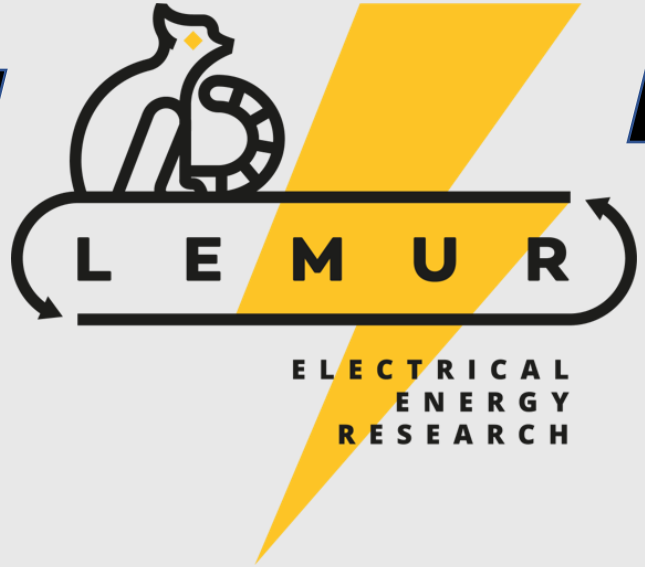
Universidad de Oviedo
Universidá d'Uviéu
University of Oviedo

L E M U R
ELECTRICAL ENERGY RESEARCH



Apagón - April 28, 2025

LEMUR. **University of Oviedo**
Department of Electrical Engineering – lemur@uniovi.es

DISCLAIMERS

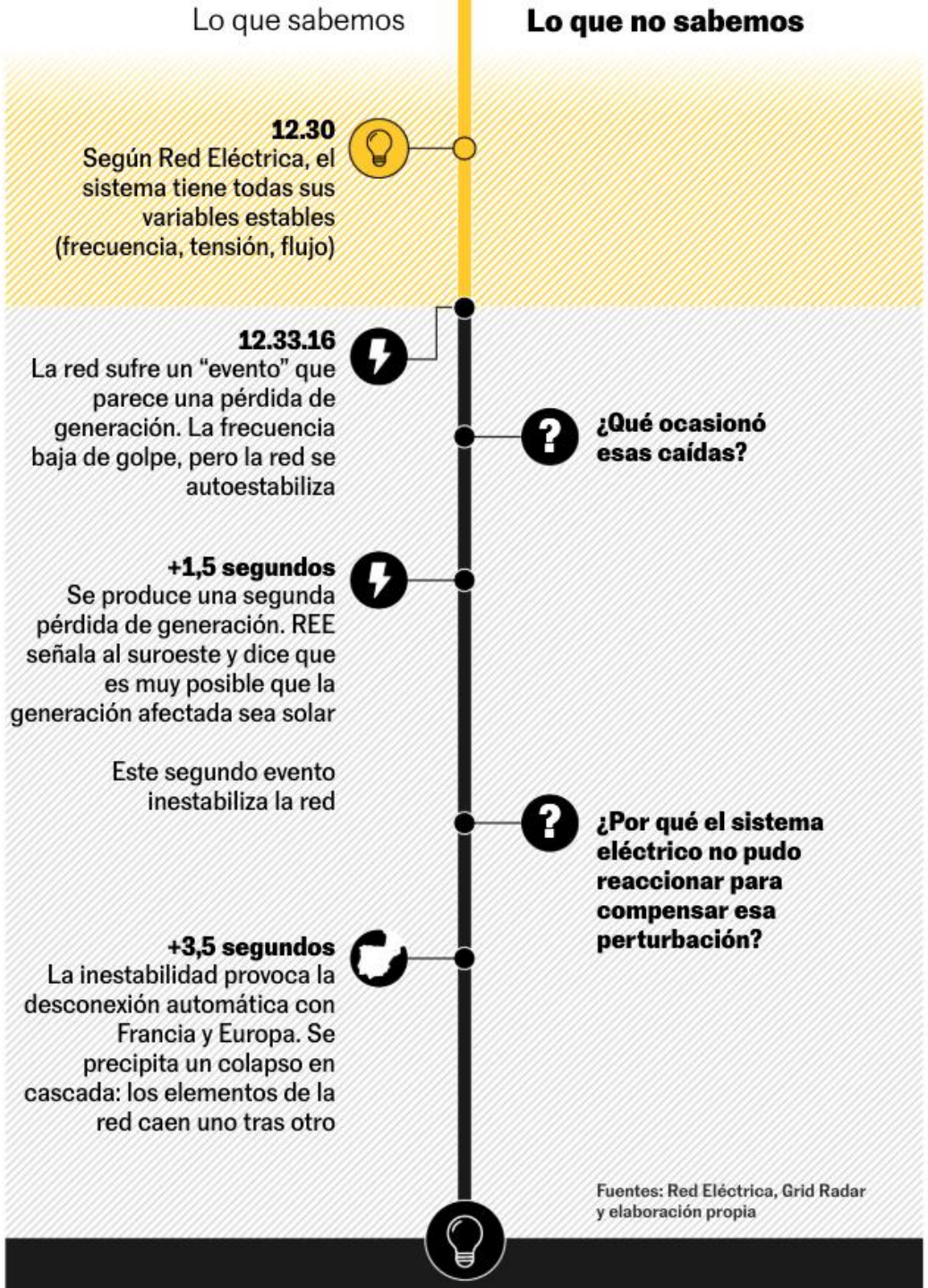
- LEMUR believes there are perfectly plausible technical explanations for the Iberian blackout of April 28, 2025.
- We are focused on the technical explanations which can be justified with knowledge of the physical infrastructure. In other words, we are not, currently, considering cyber-attacks, human errors, or extraordinary meteorological conditions.
- *For now*, we are simply presenting what data we have and will use as a basis for much more engineering analysis.
- We are NOT presenting conclusions about root causes! (yet…)

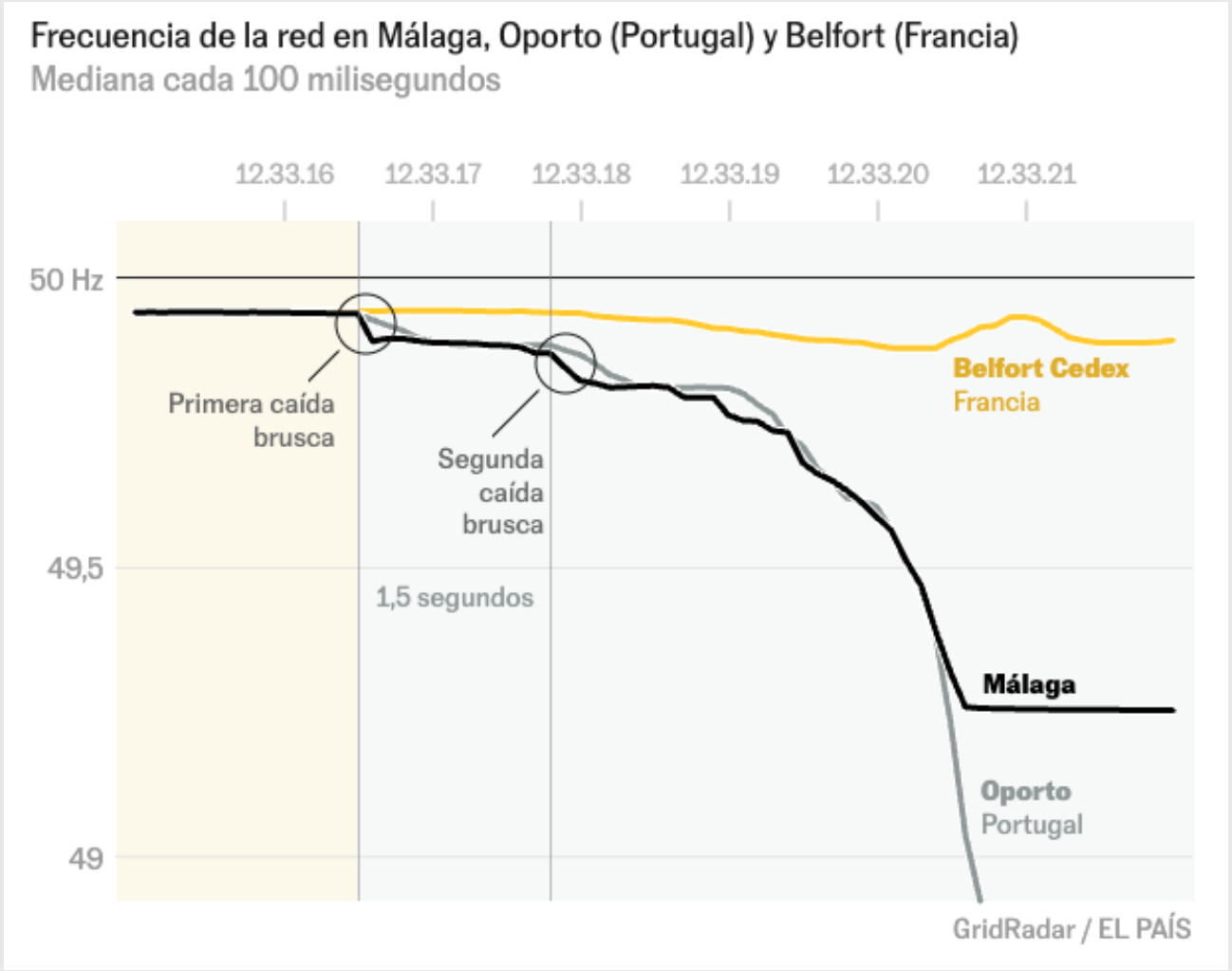
Universidad de Oviedo

LEMUR ELECTRICAL ENERGY RESEARCH

Section 1

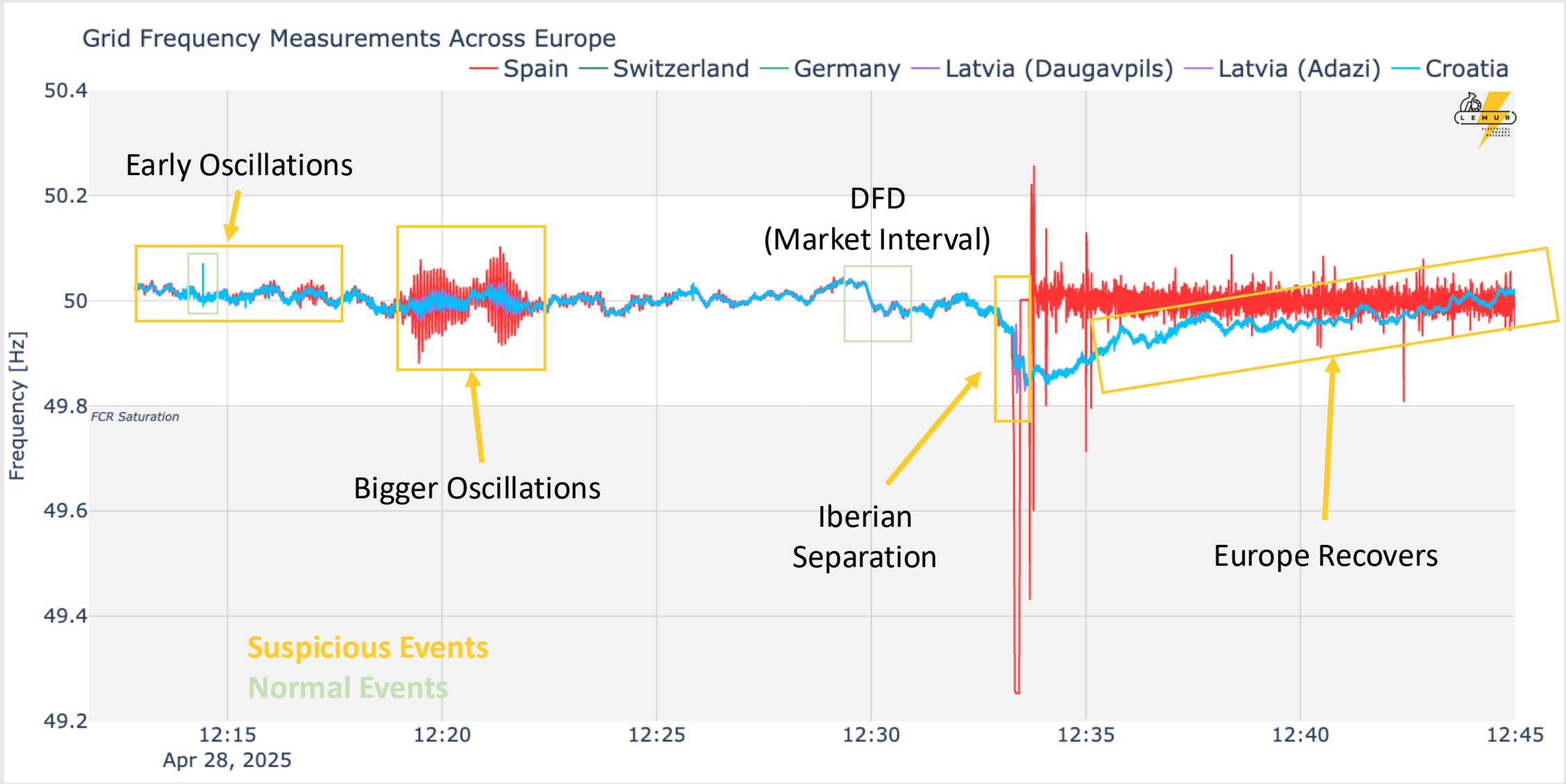
Overview of April 28



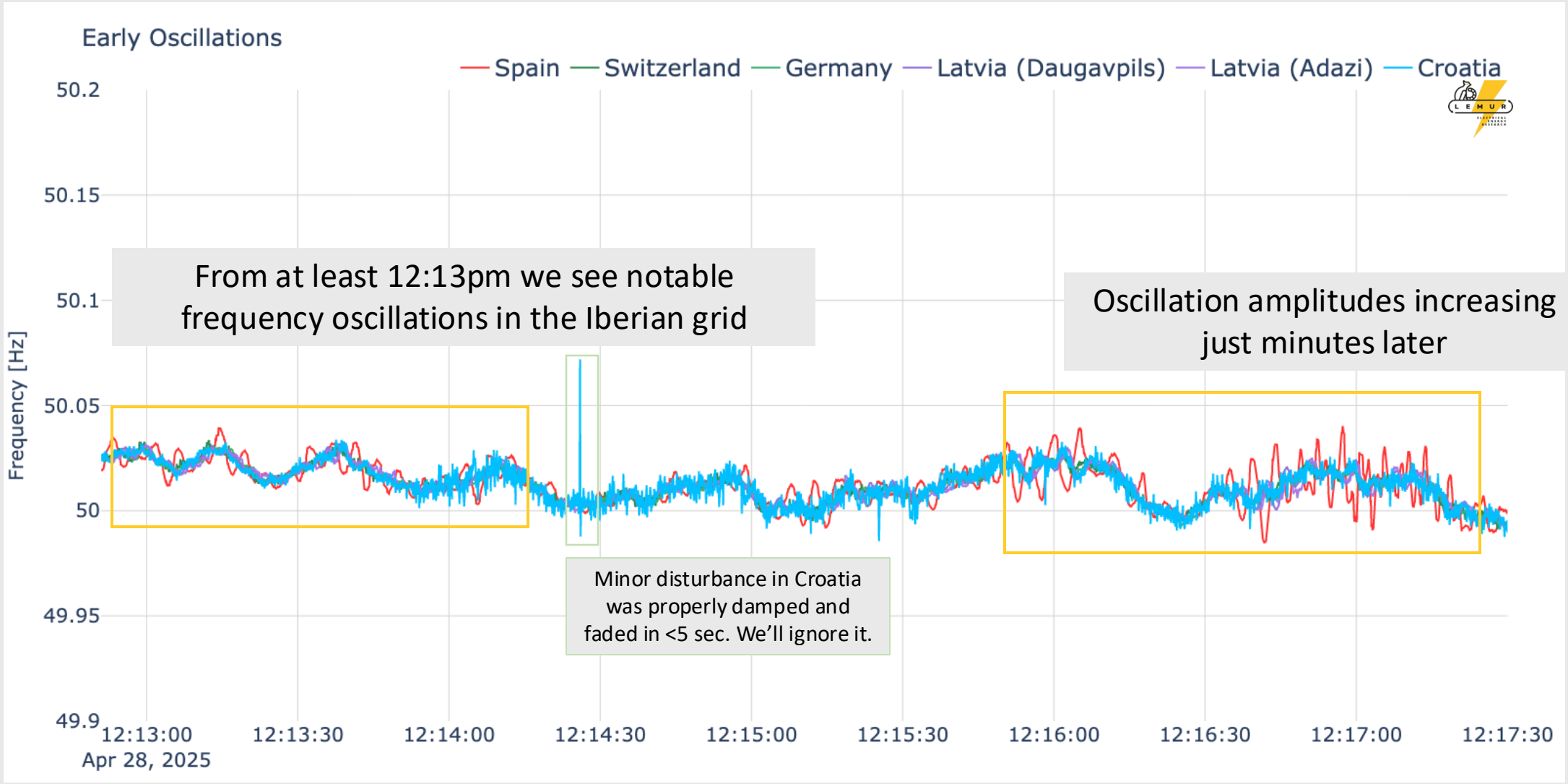


Source: El Pais, "¿Qué causó el apagón? Explicación visual y breve de lo que sabemos"

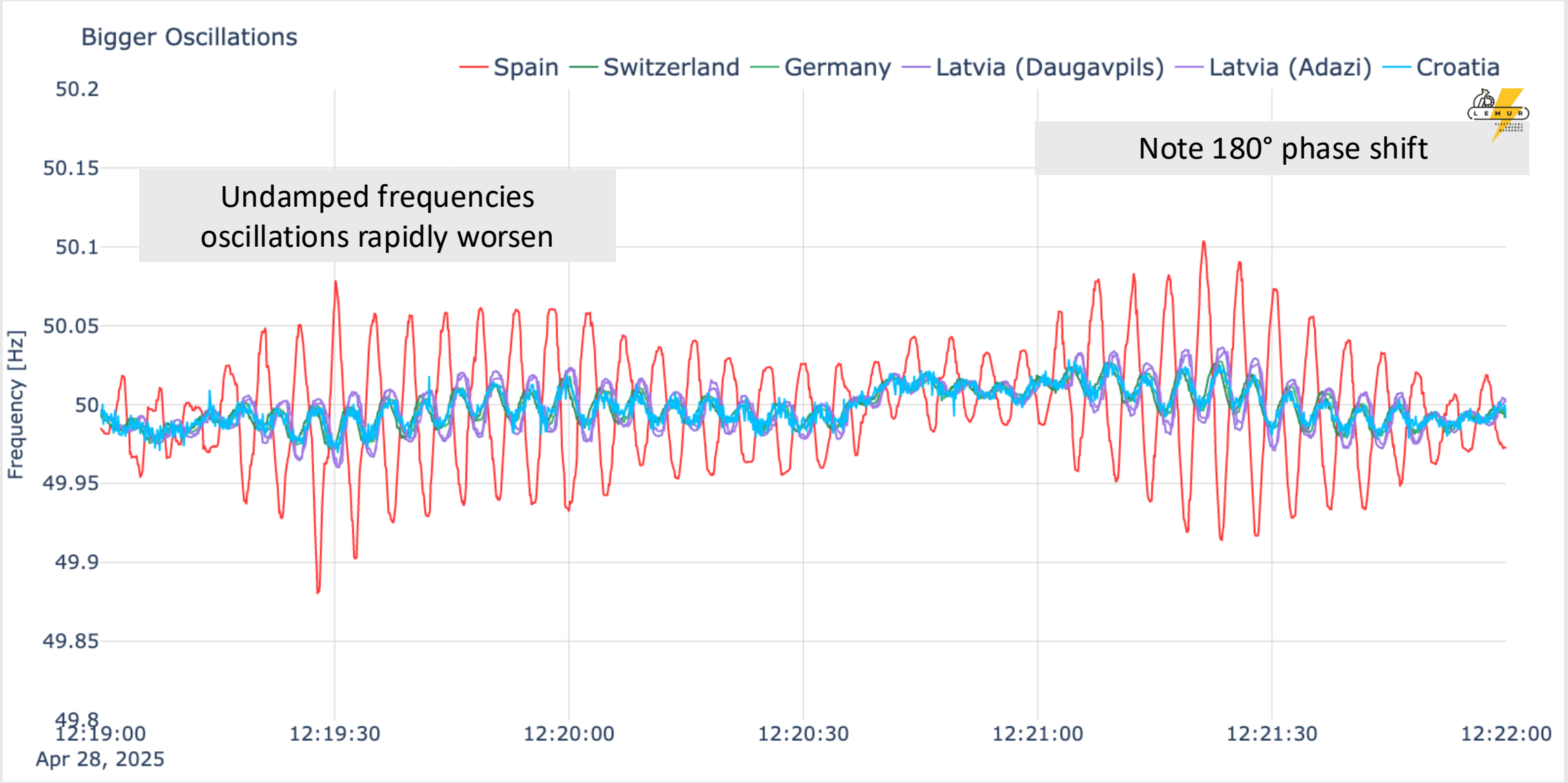
OVERVIEW OF EUROPEAN GRID FREQUENCIES JUST BEFORE THE BLACKOUT



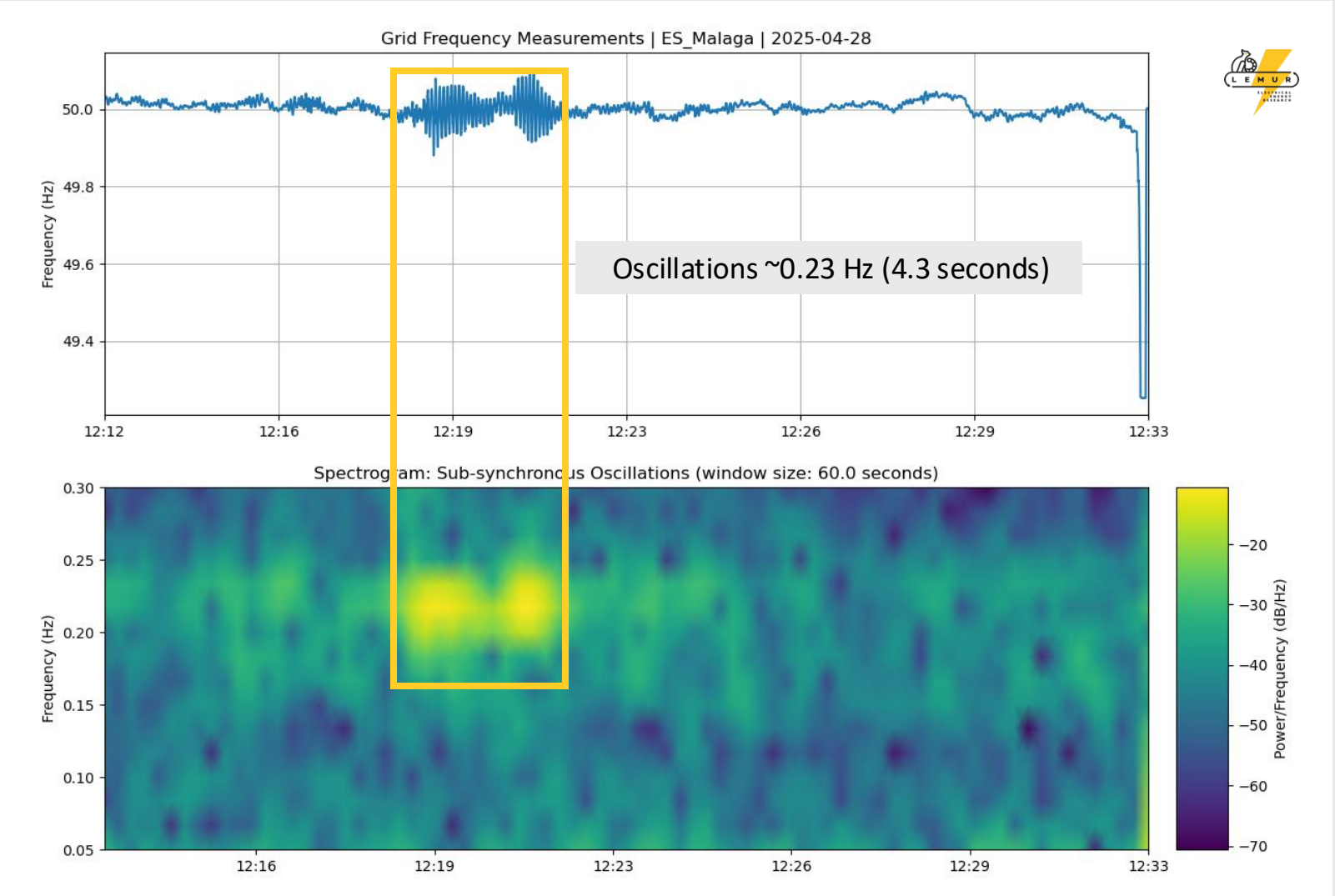
EARLY OSCILLATIONS HINT AT INSTABILITY



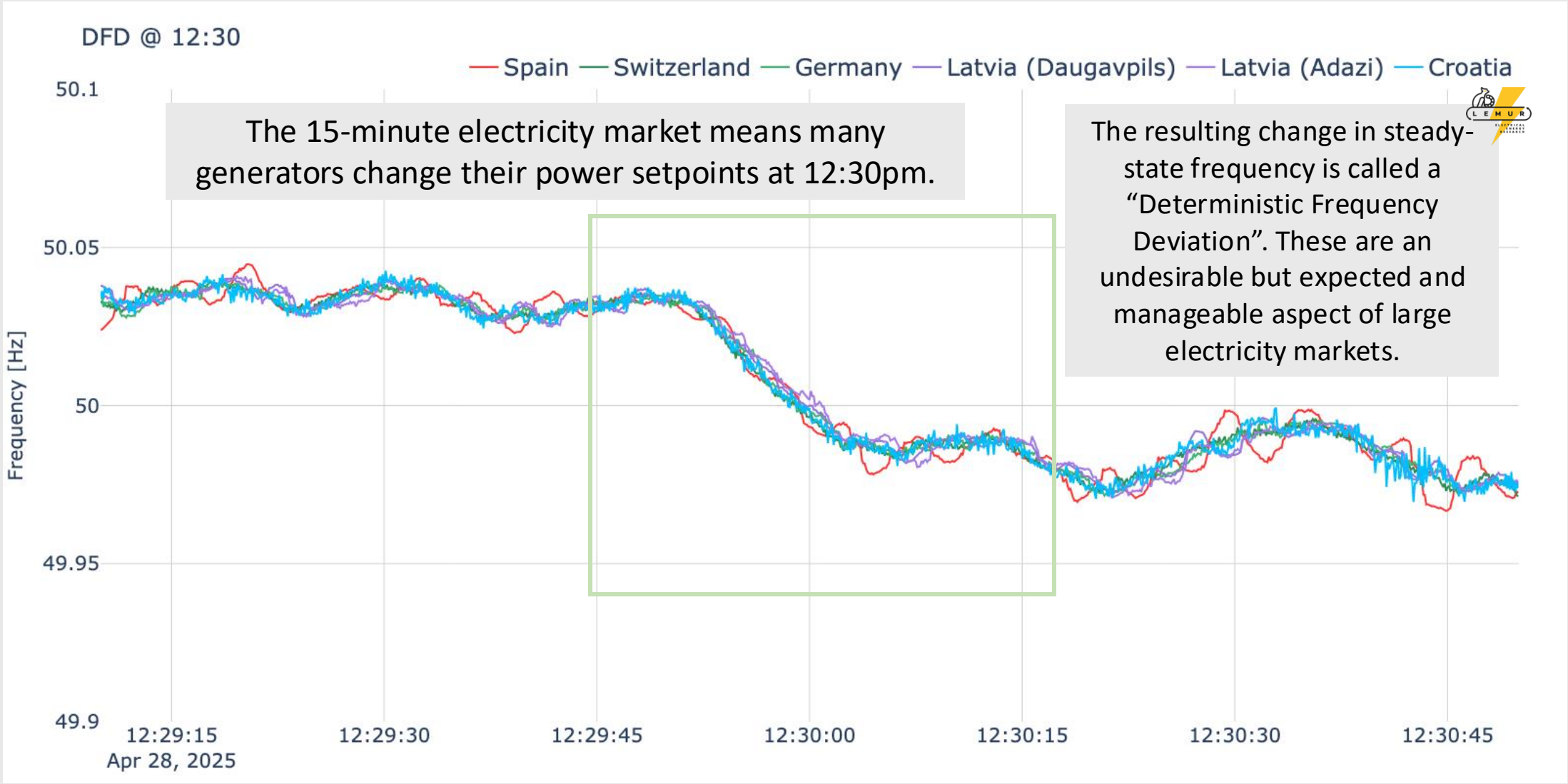
OSCILLATIONS WORSEN RAPIDLY ~ 12:20PM



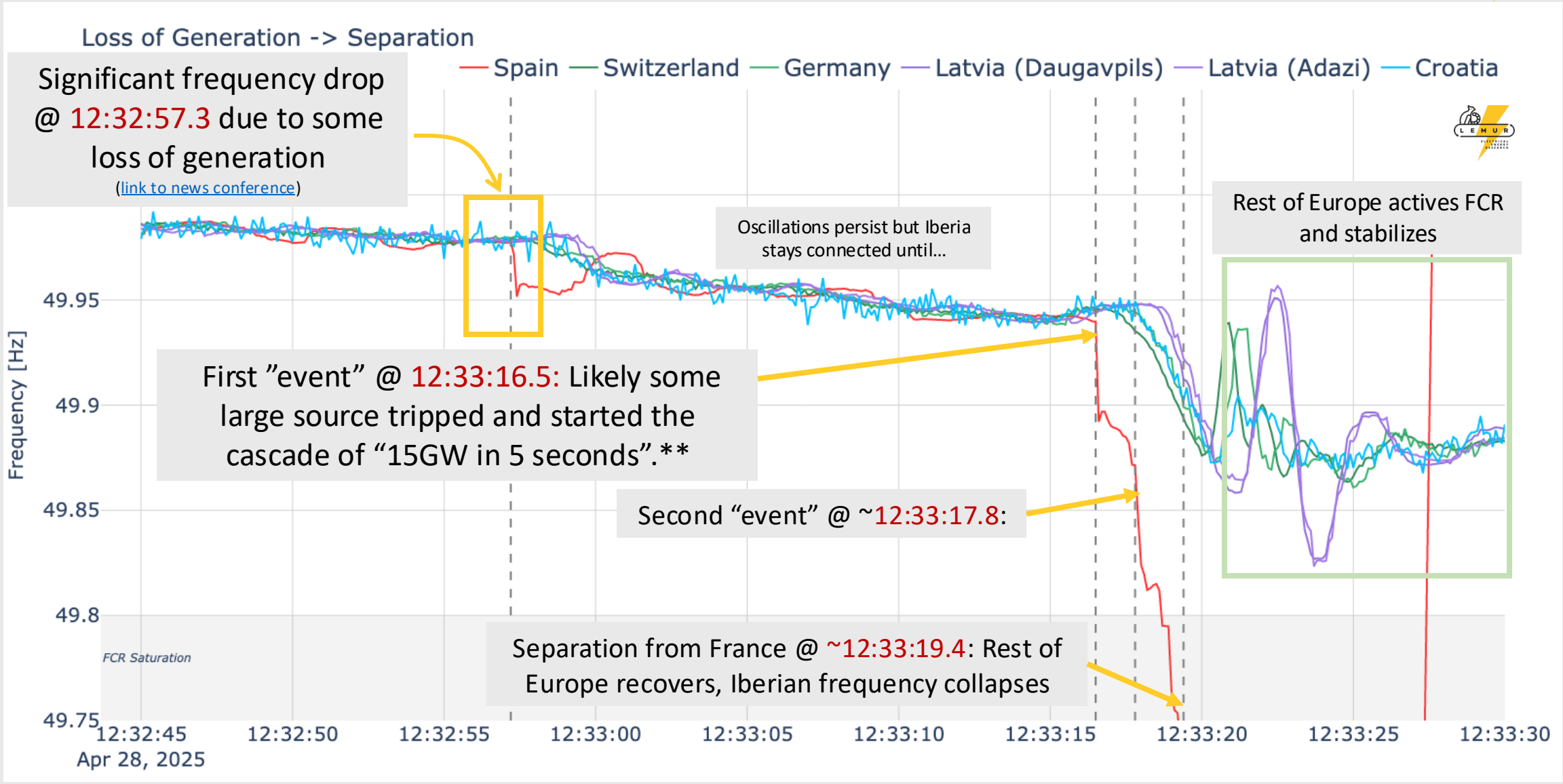
OBSERVING SUB-SYNCHRONOUS OSCILLATIONS



MARKET CHANGE AT 12:30PM – NO PROBLEM

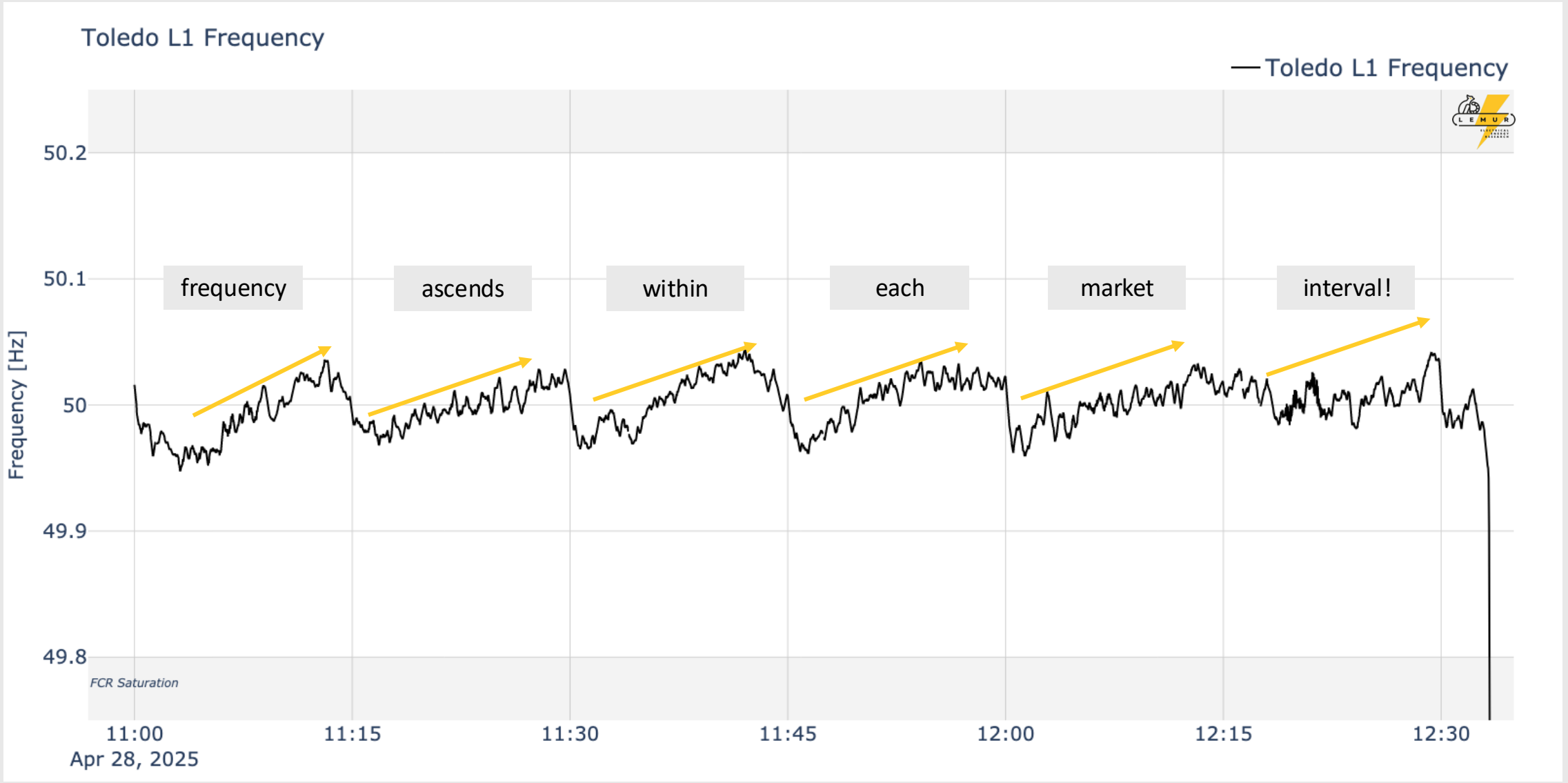


IBERIA SEPARATES FROM EUROPE



** ”desconexión repentina de dos centrales de generación eléctrica en el suroeste de la peninsula” [El Periodico de la Energia, 29 Abril 2025]

FREQUENCY IS CONSISTENTLY TO FAST ALL MORNING

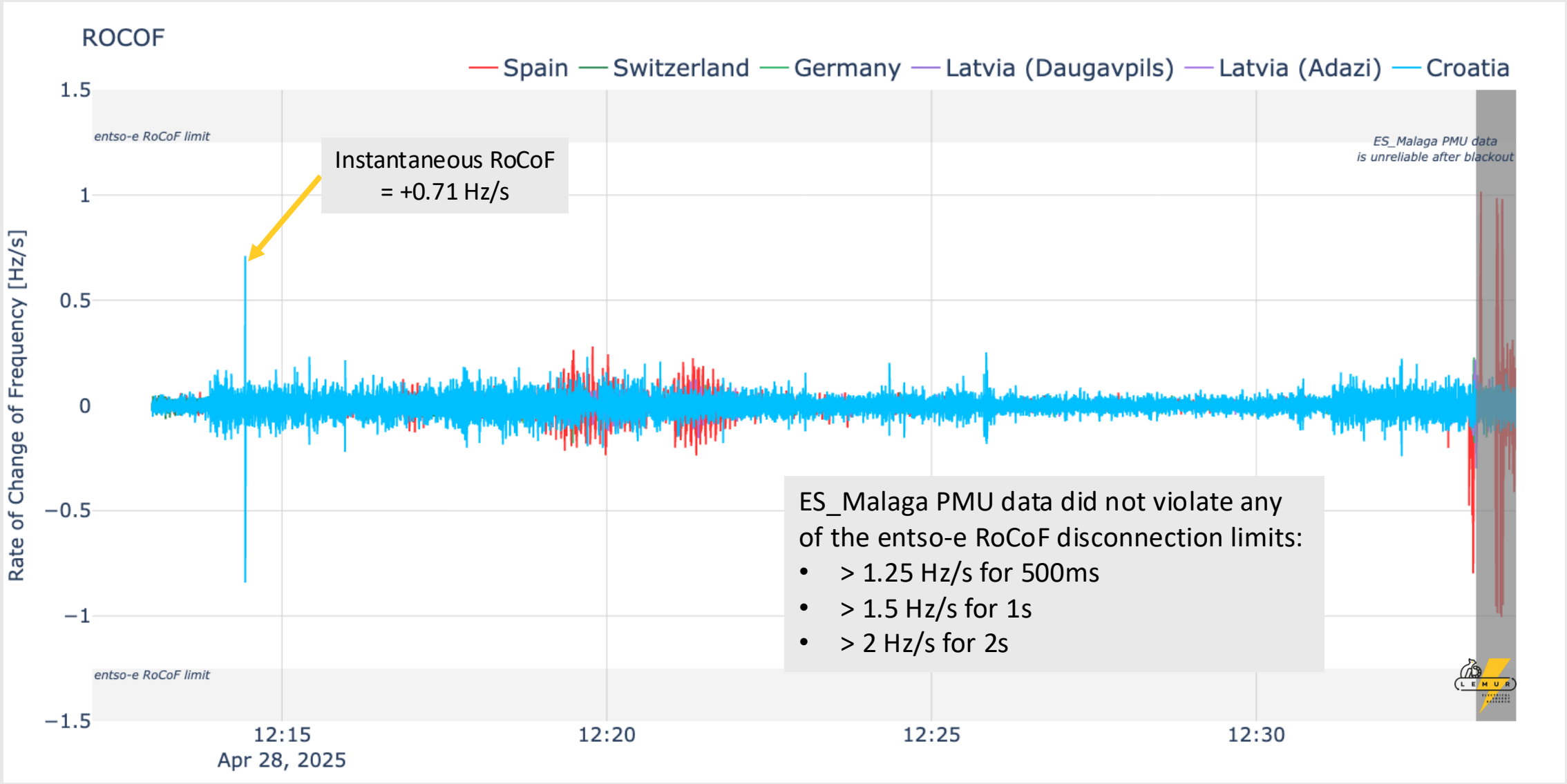


Universidad de Oviedo

Section 2

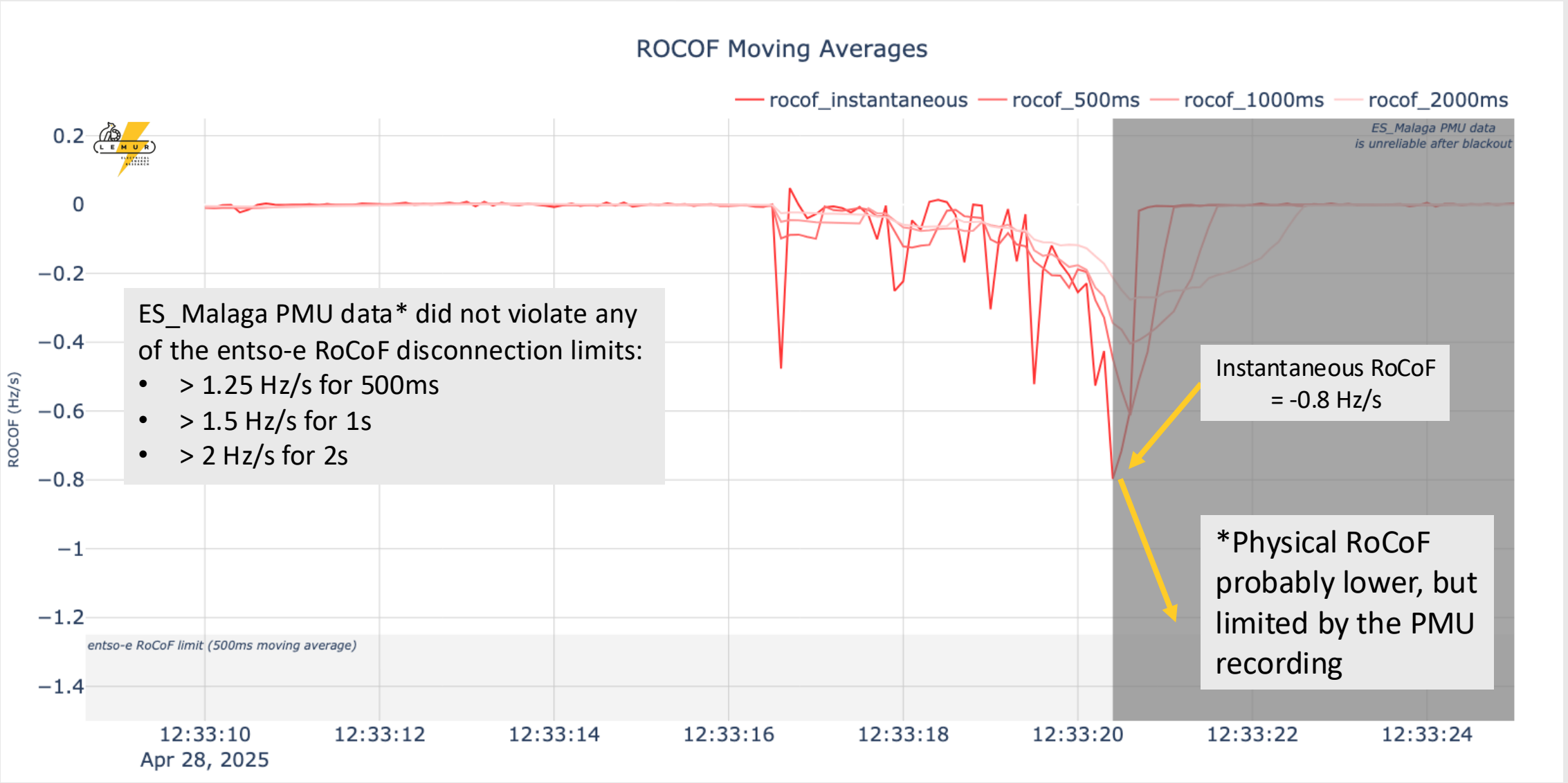
Rate of Change of Frequency

ROCOF OVERVIEW



ROCOF STAYED WITHIN LIMITS

RoCoF limits from "Rate of Change of Frequency (RoCoF withstand capability", entso-e, 31 January 2018



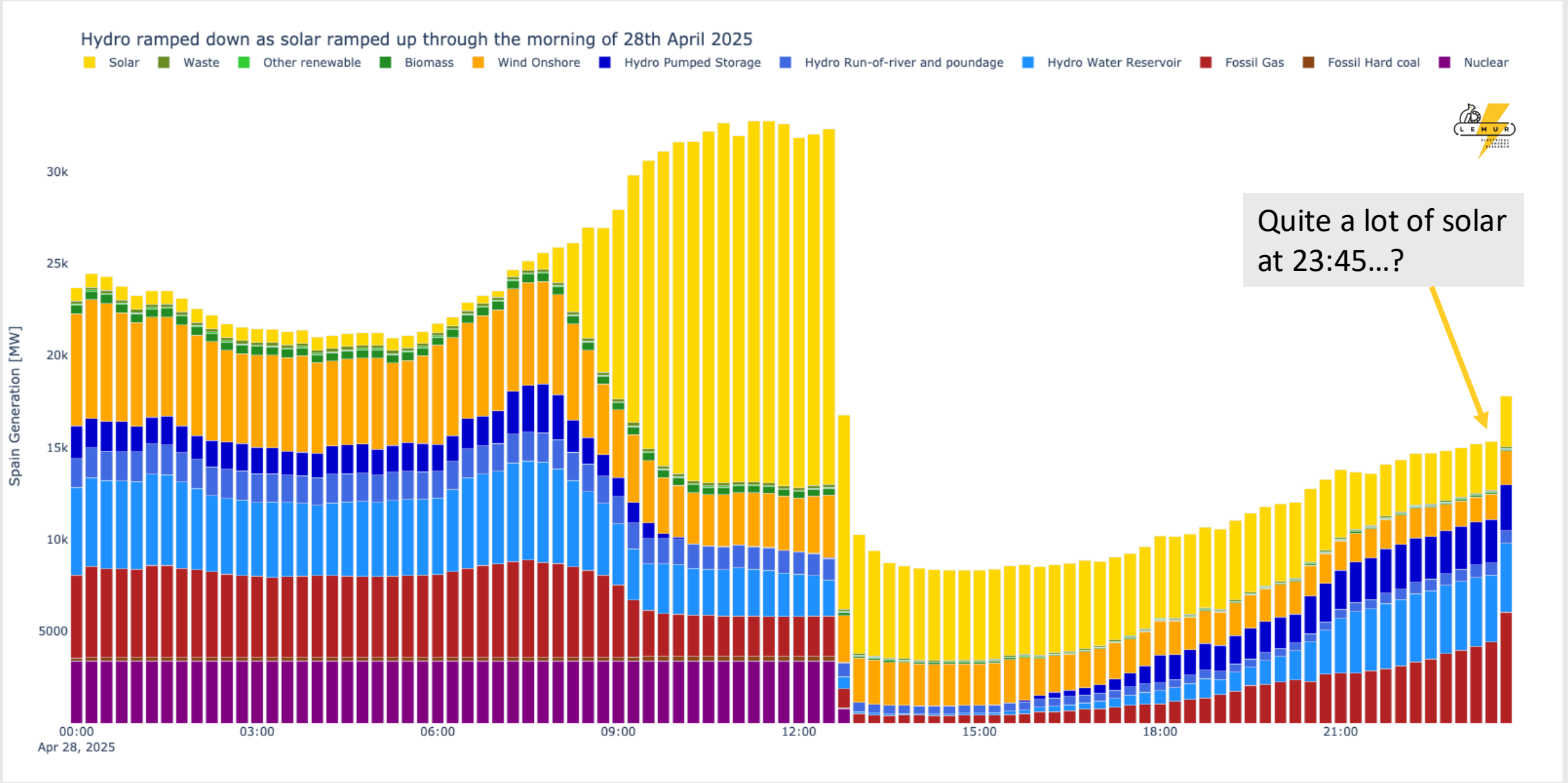
Universidad de Oviedo

LEMUR ELECTRICAL ENERGY RESEARCH

Section 3

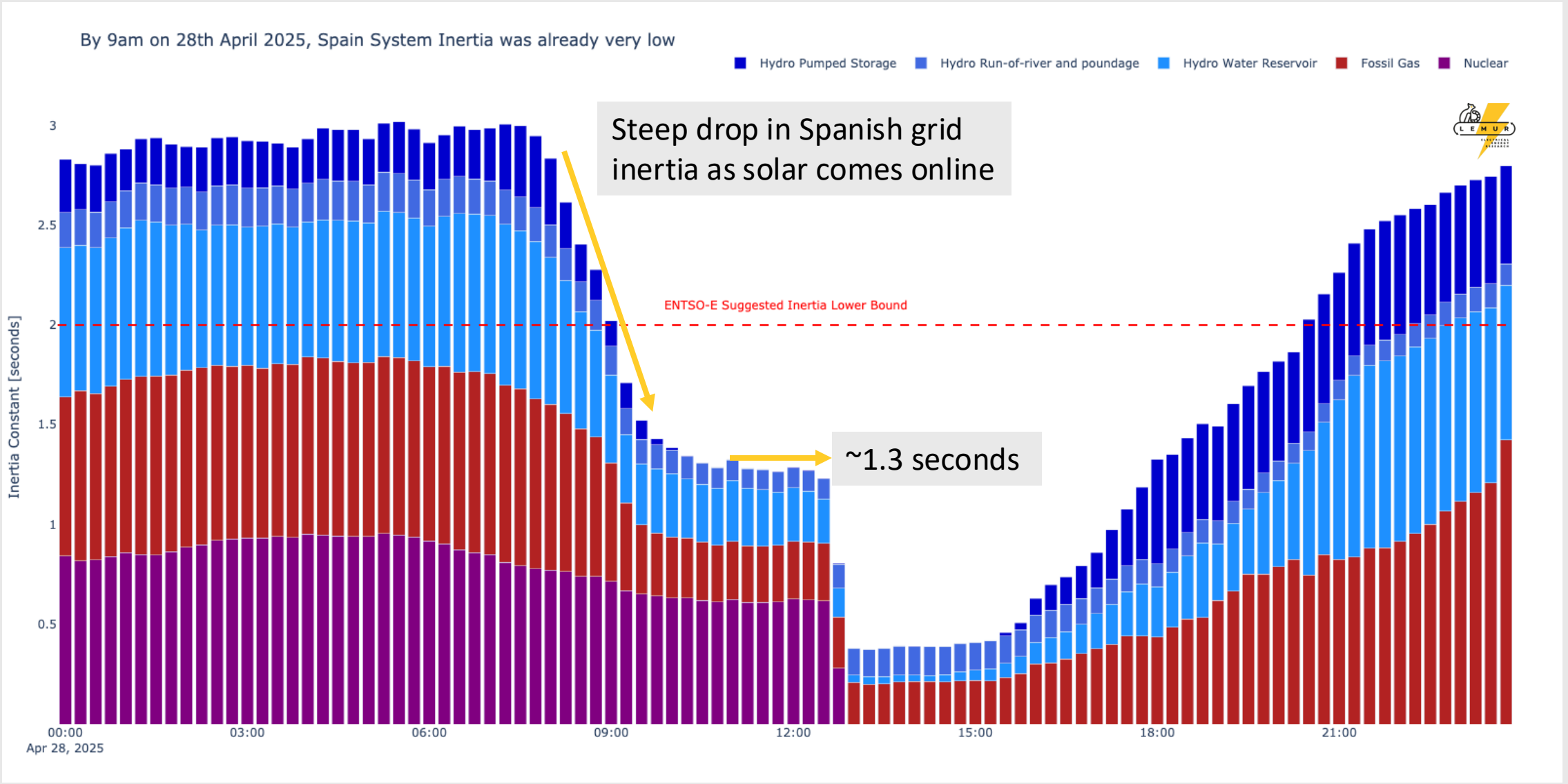
Generation, Inertia, Exports

GENERATION MIX ON APRIL 28, 2025



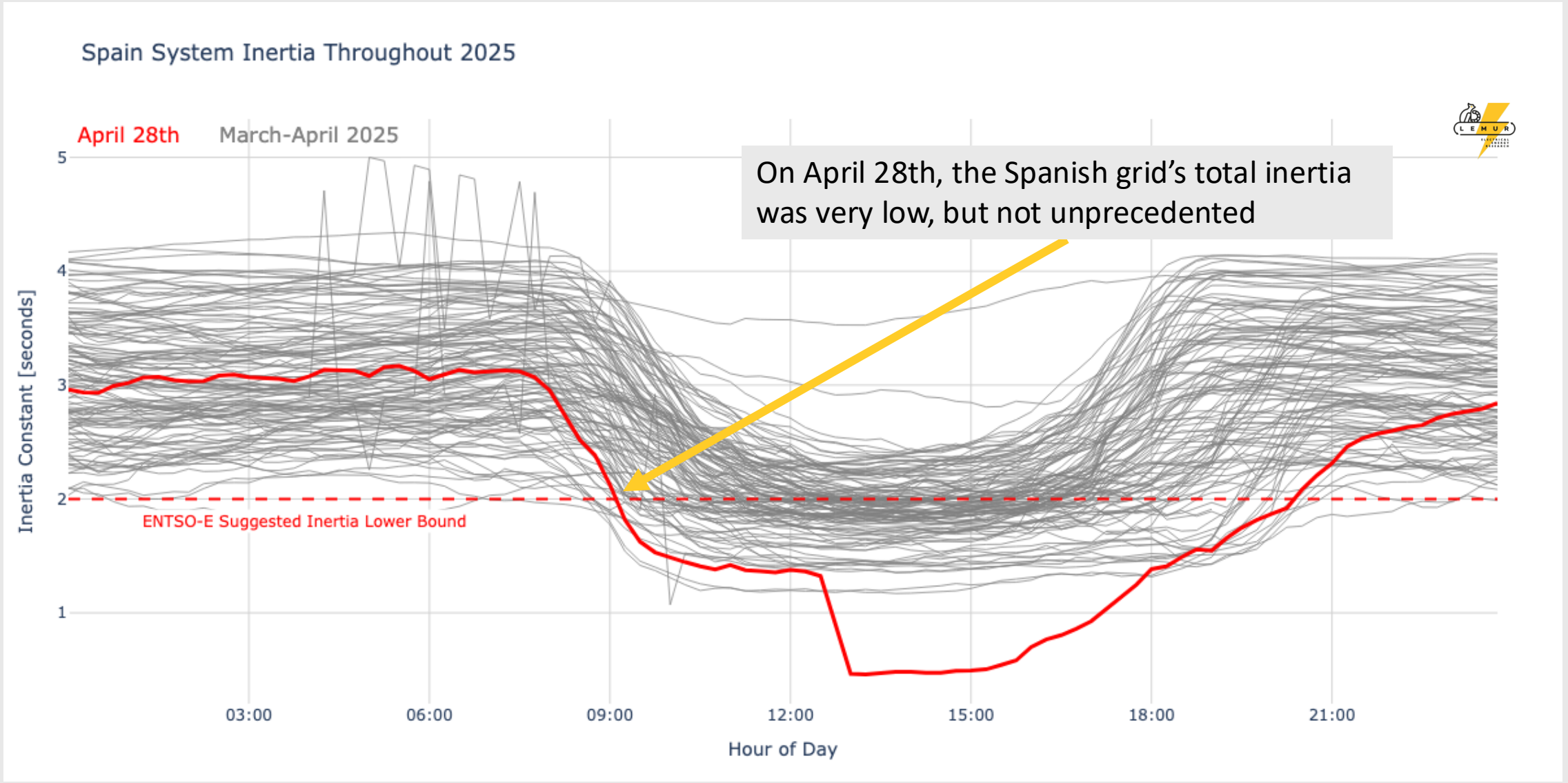
Source: ENTSO-E Transparency Platform

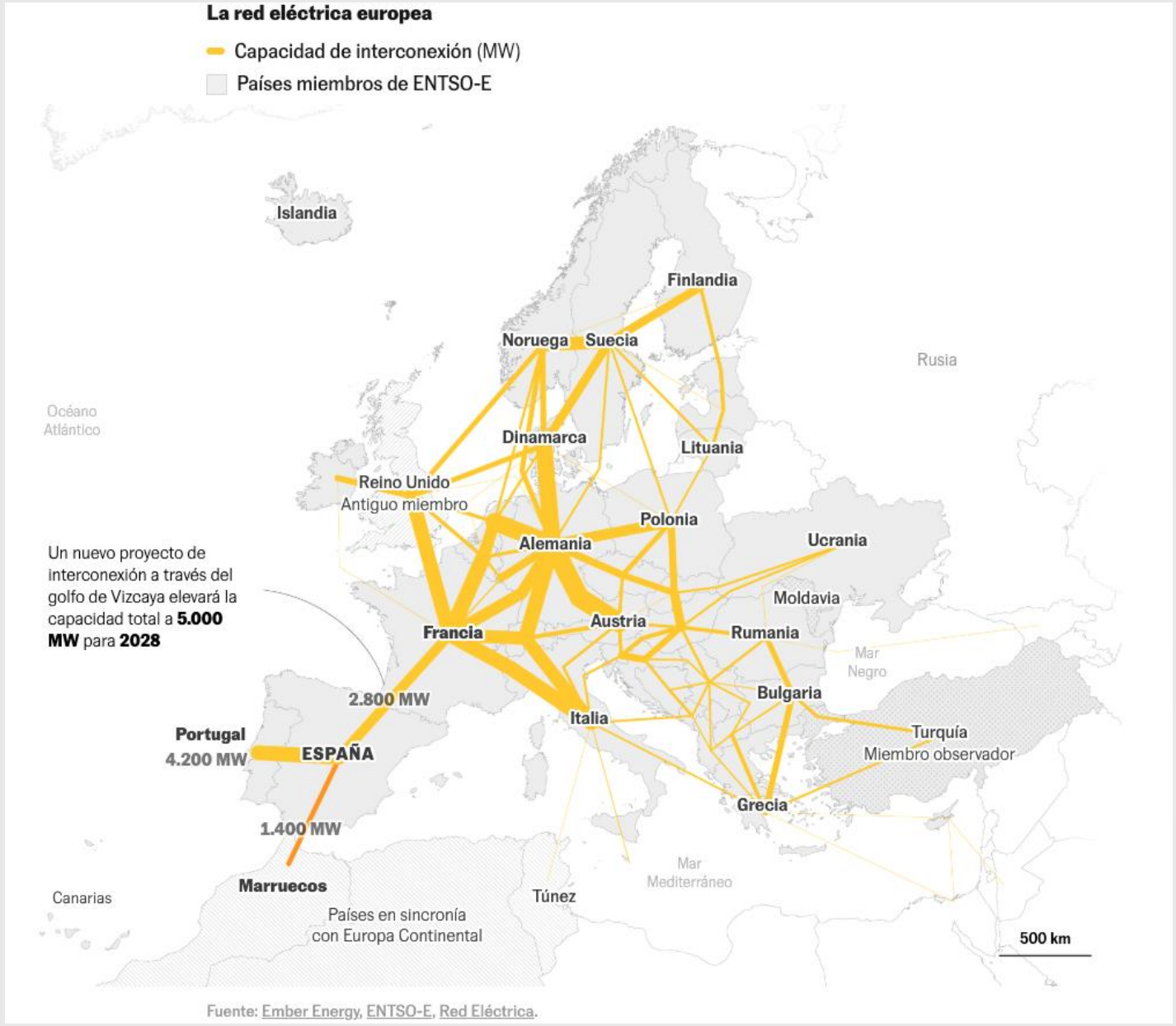
INERTIA ESTIMATES FOR APRIL 28, 2025



Inertia estimates are based on standard inertial constants for different generation categories as published in "Inertia and Rate of Change of Frequency (RoCoF)", ENTSO-E, 16 Dec. 2020

SPANISH INERTIA WAS LOW, BUT NOT UNPRECEDENTED





France, Germany, and Italy have relatively strong interchange capacity.

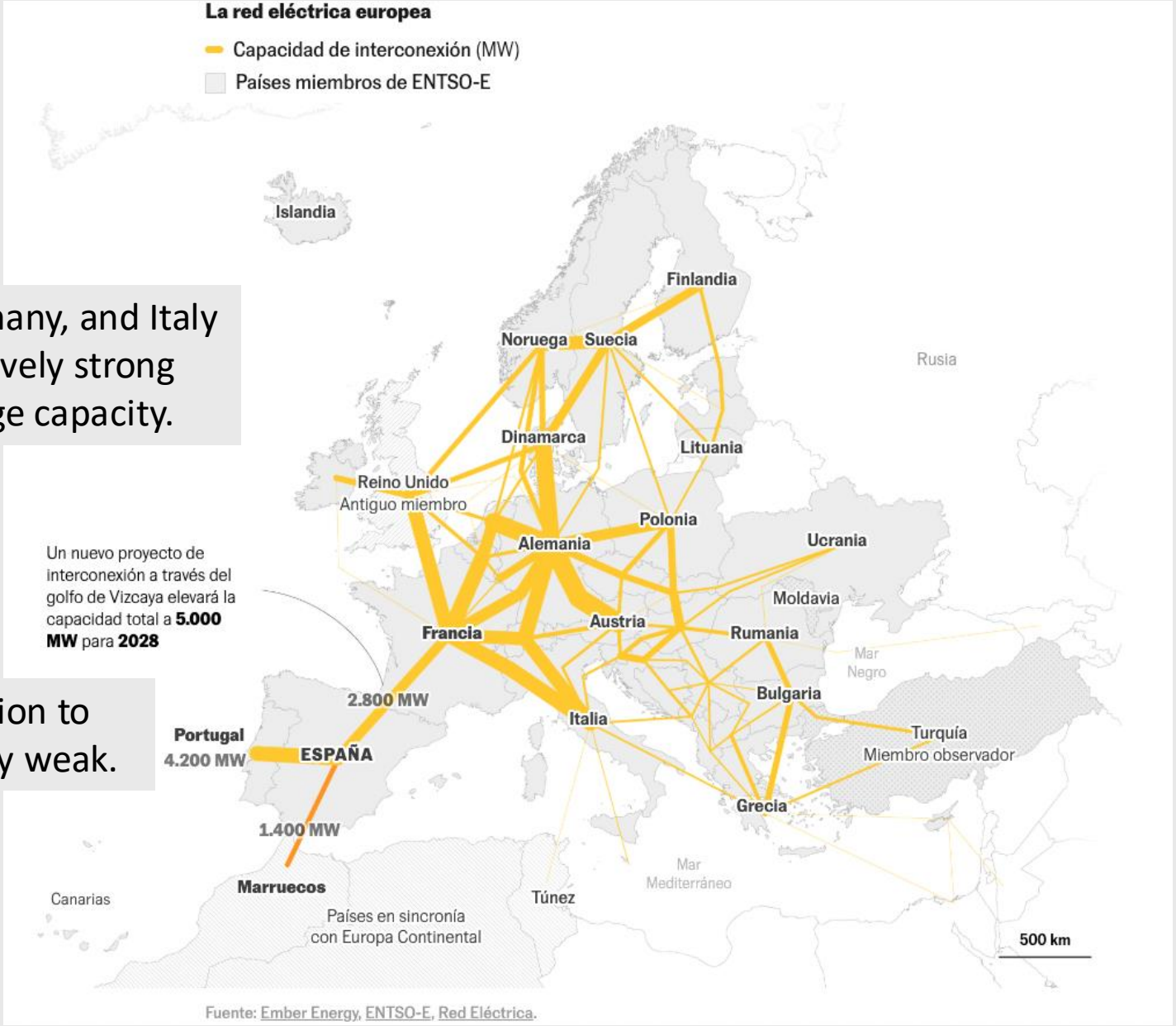
Iberian connection to France is relatively weak.

Source: El Pais, **"¿Qué causó el apagón? Explicación visual y breve de lo que sabemos"**

Universidad de Oviedo

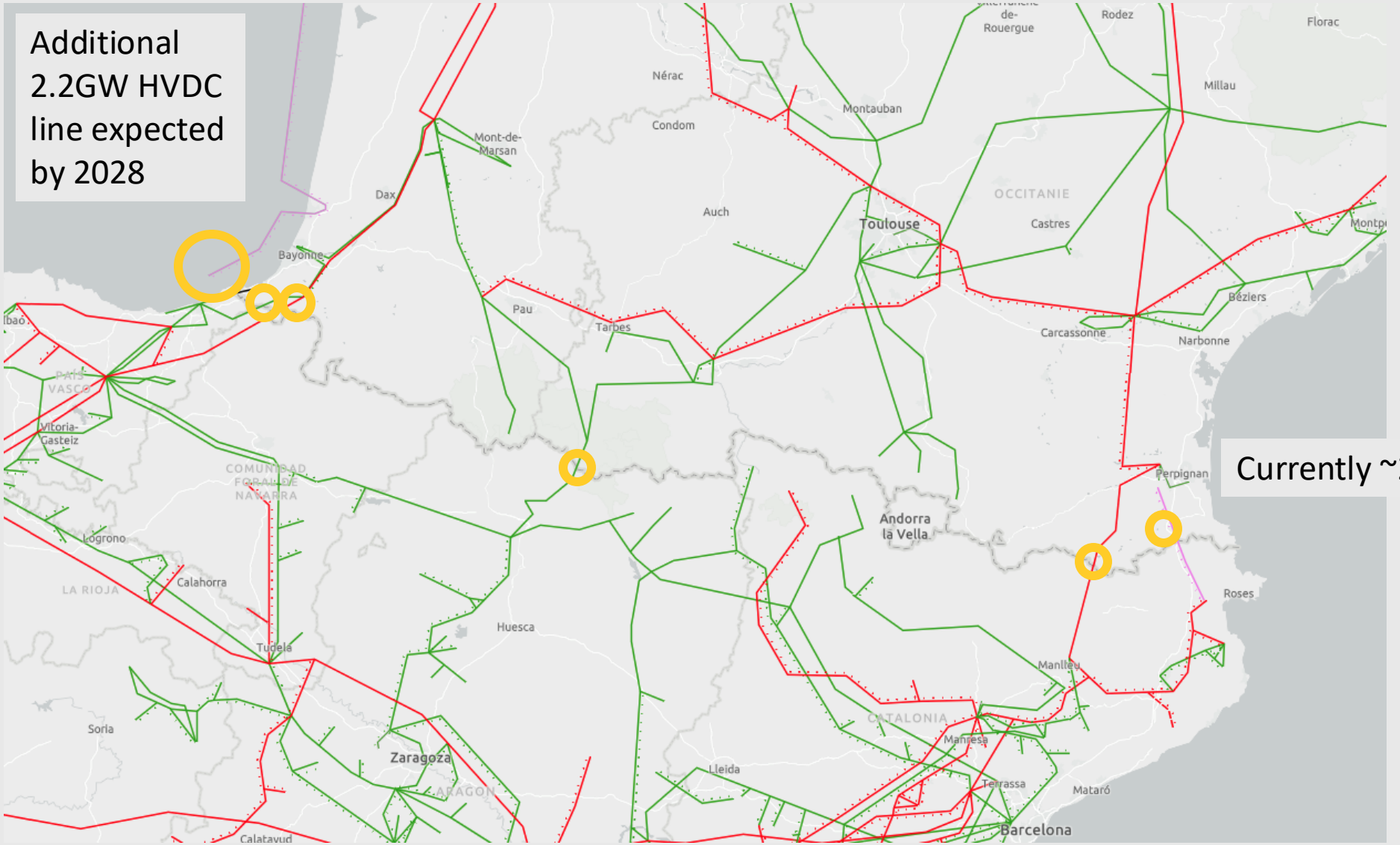
France, Germany, and Italy have relatively strong interchange capacity.

Iberian connection to France is relatively weak.



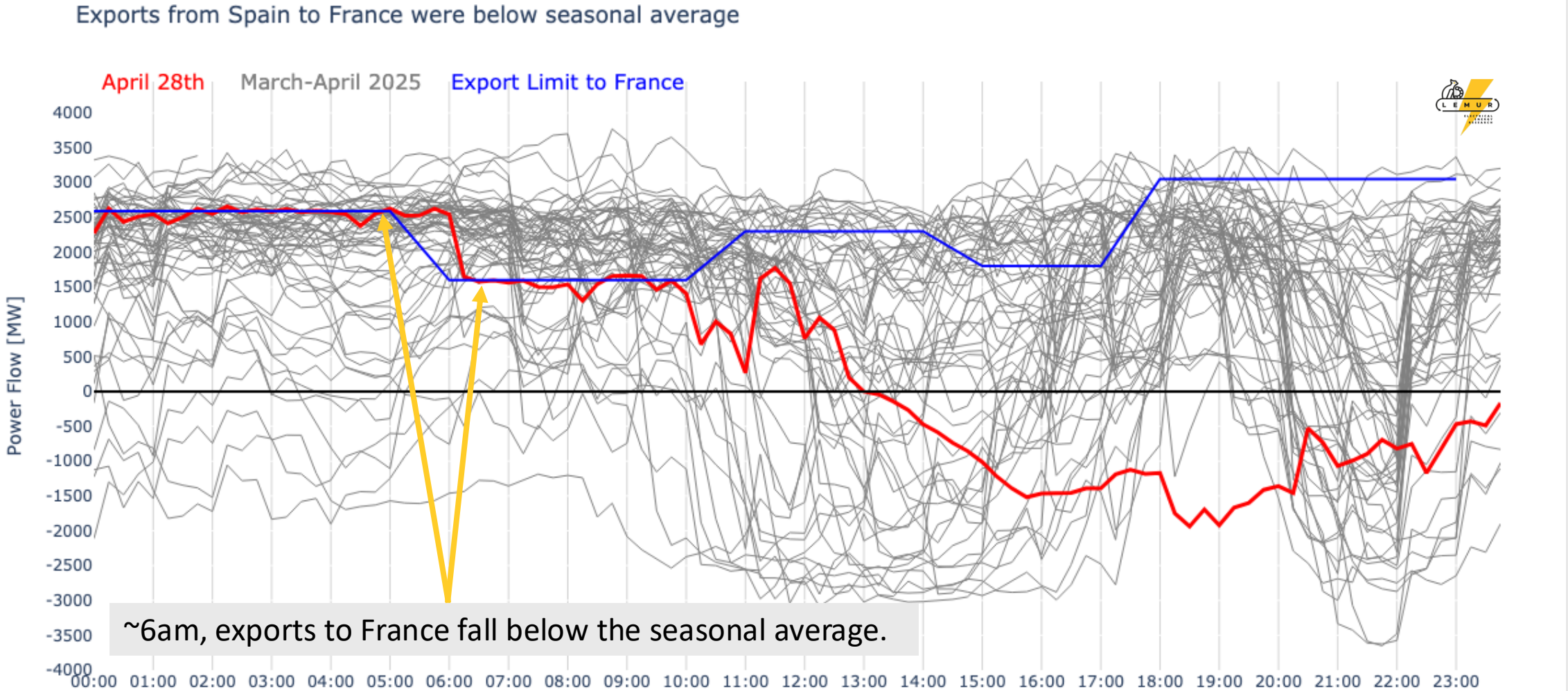
Source: El País, "¿Qué causó el apagón? Explicación visual y breve de lo que sabemos"

CONNECTIONS WITH FRANCE



Map Source: ENTSO-E

EXPORTS TO FRANCE WERE BELOW AVERAGE



CONCLUSIONS

- On April 28th, 2025, the operating conditions on the Spanish grid were challenging, but not unprecedented.
- None of the data we currently have would have required equipment tripping (and thus the large loss of load)…
- …but the conditions at an individual generator's grid connection could be very different!

- LEMUR is actively working to reconstruct the grid conditions of April 28 and will continue to publish our findings publicly.

- Help us! Any feedback or relevant data is appreciated! **lemur@uniovi.es**

Universidad de Oviedo

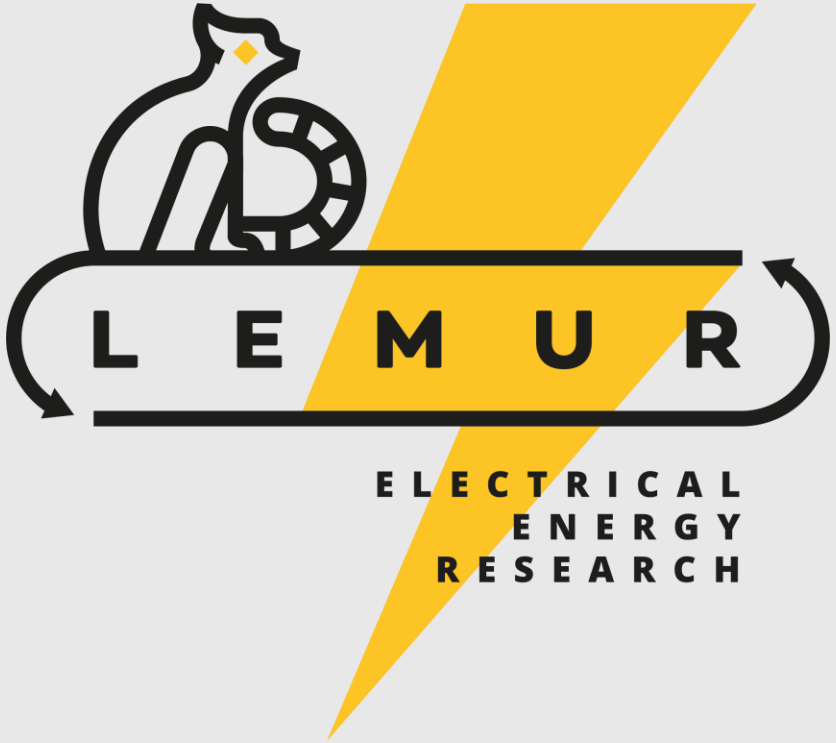
LEMUR
ELECTRICAL ENERGY RESEARCH

LEMUR

Universidad de Oviedo

OUR GOAL

LEMUR is a **multidisciplinary research team** with researchers belonging to different knowledge areas: Electrical Engineering, Power Electronics and Automation and Control Engineering. The strength is based on looking for synergies and knowledge integration among team members in order to apply for bigger and complex research projects.



Universidad de Oviedo

OUR VISION

To integrate in a laboratory an environment for testing of small scale distributed energy systems and their integration into the electrical grid. For the study and analysis, a four level approach is proposed:

- Development of generation systems and power converters for the injection of electrical energy into the grid under efficiency and reliability constraints.
- Development of energy storage systems for the compensation of transient demands at the electrical grid, including pulsating generation by renewable energy systems, grid contingencies and virtual zero demanding energy buildings.
- Development of coordinated control strategies for all the small scale generators installed at the grid in order the system to behave as a virtual integrated power plant. Development of new power flow algorithms for considering the unbalanced conditions at weak grids (single phase loads and generation systems).
- Study of new economic and infrastructure models relying on the distributed generation, which allow to maximize the benefits considering the existing and future regulations.

Universidad de Oviedo

OUR RESEARCH LINES

ANALYSIS AND DESIGN OF POWER CONVERTER TOPOLOGIES FOR ENERGY STORAGE

- Design of power electronics converters with an emphasis of multiport topologies for energy storage applications

DYNAMIC ANALYSIS AND CONTROL OF POWER CONVERTERS FOR DISTRIBUTED RESOURCES

- High dynamic performance of power converters and microgrids by advanced control systems

POWER FLOW ANALYSIS FOR HYBRID DC/AC GRIDS WITH HIGH PENETRATION OF DISTRIBUTED RESOURCES

- Impact of the integration of distributed resources in the electrical grid

ENERGY DEMAND ANALYSIS AND VISUALIZATION

- Analytic tools and visualization strategies for energy planning

APPLICATIONS

- Industrial applications and knowledge transfer

THANK YOU!

Please get in touch!