THE COMING STORM

Building electricity resilience to extreme weather

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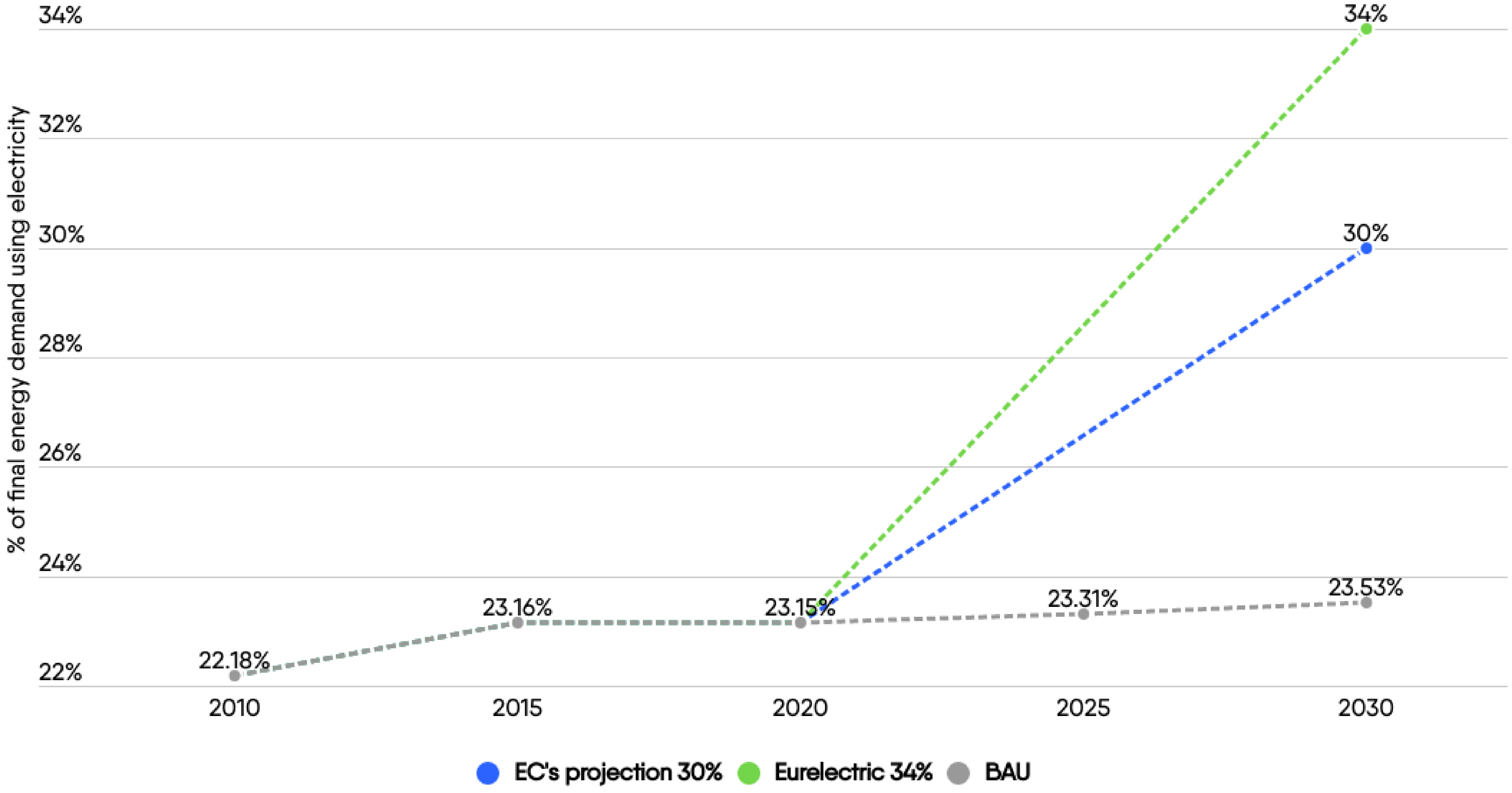
UNRIVALLED CHALLENGE

Russia's invasion of Ukraine has sparked an unrivalled energy crisis, requiring a shift away from imported fossil fuels.

Electrification will restore our energy independence. To do so it must also come with guarantees on electricity system reliability.

Electrification must jump 11 points by 2030



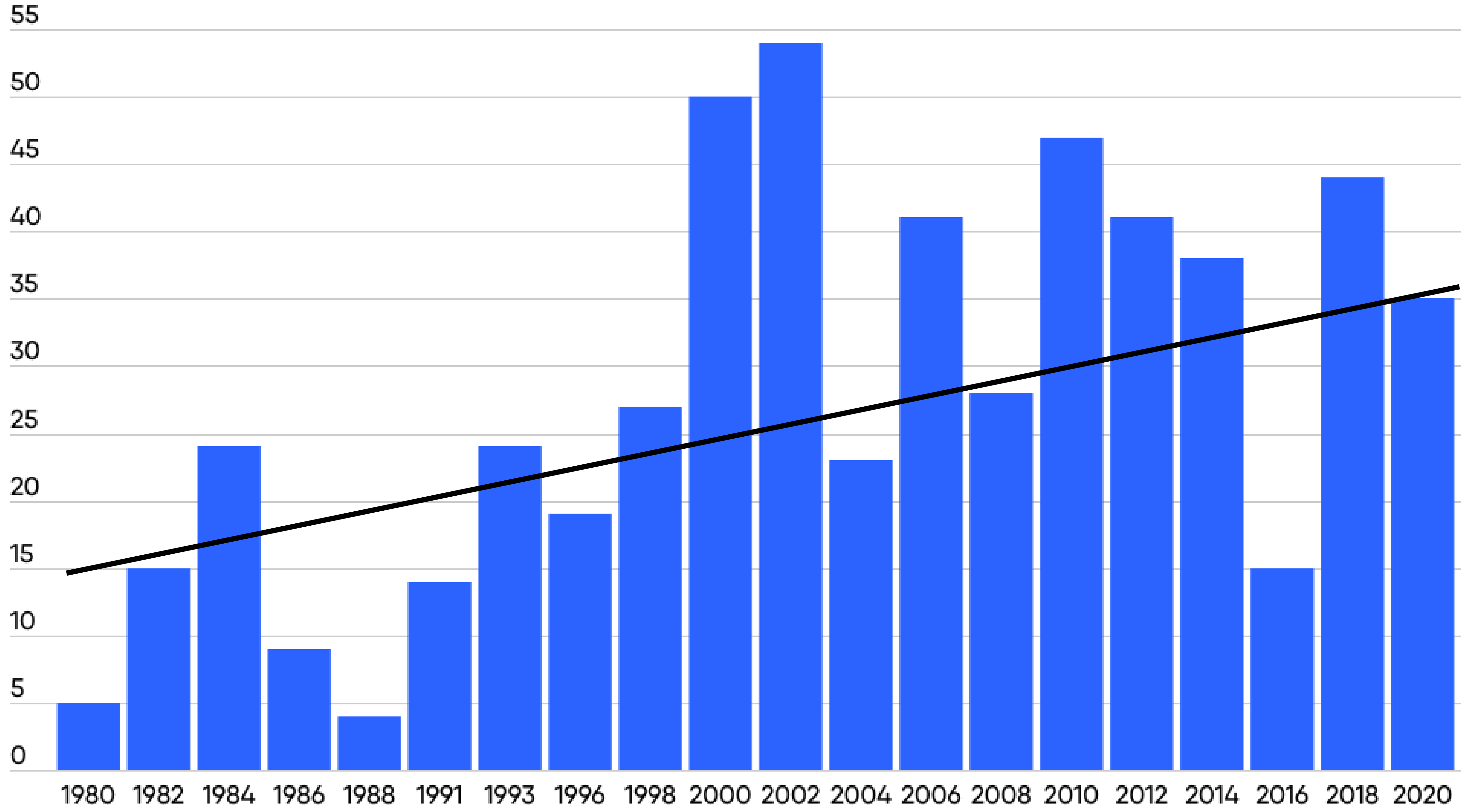
Source: Eurelectric Power Barometer 2022

The IPCC & COP27 have rung the alarm that the world is on its way to **+1.5°C** warming by **2030**.

This means more extreme weather events and more stress on the electricity system. Climate adaptation and resilience must become as much of a priority as climate mitigation.

Natural Disasters are on the rise in Europe

(number of climate related events)



Source: The International Disaster Database EM-DAT

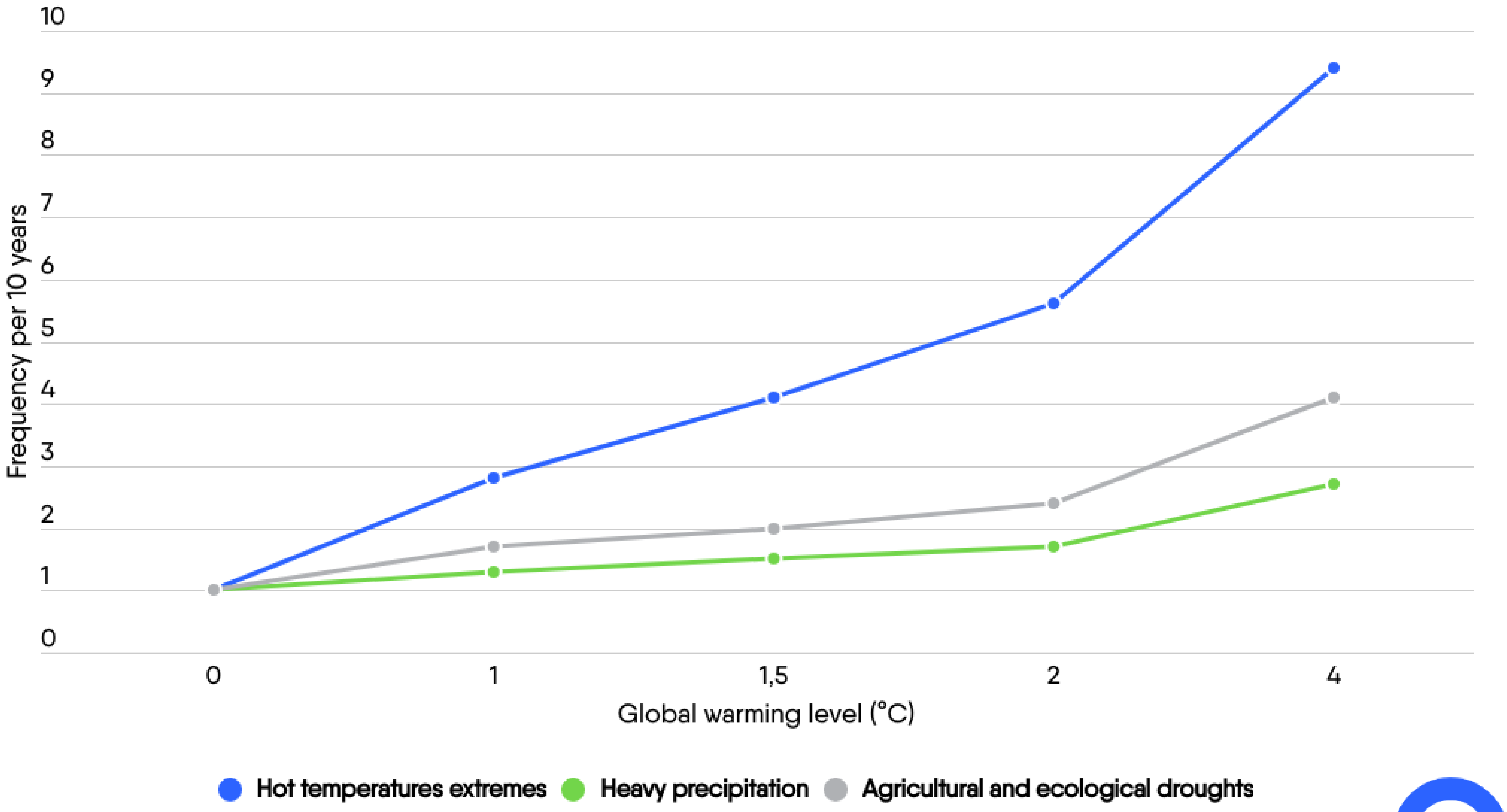
+1.5 °C by 2030 means:

x 4 more extreme temperature events

x 2 more agricultural and ecological droughts

x 1.5 more heavy precipitation episodes

Devastating 1-in-10-year events are becoming more frequent



Source: IPCC AR6 WGI figure SPM.6

The IPCC identifies 4 zones in Europe, where climate change will have a different impact.

In the Mediterranean + in Western/Central Europe: more frequent droughts.
In Northern Europe: more precipitation and rain flooding.

All across Europe: more extreme heat, fire weather, heavy precipitation, rain flooding, sea level rise, coastal flooding and severe windstorms

Fire weather

Extreme heat

Drought and aridity

Severe storms

Mean precipitation and floods

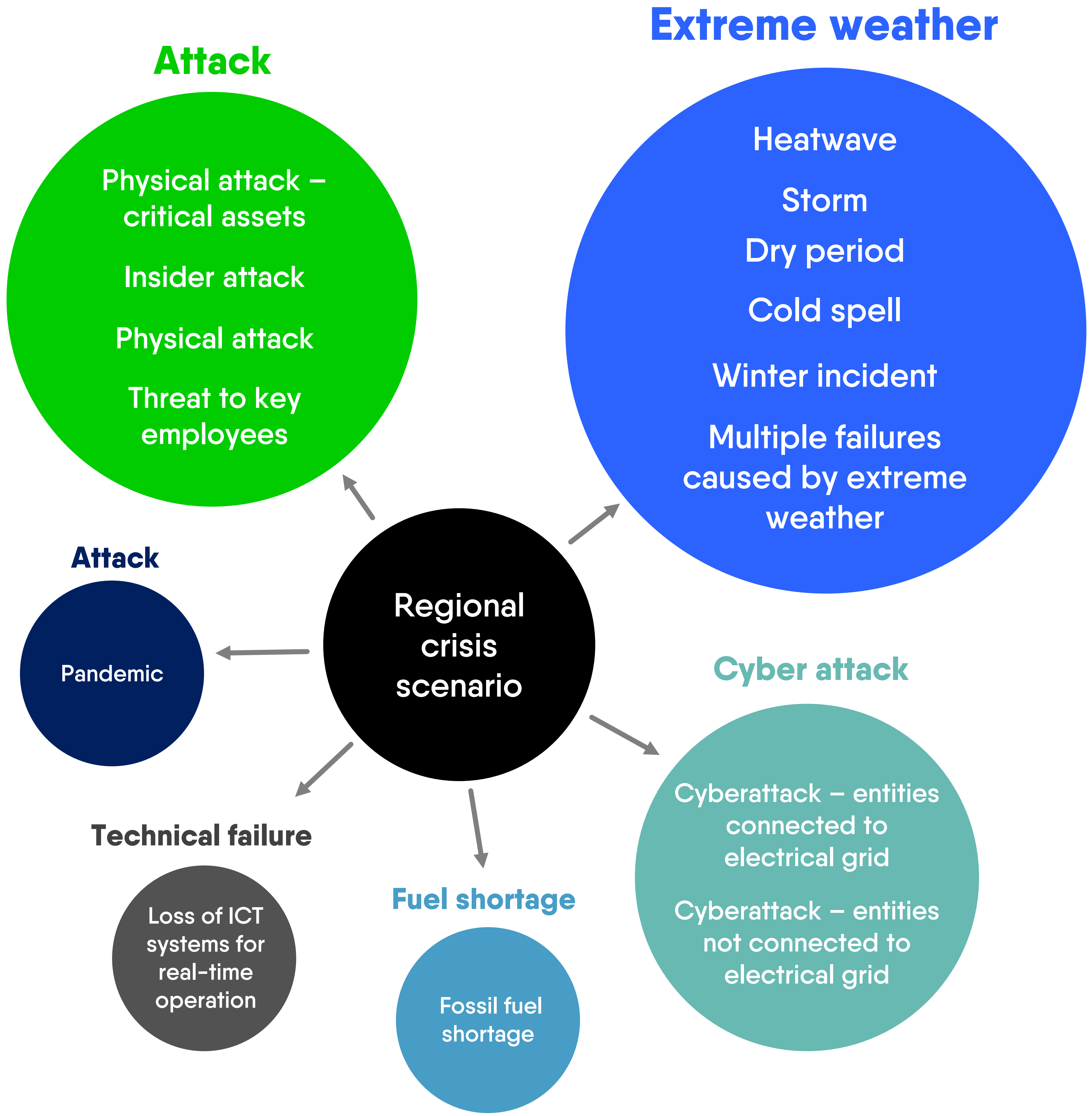
Cold spell, snow, ice and frost

From 2021-2022 extreme weather events were experienced across the whole of Europe

WHAT'S COMING FOR THE POWER SYSTEM

While cyber and physical threats also feature, extreme weather events clearly dominate ENTSO-E's ranking of the most likely and most severe scenarios facing the electricity sector.

Extreme weather prevalent in crisis scenario rankings



Exposure of generation assets in Europe

Fire weather	Extreme heat	Drought and aridity	Severe storms	Mean precipitation and floods	Cold spell, snow, ice and frost
Smoke and debris can reduce solar farm output	Affects wind turbine operation	Change in water inflows impacts provision of drinking water	High winds cause excessive mechanical loading on turbines	Change in water inflows impacts services such as flood control	Very low temperatures can affect operation of turbines
Interrupts power system and telecommunication connections	Reduced cooling tower efficiency	Reduce cooling water levels and restrict flow rates	Wind turbines shut down to prevent wear and tear	Overtopping of hydropower dams	Risk of undercooling
Difficult physical access to stations	Increased air temperature impacts generation capacity and operation	Thermal plants shut down because of insufficient cooling	ACC and cooling towers experiencee performance penalties	Lower cooling system performance of thermal & nuclear plants	Increased pressure on dams and reservoir structures

Thermal & Nuclear · Wind & Solar · Hydropower · Overarching

Exposure of transmission and distribution assets in Europe

Fire weather	Extreme heat	Drought and aridity	Severe storms	Mean precipitation and floods	Cold spell, snow, ice and frost
Power lines disconnected by emergency responders	Loss of load due to reduced grid capacity & overheating transfo rmers	Postponed maintenance or repair due to working conditions	Loss of remote system control, mountain lines become difficult to reach	Loss of interconnection lines	Avalanche risks for transmission towers
Burning trees fall on grid infrastructure	Hot spots in cable insulation and isolation failure	Increase in underground grid fault rate	Lines damaged by falling trees, Distribution towers collapse	Landslides weaken infrastructure foundations	Conductors broken by icing or snow sleeves

WHAT NEEDS TO BE DONE?

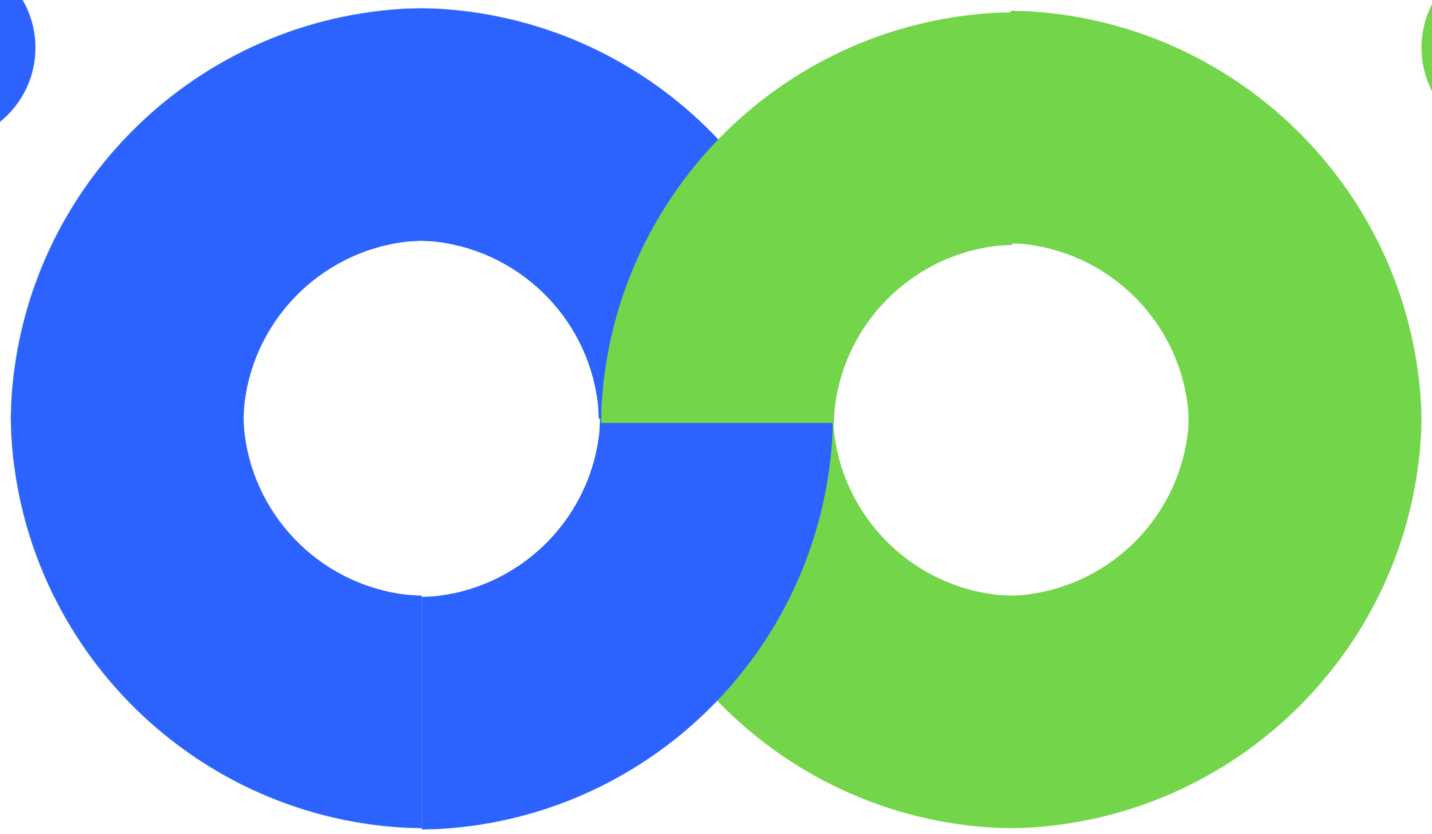
ADAPTATION MEASURES FOR A WARMING CONTINENT

Climate adaptation and climate mitigation: two sides of the same coin

Failing on decarbonisation goals would result in higher climate adaptation costs.
A failure to adapt to climate change would be devastating for the European economy.

MITIGATION OF CLIMATE CHANGE

Tackling the causes and minimising the possible impacts of climate change



ADAPTATION OF THE SYSTEM

Reducing the existing negative effects and taking advantage of any opportunities that arise

Adaptation measures of generation assets in Europe

Hydropower

Mature methods to forecast, handle and react to inflow variations.

Additional spill gates to prevent overtopping.

Trash racks and spill gates can be heated.

Facilitating the natural creation of a solid ice cover on the river.

Adapt to icing during the design stage.

The design of hydropower plants must account for their whole life cycle.

Wind & solar

Wind & solar plants are well equipped to adapt to climate change.

The increased prevalence of these technologies requires storage, thermal, flexibility and interconnection back-up.

Standard operational temperatures could be extended beyond the current -30°C to 40°C range, if cold or hot climate countries wish to incorporate more wind energy.

Thermal and nuclear

Regularly reassess the level of climate change hazard, resize cooling systems, and review operating practices.

The design of thermal & nuclear plants must account for their whole life cycle.

More precise climate projections give plant designers and investors greater confidence in future performance.

Adaptation measures of transmission and distribution assets in Europe

Adoption of mechanical fuses to reduce conductor breakages

Provision of alternative power network paths (network meshing, back feeding for laterals with many customers)

Remote control, grid automation and digitalisation to promptly reconfigure and restore the network.

Remote control to isolate only the faulted network.

Planning of network according to the “n-1” standard with alternative back feeds available in the event of damage.

“Meshing” of network should be considered where feasible.

Design of overhead lines to account for increased wind speeds and icing, also considering vegetation management.

Flood risk assessment must be carried out to ensure assets are well placed and sufficiently protected.

Coordination with local authorities to help ensure a coherent approach to flood risk assessment.

ZOOM IN

Floods in Central Europe provoked 200,000 customer outages in July 2021. 220 people died.

The storms also caused devastating damage to houses and infrastructure, to a cost of more than €46bn.

Loss of telecommunication systems also inhibited response efforts.

ZOOM IN

Storms Arwen and Eunice struck the UK and Ireland in the winter of 2021-2022.

Over one million households lost power supply.

Mutual aid between regions was crucial for restoration efforts.

ZOOM IN

Some countries have introduced measures for national regulation.

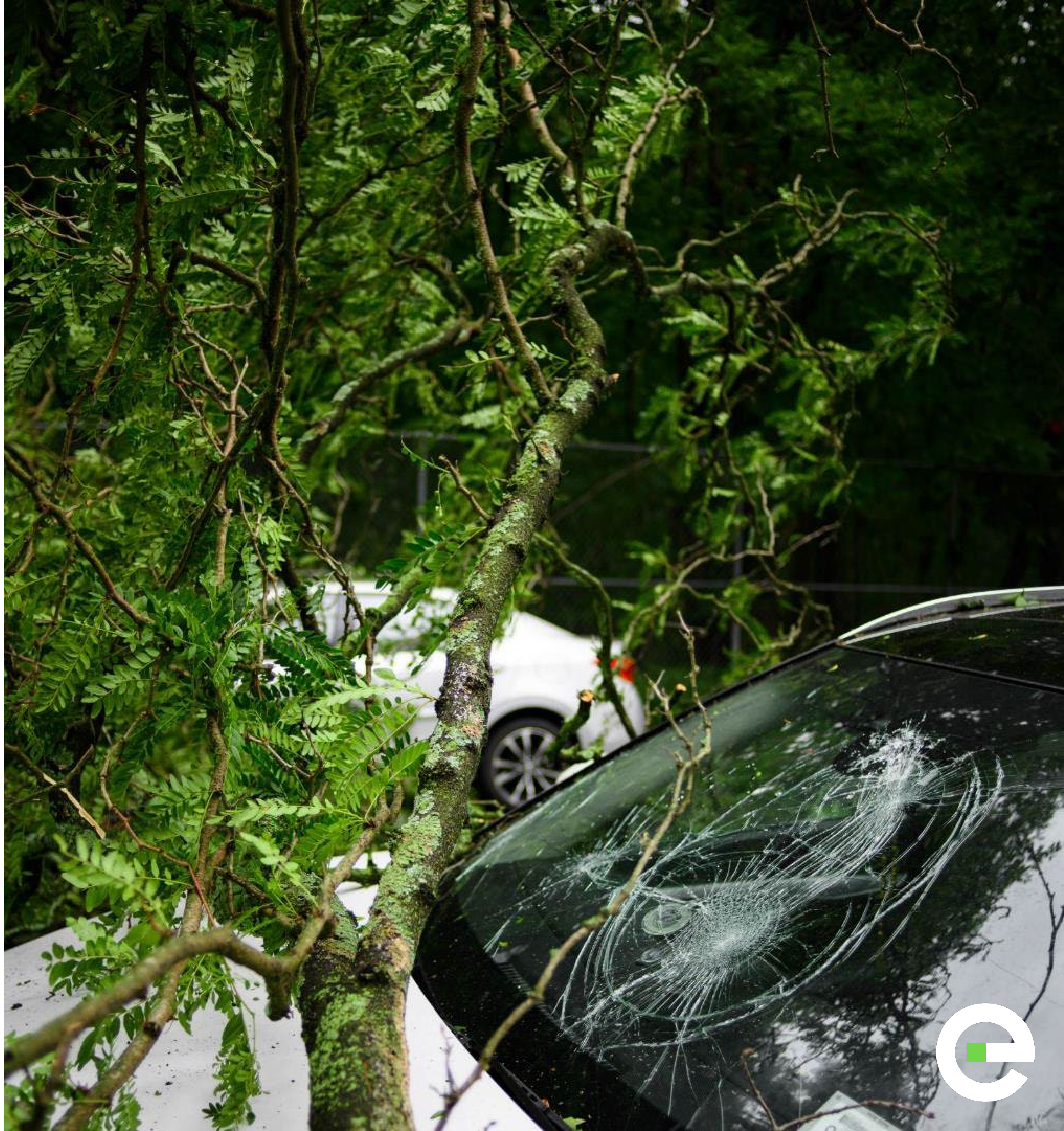
Resilience in Italy

After the intense snowfall of February 2015 in northern Italy, ARERA required DSOs to provide investment plans dedicated to resilience, identifying the priorities of interventions.

DSOs are required to publish a 3-year plan for dealing with:

1. Snow-Cable icing
2. Heatwaves
3. Windstorm-Tree fall

A Cost Benefit Analysis is provided, following guidelines approved by the Authority.



WHAT NEEDS INVESTMENT?

POWER SECTOR RESILIENCE INVESTMENT PERSPECTIVE

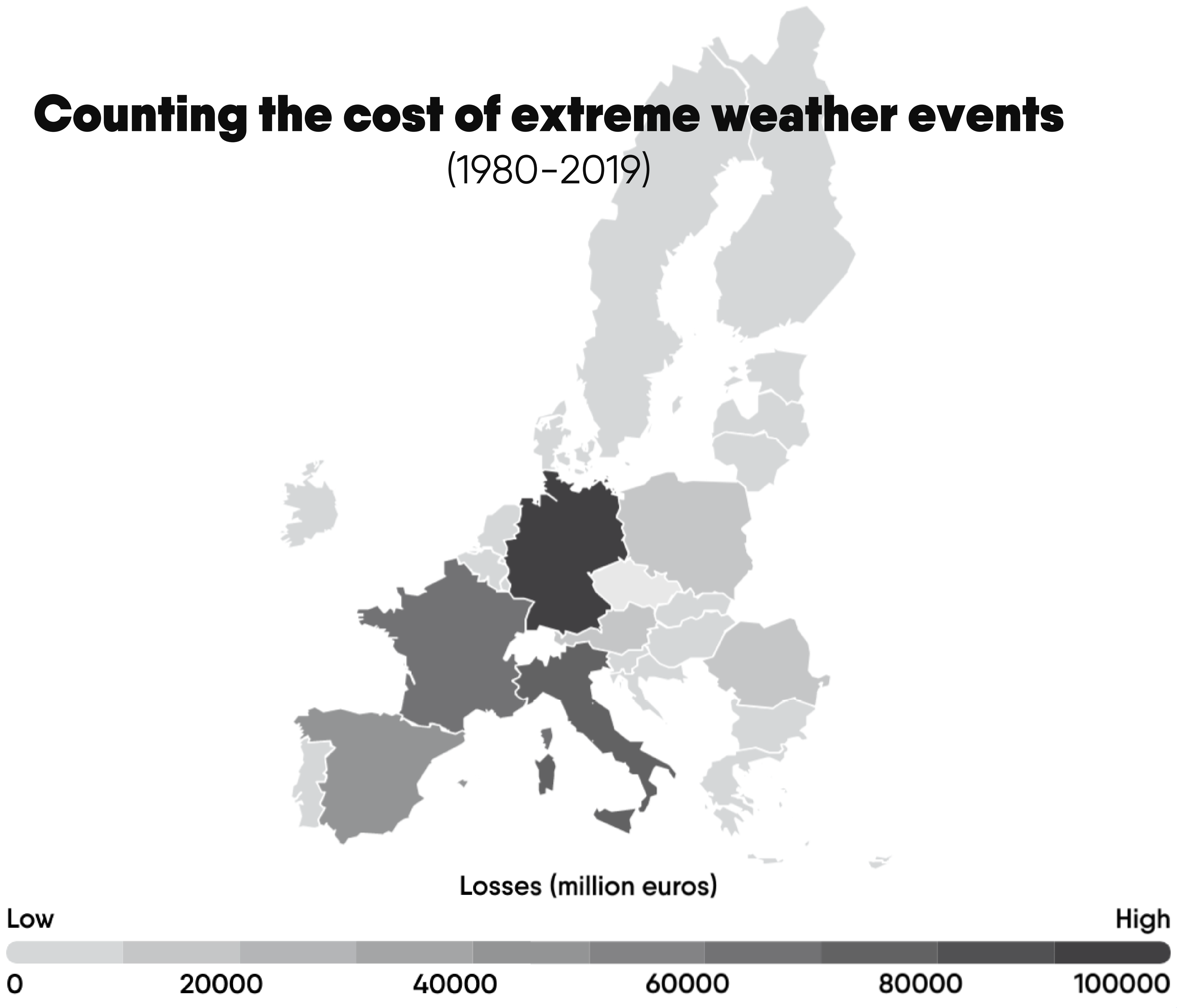
Extreme weather and climate-related events have caused over €145bn in economic losses in the EU over the past decade*.

*European Environmental Agency, Eurostat, 2022.

Between 1980 and 2019, the average economic loss due to extreme weather and climate-related events amounted to €15bn per country.

Counting the cost of extreme weather events

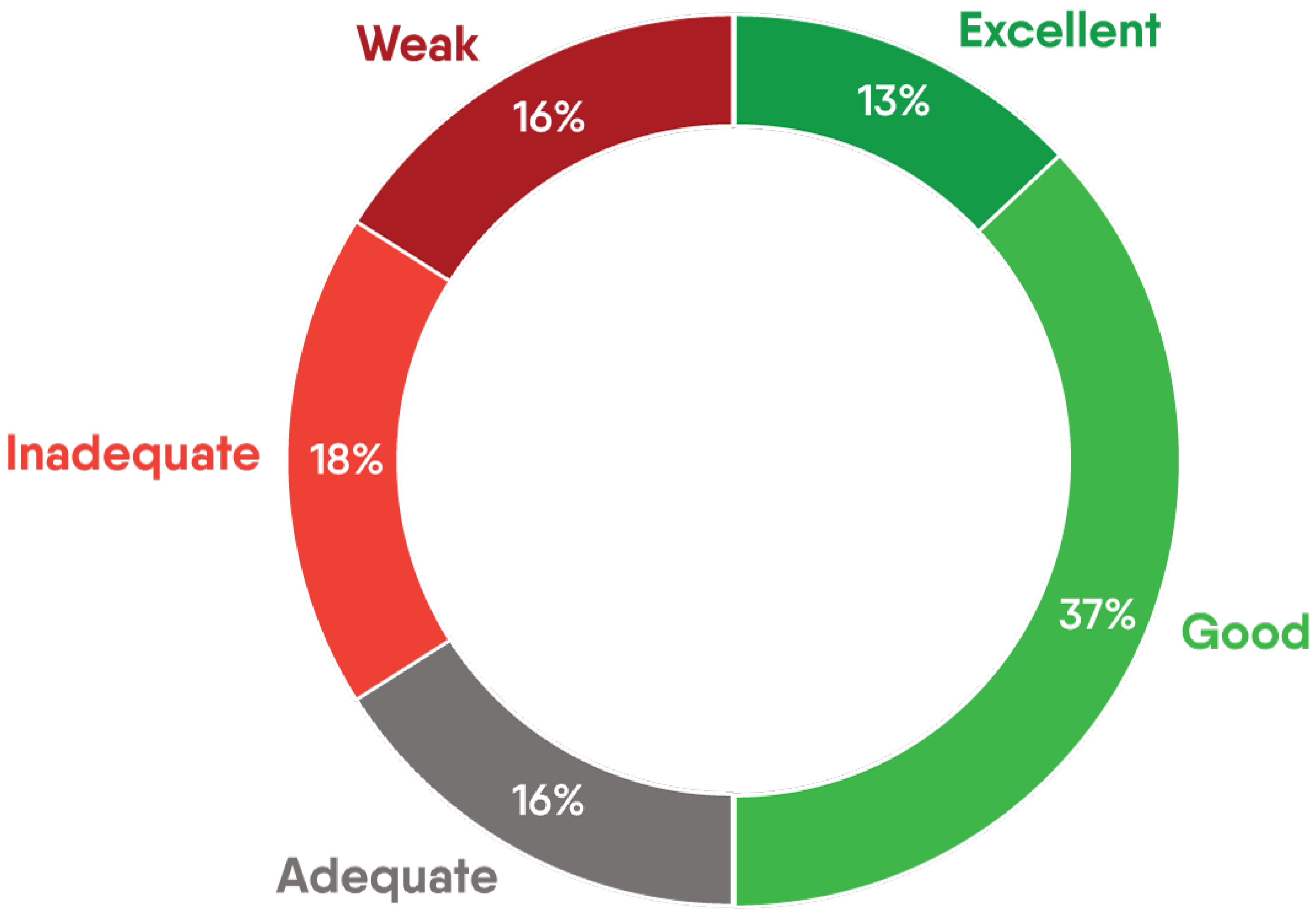
(1980-2019)



Eurelectric Power Barometer 2021, from The International Disaster Database

Despite such economic losses, around a third of IEA members are insufficiently prepared for climate risks and assessed as weak or inadequate to cope with the estimated level of risk.

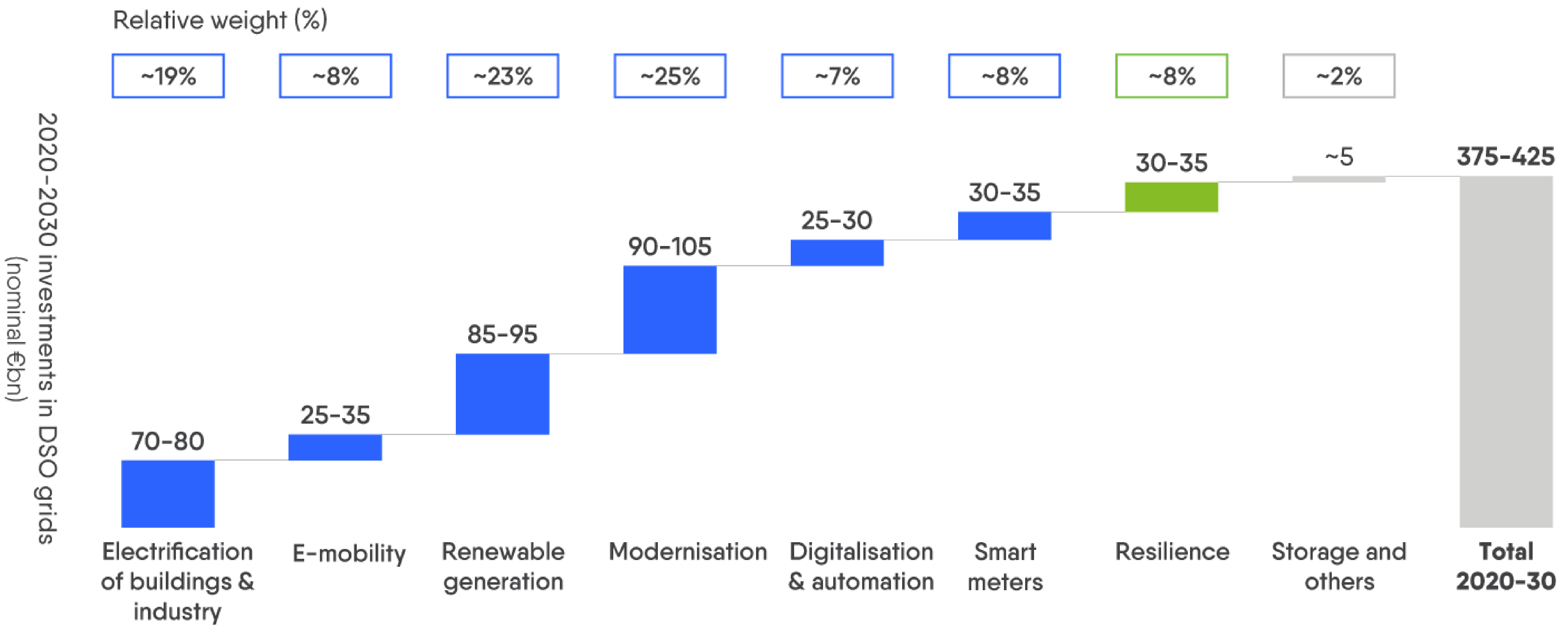
Countries need to better anticipate the risks



Source: Climate Resilience Policy Indicator, IEA member and association countries, May 2021

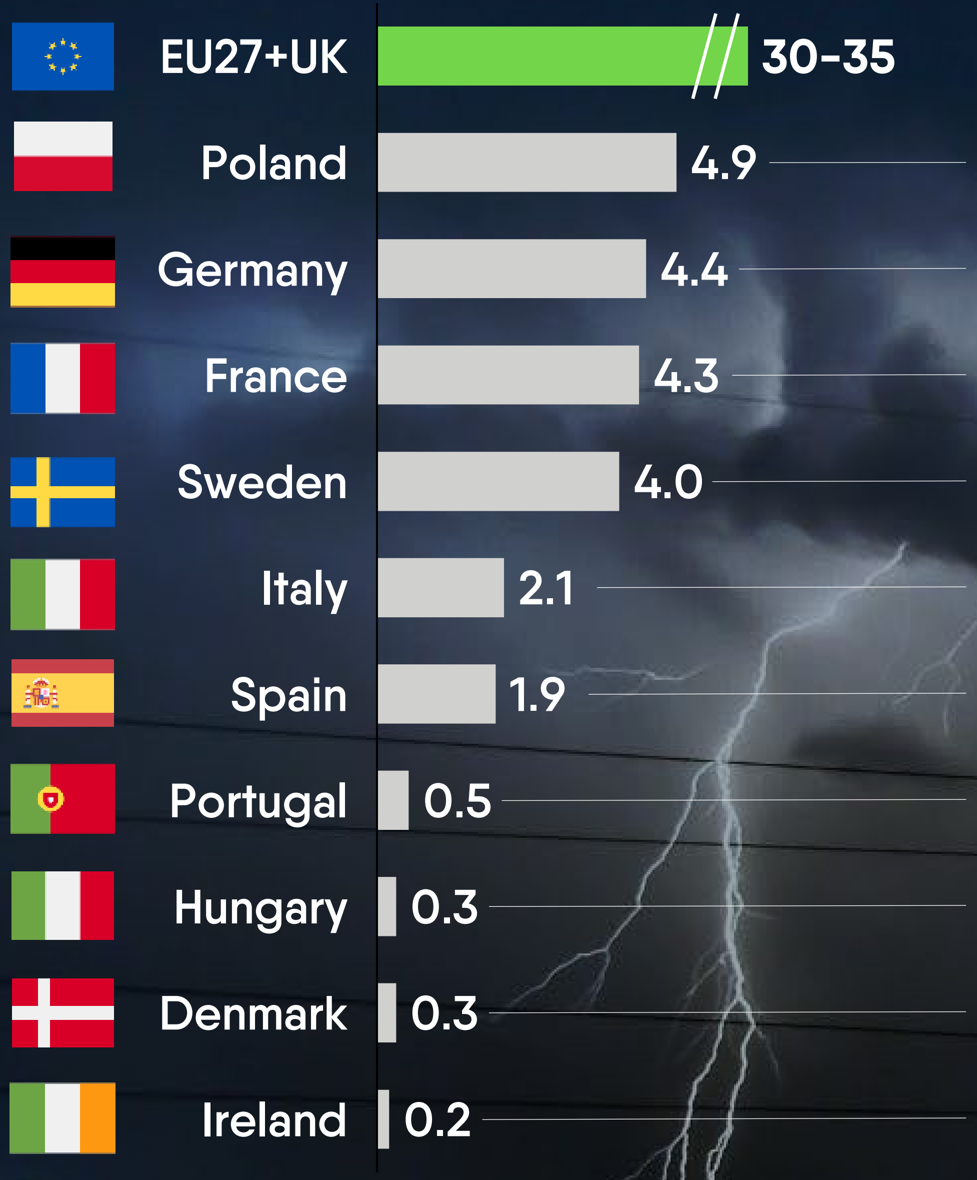
Since we estimated resilience investment needs in 2021 to be €33bn, extreme weather events have been increasing and resilience is becoming a fundamental component of grid investment.

Resilience is a growing component of grid investment



Source: DSOs and national associations; Monitor Deloitte

Electricity grid resilience will be key to climate change adaptation



- Poland: **Ambitious plan to replace overhead lines with underground cables** for the entire MV network to reach the EU average ratio in 2040
- Germany: **Structurally integrated in their investment plan** as replacements and new lines are mostly underground
- France: **Resilience plan** to ensure electricity supply under extreme weather events (floods, storms, snow, etc.)
- Sweden: **Program to shift overhead lines to underground lines and to add capacity**, to reduce the impact of weather events in grids
- Italy: **Plan to increase resilience** promoted by NRA since 2017 through a set of **incentives based on output indicators**
- Spain: Becoming of great importance due to more frequent extreme weather events. The plan will be focused on **increasing share of underground lines**
- Portugal: Becoming of great importance due to more frequent extreme weather events and low share of underground line
- Hungary: Resilience plan aims to increase **share of underground lines** to improve service quality under extreme weather, add additional capacity and lower opex costs
- Denmark: Resilience is **not a focal point** of the investment plan as there is already a **high share of underground lines**
- Ireland: In the context of a relatively **benign climate** and few extreme weather events, the resilience program includes **flood protection and continuity programs**

Resilience investments depend on technical (e.g. grid voltage levels, share of underground lines) **and economic factors** (e.g. incentives, impact of extreme weather events)

Source: DSOs and national associations; Monitor Deloitte

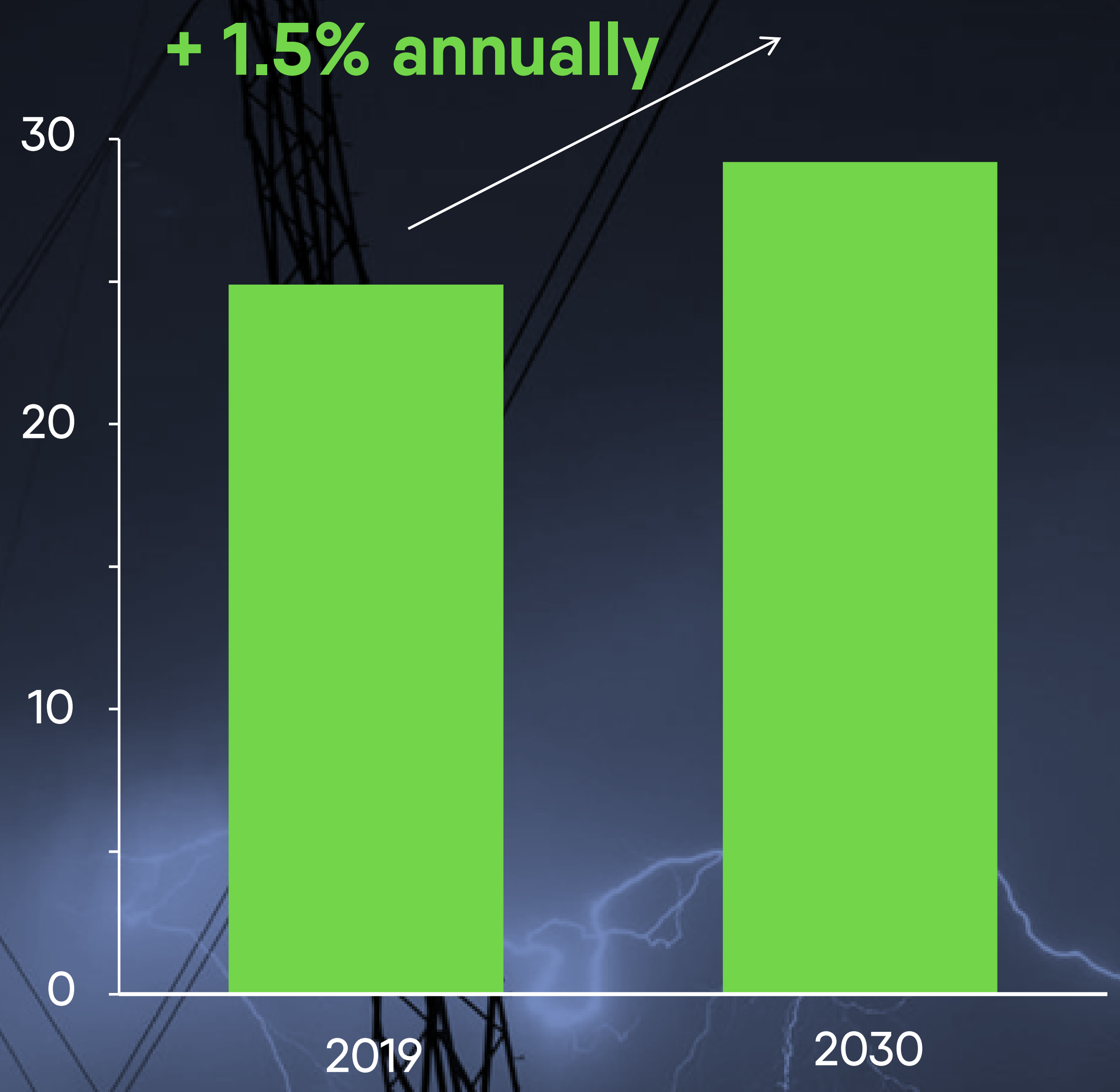
Investments in grids is a must and will bring short and long-term benefits.

Needed grid investments will result in only a 1.5% CAGR increase in the cost of electricity over 2020-2030, outside inflation.

Investments will bring short- and long-term benefits:

- Reduce long-term incremental investment needs and tariff impacts, where digital investments are key.
- Enable RES deployment and electrification that will ultimately reduce the electricity bill
- Enable flexibility measures to increase cost-effectiveness

Impact of DSO investment on electricity cost per electricity unit (€nominal/MWh; EU27+UK)



Source: Eurelectric; DSOs and associations; Monitor Deloitte

POLICY RECOMMENDATIONS

FOR A RESILIENT EUROPEAN POWER SECTOR

POLICY CHANGE

A holistic perspective is required.
More has to be done to ensure the resilience of our electricity system

2019 — 2020 — 2022 — 2023 — 2024

Q2 2019
Risk Preparedness Regulation adopted

Q2 2020
Taxonomy for sustainable activities Regulation adopted

Q1 2022
Taxonomy Delegated Act Climate Change Adaptation adopted

Q3 2022
MEPs say the EU must urgently strengthen its climate action

Q1 2023
Resilience of Critical Entities (CER) Directive scheduled to be adopted

2024
New Commission and Parliament

2025
MFF negotiations begin

REPowerEU & Recovery and Resilience facility (RRF)

Eurelectric overarching policy recommendations

01 Consider adaptation in partnership with mitigation

02 Take a holistic view to ensure stronger coordination and continuous communication between all stakeholders

03 The regulatory framework for system operators, taxonomy screening criteria for private investments and resilience funding must encourage power system climate adaptation

Eurelectric policy recommendations

European Commission

- Re-organise EU climate adaptation funding
- Involve all energy sector stakeholders in climate adaptation
- Electricity market design needs to consider its effect on the resilience of the power system
- Flexibility market design should go hand in hand with physical system design

National Regulatory authorities

- Incentivise resilience investments
- Integrate national climate adaptation plans and company investment plans
- Digital investments by system operators should be remunerated and incentivised

Best practices for generators and system operators

- Establish emergency management teams, with clearly defined roles, responsibilities, and resources, when an extreme event is forecasted to impact the power system
- Adopt a multimedia approach to providing information to the public, including traditional and social media
- Consider redundancy in the design, operation and maintenance of the power system, accounting for dependencies
- Use cost-benefit analysis and a consistent impact assessment framework for specific adaptation measures
- Support resource sharing between neighbouring system operators
- Customer flexibility and DER can support the system during extreme weather events