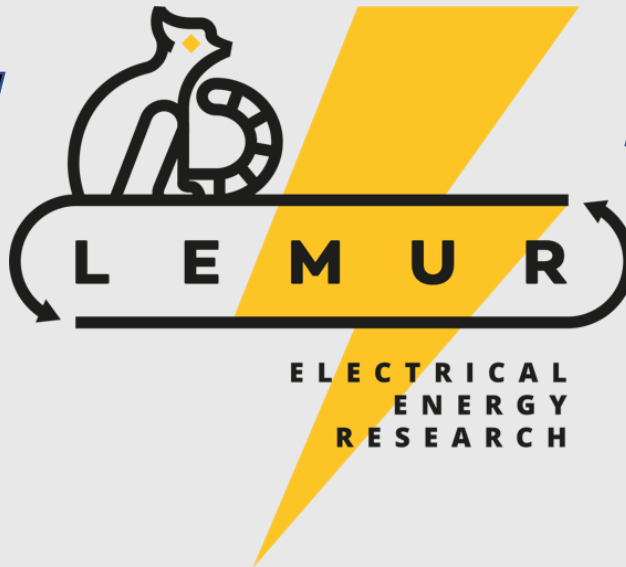
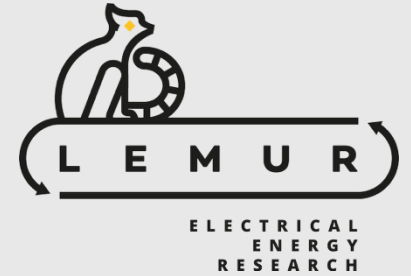




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*University of Oviedo*



Apagón - April 28, 2025

**LEMUR.** University of Oviedo  
Department of Electrical Engineering – [lemur@uniovi.es](mailto:lemur@uniovi.es)



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## Section 1

# Overview of April 28

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**12.30**

Según Red Eléctrica, el sistema tiene todas sus variables estables (frecuencia, tensión, flujo)

**12.33.16**

La red sufre un "evento" que parece una pérdida de generación. La frecuencia baja de golpe, pero la red se autoestabiliza



**¿Qué ocasionó esas caídas?**

**+1,5 segundos**

Se produce una segunda pérdida de generación. REE señala al suroeste y dice que es muy posible que la generación afectada sea solar



**¿Por qué el sistema eléctrico no pudo reaccionar para compensar esa perturbación?**

**+3,5 segundos**

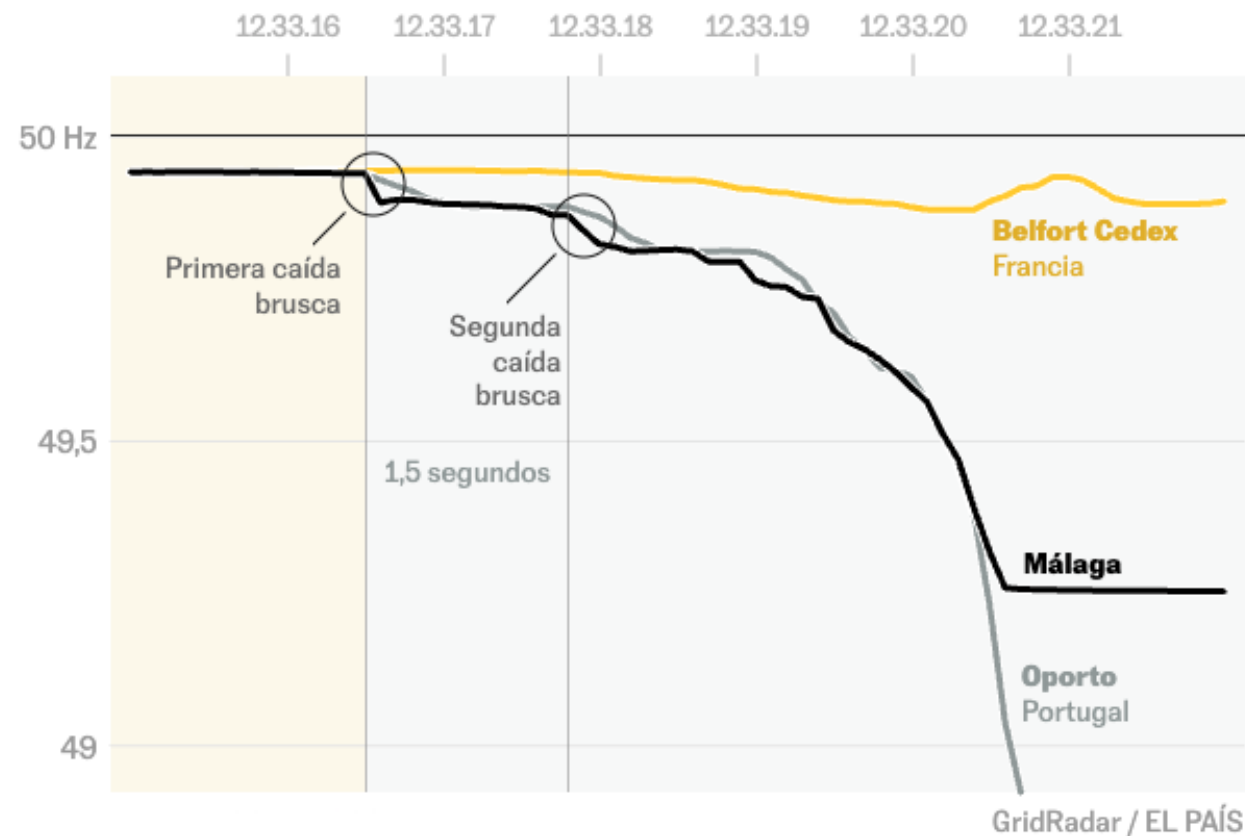
La inestabilidad provoca la desconexión automática con Francia y Europa. Se precipita un colapso en cascada: los elementos de la red caen uno tras otro



Fuentes: Red Eléctrica, Grid Radar y elaboración propia

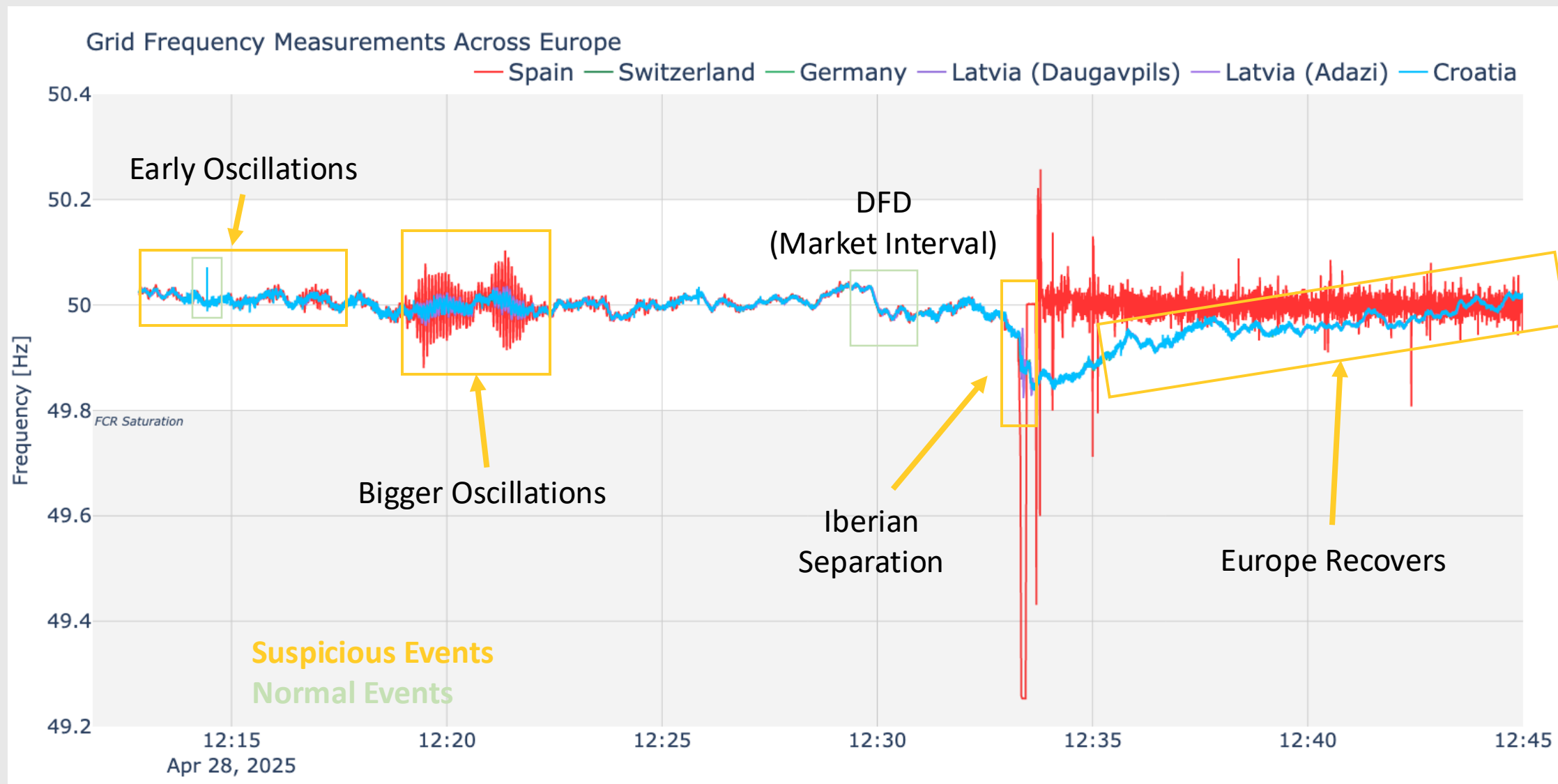


Frecuencia de la red en Málaga, Oporto (Portugal) y Belfort (Francia)  
Mediana cada 100 milisegundos



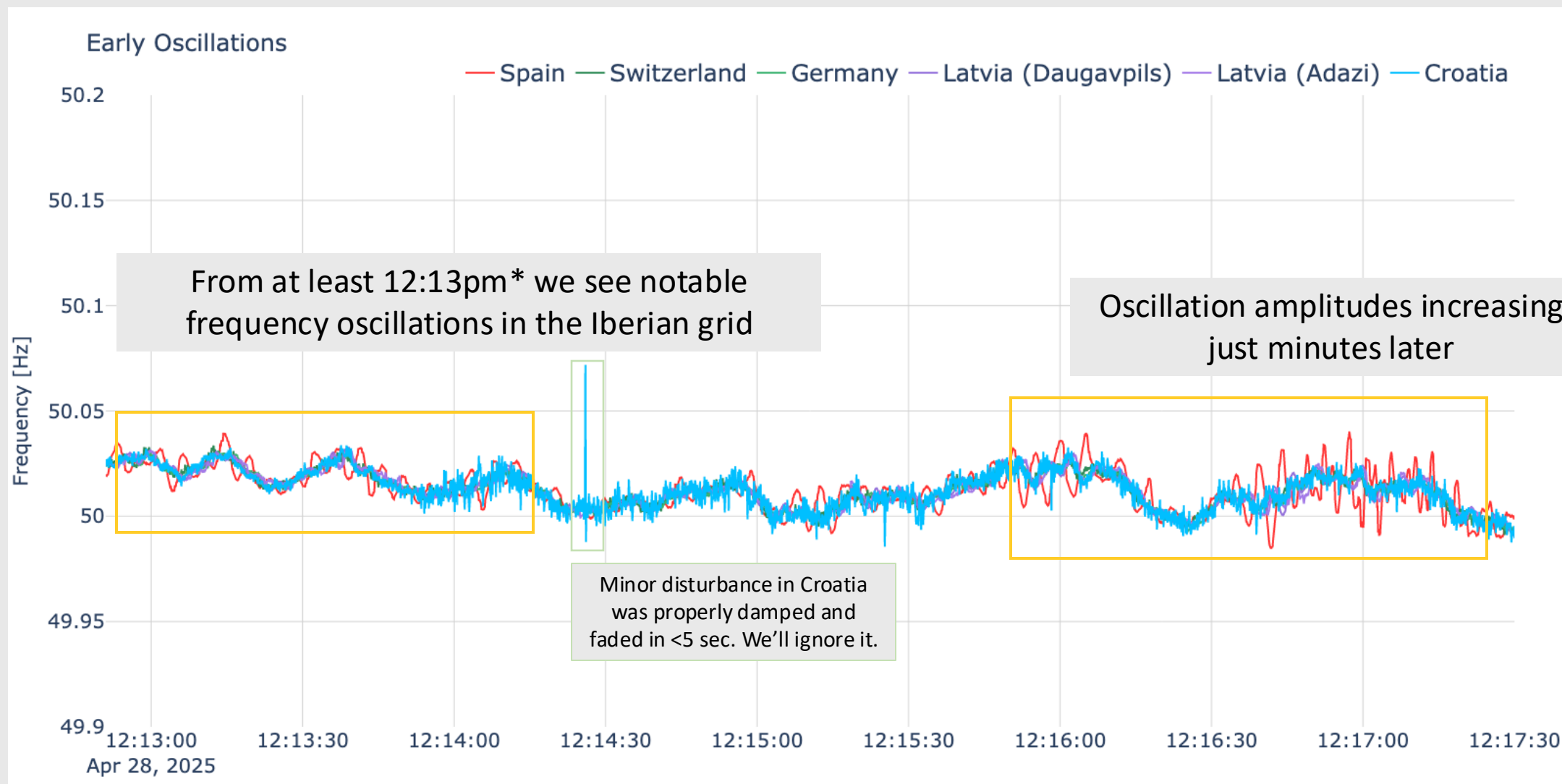


# OVERVIEW OF EUROPEAN GRID FREQUENCIES JUST BEFORE THE BLACKOUT

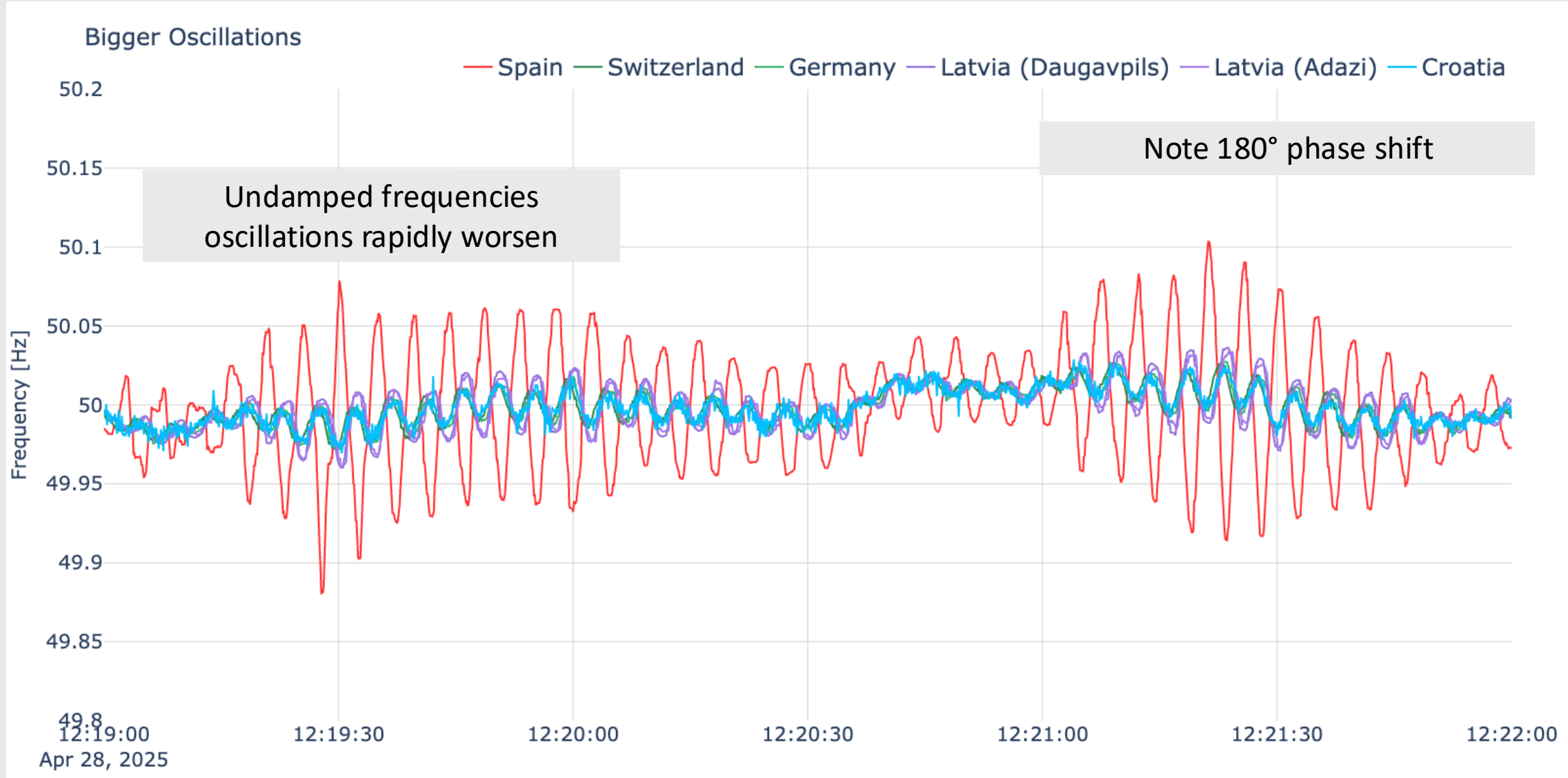


# EARLY OSCILLATIONS HINT AT INSTABILITY

\* LEMUR currently only has frequency data from 12:12:51pm – 13:12:50pm

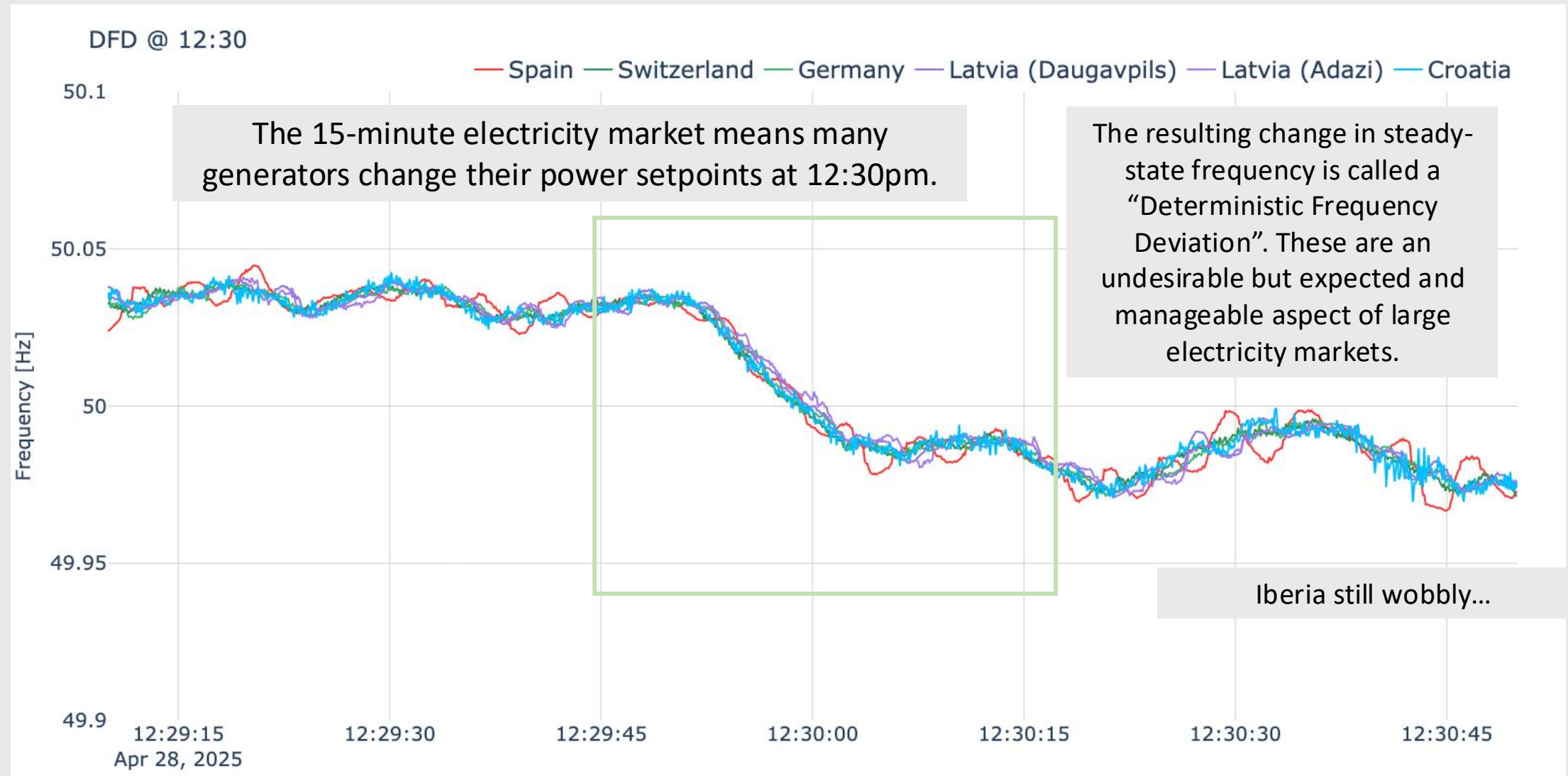


# OSCILLATIONS WORSEN RAPIDLY





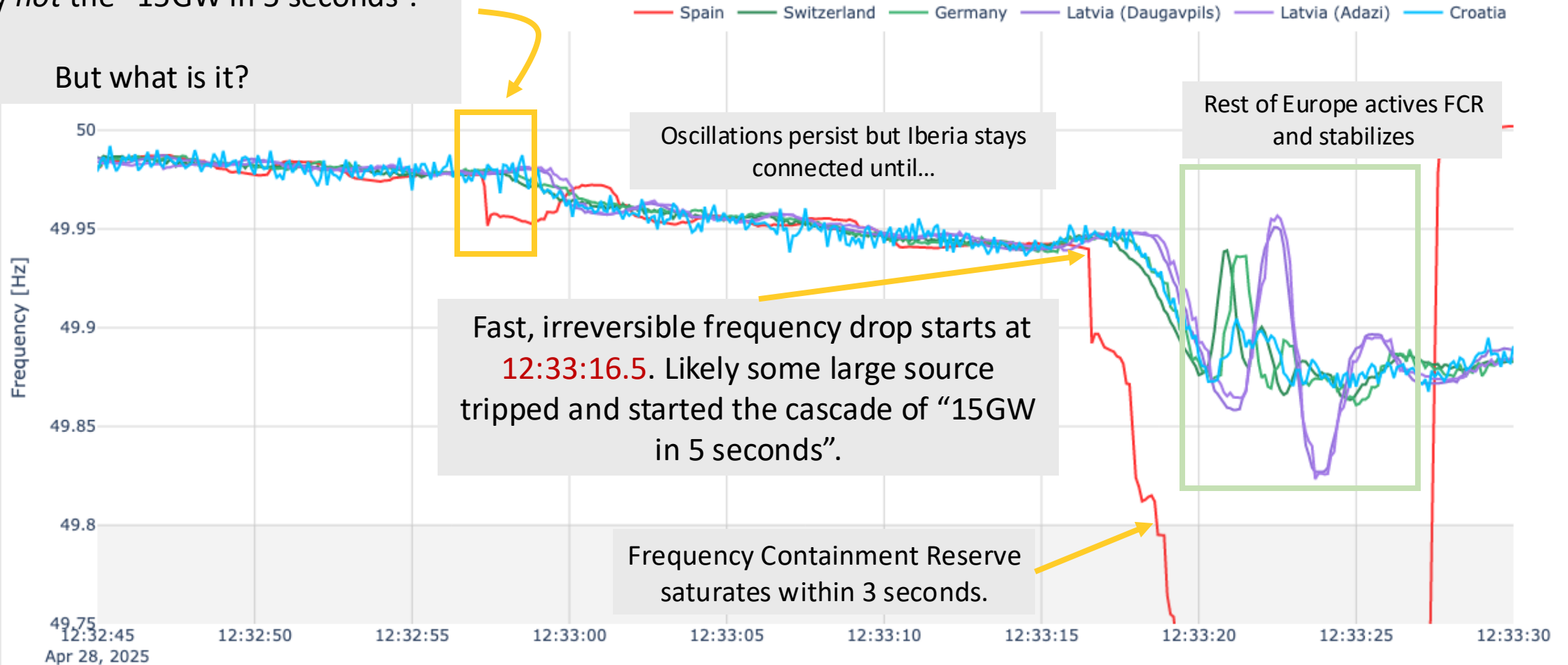
# OSCILLATIONS WORSEN RAPIDLY



# IBERIA SEPARATES FROM EUROPE

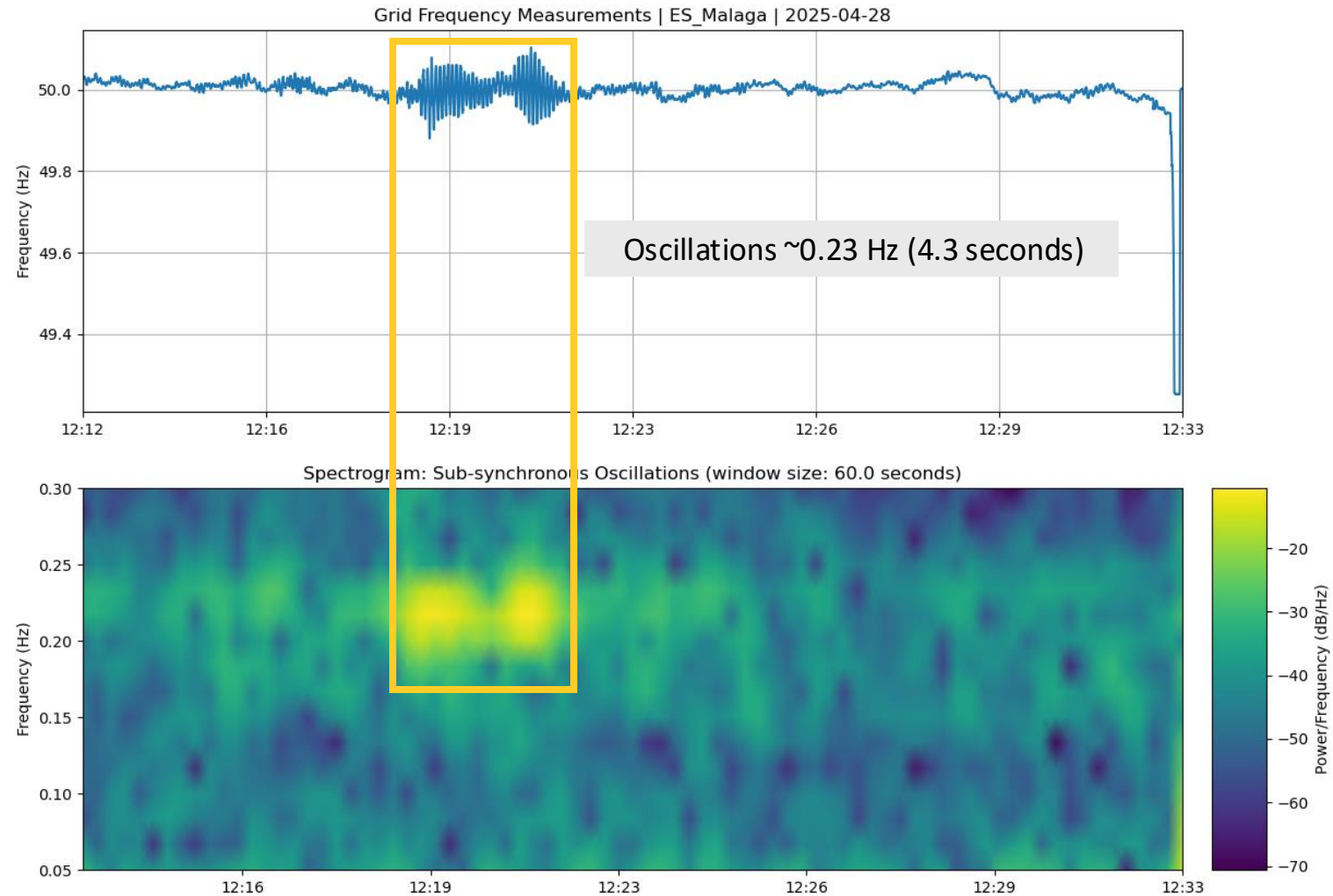
Significant frequency drop @ **12:32:57.3** is probably *not* the “15GW in 5 seconds”.

But what is it?





# IBERIA SEPARATES FROM EUROPE



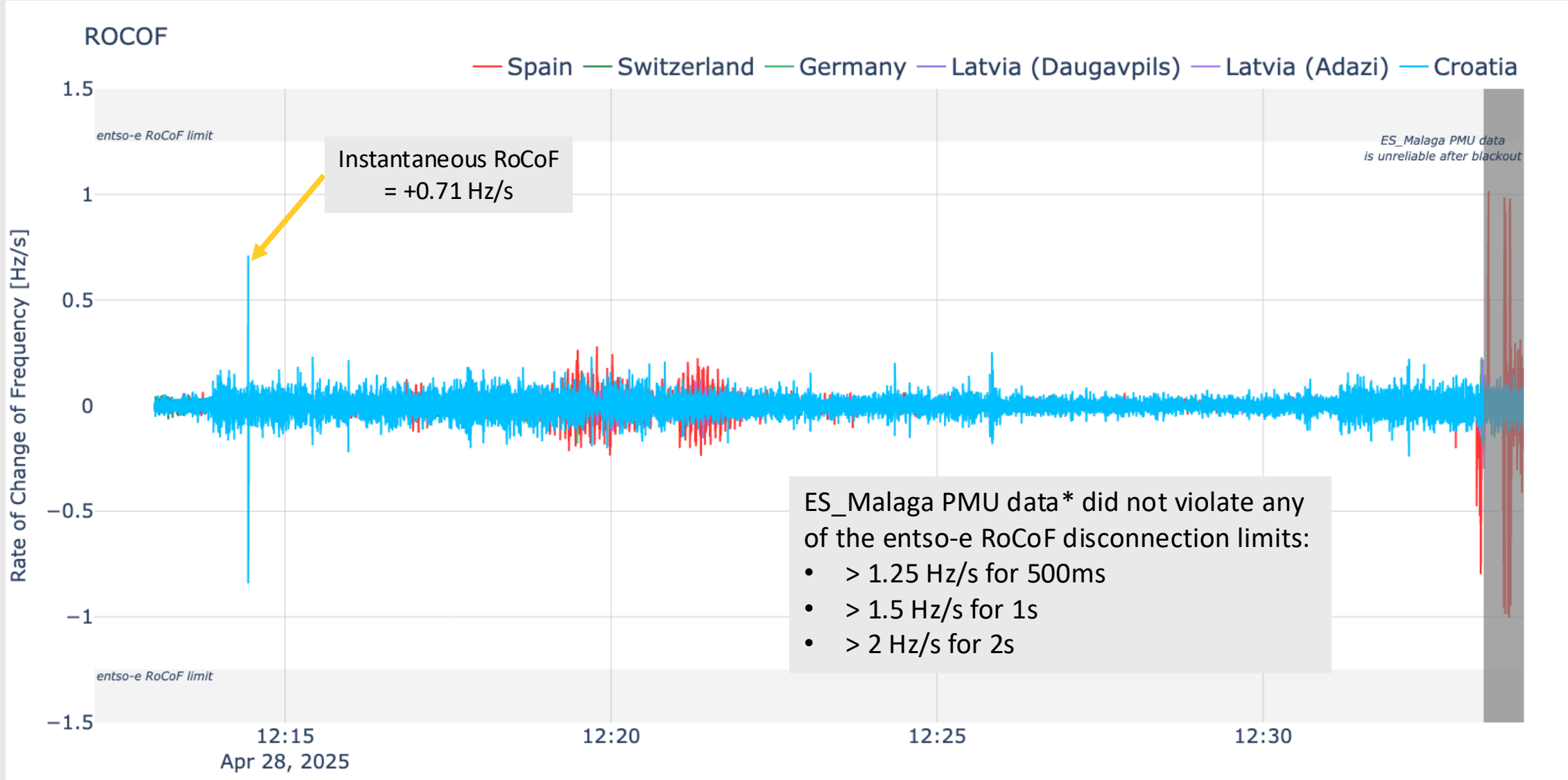


## Section 2

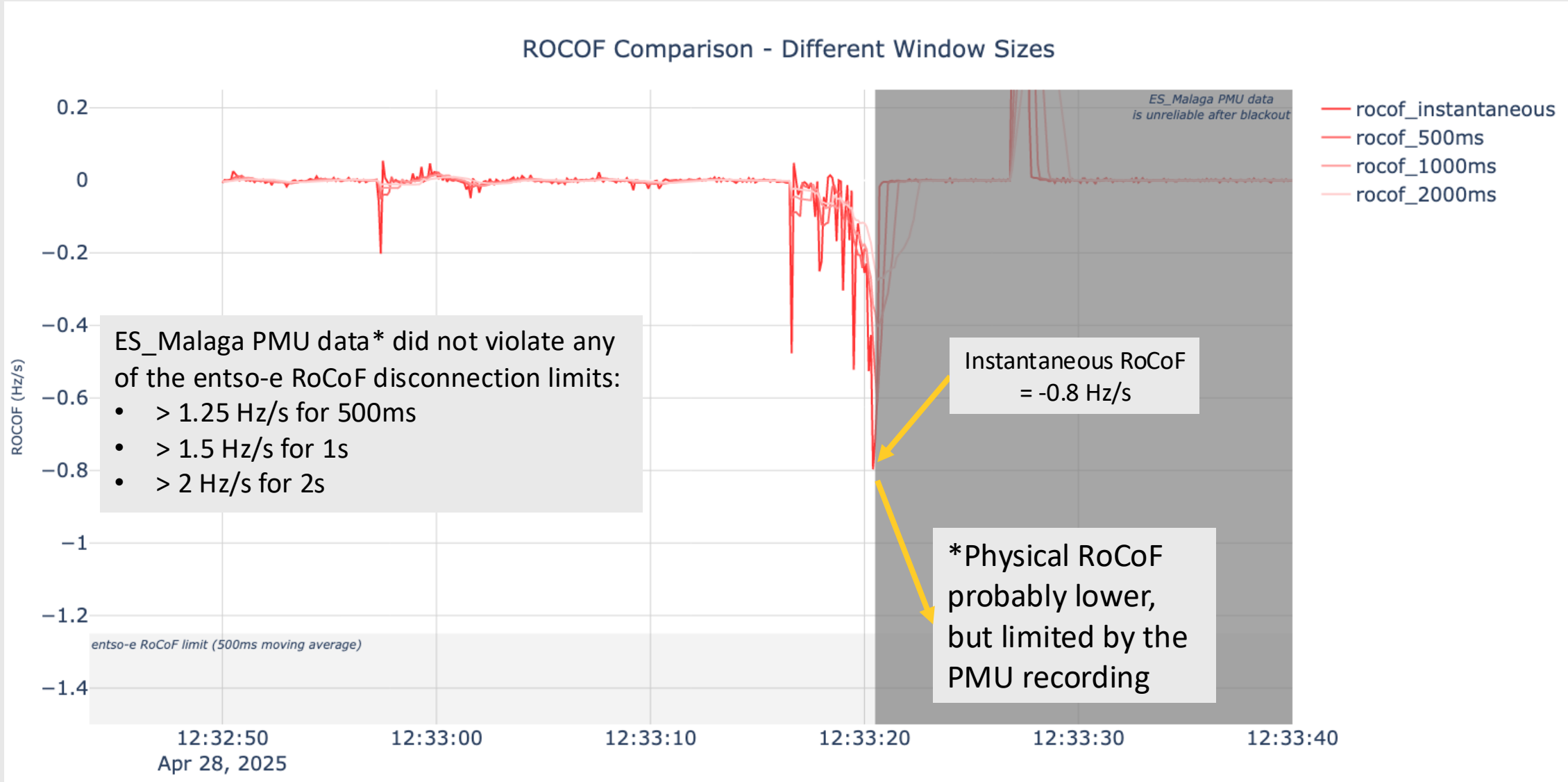
# **Rate of Change of Frequency**

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# ROCOF OVERVIEW



# ROCOF STAYED WITHIN LIMITS





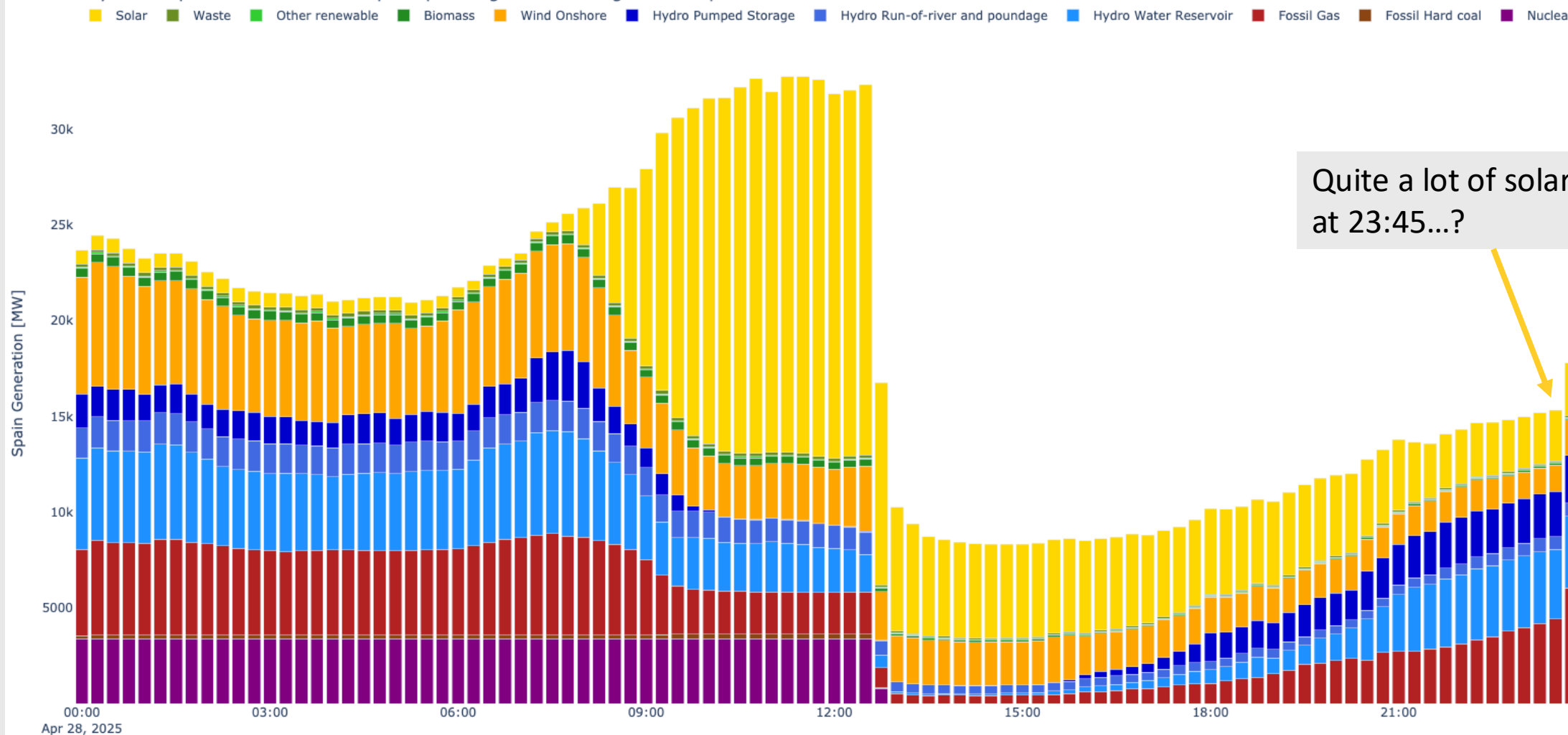
## Section 3

# Generation, Inertia, Exports



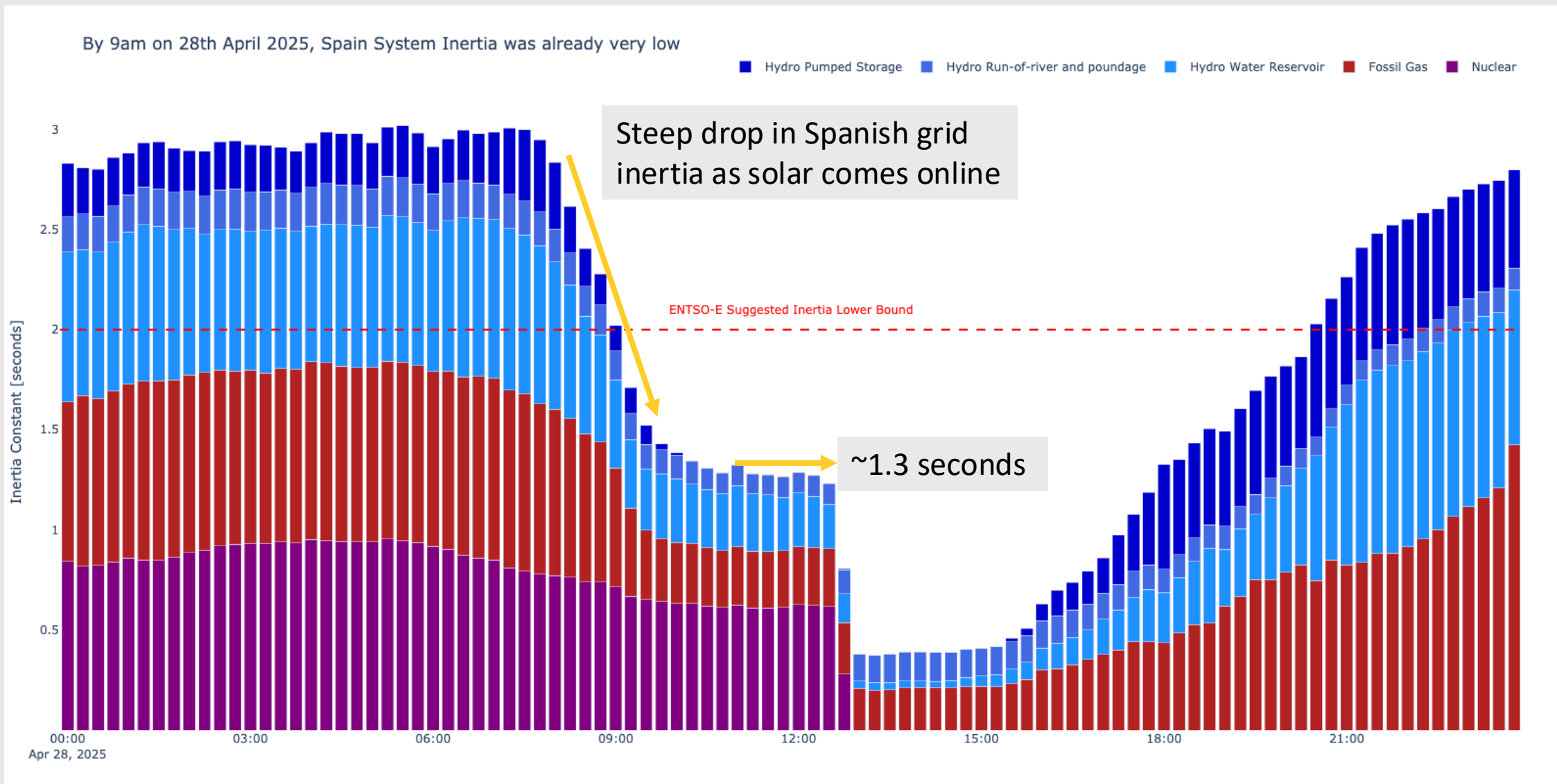
# GENERATION MIX ON APRIL 28, 2025

Hydro ramped down as solar ramped up through the morning of 28th April 2025



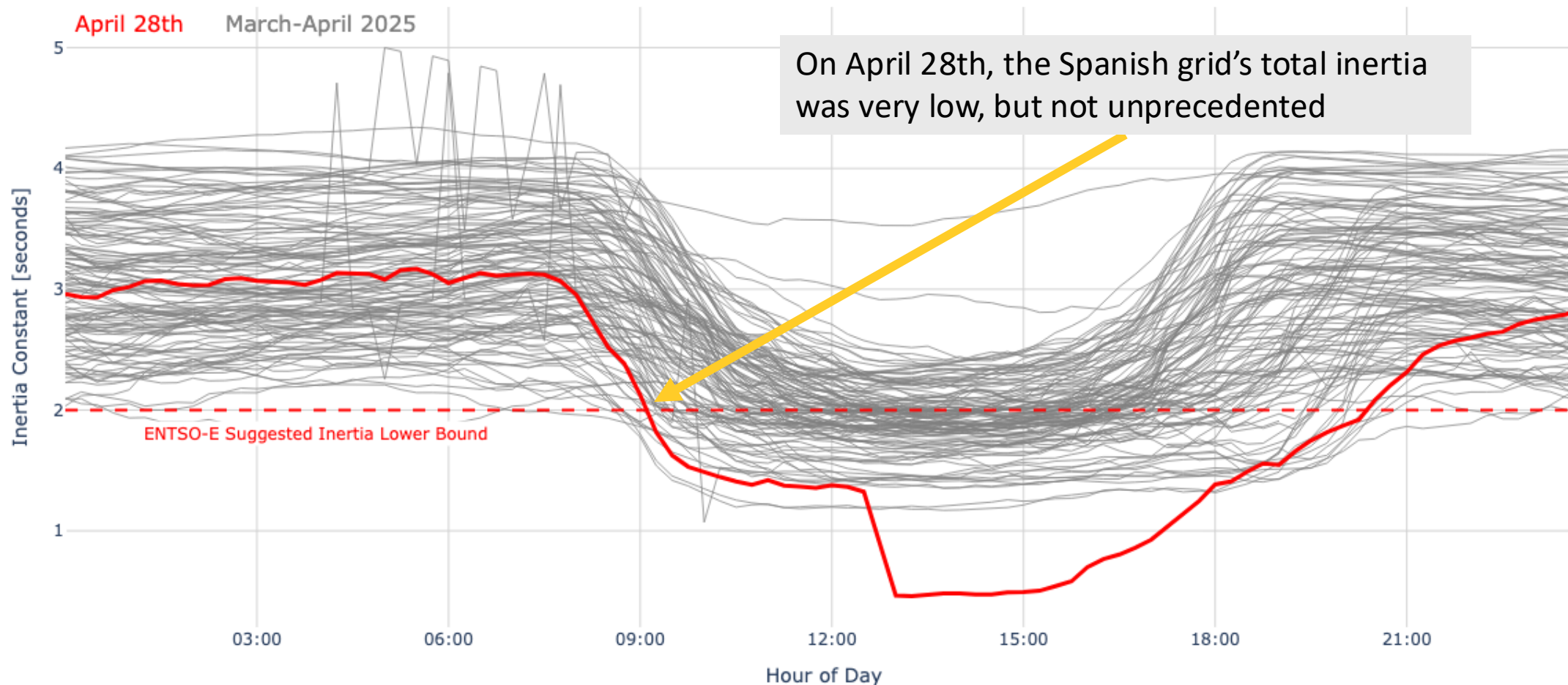


# GENERATION MIX ON APRIL 28, 2025



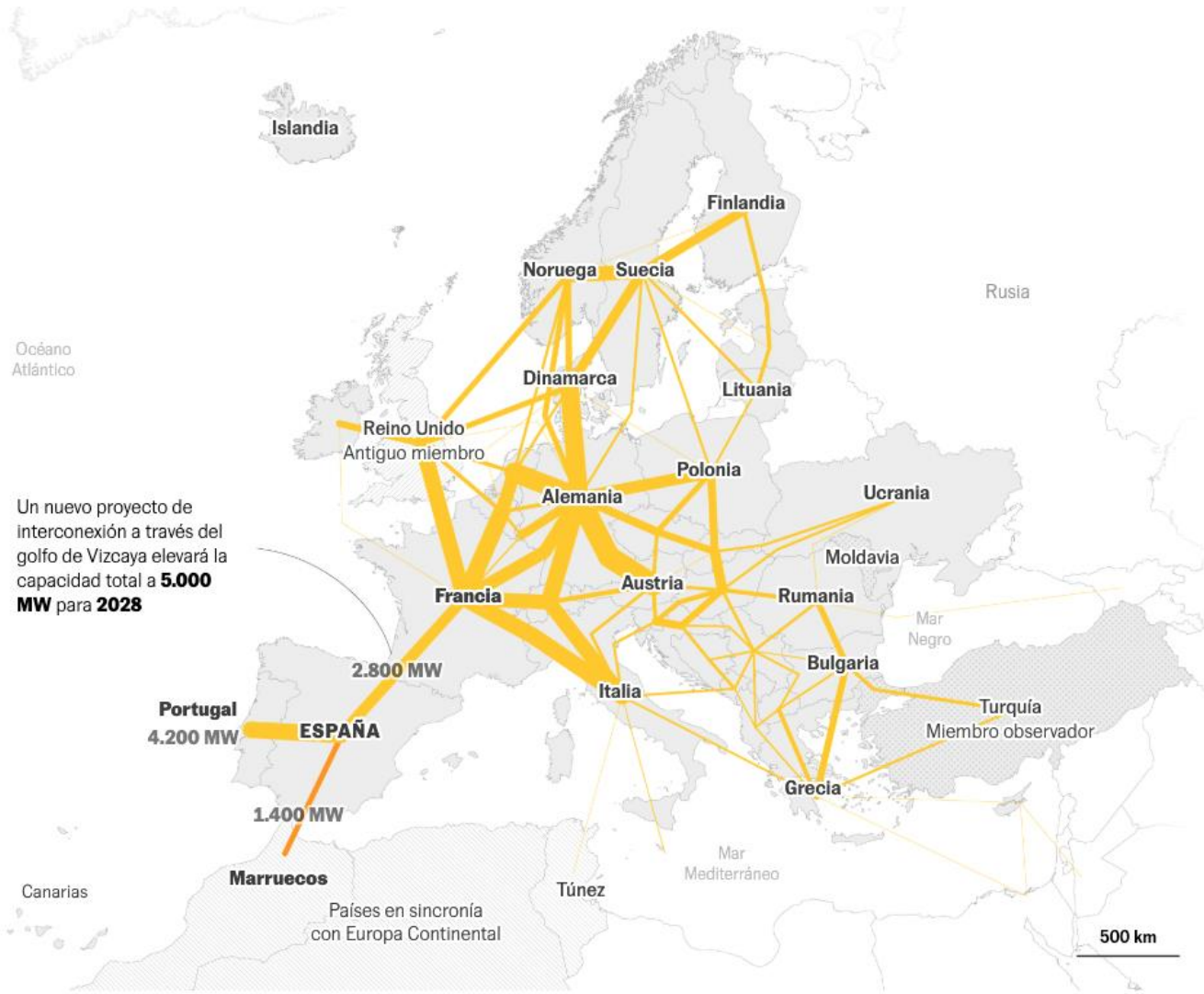
# SPANISH INERTIA WAS LOW, BUT NOT UNPRECEDENTED

Spain System Inertia Throughout 2025



### La red eléctrica europea

- Capacidad de interconexión (MW)
- Países miembros de ENTSO-E

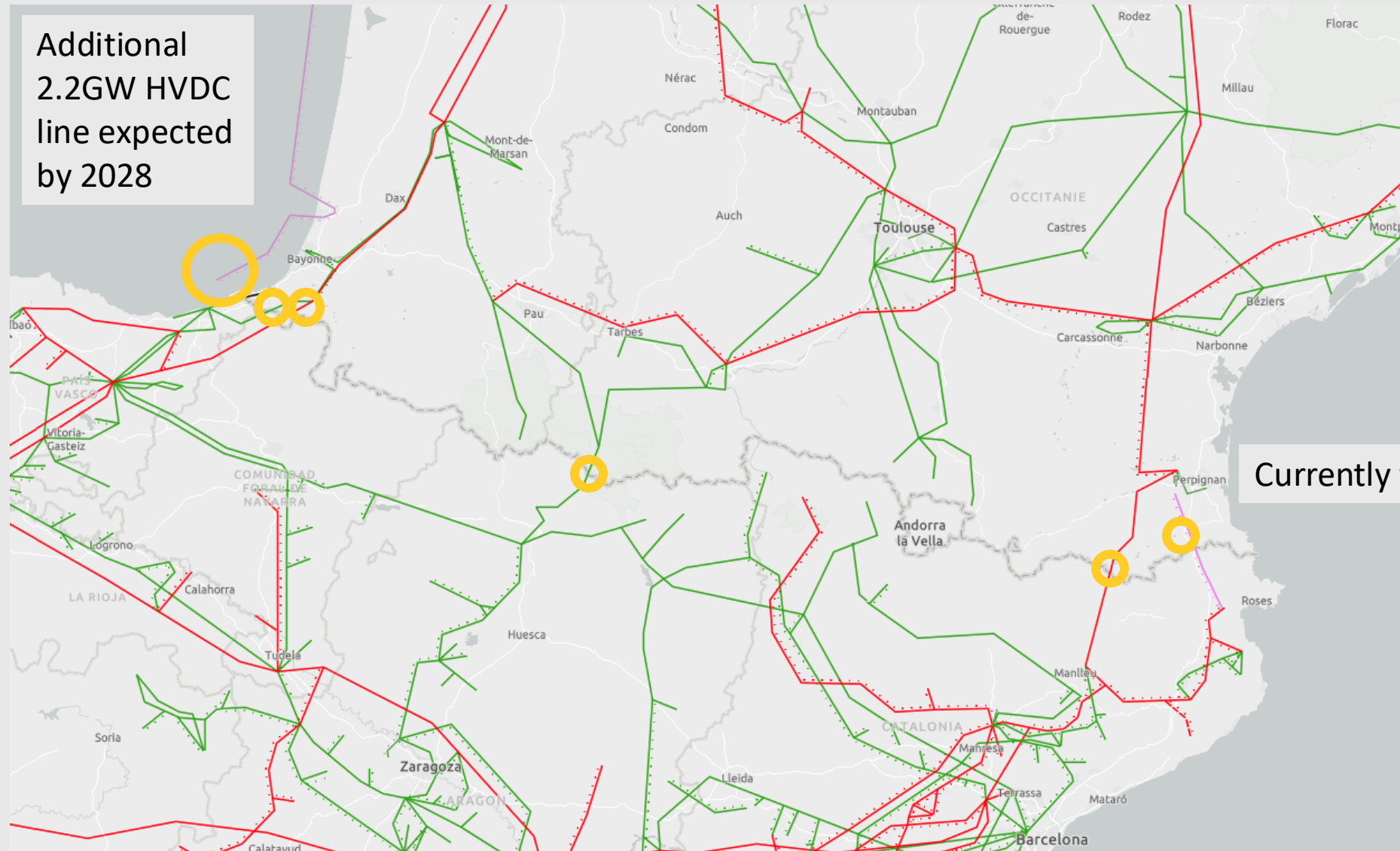


Fuente: Ember Energy, ENTSO-E, Red Eléctrica.

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

Iberian connection to France is relatively weak.

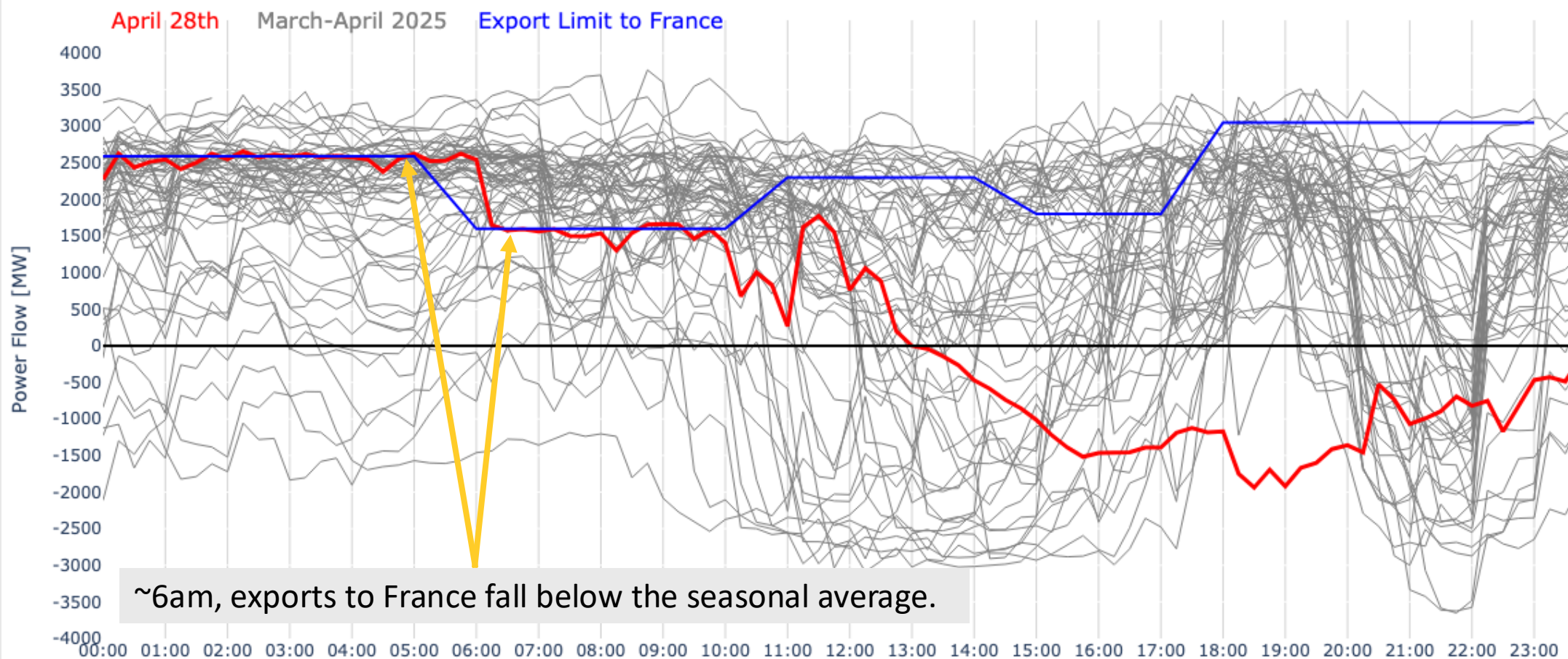
# CONNECTIONS WITH FRANCE





# EXPORTS TO FRANCE WERE BELOW AVERAGE

Exports from Spain to France were below seasonal average





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# LEMUR

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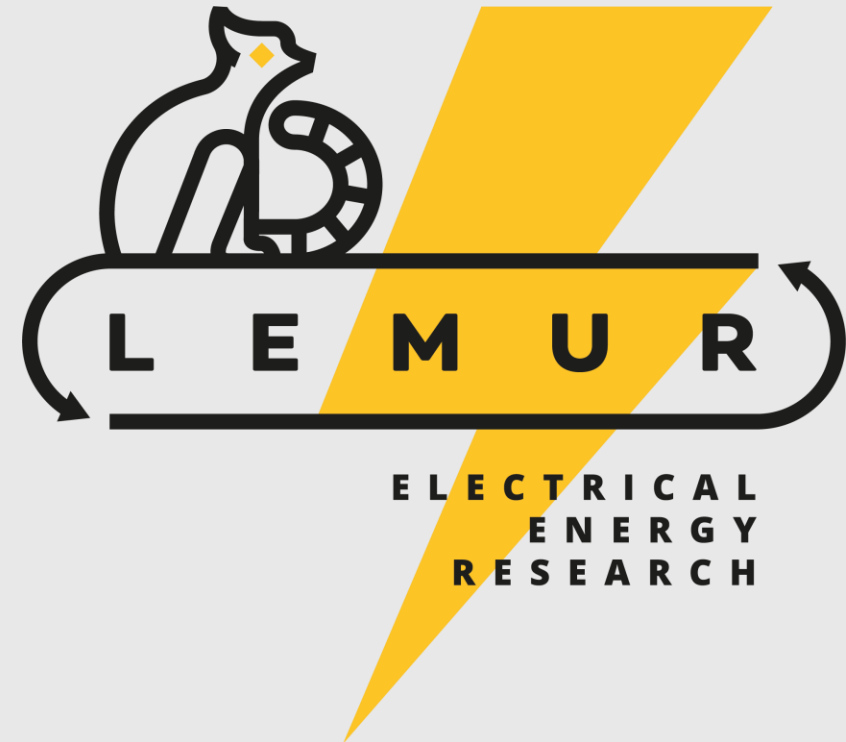




## OUR GOAL

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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.





# OUR VISION

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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.



# 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!*

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