



K4K Food4Thought:

Iberian Blackout: From Inevitable Errors to Rebuilding Trust

Author's Note: Although I'm not an electrical engineer, I've worked as an economist and energy consultant since 1997, with a focus on electricity markets and infrastructure. I studied electricity in high school and have learned a great deal over the years by listening to engineers. This note isn't intended as a technical paper, but rather a reasoned reflection on how modern power systems behave—and sometimes fail. Any simplifications are mine, so please be understanding if I don't get every technical detail exactly right. 😊

This third reflection continues the series that began after the Iberian blackout of 28 April 2025. In the earlier articles I focused first on what happened, and later on how the system responded. Now the purpose is to ask what we've learned — and what still needs rebuilding. After the publication of the ENTSO-E factual report — which followed the earlier analyses by REE and MITECO — and after reading the reactions from UNEF and the diverse interpretations that have since appeared in the media, we finally have a clearer picture of the event. At 12:33 CEST on that day, Spain and Portugal went dark in what became the largest blackout in Europe in more than twenty years.

In the days that followed, explanations and theories multiplied: **cyberattack, too much renewable energy, human error, badly tuned protection systems**. But as I wrote in my [Part 1](#) and [Part 2](#), these kinds of events are not as extraordinary as they seem. Blackouts happen even in advanced and well-managed systems, operated by competent professionals using modern technology. **Failures are inevitable**. What matters is not assigning blame but learning.

The energy transition is forcing an unprecedented transformation in how power systems are operated, and in a process of this magnitude, setbacks are to be expected. This article does not aim to close the technical debate but to offer an **economic and institutional reflection** — on what this event reveals about the limits of our models, the management of uncertainty, and, above all, the importance of **trust** as a vital asset in modern electricity systems.

What we already knew

In Part 1, written just two days after the event, I suggested looking at the blackout calmly — not as a national failure but as an opportunity to understand how complex systems behave. I reminded readers that behind every blackout there are three layers:

1. a **trigger**,
2. a **structural vulnerability**, and
3. an **operational or regulatory failure**.

The factual report by **ENTSO-E**, published on 3 October 2025, essentially confirms that same structure. There was a trigger — a cascade of generator disconnections caused by voltage stress; there were vulnerabilities — ever-tighter reactive-power margins; and there were institutional limits — rules and protections designed for a simpler system than the one we have today.

In that first article, I also stressed that blackouts should not be dramatized: they are part of the learning process of a grid that is evolving faster than its rules. Similar events have occurred in countries as advanced as the United States (2003), Germany (2006), the UK (2019), and Australia (2016). The common denominator was not incompetence but complexity. Once networks reach a certain level of interdependence, failures stop being “isolated incidents” and become emergent phenomena — the product of how thousands of automatic protections and control systems interact in real time.

What we learned afterwards

In Part 2, published on 20 June 2025, after REE and MITECO released more information, I clarified that this was not a case of failed forecasts by the system operator. REE managed reasonably the risks it knew; what failed were the things no one yet knows how to predict. I said it then and it remains true now: **we need better tools to deal with the unforeseeable.**

But those tools are no longer enough. The ENTSO-E report shows this clearly: within seconds, the Iberian system went from normal operation to total separation. Traditional N-1 criteria might not have captured those kinds of non-linear dynamics. That is why, rather than blame, we need evolution. What the TSO truly wants — and needs — is not another manual but **tools that can anticipate the unexpected**: more realistic simulations, better voltage-control capability, and mechanisms that turn data into useful real-time decisions.

Box 1 – What ENTSO-E’s factual report and the other studies say

At **12:33 CEST on 28 April 2025**, the Iberian system suffered a rapid sequence of **overvoltage-driven generator trips** that led to **loss of synchronism with Continental Europe and Morocco**. Within seconds, about **2.5 GW of generation** and roughly **15 GW of load and pumping** were disconnected.

The disturbance unfolded as a **voltage and reactive-power collapse**, not a frequency or inertia failure. Two oscillations—around 0.63 Hz and 0.21 Hz—appeared minutes earlier; actions taken to damp them, including an **HVDC-mode change on the France–Spain interconnection**, unintentionally increased system voltages and reduced reactive margins.

ENTSO-E, REE, MITECO, Comillas-IIT, and Compass Lexecon / INESC TEC all describe the same physical chain of events, though they differ in emphasis and tone:

- [REE](#) reported that several plants tripped *before* reaching protection thresholds defined in P.O. 1.1 and Order TED/749/2020 and that some units subject to P.O. 7.4 failed to provide the required dynamic voltage support.
- [MITECO](#) endorsed that account, noting that reactive-power margins were already narrow because of oscillations detected earlier that week.
- [Comillas-IIT](#) analysed the event as a **voltage-stability collapse** driven by widespread disconnection of inverter-based generation operating under fixed power-factor control and by insufficient synchronous support in weak grid areas.

- [Compass Lexecon / INESC TEC](#) agreed on the physics but argued that **operator actions to mitigate oscillations (HVDC mode change and line reconnections)** further increased voltages and eroded reactive absorption capacity; it described the event as a **system-wide voltage-control failure** rather than isolated plant errors.
- [ENTSO-E](#) reproduced the same voltage-band logic (405–410 kV at 400 kV nodes) but **did not confirm non-compliance**, citing incomplete and unsynchronised data from several generators.

System restoration progressed steadily: **Portugal** was reconnected by 00:22 on 29 April, **Spain's transmission grid** by 04:00, and **99.95% of demand** was back by 07:00, with technical close-out at 14:36.

All reports converge on the conclusion that the blackout stemmed from a **combination of model limitations, protection behaviour, and insufficient reactive-power control**, not from a single operator error or renewable-technology fault. The **ENTSO-E factual report** explicitly **avoids assigning responsibility**, leaving that to the **final investigation expected in Q1 2026**, but underlines the need for **better dynamic modelling, complete data exchange, and wider voltage-control capability across all generator types**.

How the story was told: press, sector and facts

(Optional section — can be omitted in the PV Magazine version)

After the factual report was published, the media offered very different readings. Some looked for culprits; others simply tried to understand. El Periódico de la Energía led with the headline “European experts share blame between REE and several generating plants.” Cinco Días quoted Iberdrola accusing REE of “reckless and negligent management.” El País lamented missing data from some companies, and El Economista spoke of “shared blame” between the operator’s management and high renewable output.

In contrast, PV Magazine — in articles by Pilar Sánchez Molina — adopted a more analytical approach: noting data disputes, the technical complexity of the event, and the ongoing regulatory limits affecting voltage control, without turning those issues into moral judgements. Meanwhile, UNEF reminded readers that the report did not blame renewables but instead highlighted regulatory constraints, notably the old P.O. 7.4 procedure, which limited solar and wind plants’ ability to contribute to voltage control. The association welcomed the subsequent update of PO 7.4 as a step in the right direction, though its practical implementation is still unfolding.

Between sensationalist headlines and more thoughtful analysis lies a crucial difference: some look for someone to blame; others look for ways to improve. It is in that second camp that I prefer to stand — the camp of learning, not finger-pointing.

Improving procedures is not enough: trust must be rebuilt

After a blackout, the natural instinct is to write new rules, revise protocols, multiply forms. And yes, procedures must be updated — as with Spain’s new PO 7.4 — but that only addresses part of the problem. The deeper challenge is **rebuilding trust** between generators, the system operator, and the regulator.

REE believed it had the system under control; generators believed they were meeting their obligations; the regulator believed the rules were sufficient. Yet when everything

failed at once, a deeper question emerged: **who do we trust when the system enters the unknown?**

Without trust, any new protocol is fragile. Generators will hesitate to follow instructions if they fear being punished for outcomes beyond their control. The operator will hesitate to intervene if every decision may later be questioned. And the regulator, caught between both, risks designing excessively defensive rules.

Rebuilding trust is not an administrative act; it is a process that requires transparency, honest communication, and mutual acceptance that no one knows everything. Technical resilience depends on institutional resilience: a power system is only as strong as the cooperation between those who operate it and those who regulate it. Without trust, even the best protocol becomes a dead letter.

Toward a more mature vision

We sometimes forget that resilience is measured not only in megawatts but also in **perspective**. A mature system is not one that never fails, but one that knows how to recover without losing composure.

That composure has a technical component — restoring voltage, frequency, interconnections — and a human one — maintaining cooperation among those who make it possible.

That is why, beyond new models or algorithms, we need a **pact of trust**: one that recognises that the energy transition will take us down uneven roads, and that the key is not to avoid every bump but to learn how to drive better.

The **ENTSO-E** factual report provides data; **UNEF** adds the voice of the renewable sector, reminding us that renewables were not “to blame” but part of a system that still limits their ability to contribute to voltage control. Both are valid points. But the deeper lesson is this: *the energy of the future cannot be managed only through procedures — it must also be managed through **relationships of trust**.*

Epilogue

When I wrote my first reflections, we were all looking for explanations. Today, with more perspective, I prefer to speak of learning. The 28 April blackout was not a minor incident, but neither was it a catastrophe; it was a **lesson in humility**.

The request submitted by REE to the CNMC on 7 October 2025 to introduce urgent changes to the operating procedures shows that the **concerns exposed in April have not dissipated**. Nor should this be a surprise, since the same conditions —low demand on the transmission grid, rising self-consumption, high solar generation, limited synchronous thermal capacity online, and narrow reactive-power margins— tend to reappear in spring and autumn. The [amendments](#) now under public consultation —to Operating Procedures 3.1, 3.2, 7.2 and 7.4— are designed to give the system operator greater flexibility in managing voltage and reactive reserves during these critical periods. They are exceptional and temporary measures, but underscore the need to remain flexible and adaptable.

Recognising that vulnerability is not a cause for alarm but a sign of maturity. It means accepting that even the most advanced systems are still learning to live with their own complexity. Because, in the end, that is what resilience means: **building trust while improving the tools** — knowing that even in the most civilised places, sometimes, the lights go out.

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Madrid, 9 October 2025.