Disturbances in Continental Europe Synchronous Area during the last years

09 November 2023

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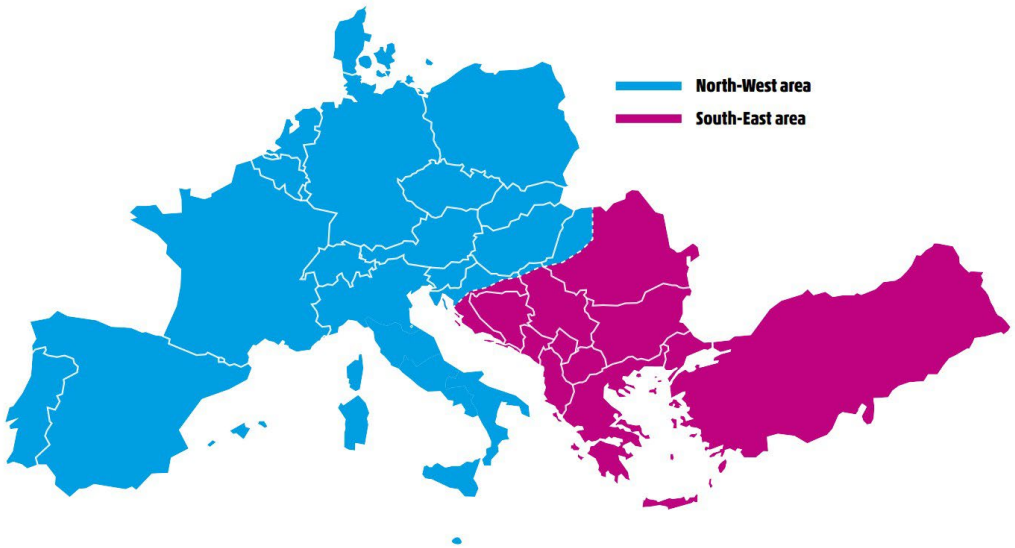
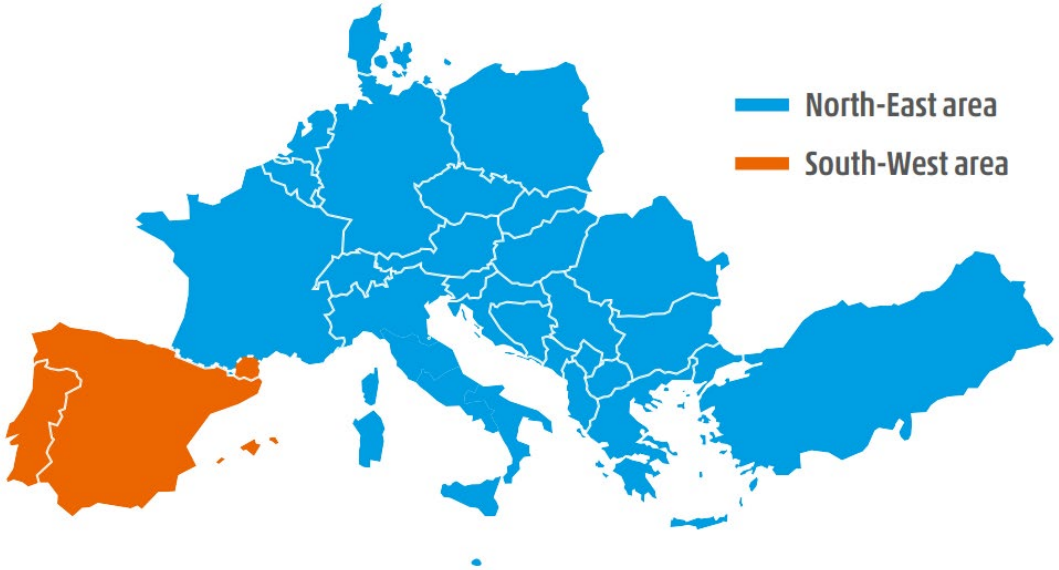
Two system splits during 2021



08 January 2021



24 July 2021

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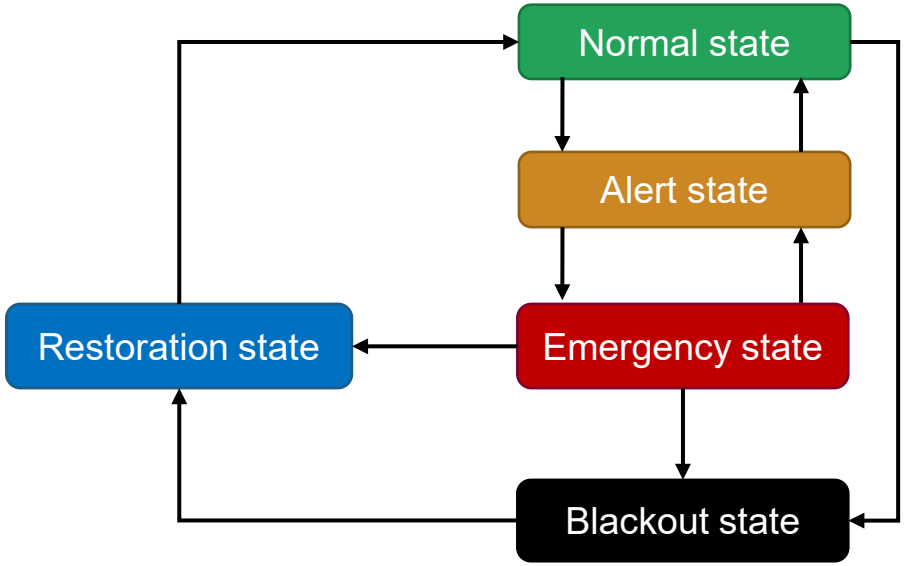
Outline

- About Continental Europe Synchronous Area
- System conditions before the incidents
- The events and dynamic behavior during the incidents
- Frequency containment and automatic system defence measures
- Generation disconnection
- Summary and recommendations



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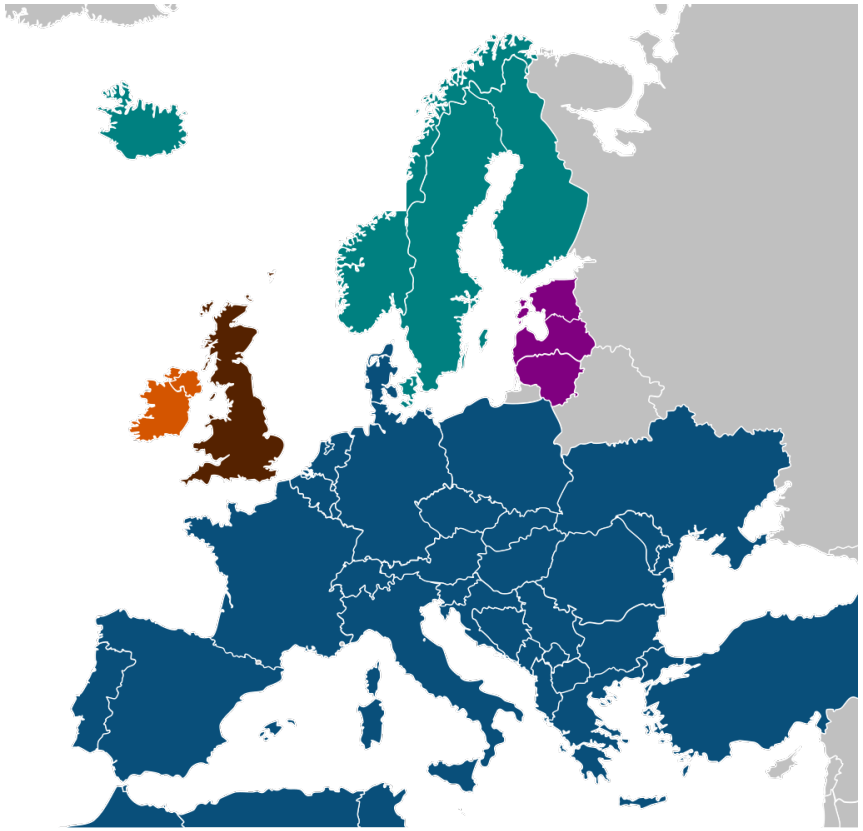
About the Continental Europe synchronous area

- The largest synchronous electrical grid (by connected power) in the world.
- The area supplies over 400 million customers, including most of the European Union.
- The Turkey Interconnected Electrical System operates in synchronous parallel mode with the ENTSO-E CE synchronous area.
- Since March 2022 Ukraine and Moldavia are synchronized to CE synchronous area.
- There is also an AC-connection to Morocco.



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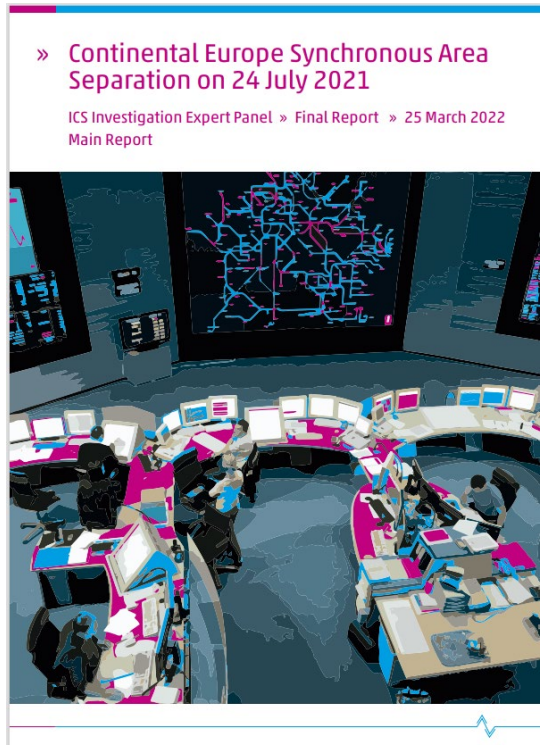
Final reports about the events



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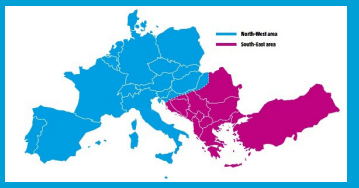
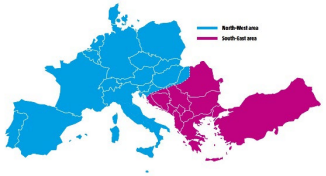
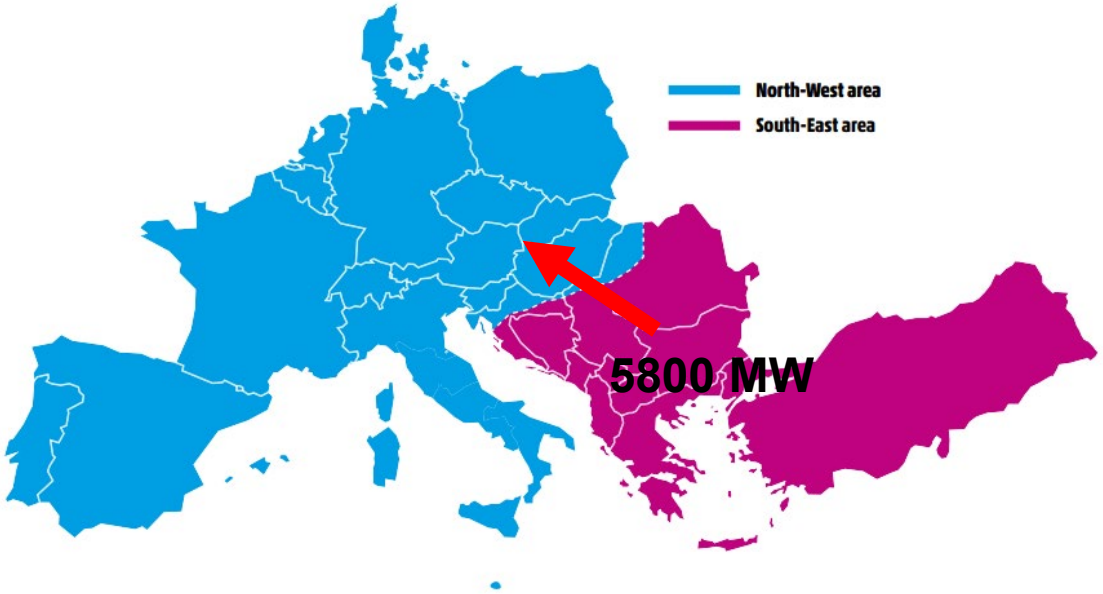
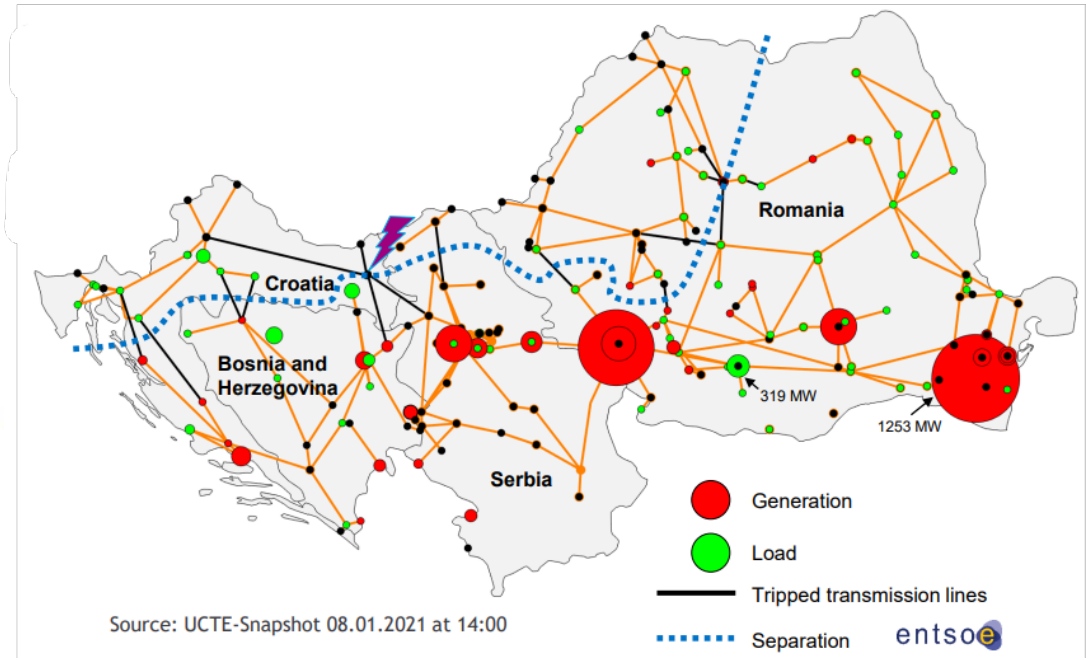


System split 08 January 2021

System conditions before the incident







Overall load flow

Local load flow

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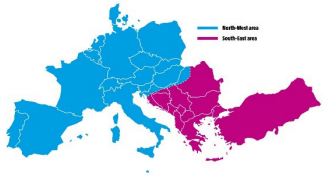
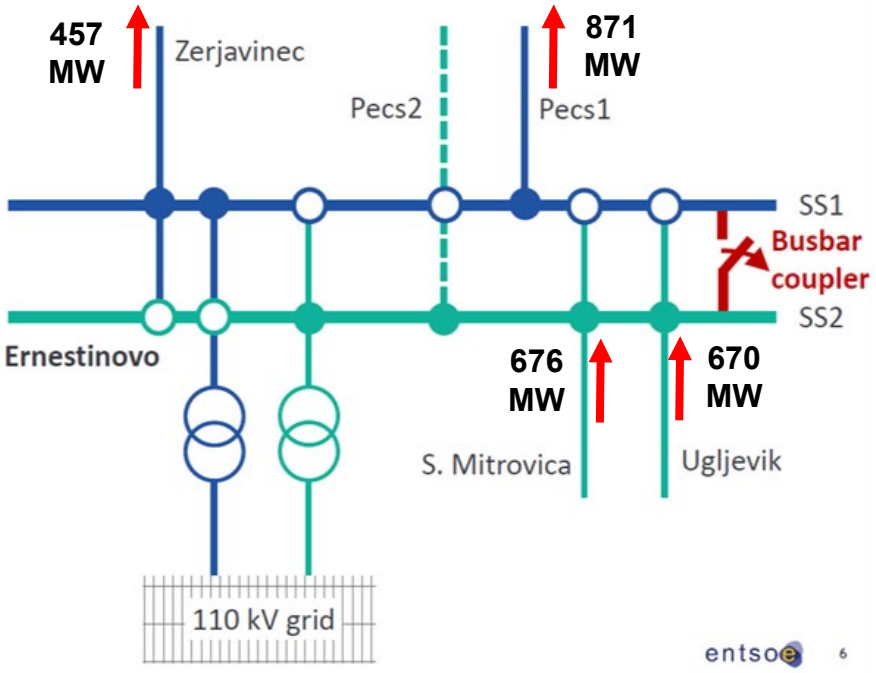
System split





Busbar coupler trips 14:04:26

Transformers trips 14:04:28

400 kV line Novi Sad – Subotica trips 14:04:49

Within ~20 sec thirteen 400/220kV trips in a cascading manner, separating the system into two areas 14:05:09

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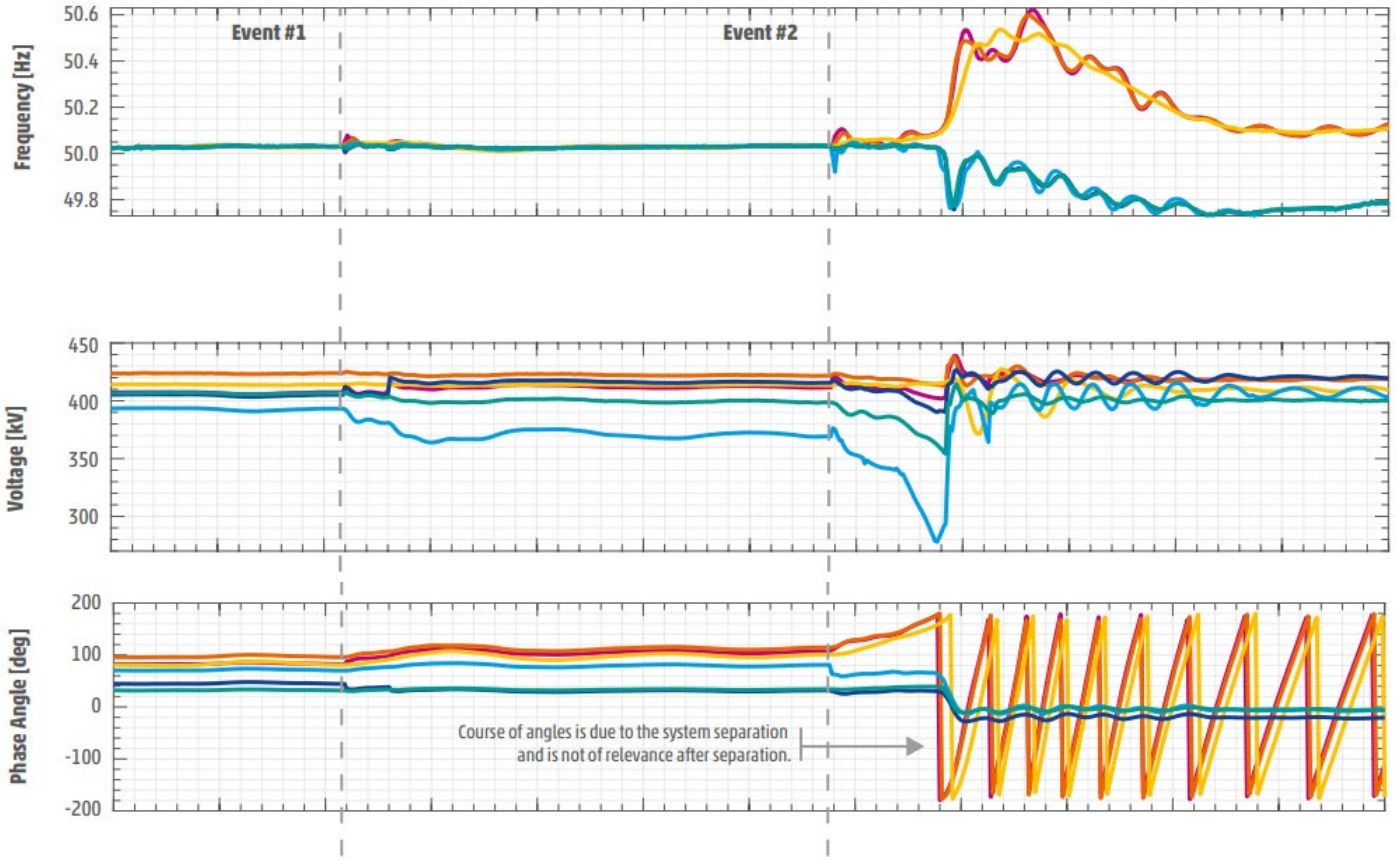
Dynamic behaviour of the system



6GW / 326GW

6GW / 70GW

Ernestinovo/Krsko (HR) Subotica (RS) Divaca (SI) S.Mitrovica (RS) Podgorica (ME) Hamitabat (TK)

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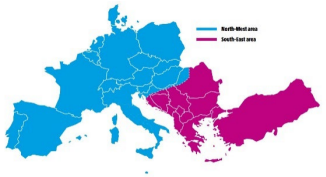
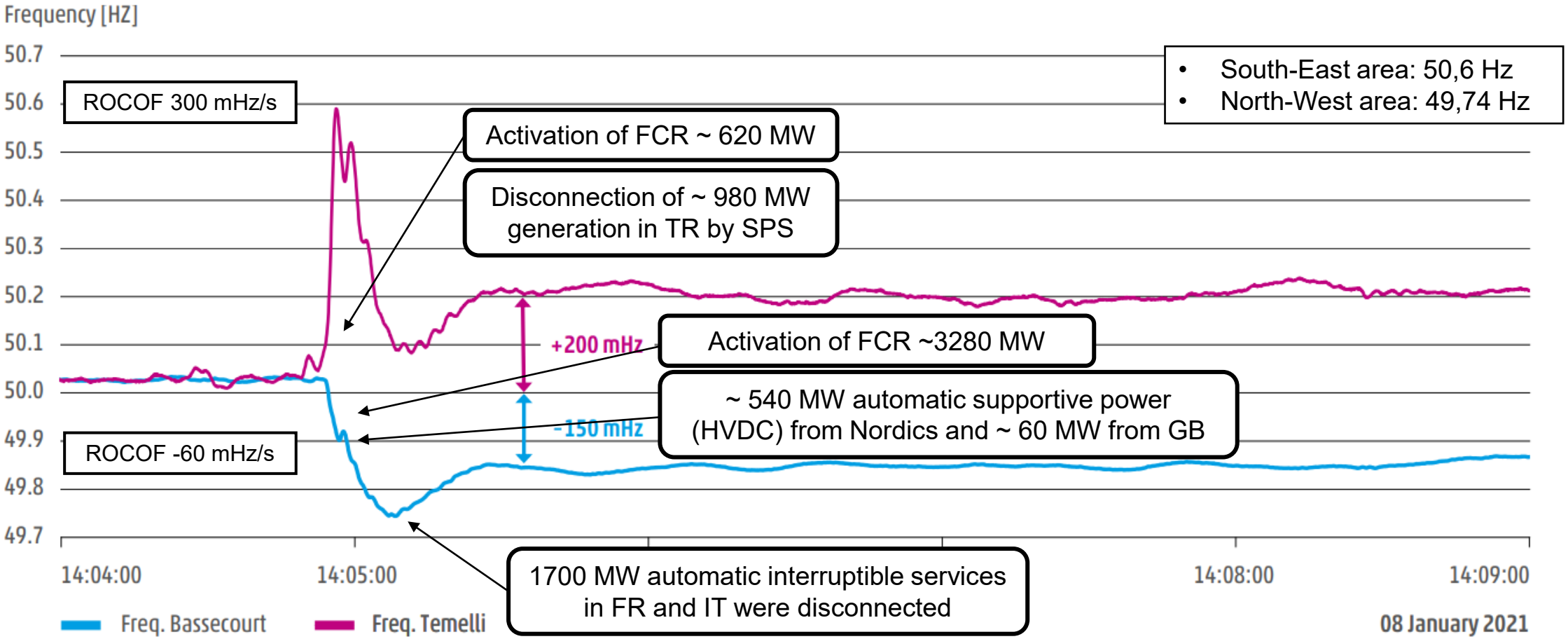
Frequency containment and system defence actions





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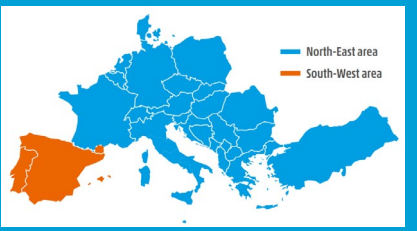

System split 24 July 2021

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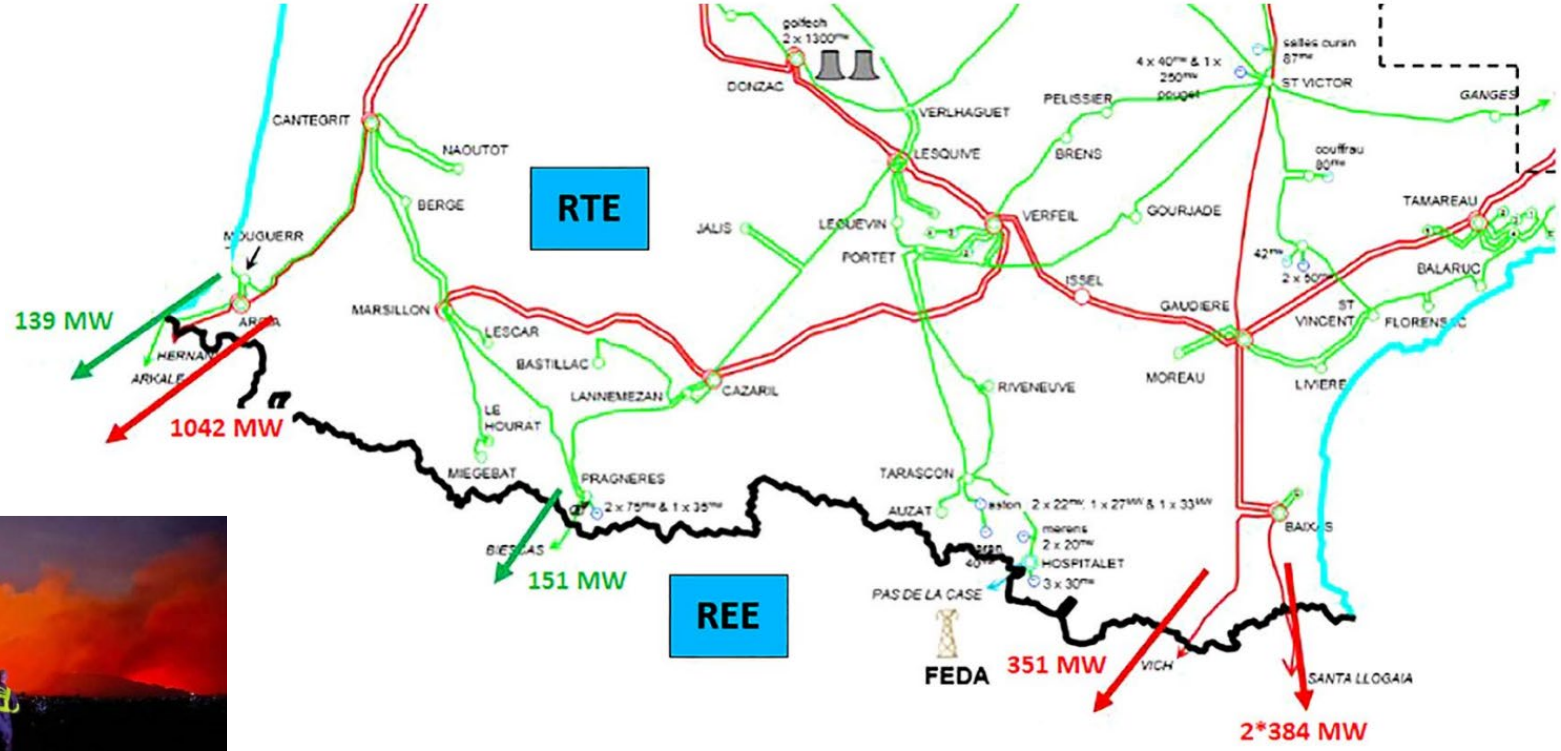
System and environmental conditions before the event



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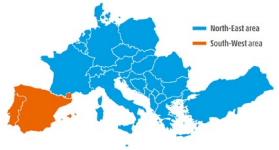
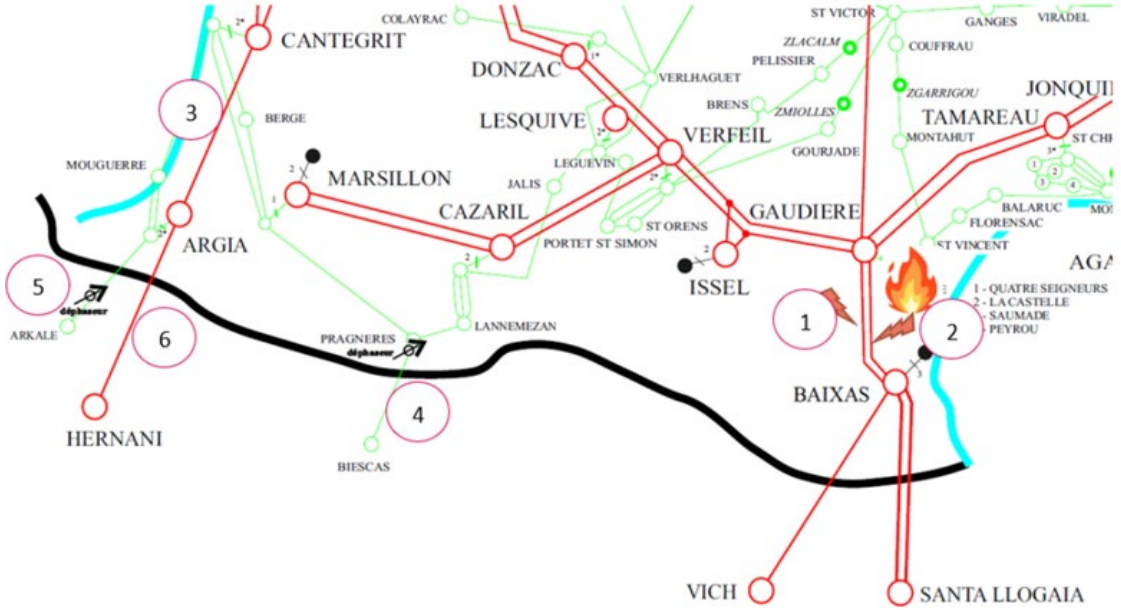


System split

1. 16:33:12 First line trips due to two phase fault
   - Remedial actions is taken to lower the power flow.
2. 16:35:24 Second line trips due to two phase fault
   - Eastern corridor between France and Spain is lost.
3. 16:36:37 Third line trips due to overload

…This third tripping caused the loss of synchronism between the French and Spanish grids, which subsequently led to the separation into two systems.



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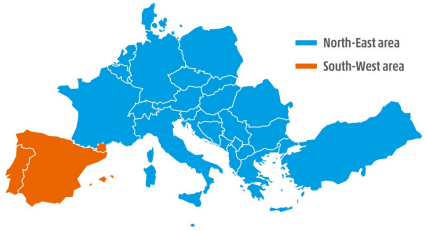
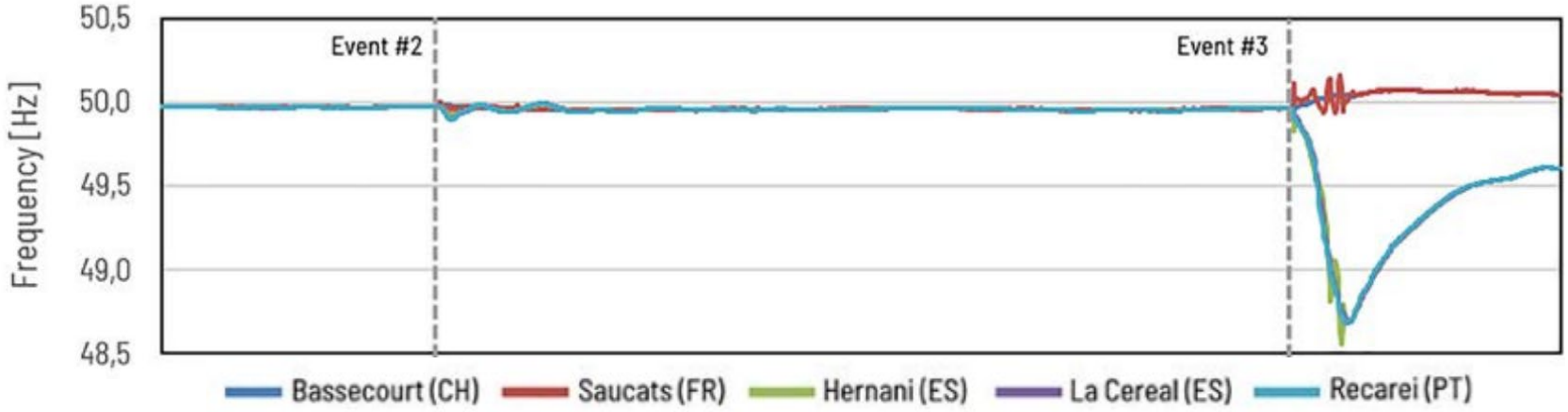
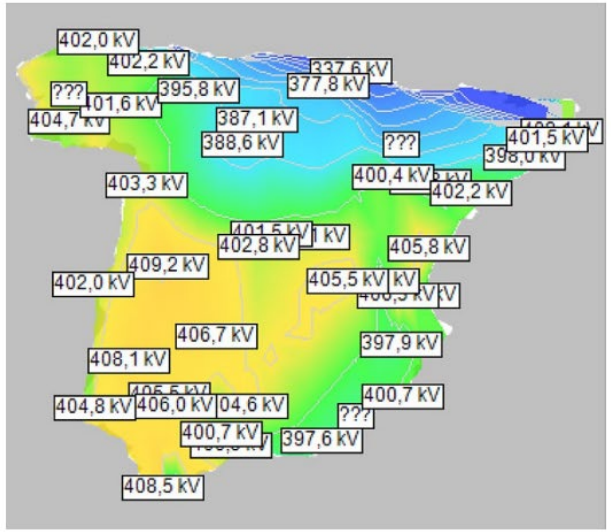
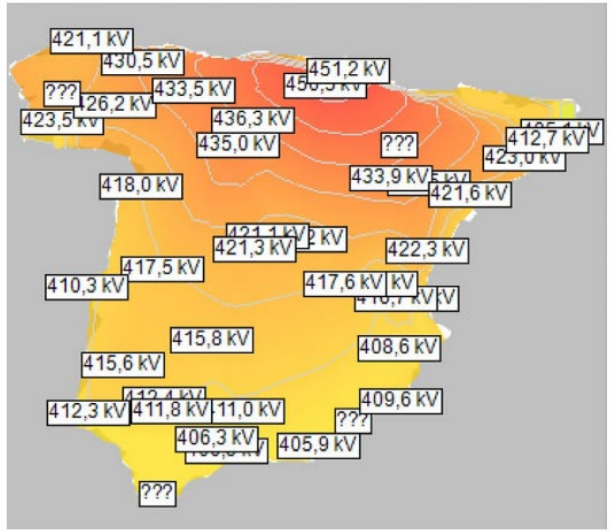
Dynamic behaviour







(a) 16:36:32 between Event #2 and #3



(b) 16:37:40 after Event #3

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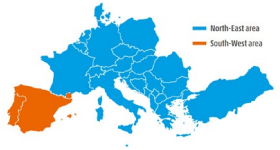
Disconnection of generation in ES and PT



Spain

Cause	Wind [MW]	Solar FV [MW]	Hydroelectric [MW]	Cogeneration, Thermal RE and waste [MW]	Solar Thermal [MW]	Combined Cycle [MW]	Total [MW]
Loss of other agent facilities	43	105.5	6.9	44.1			199.5
Voltage Out of Step (78)			10.4	24			34.4
Over-Frequency	39.2	3.6	8.3	23.8			74.9
Over-Voltage	254.4	358.5	14.9	218.4		227.7	1,073.9
Ground Over-Voltage	2.8						2.8
Under-Frequency	95	13.9	15.7	55.1			179.7
Under-Voltage	50.7	33.9		25.5	22.3		132.4
No detailed information available	226.9	172.1	19.9	463.1	94.2		976.2
Total [MW]	712	687.5	76	854.1	116.4		2,673.8

Table 20: Disconnection of generation units in Spain.

Portugal

Type	P [MW]
Wind	404
Solar	235
NG Cogen	249
Biomass Cogen	23
Biomass Other	81
Small Hydro	23
SUM	1,015

Table 21: Loss of generation, by type.

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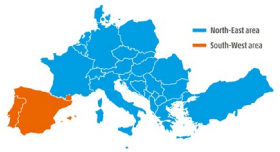
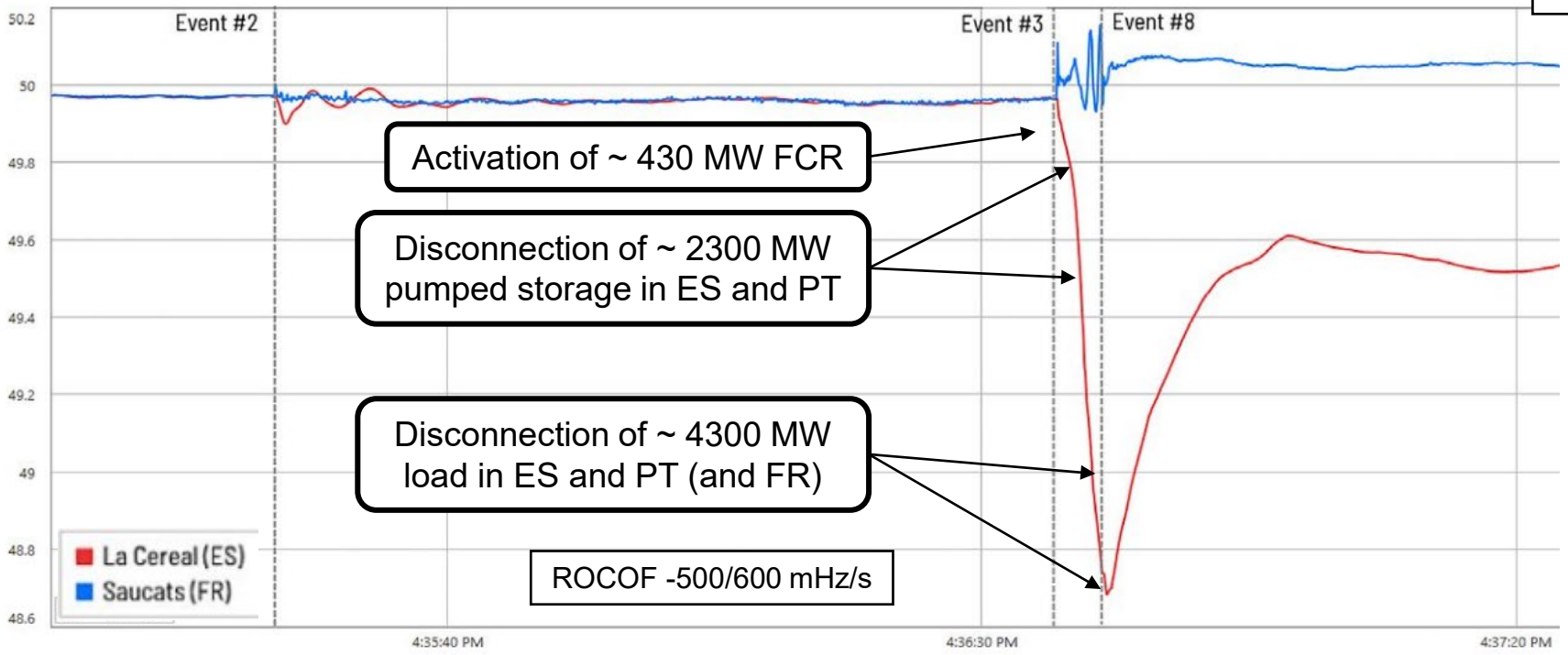
Frequency containment and system defence actions



- Iberian Peninsula: 48,68 Hz



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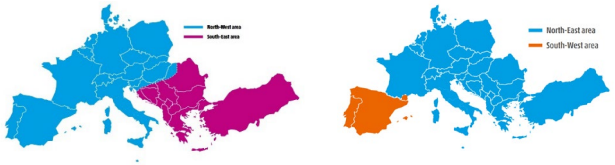
Summary – and some recommendations from the reports



- Overall the incidents were well handled,
  - correct activation of protection systems, system defence actions and good coordination between TSO:s.
- Undesired tripping of generation is a risk that needs to be mitigated to avoid more severe consequences in future disturbances,
  - reduce the volume of generation tripping, e.g by improving TSO–DSO coordination for the definition of settings of under frequency protection settings that trip the generation connected to the distribution grids.
- For critical transmission system corridors the stability margin must be assessed in operational planning and real-time operations,
  - operators must be trained in the field of dynamic stability.
- Improve the assessment and handling of weather-related risks,
  - e.g. identify best practices and best available technologies for early warnings and online monitoring tools to detect exceptional environmental conditions that significantly increase the probability of an exceptional contingency (icing, wildfires, extreme wind, cold spells, etc.) in the vicinity of transmission corridors.

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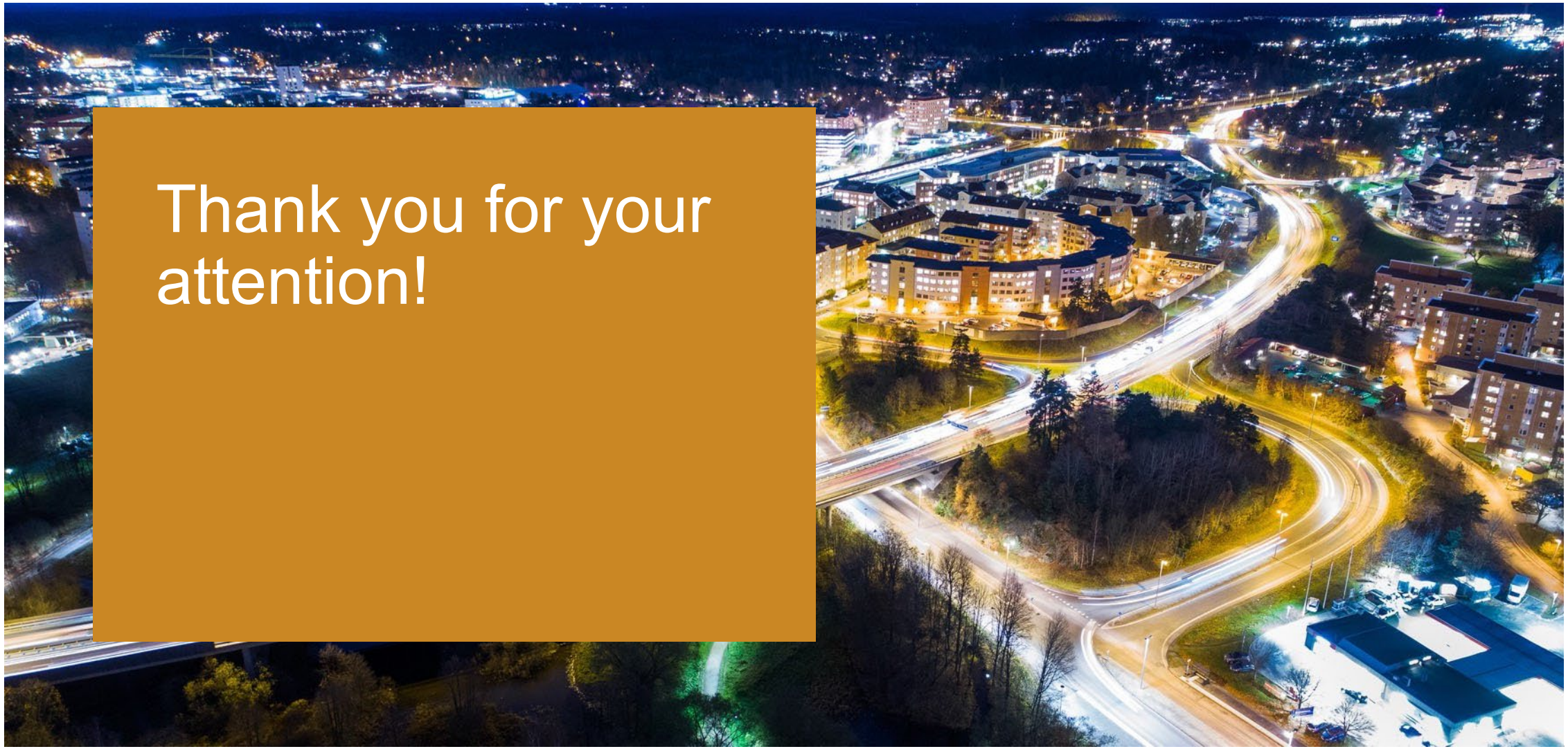
Thank you for your attention!

References

> Final report on the separation of the Continental Europe power system on 8 January 2021 (entsoe.eu)

> Final report on the power system separation of Iberia from Continental Europe on 24 July 2021 (entsoe.eu)

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