# Strengthening climate resilience

## – Strategies for enhancing DSO resilience against climate change

Eurelectric position paper

July 2025

Eurelectric represents the interests of the electricity industry in Europe. Our work covers all major issues affecting our sector. Our members represent the electricity industry in over 30 European countries.

We cover the entire industry from electricity generation and markets to distribution networks and customer issues. We also have affiliates active on several other continents and business associates from a wide variety of sectors with a direct interest in the electricity industry.

## We stand for

The vision of the European power sector is to enable and sustain:
- A vibrant competitive European economy, reliably powered by clean, carbon-neutral energy
- A smart, energy efficient and truly sustainable society for all citizens of Europe

We are committed to lead a cost-effective energy transition by:

**investing** in clean power generation and transition-enabling solutions, to reduce emissions and actively pursue efforts to become carbon-neutral well before mid-century, taking into account different starting points and commercial availability of key transition technologies;

**transforming** the energy system to make it more responsive, resilient and efficient. This includes increased use of renewable energy, digitalisation, demand side response and reinforcement of grids so they can function as platforms and enablers for customers, cities and communities;

**accelerating** the energy transition in other economic sectors by offering competitive electricity as a transformation tool for transport, heating and industry;

**embedding** sustainability in all parts of our value chain and take measures to support the transformation of existing assets towards a zero carbon society;

**innovating** to discover the cutting-edge business models and develop the breakthrough technologies that are indispensable to allow our industry to lead this transition.

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# Executive summary


This report explores how electricity Distribution System Operators (DSOs) are increasing resiliency to climate change effects and their physical impact on assets, and how policy makers could facilitate this effort. As the damage caused by extreme weather events on grid operators, already significant in 2025, is expected to increase massively, taking actions to enhance resilience is not an option anymore. DSOs are taking action.

Their efforts structure around a three-step strategy:

| | | |
|---|---|---|
| **Mapping the risks.** DSOs utilise scenarios from IPCC, EU or national data bases and translate the effects onto their infrastructure by developing internal simulations. The effects of climate change are largely local and dependent on grid topology and geography. | **Increasing the network's resistance.** DSOs can improve components used, reduce the exposure of assets, schedule the network renovation and improve the network's meshing. Investing proactively entails saved costs in the long run. | **Preparing efficient emergency response measures.** DSOs must make sure that they store enough material to replace damaged assets, that they always have an available workforce and that cooperation is ensured with public authorities and all local relevant stakeholders. |

To illustrate this strategy, six case studies from across Europe show different situations and solutions to improve distribution grids' resilience to the physical impacts of climate change. The report also sheds light on examples of national legislation of incentives and climate adaptation plans.

To enable a strengthened resilience to climate change, EU institutions and Member States should:

1. Incentivise and recognise climate adaptation measures in national regulatory frameworks.
2. The upcoming Climate Adaptation Plan should put emphasis on climate adaptation measures for critical infrastructure.
3. The National Energy and Climate Plans (NECPs) should be amended to explicitly introduce a dimension of physical grid resilience.
4. The NZIA environmental criteria for public procurement procedures should include an aspect of climate adaptation.
5. National Regulatory Authorities (NRAs) should be explicitly responsible for addressing climate adaptation of electricity infrastructure.
6. Investments in resilience should be an integral part of the Distribution Network Development Plans (DNDPs).

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# 1. Threats are increasing

The fundamental role which electricity grids play in society cannot be overstated. In its Global risks report 2025, the World Economic Forum predicted the three major global risks for the coming year to be a. State-based armed conflict, b. Extreme weather events and c. Geoeconomic confrontation – all of which affect the security of grid infrastructure. Factors which are interlinked and can risk reinforcing each other.

The effects of climate change are clear. The world has already reached an average temperature 1.5 Celsius degree warmer compared to preindustrial time, and the Copernicus institute stresses in its 2024 European state of the Climate report that Europe is the fastest warming continent in the world. This entails a crucial necessity to strengthen the physical resilience of distribution grids, which serve as critical infrastructure.

*There are several types of resilience of grids to climate change (i.e. physical, digital/cyber, operational resilience), and this paper will solely focus on physical resilience.*

## 1.1 Climate change has and will have major physical impacts on Europe

Climate change is already having a significant impact on Europe, and it will increase massively over the next decades. In 2024 the European Environment Agency (EEA) released their European Climate Risk Assessment which identifies 36 climate risks that pose a threat to Europe's energy security, food security, ecosystems, infrastructure, water resources, financial stability, and people's health. It shows that many of these risks have already reached critical levels and can become catastrophic without urgent and decisive action.

Across the continent, all the following factors will evolve drastically:

**1. Temperature**

Changing the average but also extreme heat and cold

**2. Hydrometry**

Changing the average and extreme precipitations, floods, droughts, soil moisture, weather fires

**3. Wind**

Affecting average and extreme wind conditions

**4. Snow and ice**

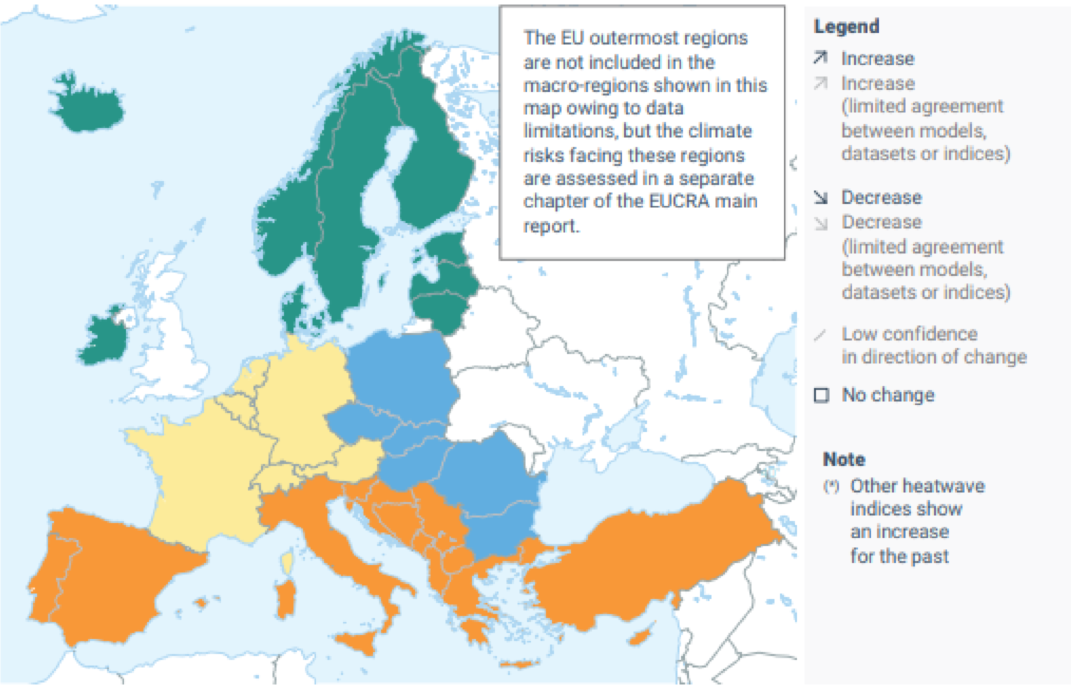
Changing the prevalence of snowfalls, ice storms, avalanches

**5. Seas and watercourses**

• Affecting water levels, oceanic soils, river flows

All these elements will move in different directions according to time and geography, hence the need to plan resilience on a local level and with a long-term perspective is crucial for DSOs. The figure below illustrates the geographical disparity between regions.

| Land regions | Northern Europe | | | Western Europe | | | Central-eastern Europe | | | Southern Europe | | | European regional seas | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Past | Future | | Past | Future | | Past | Future | | Past | Future | | | Past | Future |
| | | Low | High | | Low | High | | Low | High | | Low | High | | | |
| Mean temperature | ↗ | ↗ | ↗ | ↗ | ↗ | ↗ | ↗ | ↗ | ↗ | ↗ | ↗ | ↗ | Sea surface temperature | ↗ | ↗ |
| Heatwave days | □(*) | ↗ | ↗ | ↗ | ↗ | ↗ | ↗ | ↗ | ↗ | ↗ | ↗ | ↗ | | | |
| Total precipitation | ↗ | ↗ | ↗ | ↗ | / | ↘ | ↗ | ↗ | / | ↘ | ↘ | ↘ | Sea level | ↗ | ↗ |
| Heavy precipitation | ↗ | ↗ | ↗ | ↗ | ↗ | ↗ | ↗ | ↗ | ↗ | ↗ | ↗ | ↗ | | | |
| Drought | ↗ | ↘ | ↘ | ↗ | / | ↗ | ↗ | / | ↗ | ↗ | ↗ | ↗ | | | |




Notes: Underlying climate variables are: heatwaves (days with maximum temperatures above 35°C), heavy precipitation (maximum 1-day precipitation), and drought (using a standardised precipitation evapotranspiration index over 6 months (SPEI-6, Hargreaves' method)). Time periods and scenarios are past (1952-2021); future until the end of the century (2081-2100 relative to 1995-2014); low scenario (SSP1-2.6); and high scenario (SSP3-7.0).

Source: Copernicus Climate Change Service (C3S).

Figure 1: Observed and projected trends in key climatic risk drivers in different European regions

**Rising risks of floodings**

Europe is one of the regions with the largest projected increase in flood risks within the next decades and it is already highly impacted. In 2024, at least 335 lives were lost in the continent due to storms and floodings. In addition to Valencia's floodings in October 2024, the storm Boris in Central and Eastern Europe in September 2024 and the storm Éowyn in January 2025 emphasise the urgence to prepare for this risk.

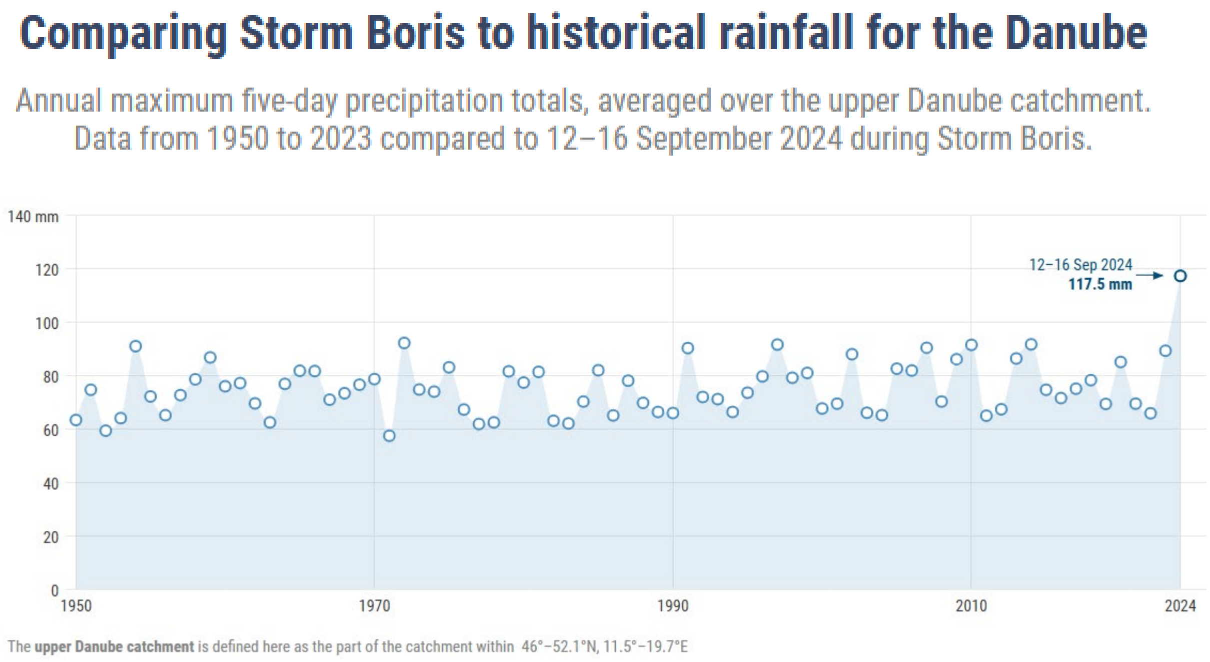



Figure 2 Average maximum five-day precipitation totals for the upper Danube catchment, 1950–2023, compared to 12–16 September 2024 during Storm Boris. Source: Copernicus Institute

**Heatwaves becoming increasingly common**
Out of the 15 most severe heatwaves in southeastern Europe between 1950 and 2024, 5 took place during 2024.

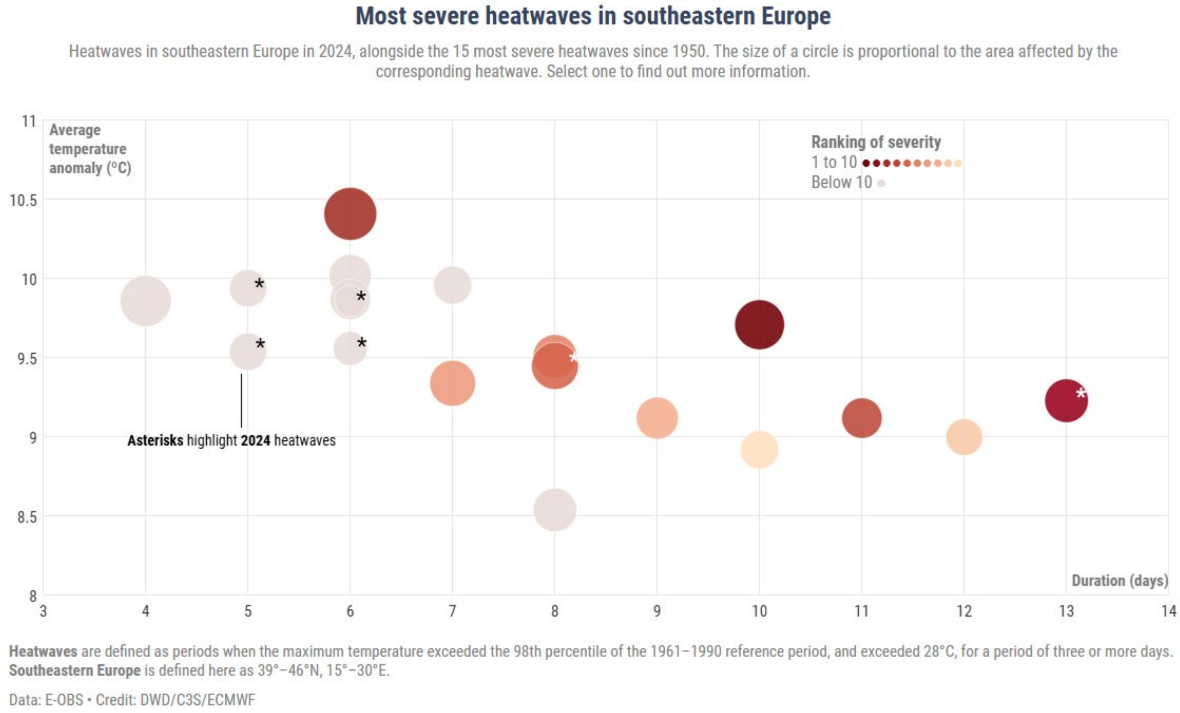



Figure 3: Heatwaves in southeastern Europe in 2024, alongside the 15 most severe heatwaves in southeastern Europe since 1950. Source: Copernicus Institute

The figure above showcases the most severe heatwaves in this region. The circle size is proportional to the area affected by the corresponding event. The 10 most severe heatwaves are indicated by darker colours and grey indicates those with a ranking of severity below 10. Southeastern Europe is defined here as 39°–46°N, 15°–30°E.

## 1.2 Impacts on grid operators

Operating an electricity grid demands technical precision and stability to maintain stable frequency and voltage levels. Climate change and its effects add a layer of complexity to this - directly damaging lines or substations.

Lines can be progressively damaged through the chronic risks incurred by changed weather conditions - such as increased average temperatures, more frequent ice formation, heavier rainfall or snowfall, and changes in wind speed and direction that exceed design parameters. These stresses can accelerate wear on equipment and reduce its operational lifespan. Lines can also be suddenly damaged through acute risks, such as a tree falling on a line during a storm. Substations can also be progressively affected by climate change, but are more likely to be radically impacted, particularly in the case of flooding.

Even though this report focuses on physical damage, it is important to keep in mind that the impact of climate change goes beyond this. It also causes unexpected and extreme shifts in electricity demand—such as sudden surges during heatwaves or cold snaps—that can push loads beyond the grid's designed capacity. This demand volatility increases the risk of instability and complicates load forecasting and operational planning for DSOs.

The effects are already tangible. Storm Éowyn, which struck Ireland and the United Kingdom between 21 and 27 January 2025, recorded historic wind speeds of 217 kph in Scotland. The physical damages on distribution lines across Northern Ireland and the Republic of Ireland created major disruptions, with 1,000,000 premises without power, i.e. a third of the homes on the island. The frequency and the impact of such weather events will increase, and so will their physical impacts on grid operators.

# 2. Resilience practices

## 2.1 Defining resilience

The International Energy Agency (IEA) defines energy system resilience as "*The capacity of the energy system and its components to cope with a hazardous event or trend, to respond in ways that maintain its essential functions, identity, and structure as well as its capacity for adaptation, learning and transformation. It encompasses the following concepts: robustness, resourcefulness, recovery*" (Paul Simons at the Asia Clean Forum on 7 June 2017).

Whereas reliability of the system focuses on the likelihood of failure, resilience allows a broader approach considering and preparing recovery. Resilience measures instead consider a long-term horizon, with the anticipation of worst-case scenarios.

In this regard, relevant metrics to assess the reliability and resilience are **the System Average Interruption Frequency Index** (SAIFI), measuring the average yearly number of times that a system customer experiences an outage, and **the System Average Interruption Duration Index** (SAIDI), the average yearly cumulative outage duration for each customer served. It is key to note that these KPIs track past power interruptions and climate-related events, but they do not assess how effective planned mitigation or adaptation measures are in the investment stage.

**Resilience can be apprehended with four criteria** Bruneau et al., 2003 / MCEER):

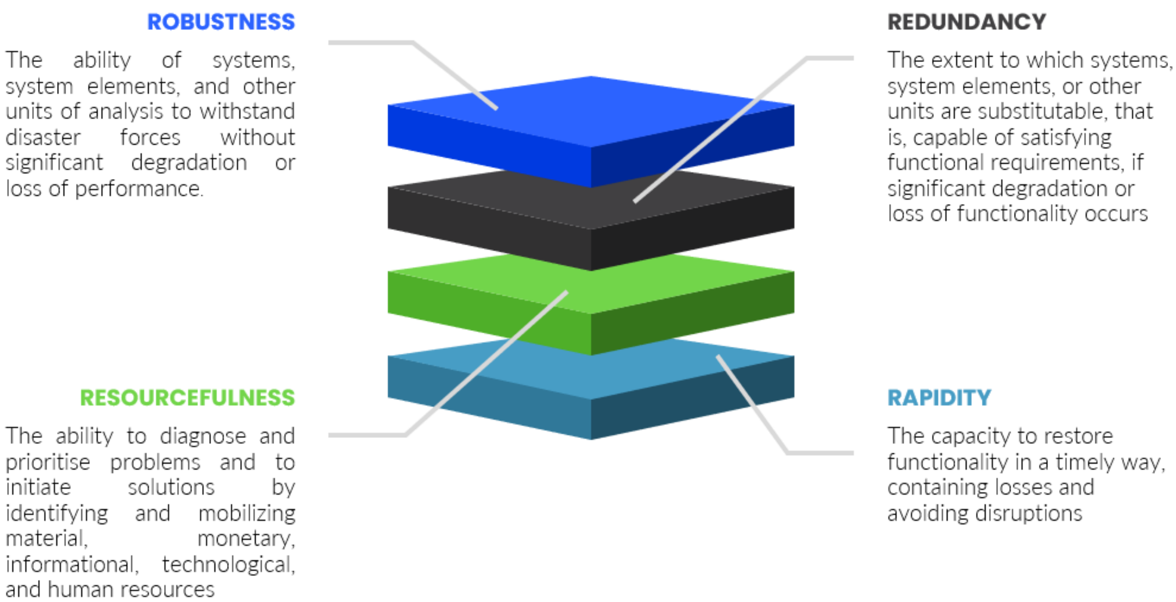



Figure 4: illustrating the four perspectives of resilience. Source: Bruneau et al., 2003 / MCEER

## 2.2 How DSOs increase resilience

Despite geographical and topographical differences in their operating regions, DSOs can follow a shared strategic approach to enhance climate resilience through three main steps:


### Mapping the exposure and the risks associated with climate change for grids

Using data from EU or national climate modelling agencies, based on IPCC scenarios, DSOs can map climate exposure of their network to identify their main vulnerabilities and prioritise action. This preliminary phase is essential and should be performed through a sequential approach considering climate evolution scenarios, associated climate risks and impacts of those risks on DSOs.

Such a mapping must be constantly evolving according to the evolutions of European climate and integrate worst-case scenarios given the critical nature of DSOs. It will then guide DSOs' renovation and expansion plans in real time to prioritise investments where most needed. In cases where public data lacks sufficient granularity or alignment, DSOs may need to develop internal models or harmonise scenarios. This includes for example CMIP5 and CMIP6* modelling frameworks or harmonising between IPCC and national scenarios.

* CMIP5 and CMIP6 – Coupled Model Intercomparison Project, phase 5 and 6. These are coordinated efforts among climate research institutions worldwide to run and compare climate models using common input scenarios.

**Reinforcing the network's resilience**
To mitigate climate change effects on assets and network, DSOs use different levers: use of more robust components, reduction of asset exposure, strengthening of interconnectivity (meshing), and tailoring of renovation plans to local risk severity.

For example, heat-resistant cables are essential in regions prone to heatwaves, while storm-prone areas may require updated design standards for wind resistance.

Another issue to address to enhance grid resilience is to reduce the direct exposure of assets. For instance, substations can be elevated in areas subject to high flooding risks, while cables can be buried in the ground in high fire risk regions. Another solution includes fully underground compact substations which are waterproofed to withstand 1 meter submersion for 30 minutes. This also makes the substation less exposed to heatwaves, fires, and wind-related damage.

In addition, network meshing can be adapted with additional lines so that a disruption on one of them because of a climate/weather impact could be immediately compensated, before the asset is repaired.

Finally, it is important that DSOs organise their renovation and modernisation schedule based on the accelerating wear of assets caused by chronic climate stress, when there is sufficient data to assess it properly.

**Preparing efficient response measures to restore the grid**
Although DSOs can improve their assets and network resilience to climate change, it is impossible to predict and adapt to all its consequences. One thing is certain: incidents will occur, it is therefore key to implement efficient response measures to ensure quick restoration of the system. A recovery and operating plan for DSOs encompasses coordination with public services for interventions (e.g. fire brigades if some critical lines could be impacted by a fire), preparation of an internal response force to be deployed and the stocking of grid components to repair or replace degraded ones.

## 2.3 Case studies from utilities around the Union

This section showcases seven examples from DSOs around the EU, and discusses the motivation for the projects, as well as results.

**2.3.1 Preparing for extreme heatwaves in Sicily**
**Operator:** E-distribuzione
**Targeted climate change impact:** Heatwaves
**Scenarios:** RCP 2.6, 4.5 and 8.5

e-distribuzione

Heatwaves are expected to be one of the most frequent and impactful extreme climate events in Europe in the next decades, especially in the Mediterranean area. All climate scenarios, such as the IPCC climate projections 2020-2050 - Representative Concentration Pathway (RCP 2.6, RCP 4.5 and RCP 8.5) show a **significant increase in intensity and frequency of heatwaves** in the near future.

A recent example of a disruptive heatwave event happened in July 2023 in the Catania area, in Sicily. The city and the province suffered a power blackout emergency caused by an exceptional heatwave that damaged underground cables, causing power outages and other linked negative effects, such as water supply problems.

Considering those events in Catania, E-distribuzione conducted a thorough analysis of the widespread power outage, highlighting how the particularly anomalous climate conditions (maximum temperatures above 40° and prolonged absence of rain) had created disruptive effects on the medium voltage network.

An event of heatwave can produce **adverse effects on feeders**, such as:

- **Significant reduction in the maximum capacity of the cables:** mainly due to (i) very high temperatures (e.g. at 40 °C the capacity is halved); (ii) the conditions of the ground, with little or no rainfall during the period, and (iii) concurrent strong increase in load, usually in terms of peak power and consumption;
- **A risk increase of infrastructure failures**: often with exponential trend - caused by exceptional operating conditions that exceeds the design parameters of standard asset limits (i.e. according to CEI standards);
- **A negative reinforcing path:** the increase of temperature during the heatwave can higher the risk of feeders' faults and at the same time increase the load; the action of counterfeeding to guarantee continuity of supply can further increase the load of the feeders, further pushing it to capacity limit (already reduced due to high temperature).

After the analysis conducted by e-distribuzione in the Catania case, it was deemed necessary to study an evolution of the resilience models of the distribution networks to take into account these extreme events in the climate scenarios. Considering the new emergency context, the Italian NRA introduced an output-based reward mechanism for investments in development of distribution networks that provides a premium up to 13% of the minimum expected investment cost of the intervention and the actual investment cost.

Therefore e-distribuzione proposed a dedicated plan, starting from 2024 with expected completion by 2027, with the aim **of increasing the resilience of the network towards prolonged heatwaves,** guaranteeing benefits to customers in terms of lower risk of widespread power outages. The interventions in the plan address specific critical points of distribution networks improving both **Robustness and Redundancy,** with focus on:

- Rebuilding of portions of the existing underground MV network with intrinsically resilient components (e.g. joint-less cables)
- Increasing network meshing through new MV outgoing lines and, if necessary, MV sorting centres or new HV/MV Transformers

The projects will be deployed in several areas of the Italian territory according to the expected frequency and impact of heatwave events in the climate scenarios.

## 2.3.2 Mitigating flood risk for substations in Ireland

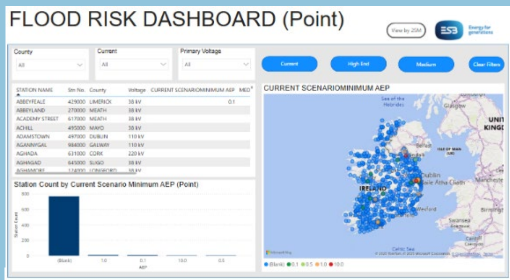
**Operator:** ESB Networks
**Targeted climate change impact:** Floods
**Scenarios:** RCP 8.5 to 2050 and RCP 4.5 to 2100

**Description:**

The approach adopted by ESB Networks to address flooding in HV Substations is (a) Identify HV Substations with Flooding Risk, (b) Assess the Likelihood and Extent of Flooding, (c) Introduce Flood Mitigation Measures

### a) Identify HV substations with flooding risk

An initial screening exercise the OPW Catchment Flood Risk Assessment Management Studies (CFRAMS)[2] and associated Preliminary Flood Risk Assessment (PFRA) performed by engineers is for the specific substation site.



ESB Networks flood risk

### b) Assess the likelihood and extent of flooding

A review of historic records of flooding in the area generally, considering local knowledge and local changes which could alter drainage patterns.


Flooding in a 38 kV substation

Utilising GIS mapping, a mapping exercise is undertaken to analyse substation sites vs the level of flooding from a pluvial or fluvial source in a range of scenarios using CFRAM River Flood data.

Figure 45: a) River flooding, b) Costal flooding, c) Previous flood records

[2] OPW Flood Risk Management

ESB Networks would also analyse and evaluate the drainage infrastructure and its capacity to handle current and projected rainfall volumes and runoff rates.

Figure 56: a) Public storm drainage b) Run off catchment areas c) Expected levels of run off

**c) Introduce flood mitigation measures**

During upgrade or full HV Substation refurbishment works long-term flood mitigation measures can be introduced. Where outages are unavailable short-term measures are employed to reduce flood risk to an acceptable level. Typical long term and short-term solutions introduced include:

- Raising the level of critical electrical equipment (where a station can be kept in service during flooding and is remotely controlled)
- Bunding critical areas/ sealing cable ducts to prevent water ingress
- Installing semi-permanent flood barriers
- Adding extra drainage including pumps in the HV Substation
- Ensuring existing drainage is clear and installing screens for debris
- Adding extra drainage including pumps in the HV Substation.
- Ensuring existing drainage is clear and installing screens for debris
- Attenuation pond – flood storage pond to attenuate discharge rate into existing drainage network
- Permanent flood barrier /wall constructed around the perimeter of the hv station site, with a pump system within the HV Substation n site.
- Relocation of the HV Substation

### 2.3.3 Improving overhead medium-voltage lines resilience in France

**Operator:** Enedis
**Targeted climate change impact:** Storms, Fires, Wind, Snow
**Scenarios:** IPCC Scenarios (SSP2-4.5 and SSP5-8.5)

With essential assets for electricity distribution, Enedis has made the resilience of its infrastructures a strategic priority.

The feedback from recent years, backed up by the IPCC climate studies, indicate an increase in average temperatures and therefore in the frequency and scale of climatic hazards, with proven risks for electricity distribution infrastructures. For this reason, Enedis established in 1999 the electricity rapid response force, which can be mobilized within 24 hours anywhere in France and developed a plan to adapt to climatic hazards.

This climate adaptation plan is based on the most recent IPCC assumptions available (CMIP6 data) and a risk analysis, to identify the main climate hazards impacting the network:

- **Chronic risks:** rise in mean temperatures, rising sea level, change in wind patterns
- **Acute risks:** storms, heatwaves, sticky snow, flooding, fires

A detailed cartography of climate risks over the whole of the French territory enables Enedis to prioritise the areas where actions are needed to increase the network's resilience. For instance, the overhead medium-voltage lines are mostly exposed to storms, fires and violent winds, especially in wooded areas. Enedis carries out two complementary actions: first, burying the most exposed overhead medium-voltage lines (in 2024, 2,600 km of lines were buried). On all the other overhead lines, scheduled renovation is carried out, with targeted investment in the structures to be renewed.

### 2.3.4 Responding in emergency to the October 2024 floods and assuring long-term resilience in the Valencia region

**Operator:** I-DE

**Targeted climate change impact:** Floods

On 29 October 2024, the Valencia region experienced the most extreme rainstorm in recent history, accompanied by tornadoes and record-breaking rainfall. Up to 400 litres per square metre fell in a single day, with the town of Turís registering a national record of 185 l/m² in just one hour. The storm caused major disruption to the electricity network, leaving 180,000 customers without power and damaging infrastructure across overhead and underground lines, particularly in the southern areas of Valencia.

I-DE activated an immediate emergency response to contain the crisis. Within 24 hours, power had been restored to half of those affected, increasing to 85% within 48 hours and 95% within 72 hours. Restoration was prioritised for critical services, including hospitals, health centres, fire stations, and public agencies. Additional crews were mobilised from across Spain, with 40 brigades and over 500 personnel deployed. More than 120 portable generators were installed to support essential infrastructure. Despite the regional control centre in Valencia becoming isolated by floodwaters, operations continued without interruption from other control centres that normally operate other areas within I-DE—highlighting the strength of contingency planning and staff commitment.

In the aftermath, I-DE launched **Project IL-LUMINA,** a major initiative to strengthen the grid's resilience and advance its digitalisation. With a planned investment of around €100 million and 90% of the work initially scheduled for completion in 2025, the project combines targeted infrastructure upgrades with strategic network redesign. Key actions include the elevation of vital assets such as switchgear, transformers, and substations; the undergrounding and rerouting of vulnerable lines; and the sealing of cables to protect against water ingress.

The key lessons learnt from the flood event are:

1. **Preparedness and planned coordination** are critical to minimising disruption and accelerating power restoration.
2. **Digital monitoring and control systems** are essential for rapid damage assessment and effective response planning.
3. **Cross-regional collaboration** significantly enhances emergency capacity and response speed during extreme weather events.

Through IL-LUMINA and its wider resilience strategy, I-DE is reinforcing the electricity network to meet the challenges of a changing climate—ensuring continuity of service and protection for the communities it serves.

### 2.3.5 Planning the climate adaptation of the Iberian distribution network

**Operator:** EDP Networks: E-REDES (PT), and Edp redes España (Begasa, Viesgo and Hidrocantabrico)
**Targeted climate change impact:** Extreme Winds, Fires, Floods, Snow
**Scenarios:** IPCC Scenarios based on CMIP5 data (RCP2,6, RCP4.5 and RCP8.5), for 3 periods (2011-2040, 2041 – 2070 and 2071 - 2100)

The adaptation plan holds the strategic goal to mitigate climate **risk in a comprehensive approach**, aimed at strengthening the adaptation of the distribution network to the effects of extreme weather events. It addresses two key perspectives:

a. **Planning based on resilience**
b. **Operational resilience** in preparation for response

In this context, the plan is structured around **four areas of action**:

1. The **Asset Management is** a roadmap of climate adaptation criteria for investment plans and projects, allowing to identify and aassess the impact of relevant climate hazards, associated exposure, potential vulnerabilities and establish prioritised strategies for distribution assets.

The main goal is ensuring the integration of climate risk in the planning process, seeking to prioritize investment with the most effective adaptation measures. It implies:

- Elaborate extreme climate hazard maps, including the historical scenario and the analysis of incidents occurred, the definition of network impact thresholds and climate (future) modelling for the 3 RCP scenarios, in 3 periods, by climate variables affecting assets: extreme wind, fire, flood and snow.

Examples of maps developed for Portugal:

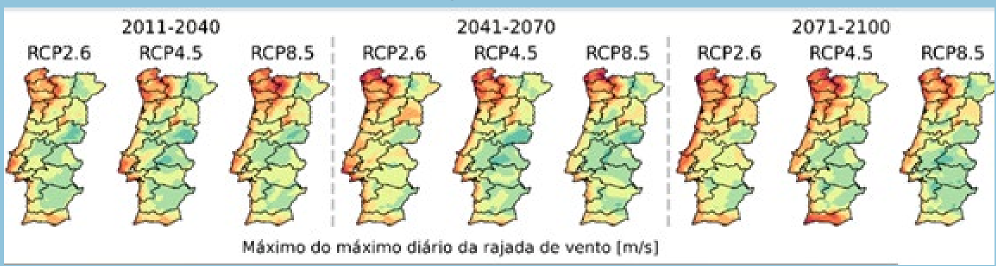



Figure 6: daily maximum wind gusts (m/s)

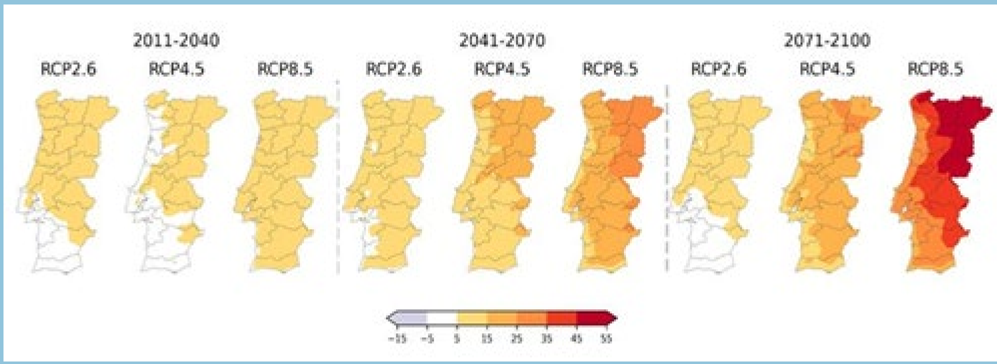



Figure 7: Fire weather index (FWI)

- Create a standard catalogue of operational and engineering adaptation measures, including the assessment of adaptation strategies performance.

2. **Resources and capabilities management,** this line of action addresses:
   - The review of the operational contingency plans, which is guided by lessons learn from the past events and opportunities of improvement identified from the implemented exercise program.
   - Optimising the logistics strategy for the most affected assets (sizing, storage and distribution) to worsening scenarios of extreme climate events.
   - Enhancing supplier contracts and fostering innovation with manufacturers in capacity-building strategies for response.

**3. Nature-based adaptation,** this line of action includes:
   - The opportunity to review and identify vegetation management criteria to promote fire-resilience.
   - The development of integrated vegetation management (IVM) models to support adaptive vegetation management.

In this context, the increase in inspections utilizing technological solutions like LiDAR and drones for monitoring high and medium voltage networks is noteworthy. Additionally, satellite images combined with AI models are used to characterize vegetation types, identify species, and predict their growth. Analytics4Vegetation, developed by E-REDES (PT), leverages this data to forecast species growth and assess the actual risk of contact with power lines. This optimizes the planning of cutting interventions by targeting only necessary areas, thereby promoting integrated vegetation management, selecting compatible uses with fire-resilient species.

**4. Adaptation Monitoring and Measurement,** this line of action includes:
   - The selection and integration of resilience metrics (4 R's) aligned with the shareholders, regulation and sustainability indexes requirements.

### 2.3.6 Creating regional adaptation plans in France

**Operator:** Enedis
**Targeted Climate change impact:** Heatwaves, Rising sea level, Flooding, Storms, Wind, Snow, Fires
**Scenarios:** IPCC Scenarios (SSP2-4.5 and SSP5-8.5)

While climate change is global, its impacts are local. Not only does it impact infrastructures, but the whole of local life: economy, accommodation, agriculture, tourism, etc. DSOs, as critical infrastructure operators, must plan for the adaptation of their networks, but these actions must be part of a broader adaptation plan at local level.

In 2023, the "PlanEt" (*Planification écologique des territoires)* initiative was launched, to support regional environmental planning. This approach, after being developed with 4 regions, is under deployment in every region within Enedis' operation perimeter (covering 95% of France).

First, a mapping of climate risks at regional level is conducted, based on IPCC scenarios projections and the associated climate impacts. Then, a territorial adaptation roadmap is created, in collaboration with key stakeholders (local authorities, other critical infrastructure operators, etc.). The actions in each roadmap are adapted to the specific risks and local impacts, for instance:

- Collaborate with public services to map high-risk areas (in case of flooding, rising sea level, fires, etc.)
- Coordinate interventions with firefighters if fires are impacting power lines
- Shift work hours in case of heatwaves
- Secure power supply for emergency shelters in the event of storms

# 3. Policy perspectives on climate resilience

## 3.1 National examples and best practises on policy

This section covers several examples of how Member States can incentivise increased resilience on national level.

### Italy: the regulatory incentive scheme for increasing resilience of distribution networks

In Italy, the National Regulatory Authority ARERA has effectively addressed the need to enhance the climate resilience of the distribution grid. Starting with investments in 2017, the NRA has required distribution companies to prepare Resilience Plans with a horizon of at least three years and to integrate them in a specific section of their Network Development Plans[3]. ARERA also defined an economic incentive mechanism for interventions with higher risk and positive net benefit[4].

In December 2023, ARERA released a new incentive mechanism[5] replacing and enhancing the previous one to widely include investments supporting the energy transition and the electrification. For the period 2024-2027, the updated regulatory mechanism rewards distribution companies for network development projects, selected and approved based on a cost-benefit analysis, through a premium equivalent to two years of gross benefit with a ceiling of 13% of the lower value between expected and actual costs. It is worth remarking that this premium is an addition to the ordinary remuneration RAB-based for the same investments.

### France: indirect incentives for grid operators to become more resilient

The French National Adaptation Plan for climate change (PNACC-3), adopted in 2024, is France's strategic response to the escalating impacts of climate change. It is designed around a +4°C warming scenario by 2100 in France, reflecting the need for adaptation across all sectors. This plan is part of a broader framework that includes the National Low Carbon Strategy (SNBC) and the Multiannual Energy Plan (PPE), ensuring coherence between mitigation and adaptation efforts. These policies aim to reduce GHG emissions while strengthening the country's resilience to climate risks such as heatwaves, droughts, floods, and sea-level rise.

As critical infrastructure operators, electricity networks operators are part of this plan, as seen in Measure 31: "Ensuring the Resilience of the Energy System." The plan calls for a comprehensive adaptation of both transmission and distribution systems to withstand more frequent and intense climate events. This includes adaptation measures against extreme heat, storms, and flooding, as well as modernising the grid through digitalisation and smart technologies.

On the other hand, to ensure the reliability of electricity supply, the government provides regulatory and financial incentives through mechanisms such as the TURPE

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[3] Delibera 31/2018

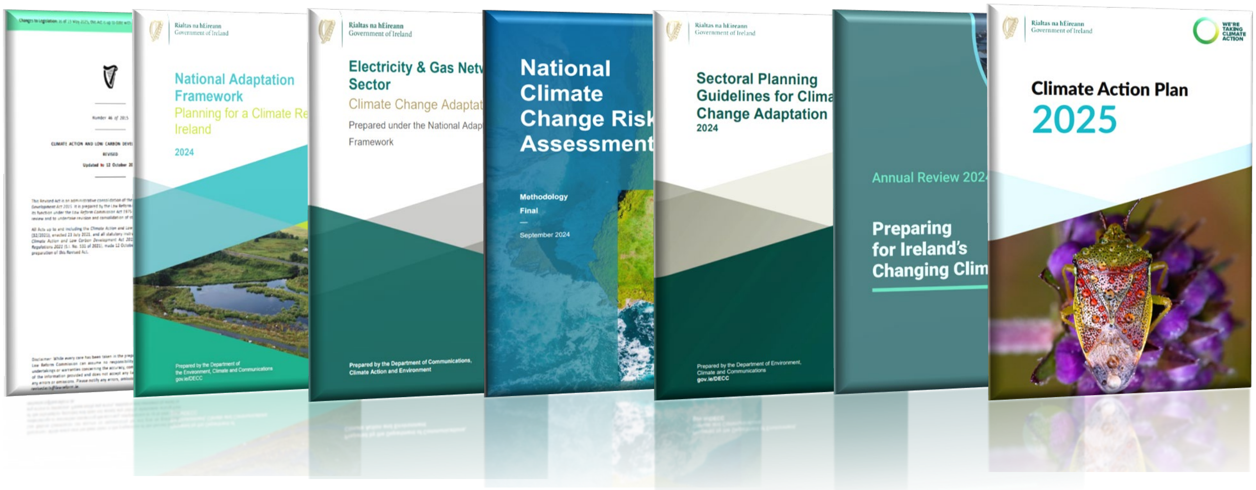
[4] Delibera 668/2018

[5] Delibera 617/2023 and following ones (Del. 472/2024 and Del. 112/2025)

(Tarif d'Utilisation des Réseaux Publics d'Électricité). This tariff system, regulated by the Commission de Régulation de l'Energie (CRE), includes performance-based incentives related to the SAIDI (System Average Interruption Duration Index). Enedis has committed to reduce this indicator below 60 minutes per year by 2030.

### Ireland: Introducing national legislation and guidelines in Ireland to support adaptation

The following provides an outline of Irish legislation, obligations, and guidelines from the Irish Government for ESB Networks as an electrical utility to address climate impacts to our network.




Section 5 of the Climate Action and Low Carbon Development Act 2015 - 2021 identifies the requirement for the minister to submit to the Government for approval a National Adaptation Framework. Section 5 also identifies the requirement for the minister to submit to the Government for approval a Sectoral Adaptation Plan [there are 11 SAP's]

The second National Adaptation Framework was published on 5$^{th}$ June 2024. It outlines how various sectors and local authorities can implement adaptation measures to minimise Ireland's vulnerability to climate change's adverse effects while taking advantage of any beneficial impacts, including Cross-cutting Adaptation Planning, Adaptation Indicators, Climate Change Adaptation and Emergency Planning and Management, and the National Climate Change Risk Assessment.

The first Sectoral Adaptation Plan was introduced in 2019 (SAP 2019) outlining 6 climate adaptation planning steps:

1. Preparing the Ground
2. Climate Impact Screening
3. Prioritisation
4. Priority Impact Assessment
5. Develop Your Plan
6. Implement Evaluate and Review

In 2024 the "Sectoral Planning Guidelines for Climate Change Adaptation" was released to provide guidance on the upcoming SAP 2025 and greater detail on requirements for each of the above steps.

The 6 climate adaptation steps are assessed by the Climate Change Advisory Council (CCAC) through a questionnaire resulting in a scorecard which is designed to help monitor and review local authorities' and Government departments' progress towards climate resilience. The results of such are released in their annual review.

Climate adaptation is identified in the Irish Climate Action Plan (CAP) 2025 though action AD/24/ "Complete a review of the national Preliminary Flood Risk Assessment to assess the potential impacts of climate change on flooding and flood risk across Ireland"

### Portugal: Policy measures for climate adaptation

In Portugal, the network operators are not bound by resilience regulatory requirements, still the adaptation strategies coupled with planning instruments (RNA 2100 and NEPC) and mutual/ preventive operational procedures to prepare crisis or alert response (SGIFR legislation).

**Framework**

1. The National Roadmap for Adaptation 2100 (RNA 2100) developed by the Portuguese Environmental Agency was published in 2024.

The work underlying the roadmap aims to assess Portugal's **vulnerability to climate change, as well as to estimate the adaptation costs for economic sectors,** support territorial and sectoral planning based on updated climate scenarios, and develop regional adaptation narratives for the five mainland regions: North, Centre, Lisbon, Alentejo, and Algarve, in response to the expected impacts of climate change by the year 2100.

The **key outcomes** are update of **reference climate scenarios** for Portugal, assessing climate risks centred on the following aspects: coastal zones, water resources, agroforestry and rural wildfires, and identify the **expected impacts**, such as: Increase in extreme weather events (heatwaves, tropical nights), decrease in water availability, Economic losses in agriculture and public health.

2. The National Strategy for Preventive Civil Protection 2030.

A guiding plan for the central and local administration of the Portuguese state, aimed at mitigating the country's vulnerabilities to risks and disasters. This strategy aligns with three important international agreements: the Sendai Framework for Disaster Risk Reduction, the Paris Agreement on climate change, and the 2030 Agenda for Sustainable Development.

The five objectives of the strategy are:

1. Strengthen governance in risk management.
2. Improve knowledge about risks.
3. Establish strategies for risk reduction.
4. Enhance preparedness for risk occurrence.
5. Engage citizens in risk awareness.

**Measures related to the electric sector**

In the electric sector, the strategy includes several preventive measures to increase infrastructure resilience and minimize the impacts of extreme weather events. Some of these measures are:

- Underground Substations: Implementation of fully underground compact substations, which are waterproofed to withstand 1 meter submersion for 30 minutes.
- Infrastructure Reinforcement: Strengthening distribution and transmission lines to withstand strong winds and floods.
- Monitoring and Maintenance: Adoption of advanced technologies for continuous monitoring and preventive maintenance of electrical grids.
- Emergency Planning: Development of contingency plans to ensure rapid service restoration in case of failures.

These actions are essential to ensure the continuity of energy supply and the safety of populations, especially in the face of increasingly frequent and severe weather events.

3. The National Energy and Climate Plan (NECP). It was recently revised and approved at the end of 2024, is the main policy instrument for energy and climate for the decade 2021–2030 highlighting the following references to the action lines focused on promoting climate resilience in networks.

**Internal energy market dimension**, promote the development of electricity grid infrastructure, with a new measure specifically aimed at enhancing the resilience of electricity distribution networks. This aligns with the challenges of the energy transition—shaped by climate impacts—and the growing electrification and digitalization of the economy. It includes converting overhead lines to underground networks in the most vulnerable or high-risk environmental areas and investing in digital infrastructure and services protected against cyber-physical risks, enabling greater grid observability and sensorisation.

**Security of supply dimension**, with action lines focused on promoting climate resilience: Conduct the necessary risk assessments, preventive action plans, and emergency plans in the energy sector, including a new measure: Develop the sectoral climate change adaptation plan for the energy sector. Promote flexibility in the electricity sector – Enhancing the flexibility of power system networks can benefit from the inclusion of climate risk assessments and the integration of adaptation measures (climate proofing) during the planning phase.

**Legal framework**

Considering the fire hazard in Portugal, there is a legislation involving several entities with annual fuel management obligations in the territory.

- According to SGIFR legislation (Integrated Rural Fire Management System), E-REDES is obliged to establish Fuel management strips associated at the power lines in rural areas, as a preventive response to wildfires.

- E-REDES also comply with the obligation of network Protection Zones (ZP) surveillance, establishing it, when it is necessary to replace the landowner, to ensure the security of the infrastructure.

## 3.2 Overview of relevant legislation on EU-level

Table 1: EU-level legislation governing climate adaptation measures for Distribution System Operators[6].

| Legislation | Summary of climate adaptation measure |
|---|---|
| Corporate Sustainability Reporting Directive (2022/2464) | Includes the requirement for utilities/companies to report on the measures introduced to assess and address climate impact to their infrastructure which entails the obligation to **develop an adaptation plan.**<br><br>Companies must report on:<br>• **Risks and opportunities** related to environmental, social, and governance (ESG) issues;<br>• **The impact of their activities** on the environment and society. |
| The Taxonomy regulation (2020/852) – Annex A | Regulation relevant for investment purposes. It identifies the eligible activities or assets, including Distribution of Electricity, determining **how an activity contributes to climate change adaptation**. It also ensures that **no significant harm** to climate change adaptation is being made. |
| Directive on the Resilience of Critical Entities (2022/2557). Art 13(1)a | Member States shall ensure that critical entities take **appropriate and proportionate technical, security and organisational measures** to prevent incidents, considering climate change adaptation. |
| National Energy and Climate Plans (NECPs) Governance Regulation (2018/1999) Art 19(1) & ANNEX VIII | Every second year, Member States are mandated to report to the Commission on their **climate change adaptation planning and strategies**. This should include implemented and planned actions as well as climate change projections on extreme-weather and correlated vulnerabilities.<br><br>Climate adaptation measures for grids are not explicitly mentioned. However, some NECPs such as the Italian and French explicitly cover grid resilience. |
| Distribution Network Development Plans (DNDPs) The Electricity Directive (2019/944) Art. 32(3)-32(4) | The Distribution Network Development Plans (DNDPs) for DSOs are submitted to the regulatory authority every second year. The investment plans should include grid investments for the next five-to-ten years and does not explicitly mention adaptation measures.<br><br>As with a directive, the national transposition slightly varies, and reporting obligations are mandated through national legislation. **Several Member States do include grid resilience investments in their DNDPs**. For instance, in Italy there is an annex stipulating that investments by DSOs for resilience for the next 3 years should be included. In France, climate adaptation measures for DSOs are also integrated. |
| Regulation on risk-preparedness in the electricity sector | • Mandates ENTSO-E to draw up and update regional **electricity crisis scenarios** and identify **the most relevant risks for each region** such as extreme weather conditions, natural disasters, fuel shortages or malicious attacks.<br>• Mandates Member States to establish and update their national electricity crisis scenarios. |

[6] Voluntary measures are omitted from the table.

# 4. Actionable policy recommendations

At a time when European DSOs are facing substantial investment needs—estimated at €67 billion annually between 2030 and 2050 to meet EU climate targets—resilience must be integrated into all grid development. Infrastructure installed today is expected to operate for 30 to 50 years, meaning that planning for climate conditions in 2075 must begin immediately.

Eurelectric therefore recommends EU policymakers to **encourage economic incentives** to invest in adaptation and risk mitigation. In the case of disruptive events, **ensuring proactive response** measures and when necessary – **a coordinated response should be aligned at EU-level**. Any new initiatives should align with standards already in place, to avoid increased administrative burden.

Table 2 below outlines the 6 main recommendations to facilitate climate adaptation measures:

| | Action | Legislation | For |
|---|---|---|---|
| 1 | **Incentivise and recognise climate adaptation measures in national regulatory frameworks.** Regulatory authorities play a key role in ensuring that DSOs are able to invest in the future and proactively strengthen resilience. A commendable incentive scheme was introduced in Italy in Dec 2023 by ARERA, the Italian Regulatory Authority for Energy, Networks and Environment. More on p. 20. Any incentive scheme should be designed to enable DSOs to balance resilience measures with other investment priorities. | *Each national regulatory framework governing DSOs* | NRAs and Member States |
| 2 | **The upcoming Climate Adaptation Plan should put emphasis on climate adaptation measures for critical infrastructure.** The EU Commission should<br>• **Assess the risks** posed for critical infrastructure<br>• **Identify critical variables** for each sector and corresponding actions<br>• **Ensure alignment with climate adaptation measures in several national NECPs**<br>• **Involve and include** the main stakeholders, such as the NRAs, Distribution System Operators, Transmission System Operators, and generators. | A European Climate Adaptation Plan, announced in the Political Guidelines 2024-2029, H2 2026 | EU institutions |
| 3 | **The National Energy and Climate Plans (NECPs) should be amended to explicitly introduce a dimension of physical grid resilience.** Currently, it is up to each Member State to decide, and several MS are already including this. This would provide all Member States with a clear mandate and make the necessary connection between grids and climate adaptation. The plans should:<br>• **Assess the risks posed for critical infrastructure**<br>• **Identify critical variables** for each sector and corresponding **actions** to be developed by the sectors<br>• **Involve and include** the main stakeholders, such as the NRAs, Distribution System Operators, Transmission System Operators, and generators. | Governance Regulation (2018/1999) | EU institutions |

| | | | |
|---|---|---|---|
| 4 | **The NZIA environmental criteria for public procurement procedures should include an aspect of climate adaptation.** This would provide incentives to manufacturers and projects which include climate adaptation measures into their strategies. This KPI under Art 25(1) should consider that resilience measures are challenging to quantitatively measure and should allow for a range of metrics to fully encompass adaptation measures. | Net Zero Industry Act (NZIA) (2024/1735) Art. 25(1) | EU Commission |
| 5 | **National Regulatory Authorities (NRAs) should be explicitly responsible for addressing climate adaptation of electricity infrastructure.** This can be achieved by amending the Governance Regulation and would provide a clear mandate for the responsibility. | Governance Regulation (2018/1999) | EU Commission |
| 6 | **Investments in resilience should be an integral part of the Distribution Network Development Plans (DNDPs).** On national level, Member states should ensure to transpose the Directive with a systemic view. Meanwhile noting that this tool does not suffice as the single planning overview for DSOs and needs to be complemented by longer-term analysis. | The Electricity Directive (2019/944) Art. 32(3)-32(4) | Member States |

Eurelectric pursues in all its activities the application of the following sustainable development values:

Economic Development

- Growth, added-value, efficiency

Environmental Leadership

- Commitment, innovation, pro-activeness

Social Responsibility

- Transparency, ethics, accountability

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