

# Research. **Connect.** Lead

## Resilience and preparedness in Europe's energy transition: the role of low-carbon energy R&I

### KEY ARGUMENT

Resilience and preparedness must **become core performance criteria of Europe's energy systems**. Low-carbon energy R&I is the strategic lever to achieve this transformation.

### MAIN TAKEWAYS: 8 CHALLENGES, 3 CLUSTERS

#### 1 Geopolitical and systemic governance

- **Geopolitical dependencies and supply chain risks:** Europe relies on a limited number of external suppliers for key low-carbon energy components. Supply constraints and export restrictions intensify vulnerability across the energy value chain.
- **Public governance and coordination gaps:** Fragmented governance between EU, national and regional levels hinders coherent responses to energy crises. Divergence in standards weakens adaptability.

#### 2 Physical and digital infrastructure

- **Cascading effects and systemic interdependencies:** Failures in energy systems cascade into transport, ICT, healthcare and industry. The April 2025 Iberian blackout illustrated how a power outage can disrupt multiple sectors simultaneously.
- **Infrastructure vulnerabilities:** Rapid deployment of low-carbon infrastructure introduces new potential failure points. Sector coupling across electricity, heat and hydrogen adds operational complexity.
- **Cybersecurity threats and hybrid risks:** Smart grids, automated renewable systems and hydrogen networks are vulnerable to cyberattacks and hybrid threats combining digital intrusion, physical sabotage and disinformation.

#### 3 Societal and climate dynamics

- **Climate-driven stressors:** Heatwaves, droughts, floods, storms and wildfires disrupt electricity networks. Variable hydropower, nuclear constraints and extended periods of low wind and solar output (Dunkelflaute) stress the system.
- **Societal dynamics and demand-side vulnerabilities:** Shifts in consumption patterns and community capacity to adapt determine how effectively systems respond to stress. The winter of 2022-23 demonstrated both the importance and the limits of societal responsiveness.
- **Misinformation and public trust:** Inaccurate narratives about technologies and policy objectives undermine confidence and hinder coordinated responses. Without trust, societies become more vulnerable to shocks and less prepared to manage systemic change.

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### THREE POLICY RECOMMENDATIONS

#### 1 Strategic direction and governance

- Reframe energy security through a systems lens, beyond supply continuity.
- Position low-carbon energy R&I as a strategic enabler of resilience through research priorities and funding.
- Institutionalise anticipatory governance: foresight, scenario analysis, stress-testing and risk assessment.
- Align FP10, ECF, the broader MFF and the revised SET Plan around resilience objectives.
- Establish a European Resilience Observatory for sustained strategic intelligence.

#### 2 Technological and infrastructure resilience

- Adopt systems-based R&I integrating technical, institutional and operational dimensions.
- Strengthen cyber-physical security through cross-disciplinary R&I and stress-testing.
- Secure critical supply chains; prioritise material substitution and circular practices.
- Deploy digital twins and AI-based analytics for anticipatory operation.
- Advance interoperability across electricity, heat, gas and hydrogen networks.

#### 2 Societal and operational preparedness

- Embed "preparedness by design" in regulations from the outset.
- Strengthen local and societal readiness through community energy schemes and training.
- Promote demand-side resilience with fair incentive schemes and regulatory frameworks.
- Invest in energy literacy and transparent communication to counter misinformation.

### PARADIGM SHIFT REQUIRED

Efficiency alone is no longer sufficient. It must be complemented by redundancy, adaptability and foresight. Resilience and preparedness must be recognised as key measures of system performance and policy success.

**Resilience and preparedness must become foundational principles of Europe's energy transition, embedded in governance, enabled by technology and sustained by societal trust**