts and develop and implement mitigation and management strategies for as long as they are supported by the regulatory mechanism and as they become business as usual activities.

11 Issuing Information

Title	Reference	Date
SSEN Climate Change Adaptation Report - Third Round	SSEN CCAR 3	20 December 2021

Appendix A ENA Third Round Climate Change Adaptation Report

Please note that the attached hyperlink may not work with some of the mobile devices.

ENA CCAR3.pdf

Appendix B Examples of mitigation measures employed across the SSEN network

The flood resilience required for strategic secondary substations was acknowledged in the Second Round Report. The two photographs below show a secondary substation which has been installed on a raised foundation above the predicted flood level.

Photographs 1 & 2 – Example of enhanced flooding protection

As the outcome of the First Round Reporting review, class 2 surge arresters have been standardised in SSEN Distribution. The photograph below shows a 200 kVA pole mounted transformer equipped with class 2 surge arresters to mitigate against the failings related to increased lightning activity.

Photograph 3 – Example of a pole mounted transformer with surge arresters

Photographs below show examples of flood protection initiatives for grid and super grid substations in SSEN Transmission.

Photograph 4 & 5 – Example of a HV transformer and associated control equipment protected by a raised bund wall with step access

Photograph 6 – Example of a grid substation switchroom access with additional flood gate protection

Photographs 7 & 8 – Example of a two-stage flood control channel with raised embankments near the super grid substation