# Research. Connect. Lead

## Unlocking the power of AI in Europe's energy systems

## KEY ARGUMENT

AI can significantly improve the efficiency, flexibility, and decarbonisation of Europe's energy systems, but only if deployed through **coordinated governance**, **quality data** and **strategic investment** at the EU level.

## MAIN TAKEWAYS

1 **Accelerate deployment**

- 👍 Smart grids, predictive maintenance, renewable forecasting, cybersecurity, materials discovery, Energy-as-a-Service.
- ⚠ Siloed data, legacy infrastructure, "black box" systems erode operator trust.

2 **Foster R&I and coordination**

- 👍 EU-wide AI energy testbeds; Common European Energy Data Space; strategic open-source models.
- ⚠ Fragmented funding; pilots that don't scale; workforce skills gap.

3 **Sustainably integrate data centres**

- 👍 Flexible demand, waste heat for district heating, grid flexibility services.
- ⚠ ~70% of EU cloud held by 3 non-European providers; grid congestion; local price spikes.

4 **Enhance transparency and oversight**

- 👍 EU leadership in Explainable AI for Energy (XAI-E); AI Act "high-risk" classification as opportunity.
- ⚠ No standard explainability metrics; black-box cybersecurity vulnerabilities.

5 **Establish coordination and governance**

- 👍 Unified regulatory environment; public-private partnerships; EU seal of approval for responsible AI.
- ⚠ Cross-border governance misaligned; industry reluctance to share data.

## THREE POLICY RECOMMENDATIONS

1 **Create an EU AI in Energy Mission Board**
Coordinate funding, host sandboxes for policymaker–academia–industry collaboration, issue an EU seal of approval for responsible AI solutions in energy.

2 **Build secure data and innovation ecosystems**
Implement the Common European Energy Data Space; create a network of AI energy testbeds; mandate interoperability standards to prevent vendor lock-in.

3 **Develop AI in energy competencies**
Require lifecycle sustainability assessments for large-scale AI deployments; redesign curricula; launch EU-wide campaigns to build public trust in responsible AI.

Europe can ensure that digitalisation directly contributes to climate goals, setting a global standard for transparent, fair and sustainable digital energy governance.

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

## 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**

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## From lab to leadership: bridging Europe's research-to-impact gap

## KEY ARGUMENT

Europe's competitiveness is held back not by a lack of research excellence, but by structural weaknesses that prevent low-carbon energy innovation from scaling from lab to market. EERA Innovation Hubs are proposed as the framework to close this gap.

## MAIN TAKEWAYS: 5 STRUCTURAL CHALLENGES

1 **Lack of strategic investment and de-risking**

Public support schemes operate in isolation, lacking coordination at national and EU levels. European startups face barriers to securing growth capital, limiting their ability to scale within the Single Market. While the EU's share of global patents remains high, only a third are exploited commercially.

2 **Regulatory and market barriers**

Inconsistent testing rules, certification requirements and IP policies across Member States create uncertainty. Technologies stall at the pilot phase, trapped by legal uncertainty rather than technical limitations. Complex regulations are a key reason European scale-ups relocate outside the EU.

3 **Skills misalignment**

Significant skills shortages in key green energy and digital sectors. Fragmented national approaches and slow adaptation of vocational training systems compound the problem.

4 **Limited access to research and technology infrastructures**

SMEs and startups lack the financial and administrative capacity to access essential research and technology infrastructure, especially across borders. Fragmented access schemes, administrative burdens and insufficient coordination slow the scaling of technologies from laboratory to market.

5 **Fragmented innovation policy landscape**

Innovation strategies evolve independently within Member States, creating overlapping initiatives and inefficient use of public funds. Internal market barriers are equivalent to internal trade barriers of 45–110%. Excellence is concentrated in a few economic poles, leaving large parts of Europe underrepresented.

## THE EERA RESPONSE: Innovation Hubs

### What they are

Mission-driven, networked catalysts. Neutral, pan-European platforms linking research, industry, finance and policy to accelerate technology transfer, de-risk investments and strengthen Europe's technological sovereignty.

### What the concept entails

- Bridges the 'innovation valleys of death' between TRL 1-4 (laboratory), TRL 5-7 (demonstration) and TRL 8-9 (industrial deployment).
- Provides an operational interface between public and private actors.
- Consolidates pilot infrastructure and demonstration facilities under shared missions.
- Offers policymakers evidence-based insights into technological readiness and investment gaps.

### Policy recommendations to materialise the proposal

- Build an integrated, end-to-end innovation financing and de-risking architecture, and align FP10 funding calls to support the whole TRL spectrum, from early research to deployment.
- Institutionalise research–industry–finance collaboration through mission-driven platforms.
- Strengthen the enabling ecosystem: skills, infrastructures and knowledge transfer, including the creation of a long-term one-stop-shop mechanism for transnational access to research infrastructures.

Europe's competitiveness deficit does not stem from a lack of ideas, but from the weak conversion of knowledge into industrial strength.