

# Blackout in Spain and Portugal on 28 April 2025

Expert Panel Factual Report >> 27 October 2025 >> ESIG workshop



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# 1. Introduction



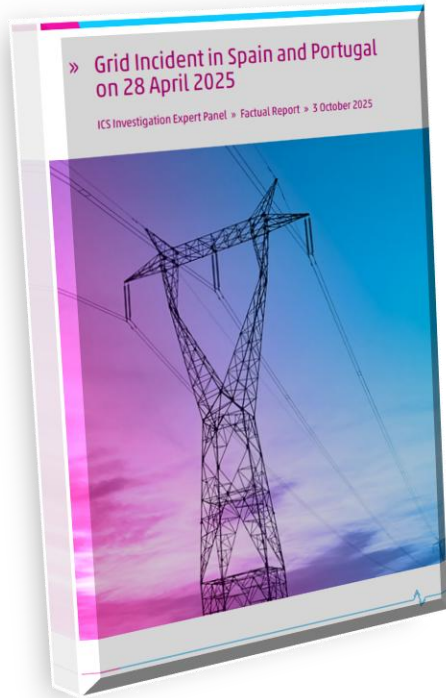
## Significance of the incident

- On 28 April 2025, at 12:33 CEST, continental Spain and Portugal suffered a blackout.
- A small area in the South of France (at the border with Spain) was also affected during a very short period of time.
- The rest of the European power system did not experience any disturbance resulting from the incident.
- **This was the most severe blackout incident on the European power system in over 20 years, and the first ever of its kind (overvoltage).**
- It had major repercussions for citizens and society.



**Figure:** Geographic area affected by the 28 April 2025 incident

# Purpose and scope of the factual report published on 3 October



- The purpose of this report is to provide a **technical and objective account** of the incident, based on factual evidence.
- It aims to **support transparency, learning and continuous improvement** of the power system across Europe.
- The report is **not intended to allocate liability or responsibility** to any party.
- This report has been agreed and **prepared by the Expert Panel**, set up in accordance with EU rules.
- While the data presented in the report and in this PowerPoint are based on most reliable data made available to the Expert Panel by a range of data providers, no representation or warranty, express or implied, is made as to the fairness, completeness or correctness of information and opinions contained in the report and this PowerPoint.

# Contents of the factual report

## What is in this report:

- Facts and data on the incident
- Description of the [system conditions](#) on 28 April 2025
- Details on the [sequence of events](#) that occurred on the day from 9:00 CEST onwards
- Details on the [restoration](#) process
- It serves solely as a factual report to inform stakeholders and governance bodies

## What is not in this report:

- Analysis
- Root causes
- Recommendations

*These elements will be included in the **final report**, expected to be delivered in Q1 2026.*

# Expert Panel: role and composition

- The Expert Panel is a body legally mandated by EU Regulation to investigate technically any major grid incidents (Scale 2 and 3).
- The composition of the Expert Panel is determined in accordance with EU Regulation.
- The Expert Panel for the 28 April 2025 incident is co-led by Klaus Kaschnitz and Richárd Balog.



The Expert Panel includes **45 members** from:

## TSOs and RCCs of:

Belgium  
Denmark  
France  
Germany  
Greece  
Ireland  
Italy  
Poland  
Portugal  
Romania  
Spain

## ENTSO-E

## ACER

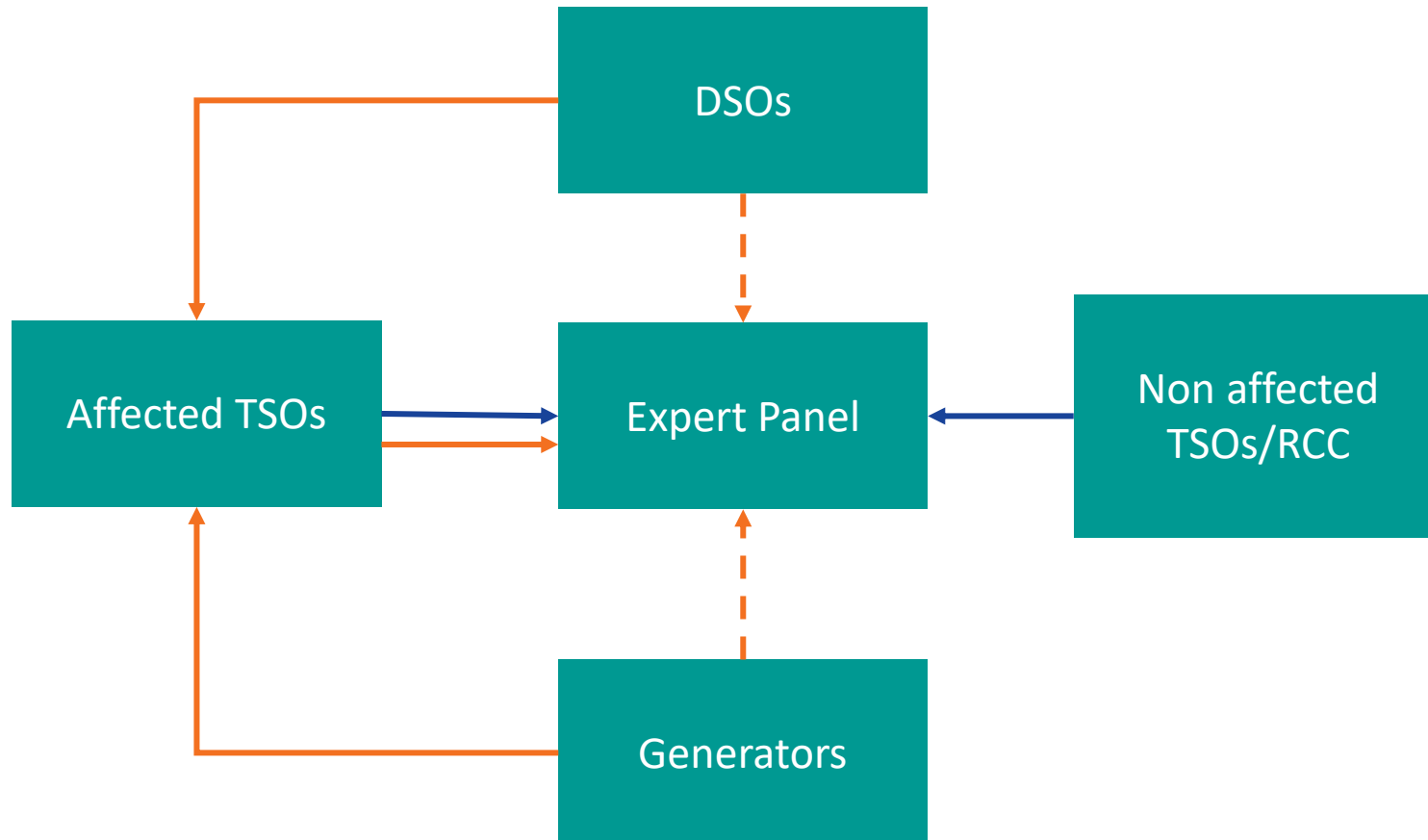
## NRAs of:

Belgium  
Czech Republic  
France  
Germany  
Hungary  
Italy  
Poland  
Portugal  
Romania  
Spain  
Sweden  
Switzerland

## 2. Sequence of events on 28 April 2025



# Data from different parties as basis for investigation



- Significant difficulties arose in obtaining high-quality data from several DSOs and generation companies from Spain.
- These delays slowed the initial, more ambitious timeline of the investigation.
- The Expert Panel completed the data collection phase and was able to publish its factual report ahead of the legal deadline. However there is still some information missing from third parties of Spain.



## **System conditions before the incident**

9:00 to 12:32 CEST

# A typical spring day in South-West Spain

Figure: Geographic distribution of generation in Spain at 12:32 CEST

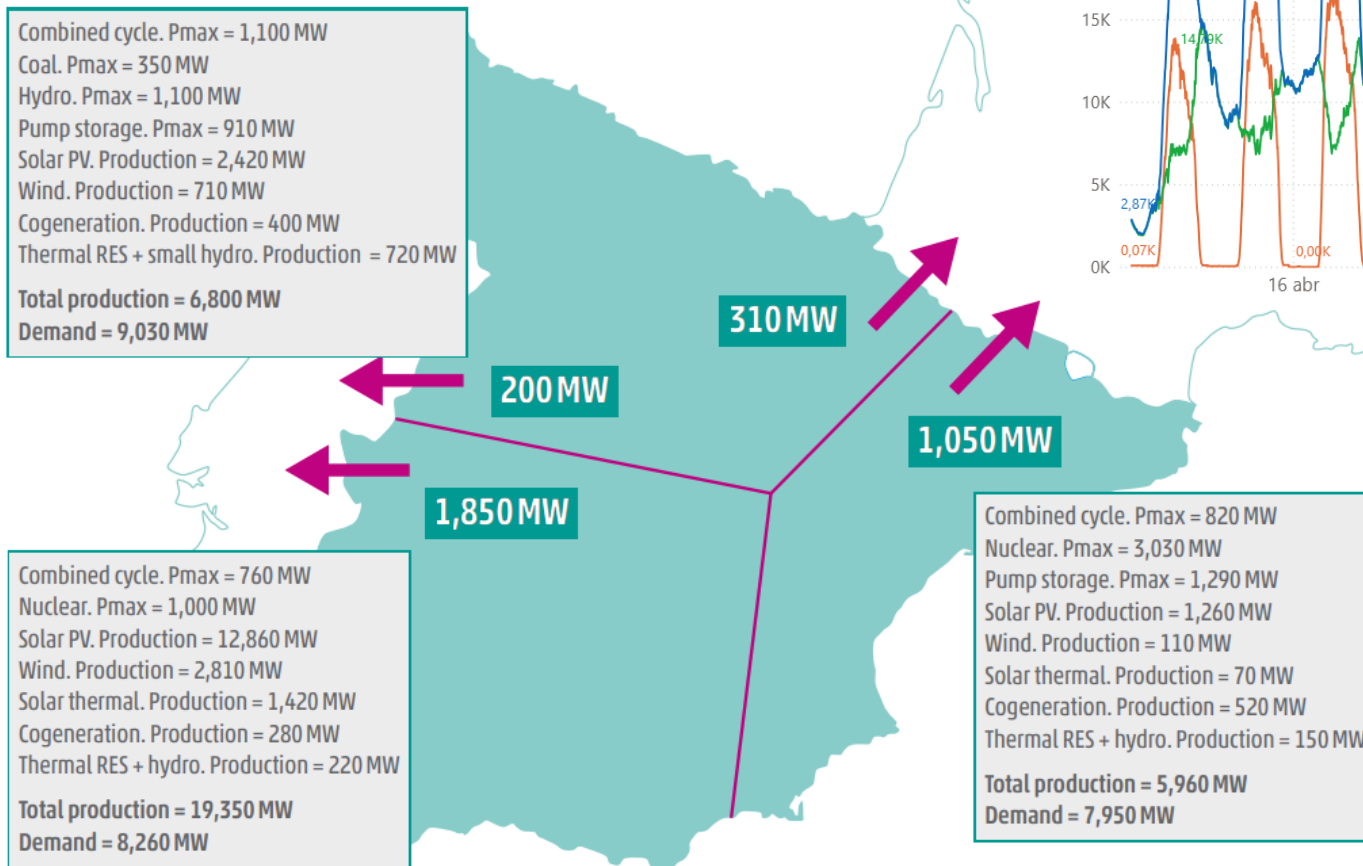
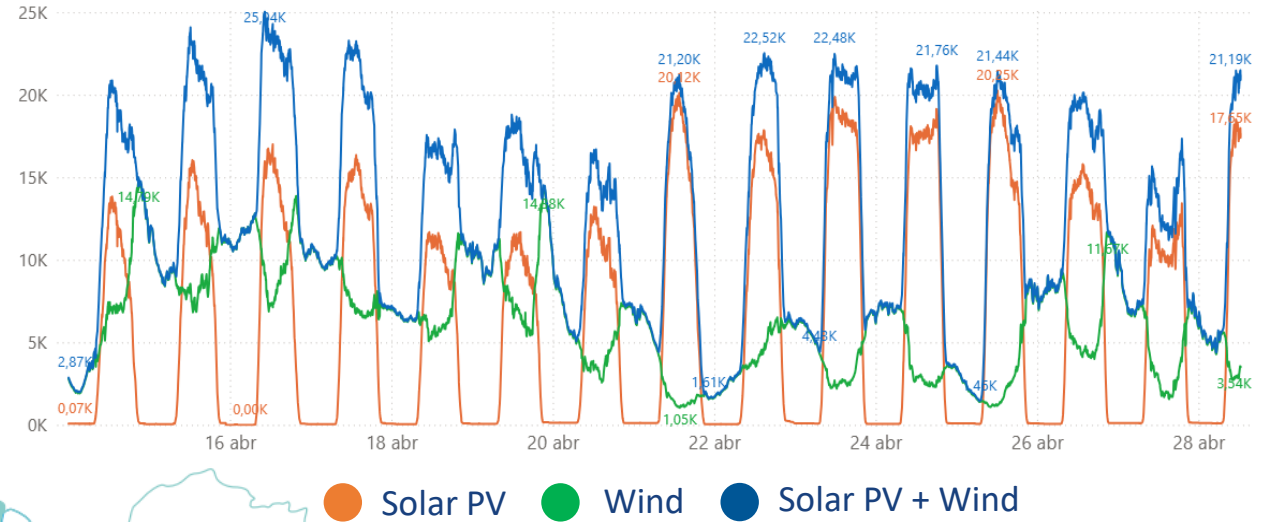


Figure: PV and wind production in Spain in previous days

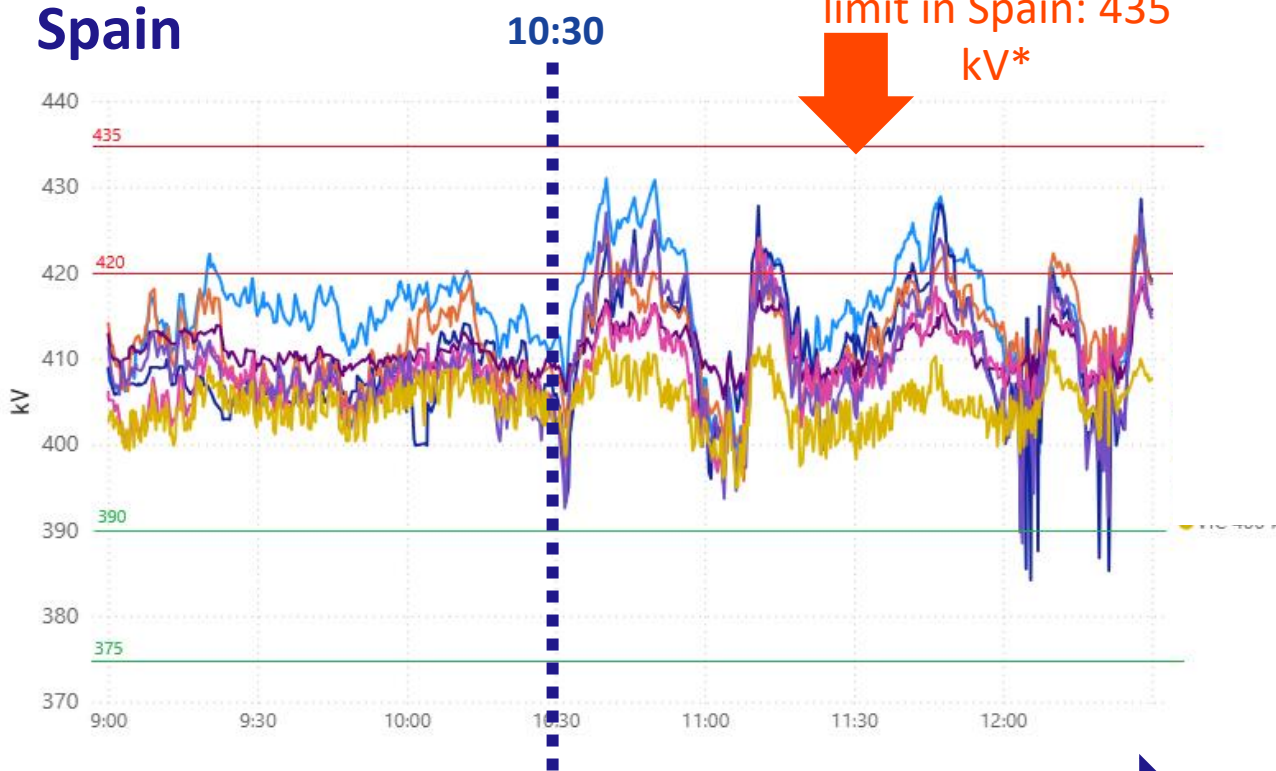


Renewable infeed followed patterns usually observed on a spring day in Spain.

**High concentration of renewables in South-West Spain at noon CEST.**

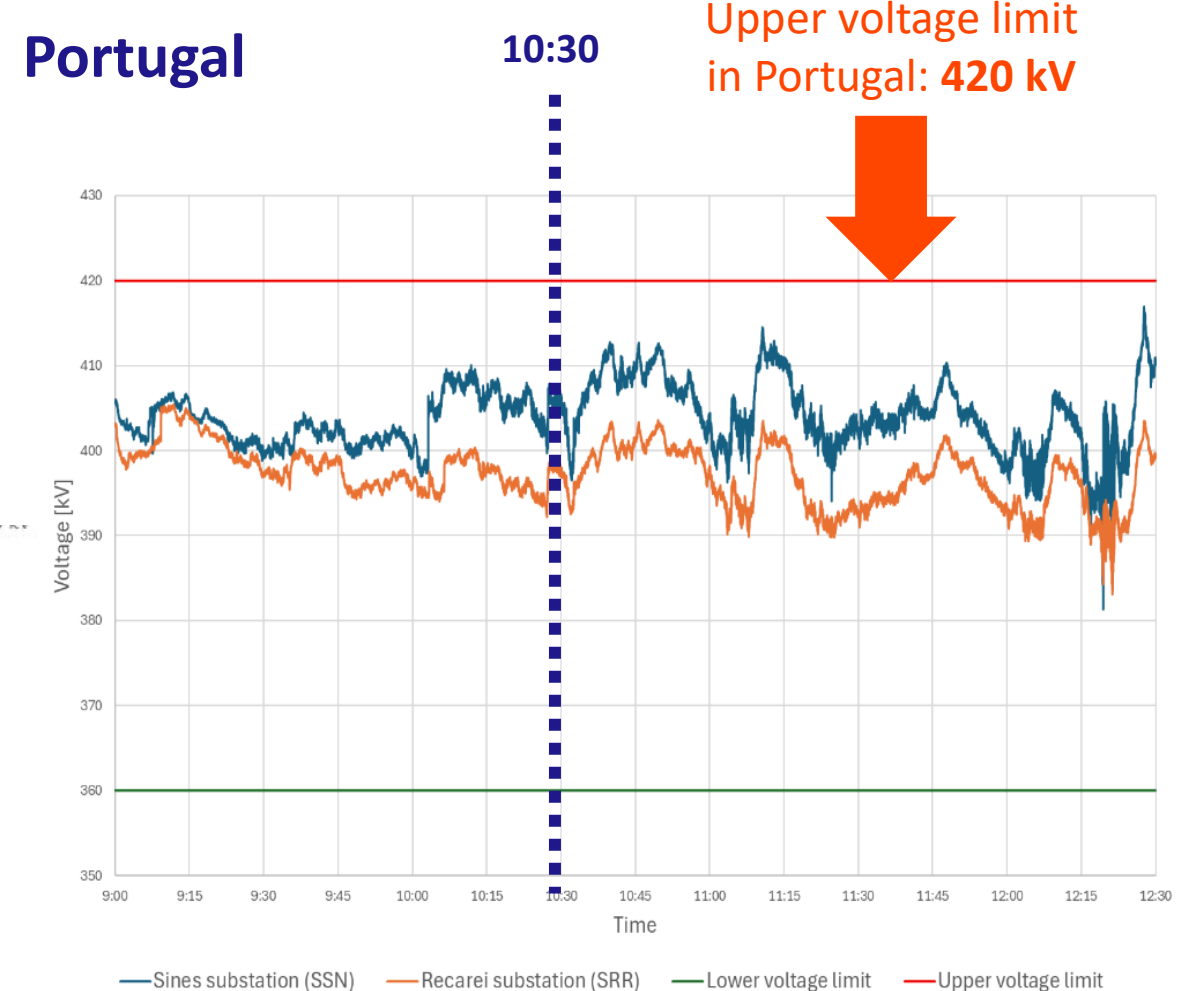
# First voltage fluctuations observed in Spain

Within the normal range of operations

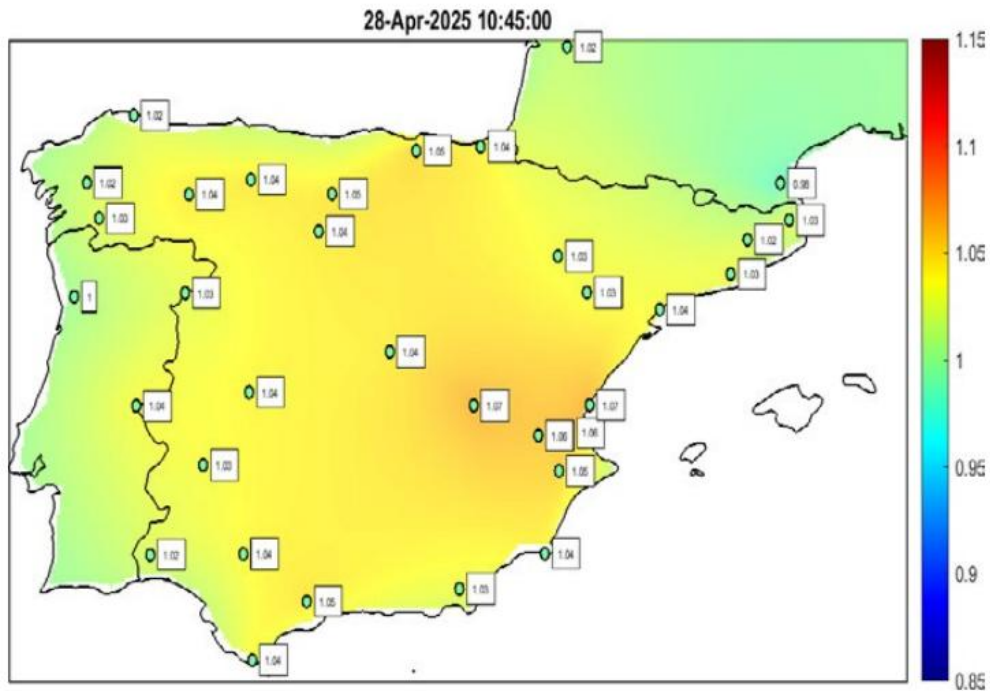


\* These values may occur eventually at the 400 kV level (confirmed by CNMC, Spanish regulator)

First significant variations of the voltage from 10:30 CEST



# Voltage control capability of an electrical system



**Figure:** Voltage heatmap at 10:45

## Actions to control voltage

### Manual topological actions:

- (dis)connecting lines
- (dis)connecting shunt reactors / capacitors
- changing tap position of transformer

### Automatic actions:

- Generation and absorption of reactive power (Q) by grid users (generators and consumers)
- STATCOM, HVDC – converter stations

# Contribution to voltage control by generators

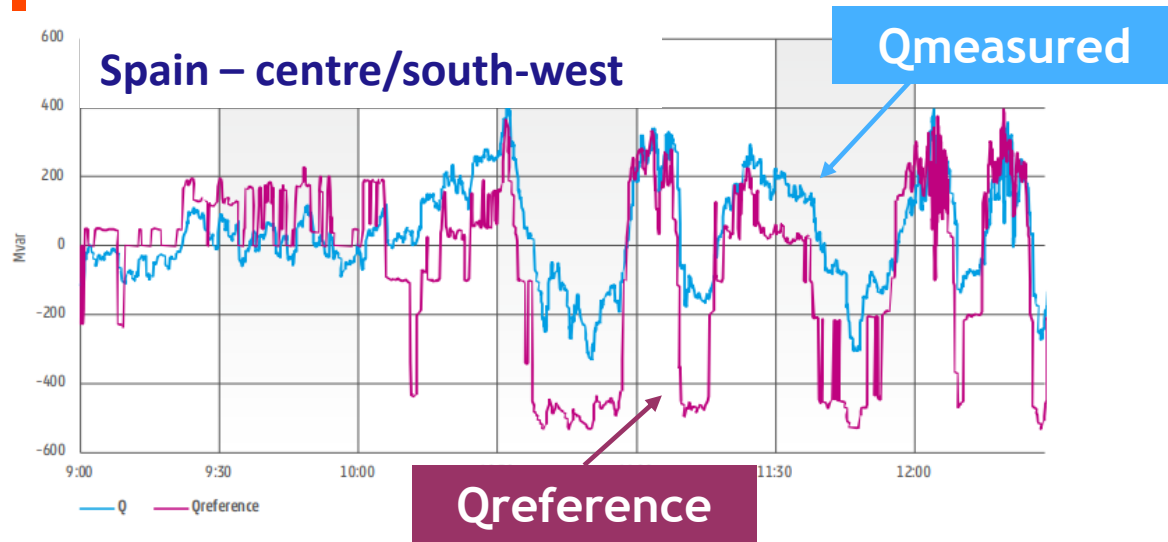


Figure: Reactive power provided (Q) and the reference reactive power (Qref) aggregated for conventional generation units larger than 100 MW of power installed capacity in the centre/south-west area of Spain

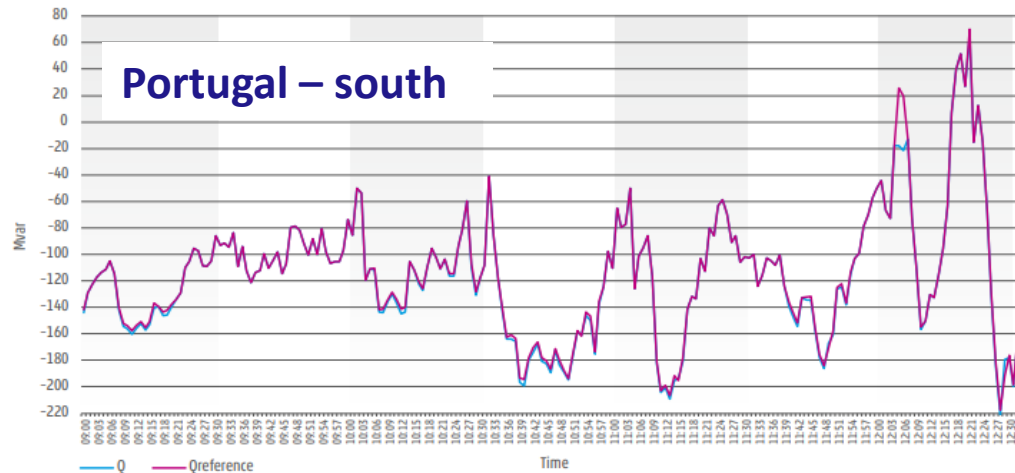


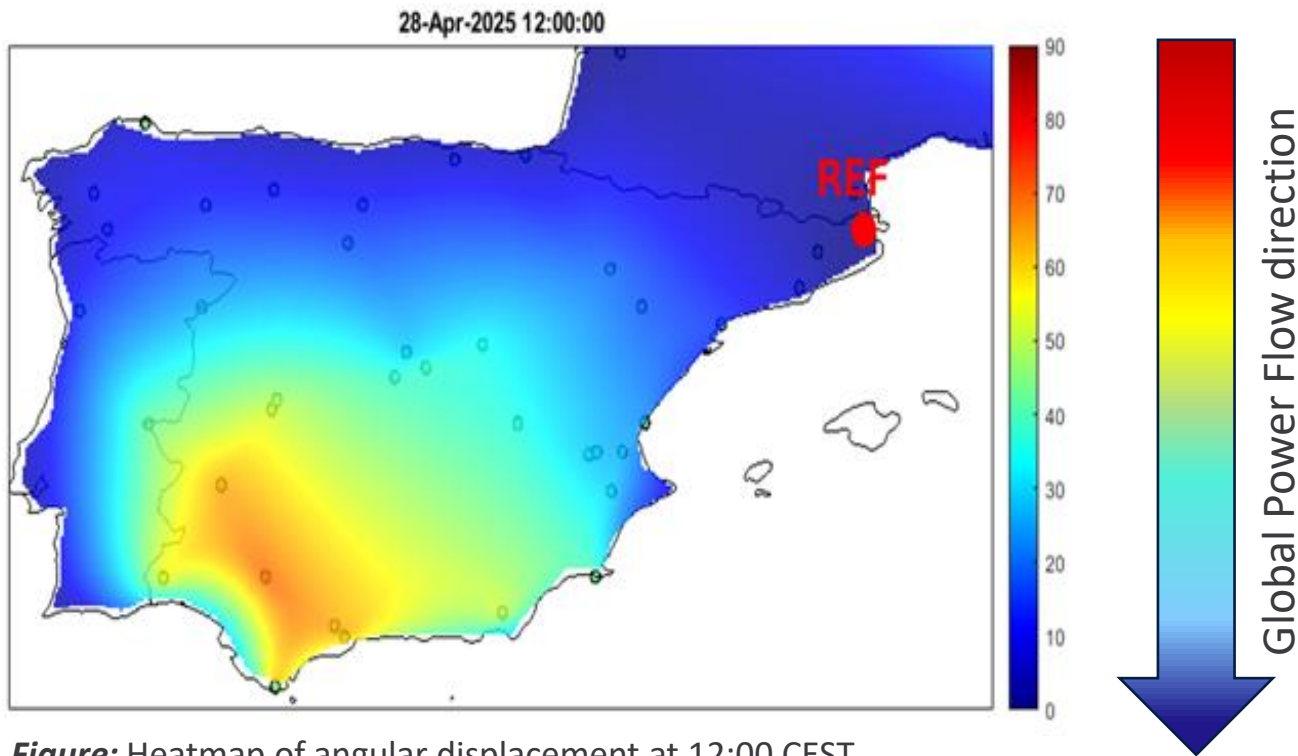
Figure: Provided reactive power (Q) and reference reactive power (Qreference) for generating relevant power plants with more than 100 MW of power installed capacity in the south area of Portugal (REN's SCADA measurements)

## Voltage control requirements in Spain:

- A difference was observed between reference and measured values (applicable only to conventional generators - RES generators were required to provide the service via fixed power factor).
- As explained by the Spanish regulator, Qreference is the reactive power control service to be provided by generators, without prejudice that compliance allows a time margin of 25% outside that area.

In the evening of 27 April, a generation unit in Andalusia was declared unavailable until 29 April. This unit was initially scheduled for the entire day on 28 April. It was replaced by another unit during the night from 27 to 28 April. In the morning of 28 April, the Spanish TSO performed security assessments and concluded that it was not necessary to replace it for the rest of the day.

# Initial conditions before start of oscillations (12:00 CEST)

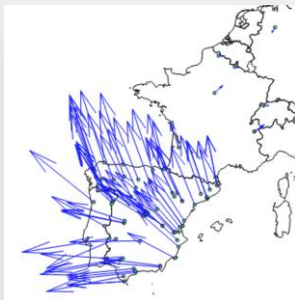
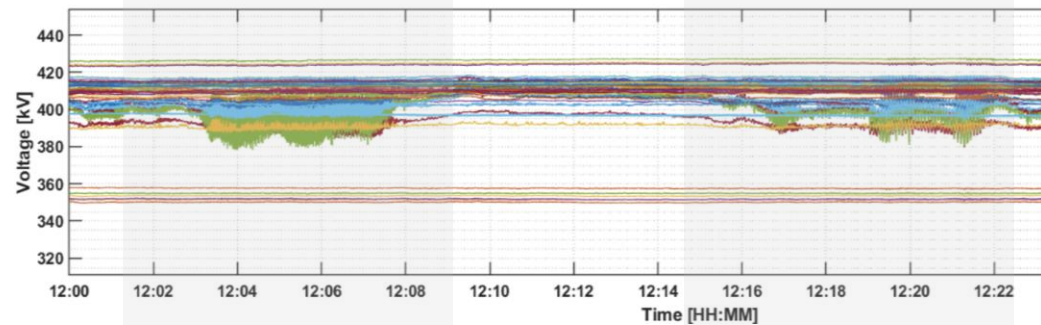
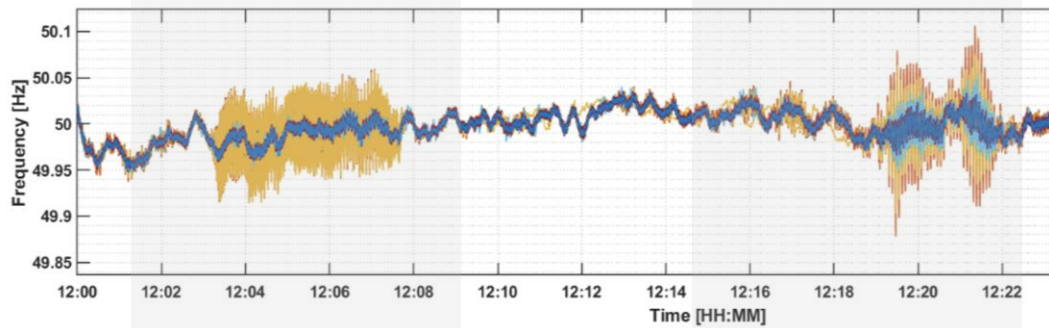


**Figure:** Heatmap of angular displacement at 12:00 CEST

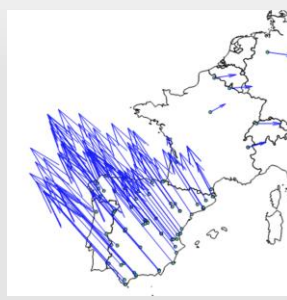
## Technical interpretation of the heatmap of angular displacement at 12:00 CEST:

- Heterogeneous distribution of generation in Spain before the incident
- Southwest region is “pushing” active power in the surrounding areas

# Actions taken to mitigate the oscillations



*Local oscillation  
with 0,63 Hz*



*Inter-area  
oscillation with  
0,21 Hz*

**According to common protocol, Spanish and French TSOs took several mitigating measures:**

- Lines were switched on to decrease the system impedance.
- Fixed power operation mode was set up on the HVDC link between Spain and France.
- The flow between Spain and France was reduced.

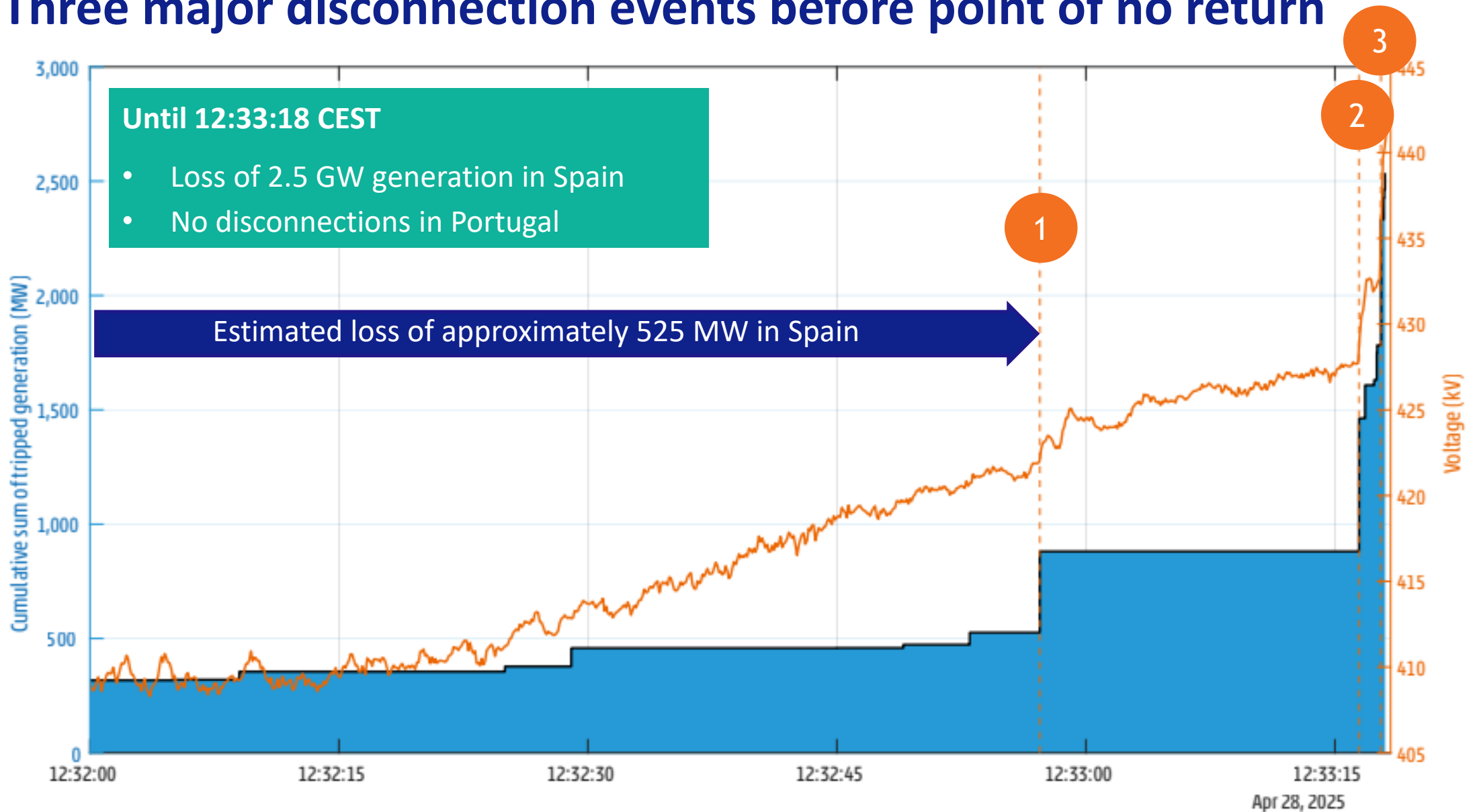
**The mitigation measures were successful in damping the oscillations, but voltages increased, though still within operational range.**



## **Sequence of events during the incident**

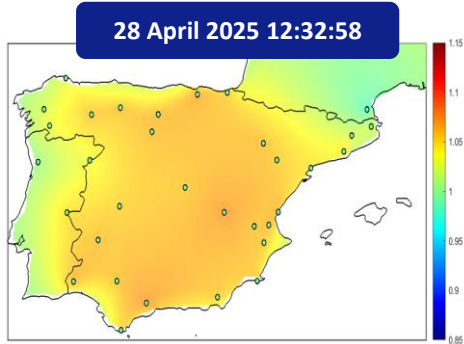
**12:32 – 12:33 CEST**

# Three major disconnection events before point of no return



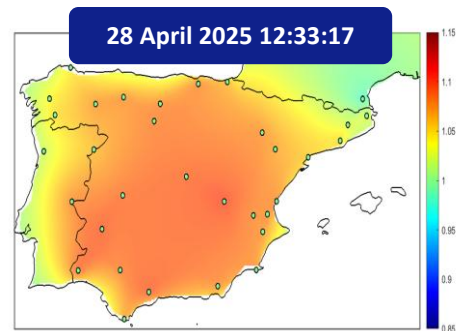
# Rapid unfolding of the sequence of tripping events during the incident

Figures: Heat maps of the voltage in the transmission grid (in p.u.) just after each of the first three generation trips (source: PMU data from Red Electrica, REN and RTE)

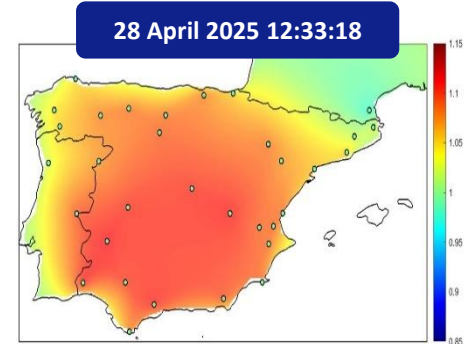


**First event:** Events started milliseconds after 12:32:57 CEST with the tripping of a generation transformer in the region of Granada, due to the activation of an overvoltage protection.

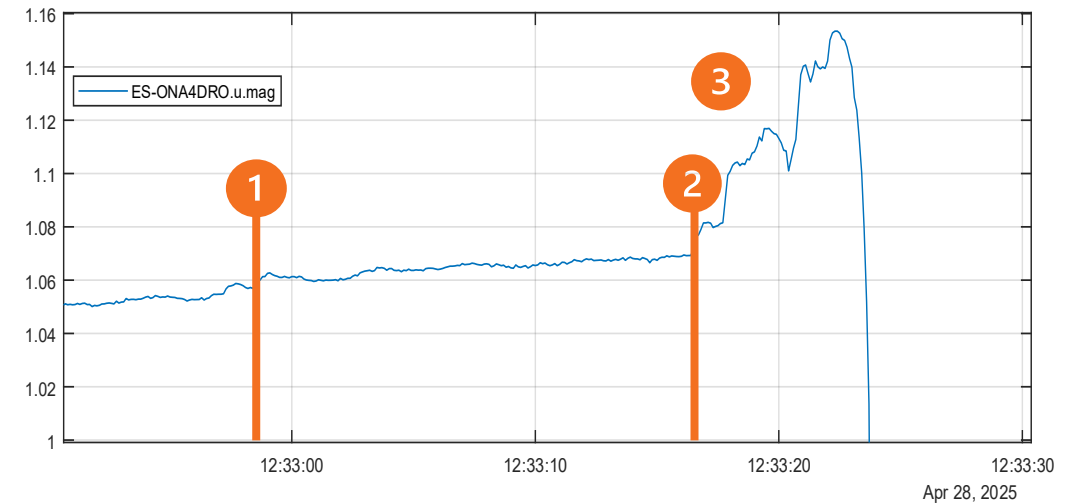
The transformer was injecting 355 MW into the grid at this time and there were 417.9 kV in the 400 kV transmission side.



**Second event:** Included trips of PV and thermo-solar facilities connected to two 400 kV transmission substations, in Badajoz, with a total interrupted injection of around 725 MW. The last SCADA voltage reading was 434.0kV at evacuation bay, 430.5kV and 429.9kV at busbars.



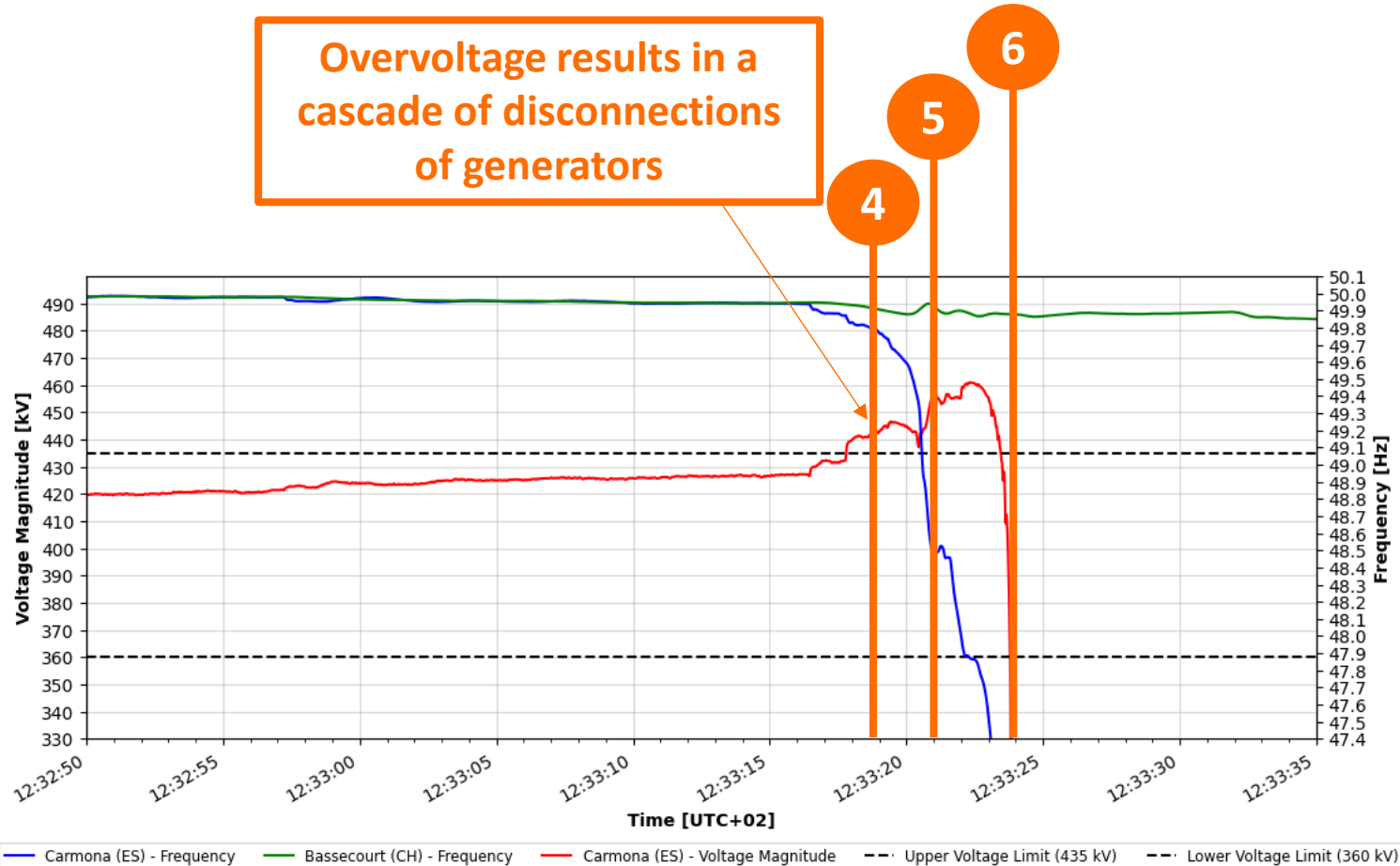
**Third event:** Included several trips between 12:33:17 CEST and 12:33:18 CEST, which led to disconnection of wind and solar generation in Segovia, Huelva, Badajoz, Sevilla and Caceres for a total of approximately 930 MW (or more than 1,100 MW, as implied by the variation of frequency).



**Figure:** Evolution of voltage in the node Carmona during tripping events. Voltages in nodes closest to the three events are not shown

# Voltage and frequency evolution during the incident

Overvoltage results in a cascade of disconnections of generators



4

**12:33:19 CEST**

- Decrease of frequency on Iberian Peninsula and loss of synchronism with rest of Continental Europe
- System Defence Plans (automatic load shedding) were activated in Spain and Portugal but unable to stop the blackout due to its overvoltage nature

5

**12:33:21 CEST**


- Disconnection of all AC lines from Spain to Morocco and France

6

**12:33:24 CEST**

- The HVDC stops exporting power from Spain to France

**Figure:** Evolution of the frequency and the voltage in the substation of Carmona (Spain) and of the frequency in the Bassencourt, Switzerland) during the incident (sources: Red Electrica, Swissgrid).

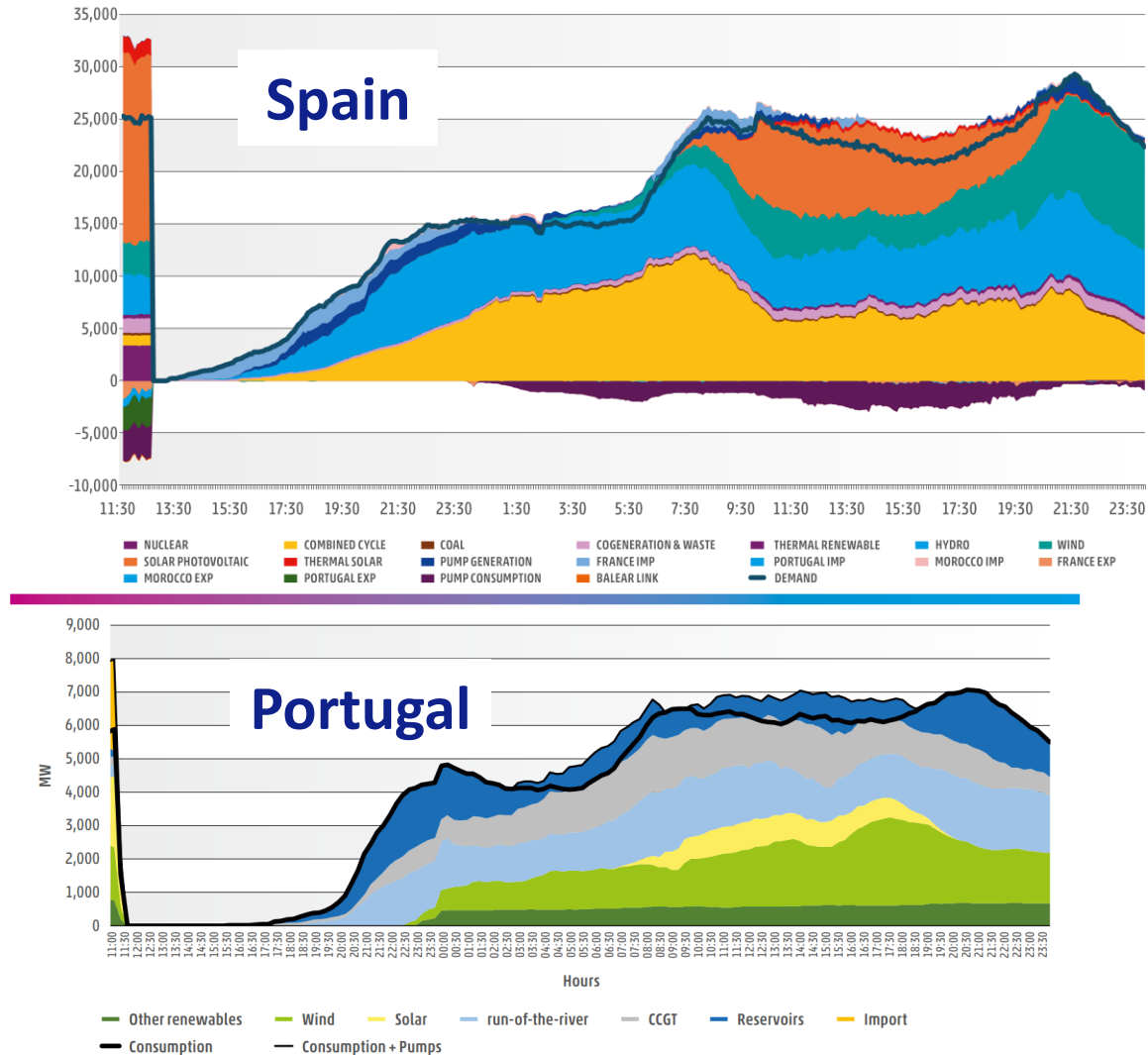


## **Restoration process**

From 12:33 CEST

# Restoration process

Figures: Evolution of generation and load until end of 29 April



The restoration of supply in Spain and Portugal adopted two strategies:

- The power system restoration of the electrical system started with the support of the **interconnections of France and Morocco** to the Spanish system, and later via the complementary activation of black-start processes in certain power plants.
- In the Portuguese system the restoration started by black-start processes in two power plants and later supported by the interconnections of Spain.

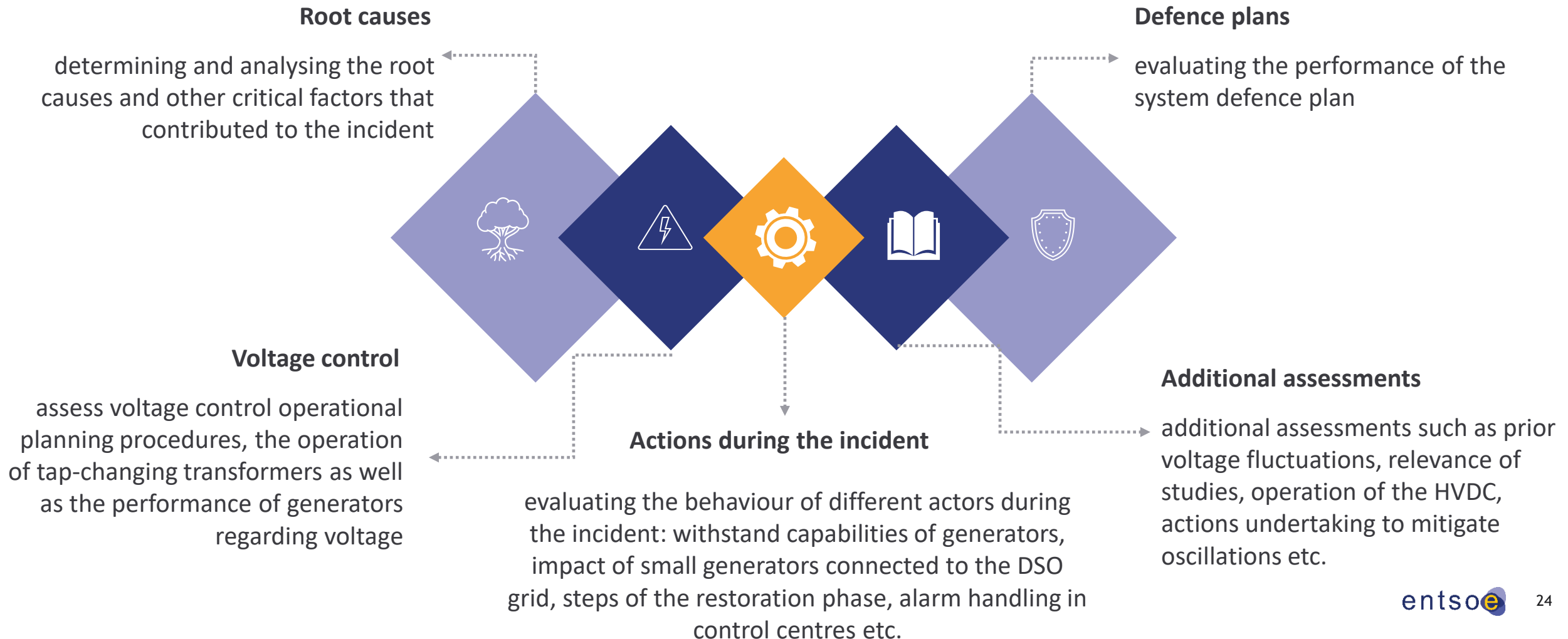
Figure 4-29: Evolution of generation and load of the Portuguese system until the end of 29 April - REN

### 3. Next steps towards the final report



# Next steps towards the Final Report

The final report will focus notably on the following aspects – expected to be released in Q1 2026



Thank you

