

Greenwheel Insights

Electricity systems in transition: Resiliency lessons from the Iberian blackout

Summary

On 28 April 2025, a rapid voltage rise on Spain's grid triggered a chain reaction of generator disconnections, which **plunged Spain and Portugal into a blackout** in just 83 seconds. A new report concludes that Spain's typically high share of renewables was not the primary cause but was just one factor in a **combination of regulatory and technical circumstances that had not kept pace with the changing generation mix**.

The report's **21 recommendations** cover all European grid operators and regulators, pointing to a **strengthened investment case for grid infrastructure**, a more supportive role for **renewables on European grids enabling further expansion**, and likely **harmonisation of European grid access rules** through the EU Grids Package.



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*"This report is a landmark for investors in European electricity systems. It **confirms that the blackout in Spain and Portugal in April 2025 was not an inevitable consequence of a renewables-dominated grid, but a failure of the regulatory and technical infrastructure needed to manage it**. The cascading voltage surge that protection systems could not arrest reflects years of grid governance lagging the pace of change to the technical foundation of the system.*

*The report's recommendations are directed at all European transmission system and regulators. That is the key signal for investors: **the vulnerabilities it identifies are systemic but addressable, and the investment and regulatory response required is continental in scale**. These conclusions **reinforce the case for substantial investments to future-proof grids** to handle substantial electricity demand growth and a more complex supply-demand environment. **They also speak directly to Redwheel-Ecofin investment strategies, which target the companies and assets driving the transition to a more resilient and efficient power network across Europe.**"*

Background

On the 28th of April 2025, voltage levels on Spain's electricity grid began to rise and then oscillate. Initial action worked to damp the oscillations but pushed voltages even higher. This **triggered a rapid chain reaction**: power plants began disconnecting automatically to protect their equipment, causing voltage to rise further still, triggering further disconnections and overwhelming system defences. **Within just 83 seconds, Spain and Portugal lost their connection to the wider European grid and fell into a blackout**. Restoration took around 12 hours in Portugal and 16 hours in Spain.

Some commentators initially blamed the high penetration of intermittent renewables on the Spanish grid, but the cause remained contested. A new report published on 20th March 2026 by an Expert Panel convened under EU regulations, **identifies the combination of factors** that made the system vulnerable and triggered the cascade, and **recommendations to prevent recurrence**.¹

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The blackout was the result of several interconnected factors

Solar and wind accounted for around 70% of generation before the blackout. This was a key contributor to high voltage levels, but **this share of renewables is not unusual.** The initial voltage oscillation was caused by a generator in southern Spain interacting unusually with the grid. Corrective actions successfully addressed this problem but raised voltage further, kicking off the cascade.

The report identifies a combination of factors that made the system vulnerable to cascading voltage control failures. These are listed without a criticality ranking. Broadly, these are:

- **Renewables couldn't help stabilise voltage.** Solar and wind plants were required to follow a fixed ratio of 'active' to 'reactive' power, meaning they had limited ability to help manage grid voltage fluctuations. When their active power output fell, either by market instruction or for automatic self-protection, their reactive power absorption also fell, triggering yet higher voltages.
- **Conventional generators underperformed, and live data was limited.** Several large thermal and hydro plants did not meet their reactive power obligations. However, the regulations didn't specify requirements, and there were no penalties for non-compliance. The system operator also lacked tools to track non-compliance in real time, limiting early warning.
- **'Shunt' reactors, designed only to manage voltage, were operated manually and couldn't be connected in time.** Shunt reactors - large electrical coils connected to the transmission system - are designed to absorb excess reactive power and reduce voltage.
- **Spain allows its grid to operate at voltages higher than the rest of Europe.** Spain's grid can operate over a 400-435 kV range, compared to the European norm of 380-420 kV. This left very little to no margin between the allowed operational limit and the voltage thresholds at which generators can disconnect for self-protection, and a very high voltage gradient between Spain and the rest of Europe, triggering instability and ultimately disconnection from the rest of the continent.
- **Disconnection settings were below regulatory thresholds for many generators,** meaning they tripped offline before they were required to. Additionally, some generators disconnected earlier than this but causes for some cannot be determined as the relevant data is not collected.

More broadly, **automatic defence mechanisms activated as designed, but the cascade of disconnections happened faster than they could respond.**

Twenty-one recommendations for improved resilience

The report lists 21 recommendations to improve systemic resilience across European grids. Key themes are:

- **Switch renewables to dynamic voltage control.** Require all generators, including existing renewables, to respond actively to voltage fluctuations, with economic penalties for non-compliance. This is the most consequential regulatory change identified.
- **Automate and strengthen reactive power management.** Introduce automatic control of shunt reactors and ensure grid operators have real-time visibility of generators' actual and required reactive power output.

- **Harmonise voltage operating range and build a pan-European oscillation management framework.** Spain's wider-than-European-standard voltage band should be changed to operate within the range used by the rest of the continent. Minimum damping standards should be defined, dynamic grid models should be shared across grid operators, automatic early warning systems developed, and stabilisation capabilities at large generators prioritised.
- **Fix and enforce generator disconnection thresholds** across all generators, require small rooftop PV systems to withstand high-voltage episodes without tripping, and conduct regular compliance checks.
- **Modernise system defence plans.** Current plans were designed for grids dominated by conventional generators and should be updated to reflect systems with high volumes of renewable and distributed generators.
- **Strengthen data governance and restoration readiness.** Establish a standardised framework for incident reporting, conduct real black-start tests (not just simulations), ensure backup communications for grid operators and generators.

Implications for investors

The blackout was not caused by too much renewable energy but by grid infrastructure and rules that were not designed to accommodate it. **The causes and recommendations outlined above point to three key takeaways** for investors:

- **The case for investment in grid infrastructure and supporting technology is strengthened.** The need for more grid capacity and management infrastructure (including batteries), voltage control equipment, and monitoring and automation technologies across Europe is clear, and will continue to grow alongside increasing renewable penetration and electrification of European economies.
- **Renewables are maturing as grid participants, supporting further growth.** The report's highest-priority recommendations include requiring all generators, including existing ones, to allow dynamic voltage control. This allows for greater integration of intermittent generation but implies short-term upgrade costs to existing capacity.
- **Harmonisation of grid access rules and processes brings simplification.** The report recommends that the European electricity regulator (ENTSO-E) issue binding guidance on voltage control modes, protection settings and other requirements covering all electricity system operators in Europe. Although this may produce stricter requirements and penalties for non-compliance, this would simplify the investment landscape.

The report's recommendations are advisory, and the authors invite European regulators to consider their translation into binding requirements. **It is likely that these recommendations will inform the development of the EU Grids Package announced in late 2025**, partly in response to the blackout.

ⁱ [ICS Investigation Expert Panel \(2026\)](#)

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