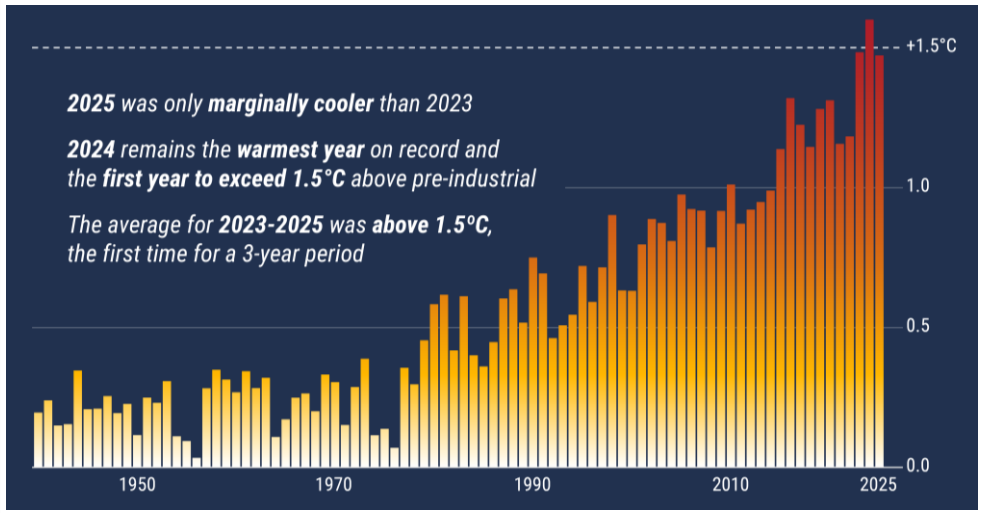
Climate change: main highlights

Climate change is driving a continuous **increase** in **global surface air temperature**, exceeding pre-industrial levels by **nearly 1.5° C in 2025**, thus representing the **third-warmest year on record.**

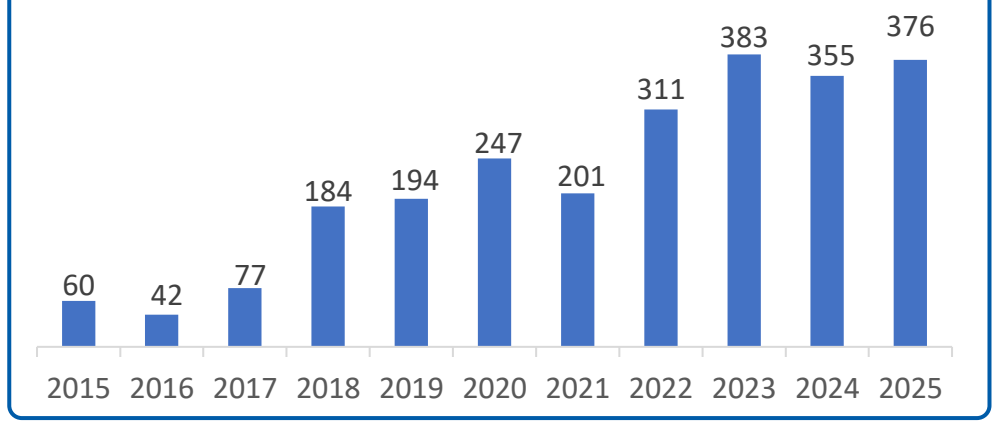
Further warming expected in the coming years is increasing the likelihood of **extreme weather events**, as already observed in recent years.

Global annual surface air temperature increase since 1940



Source: "Global Climate Highlights 2025", Copernicus, Data ERA5,

Extreme events trend in Italy



Source: Report «Città Clima – Bilancio 2025» Legambiente

In Italy, in 2025, over 375 extreme weather events have been observed, in increase of 5,9% vs 2024.

Categories with greater increase

+94,1%
Extreme heat waves

+42,4%
Landslides due to heavy rainfalls

+28,3%
Extreme winds phenomena

Source: Report «Città Clima – Bilancio 2025» Legambiente

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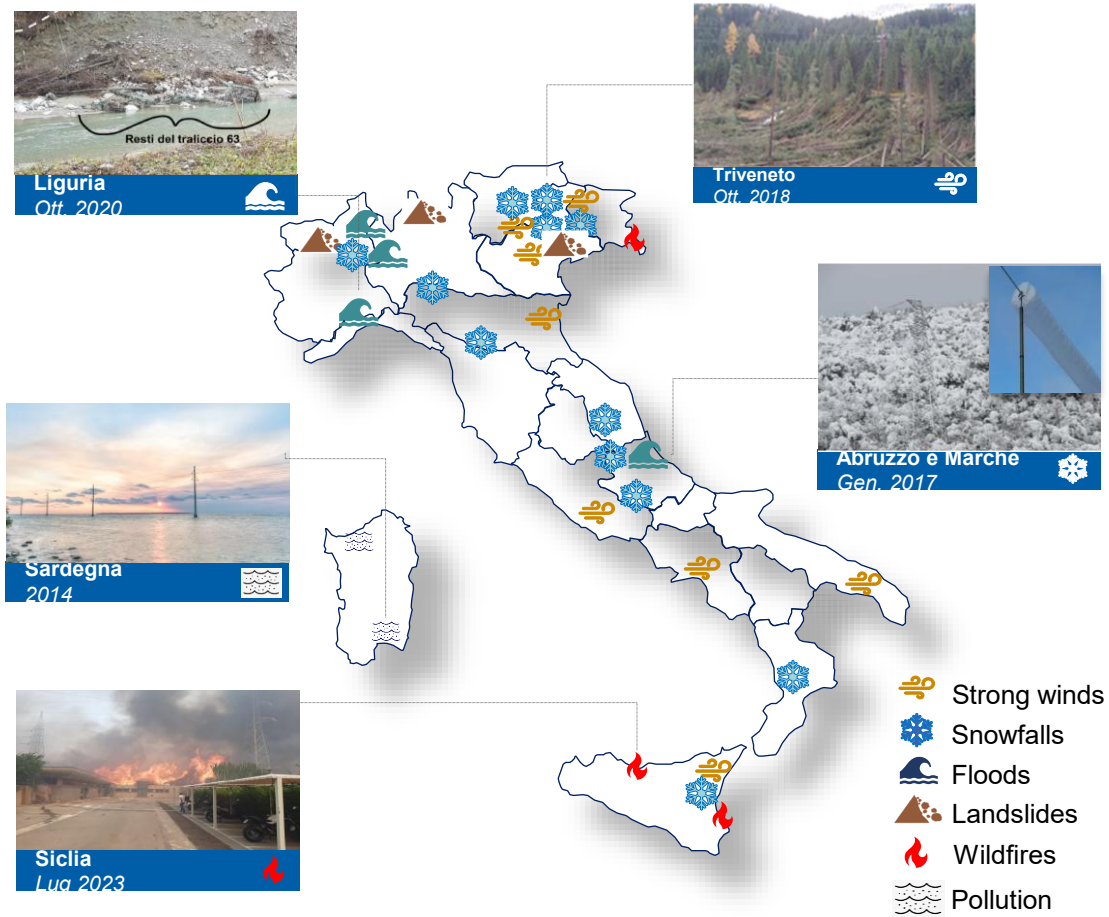
Impacts on the Italian National Transmission Grid (NTG)

MAIN EVENTS IN ITALY



MAIN PHOENOMENA WITH IMPACT ON NTG

The formation of **snow sleeves** on NTG line conductors can induce **stresses exceeding design limits** and lead to **short circuits** or **structural failures**

The action of **wind** can cause **direct damage** to NTG lines or lead to the **fall** of **nearby trees**, which, when uprooted, may potentially come into contact with the lines in the nearby

Hydrogeological phenomena, such as **floods**, **overflows**, and **landslides**, can cause failure events on NTG lines or substations, leading to **short circuits** or **structural damage**.

Climate change represents one of the **main challenge** for TSOs to ensure **reliability** and **continuity** of the **energy supply** and require to develop and adopt **innovative** and **forward-looking methodologies** to anticipate future trends and guarantee the **adaptation** of **critical infrastructures**

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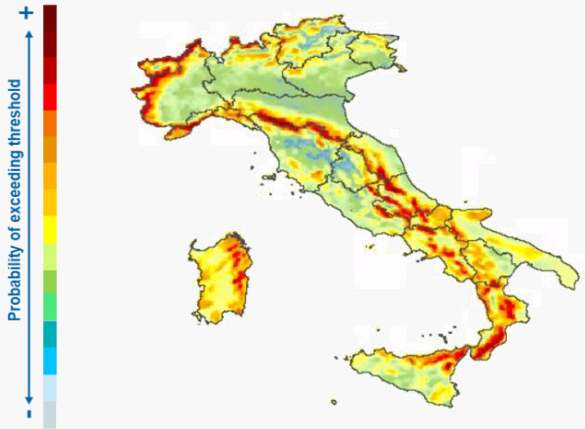
The Resilience Methodology

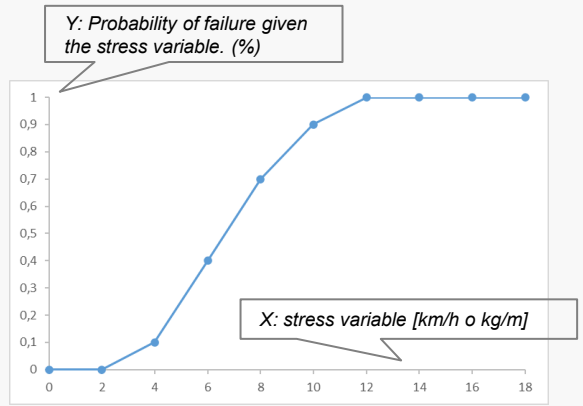
Terna has adopted the **Resilience Methodology,** a prospective, risk-based approach to identify the most vulnerable areas of NTG, calculate the risk of outage and quantify the benefit of resilience intervention. The methodology is characterized by the following key pillars:

PROSPECTIVE CLIMATE HAZARD



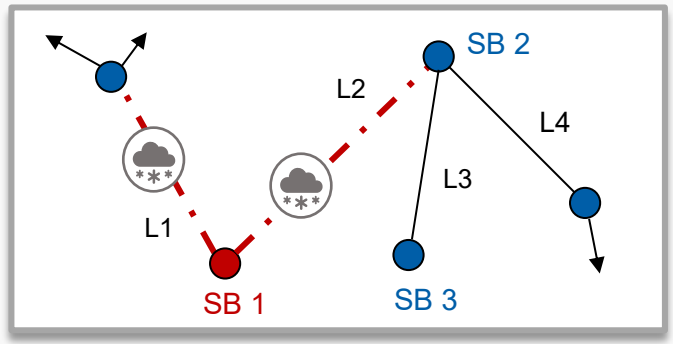
Use of specific **prospective climatological models** for each threat to determine the **probability of occurrence** of **severe weather events**, with high spatial resolution.

ASSETS VULNERABILITY



Vulnerability assessment of **OHLs** (failure probability): **vulnerability curves,** which are function of the **threat intensity**, are built by adopting an **engineering approach** based **on technical standards**.

CONTINGENCIES ANALYSIS



A **contingency analysis approach** to evaluate system resilience, quantifying **substations' outage Return Periods (RP)** and **EENS (Expected Energy Not Served)** after the simulation of **weather-induced multiple contingencies (N-k)**.

Resilience Methodology, approved by the Italian Regulatory Authority (ARERA) after a public consultation, is now embedded in the National Grid Code and applied within Terna's Resilience Plan

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Terna's Resilience Plan | Drivers

- All the intervention planned by Terna aimed at increasing the resilience of NTG are included in the **Resilience Plan**
- **Investments** to enhance transmission grid's resilience are identified accordingly to **5 main drivers**

Risk modelling

Development and consolidation of methodological approaches aimed at modelling meteorological and environmental phenomena with a significant impact on the NTG and assessing the associated risk of outage

Technological innovation

Study of new technologies to further enrich the portfolio of solutions available to the TSO to increase grid resilience and thus have a diversified and efficient mix

Partnership and scientific research

Strengthening collaboration with research institutes and academic institutions to combine multidisciplinary know-how and expertise essential for the study and modelling of complex phenomena such as extreme events, especially with regard to climate change.

Risk management

Further identify strengthening initiatives aimed at reducing the risk of outage due to extreme weather events

Digitalization

Development and implementation of new tools and devices aimed at enhancing capabilities in terms of control, management, real-time monitoring of assets and short-term forecasting, to anticipate potential critical issues.

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Terna's Resilience Plan | Types of intervention

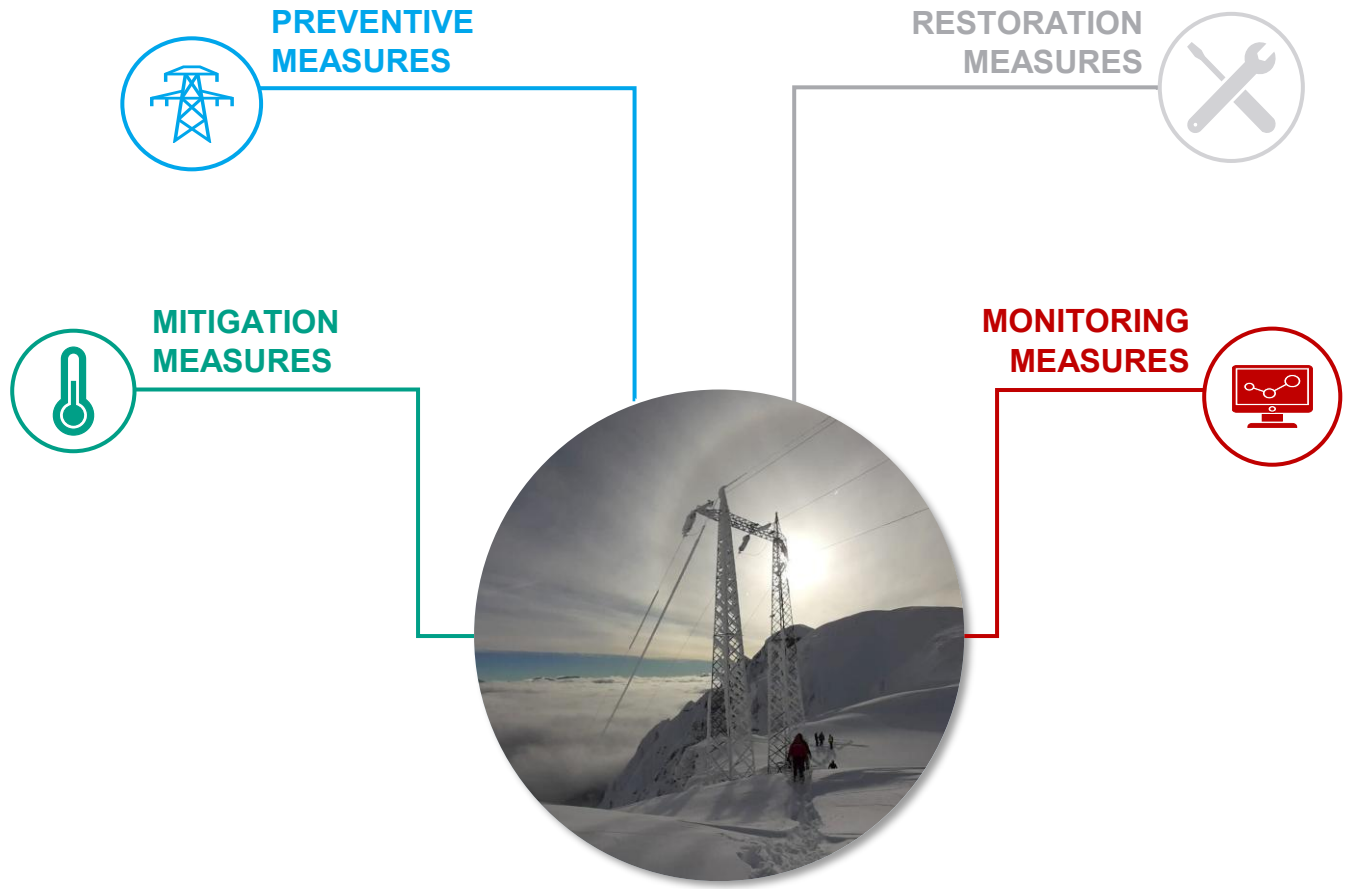
TYPES OF MEASURES

Preventive Measures, i.e. interventions implemented ex-ante to prevent the occurrence of failures such as, for example, the construction of new lines or cables or the undergrounding of existing overhead lines;

Mitigation Measures, i.e. capital light interventions to contain risks on the electrical system and reduce damage due to critical event;

Measures for restoration, i.e. interventions implemented ex-post, in response to the actual occurrence of failures to reduce outage times through equipment (e.g. generators, specialist vehicles) or remote protection and control devices;

Monitoring Measures, i.e. innovative technologies designed to anticipate critical situations and assess the need for real-time action aimed at preventing, mitigating or swiftly restoring any potential impact, such as predictive warning systems or IoT (Internet of Things) monitoring systems.



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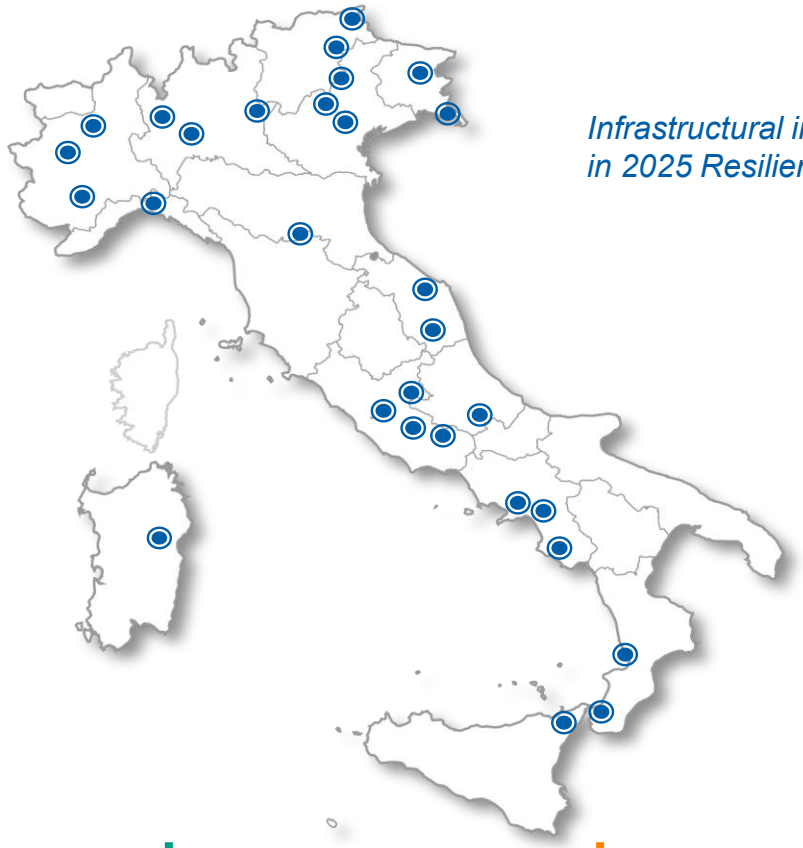
Terna's Resilience Plan | Preventive measures



Infrastructural interventions in 2025 Resilience Plan

34
 # Infrastructural interventions

63
 # Substations with reduced risk of outage

~500 km
of new lines or reinforcements

INFRASTRUCTURAL SOLUTIONS

Preventive interventions are infrastructural interventions aimed at increasing network resilience, also leveraging on technology diversification, increasing network meshing, and improving the reliability and robustness of existing assets:

- **Reinforce existing asset,** improving the mechanical characteristics with total or partial reconstruction to better resist against extreme conditions;
- **overhead lines conversion into underground cables**: reduce the exposure of asset to the effects of severe weather events;
- **new lines building (OHL or cable)**: increase the grid redundancy through meshing of the transmission grid.

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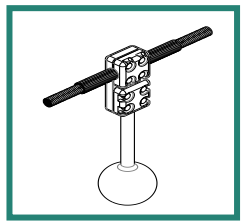
Terna's Resilience Plan | Mitigation, restoration, monitoring actions

MITIGATION

Anti-tortional devices to reduce wires' rotation which is at the basis of wet-snow sleeve formation



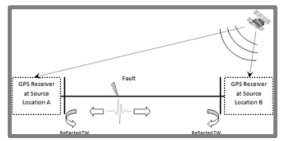
New "Icephobic" paint use of new conductors with hydrophobic paint reduce the risk of wet-ice sleeve formation

Interphase spacer devices: avoid the contact between phases

RESTORATION

New Emergency Plan

- fast recovery devices, such as generator sets, the operation *(power supply)* in loading islands
- New fault locator and protection system



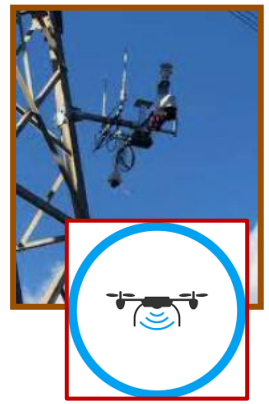
Advanced operational equipment

- Reinforcement of the vehicle fleet
- Reinforcement of satellite communications

- increased use of helicopters for inspections and emergency response

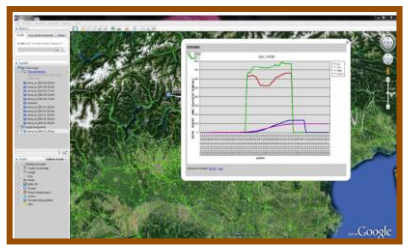
MONITORING

Remote monitoring
New technologies such as satellite or Wireless Sensor Network.



Monitoring tools

Forecast and alert systems able to foresee severe conditions in grid operations and to suggest possible real-time solutions



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