K4K Food4Thought:

Iberian Blackout: What Happened and What Comes Next?

This follow-up builds on an earlier note I published shortly after the 28 April blackout, when the facts were still emerging and much remained uncertain. Now, with the benefit of additional details — including official statements and reports from **Red Eléctrica de España (REE)** and the **Ministry for the Ecological Transition and the Demographic Challenge (MITECO)**[1] — I revisit the event with a clearer picture of what went wrong and why.

What follows is not a full technical analysis, but an informed commentary on how the blackout unfolded, how REE managed risk under uncertainty, and what lessons can be drawn about operational responsibility, simulation limits, and system preparedness.

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. 😇

Where REE and MITECO agree

REE and MITECO offer a broadly aligned explanation of the 28 April blackout: something that should have worked, did not. Their assessments start from the same premise — that if all parties had fulfilled their technical obligations, the blackout would not have occurred. Let's begin with where there is consensus because there's quite a lot of it.

REE conducts daily simulations to assess the viability of the power system based on the **Base Daily Operating Schedule (PDBF)**, which is derived from the results of the day-ahead market. These simulations always identify infeasibilities. To address them, REE procures generation — primarily combined-cycle gas turbines (CCGTs) — through the Phase 1 Upward Technical Constraints mechanism (RF1U), along with other **ancillary services**. Some of these services can be provided by renewable technologies, and their purpose is to deliver the necessary flexibility.

As acknowledged by the Minister for the Ecological Transition and the Demographic Challenge, Sarah Aagesen, in the official press conference, one of the ten thermal power plants contracted to provide voltage regulation on 28 April declared itself unavailable at eight o'clock on the evening of 27 April. REE reran its simulations and

[1] See MITECO Expert report 28A June 2025, MITECO press release 17 June 2025, MITECO press conference 17 June 2025, REE press release 18 June 2025, and REE report 28A 18 June 2025.

concluded that, *ex ante*, the system remained viable, so no replacement capacity was contracted. This was a reasonable assessment based on the known risks at the time — REE was managing the known unknowns as best it could. What unfolded later fell into the realm of unknown unknowns: real-time conditions exposed vulnerabilities that had not been captured in earlier modelling — in other words, events beyond the scope of the **n-1 security criteria** REE typically applies.

When the System Failed: real-Time Complications

In real time, both **natural oscillations** (arising from the inherent dynamics of the power system and therefore to some extent foreseeable) and **forced oscillations** (caused by external periodic inputs or equipment malfunctions) occurred; one of the latter triggered by a photovoltaic installation located in the province of Badajoz. REE issued instructions to mitigate the disturbance, which helped contain the immediate issue, but these actions led to secondary problems — especially in **reactive power management**. This caused voltage levels to rise along high-voltage lines and an accumulation of reactive power that, under conditions of low demand, became increasingly difficult to control.

At this point, events became harder to untangle. What appears clear is that **certain power plants contracted to absorb reactive power did not meet their technical obligations**. As a result, despite REE's efforts, voltage levels continued to rise, frequency began to drop, and safety systems across the grid began to trigger disconnections of generation and demand — in some cases pre-emptively before safety thresholds were officially breached. These **cascading events culminated in the blackout**.

Did the French Interconnector play a role?

As an aside, it is worth noting that Spain was exporting to France during hour 13 [12:00–13:00], but price forecasts for hour 14 [13:00–14:00] suggested France would become cheaper, implying a **reversal of flow**. How this factored into REE's pre-contingency planning is unclear — no public statements that I can find reference this directly. While reductions in exports did form part of the real-time response to oscillations, this may not have caught REE off guard, as a reversal was already anticipated from market signals. The precise role of the interconnector in the sequence of events remains unclear, but it was probably not decisive.

REE adjusts its Operating Assumptions

In the aftermath of the blackout, REE has increased its procurement of thermal capacity through RF1U. Some have interpreted this as an admission of fault. A more plausible explanation is that REE has updated its simulation parameters to reflect a higher probability that certain flexibility providers may fail to deliver when needed. This is not an admission of failure — it is a rational recalibration of assumptions to reduce operational risk. The result is a new, technically grounded operating mode in which more thermal generation is proactively secured. This procurement remains pay-as-bid, as per current regulations.

There is, however, an uncomfortable irony: the same thermal units whose underperformance may have contributed to the blackout are now being rewarded with increased dispatch opportunities and revenue.

Compliance vs. Blame

REE and MITECO agree on a fundamental point: had all actors met their obligations, the blackout would not have occurred. This implies that the blackout was the result of localized non-compliance, not a systemic design flaw.

Crucially, this was not a failure of renewable energy — nor of any particular technology class. Under Spanish law, all generators, including renewables, are required to comply with the **Procedimientos de Operación (POs)**, published in the **Boletín Oficial del Estado (BOE)**, which are legally binding. If a plant operated in accordance with these procedures, it cannot be held legally responsible for the outcome, regardless of its technology. While some renewable units may have disconnected earlier than ideal, that alone does not justify blanket blame.

What Comes Next: Three Priorities

Technical solutions have been proposed. But in my view, the **next steps are straightforward**:

1. **Restore trust in flexibility providers.** Generators assigned to RF1U and other ancillary services must demonstrate their technical competence to regain REE's trust. If REE can once again rely on these resources to perform as expected, it will be able to reduce its reliance on additional thermal reserves — which would, in turn, lower system costs for consumers. These costs have been particularly high since the blackout, as shown in Table 1 below.

Table 1: Components of the final price (Spanish mainland)

	Jan 25	Feb 25	Mar 25	Apr 25	May 25	Jun 25[1]
Day-ahead market	100.35	110.76	55.56	29.11	17.86	63.71
Intraday market (MIBEL and continuous auctions)	-0.1	-0.1	-0.1	-	-0.07	-0.24
Ancillary Services	11.56	16.32	15.87	18.37	26.21	17.68
of which Technical Restrictions	4.21	4.07	6.62	11.34	21.97	12.49
Capacity payments	0.27	0.27	0.18	0.14	0.13	0.13
Final price (€/MWh)	112.08	127.25	71.51	47.62	44.13	81.28

1: Data available as of 19 June 2025.

Source: REE (https://www.ree.es/en/datos/markets/componets-price-energy-at-closing?start_date=2025-01-01T00:00&end_date=2025-06-30T23:59&time_trunc=month&systemElectric=peninsular)

2. **Create markets for flexibility.** Spain needs a broader suite of markets to remunerate flexibility services. The CNMC's approval of proposed changes to Operating Procedure 7.4 — published on 19 June 2025[2] — marks an important first step: the creation of a dedicated market for voltage control through the injection or absorption of reactive power. But this alone won't be enough. The next priority is to accelerate the deployment of this and other frameworks, ensuring they set out clear technical requirements and deliver strong, predictable economic signals to a wide range of flexibility providers.

3. **Enable targeted investment.** Once adequate incentives are in place, investment in grid-connected infrastructure — retrofitting existing assets or adding new ones — should be actively supported to manage these types of events and ensure all assets meet their technical obligations.

Final thought: Sunlight and Perspective

We were lucky in our unluckiness. For all its technical complexity and work that still lies ahead, it's worth remembering that the blackout struck in the middle of the day. For most people, most of the time, it was not really a blackout. The sun was shining, the

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[2] https://www.cnmc.es/sites/default/files/5996224.pdf.

weather was fair, and many simply paused, stopped work once the laptops ran out of juice, and chilled.

There's a broader parallel here. Spain is often spoken of as a country in constant crisis — yet by most measures, we are fortunate: safe, comfortable, and surrounded by sunshine. Sometimes, perspective is the rarest form of resilience.

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Madrid, 20 June 2025.