CIGRE e-Session 2020

C4-110

Frequency analysis in the Romanian power system under major grid disturbances

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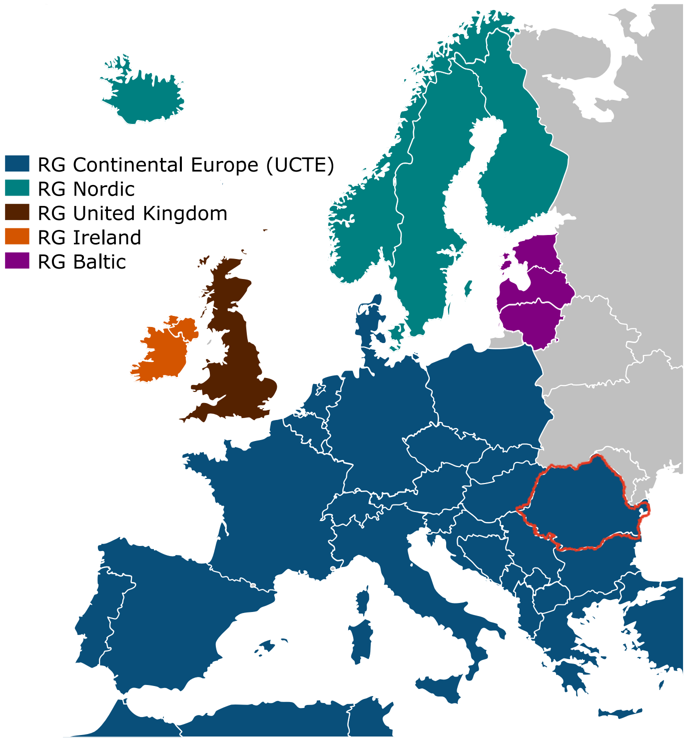
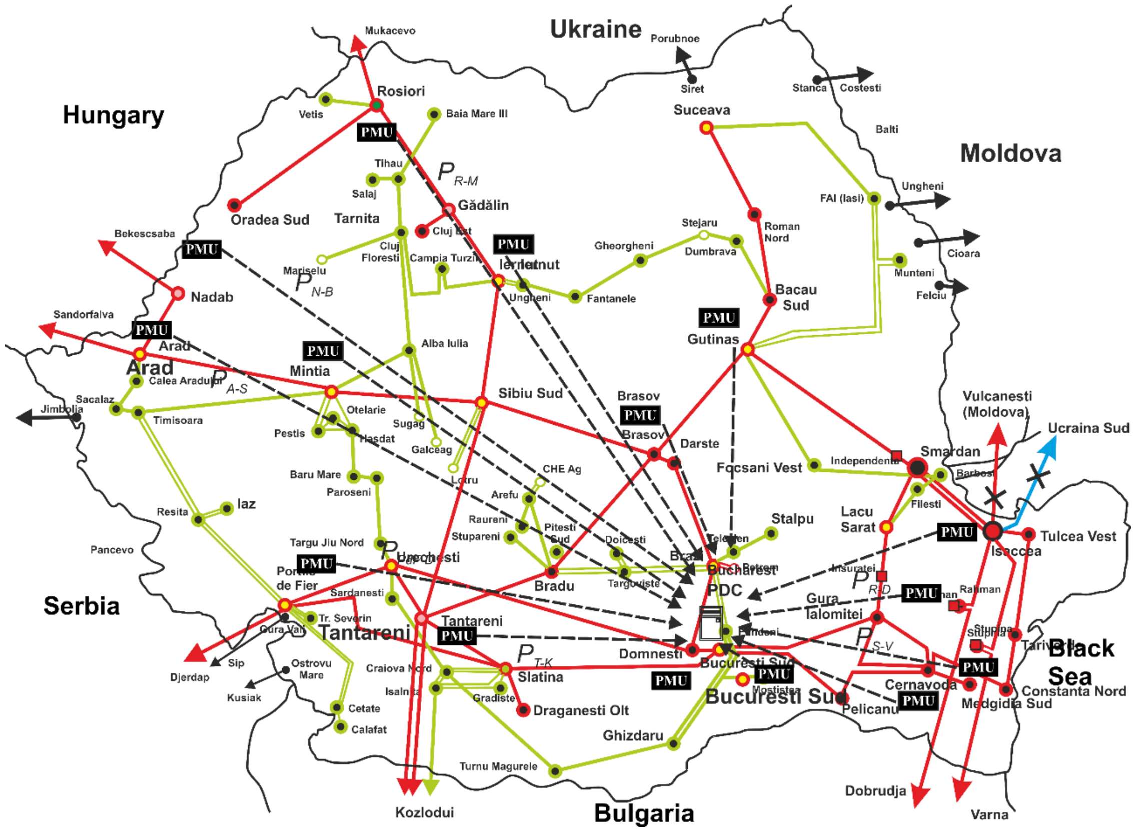
Online: www.re-serve.eu

A. The Wide Area Measurement System in Romania

ENTSO-E System



Romanian Transmission System



WAMS in Romania

- 15 PMUs + 1 central PDC
- manufactured by Schweitzer Engineering Laboratories (SEL)
- Located at border buses and at the most important power plants
- Reporting rate: 25 values per second (40 ms time interval)

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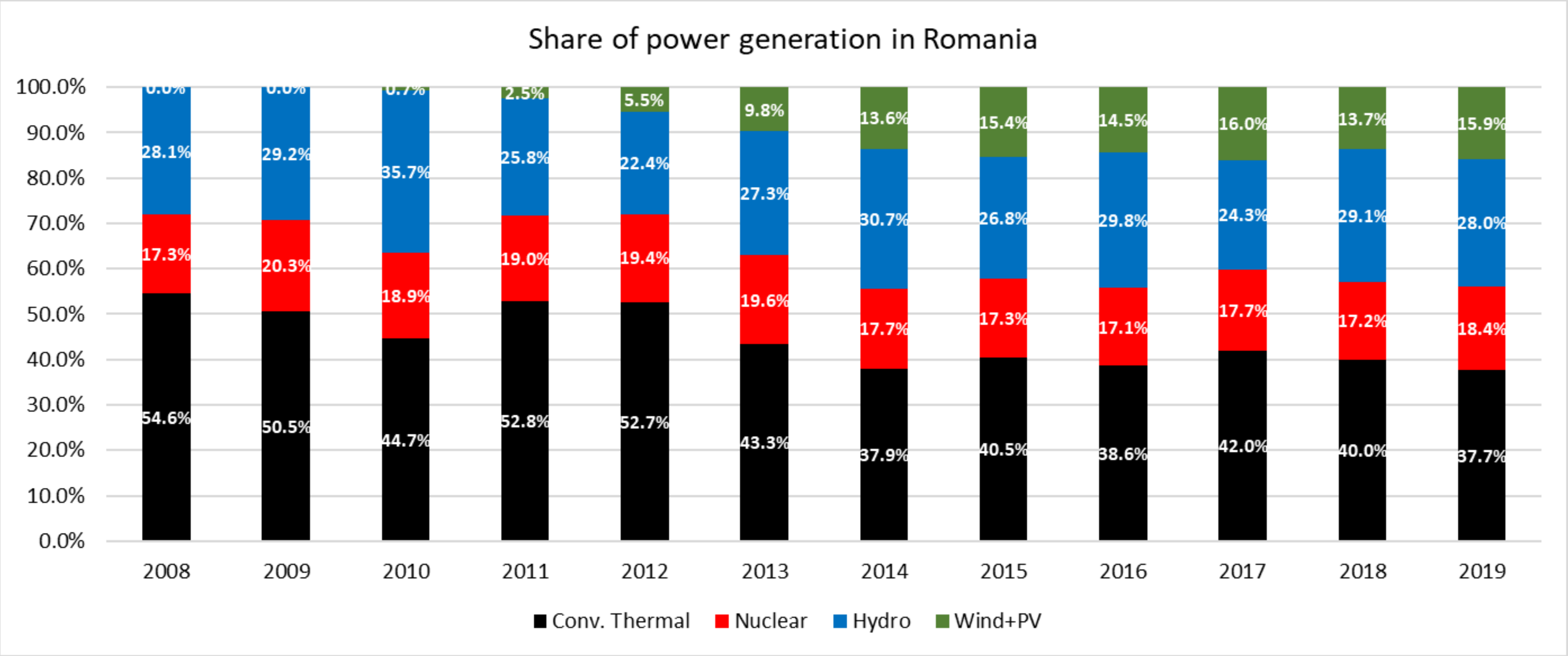
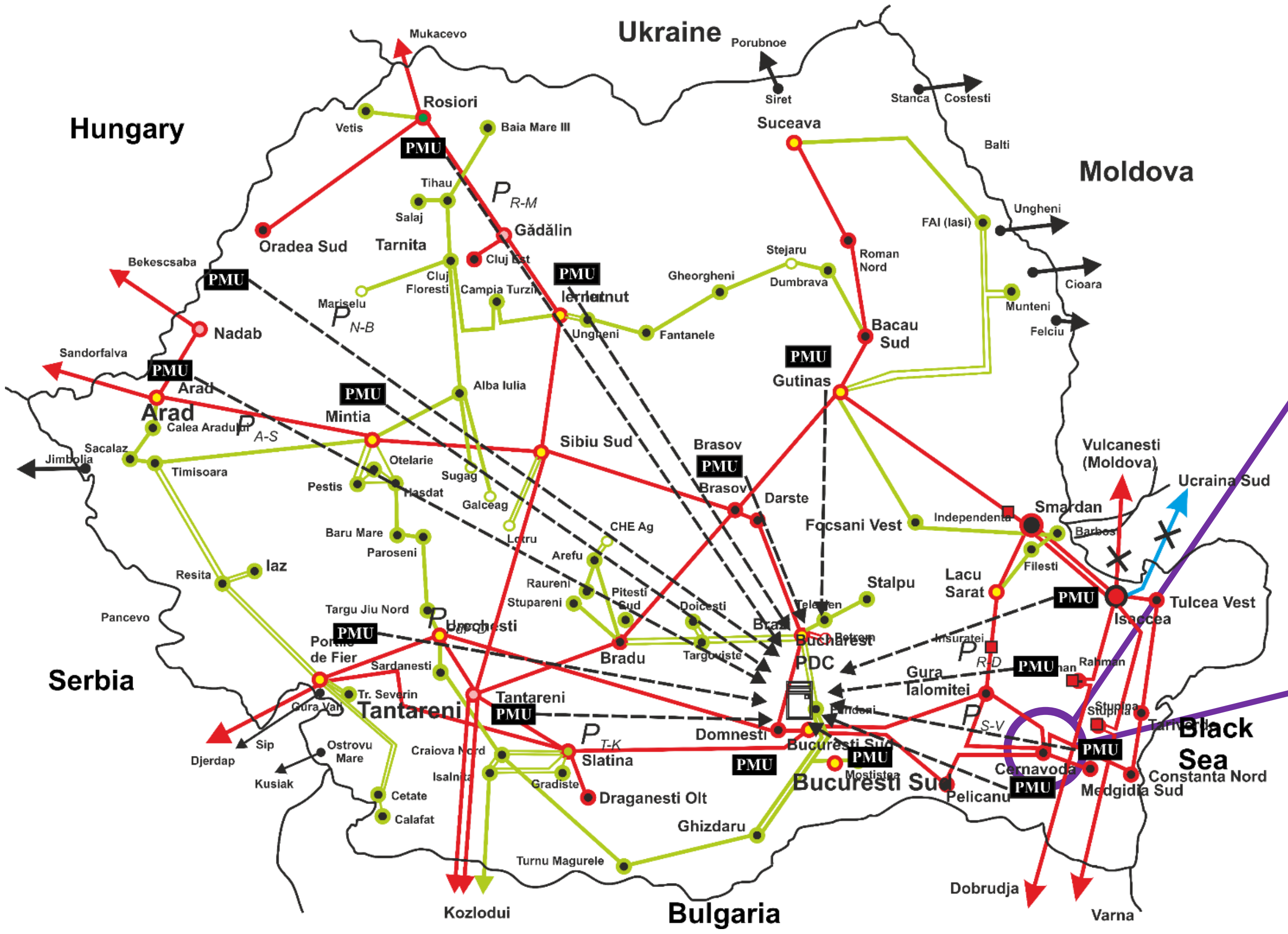
A. The Wide Area Measurement System in Romania



Type of plant	H [MWs/MVA]
Nuclear	6-7
Coal and Natural Gas	3-6
Large Hydro	2-4
Small Hydro	1
Synch. Condenser	1
PV and Wind	0-1

B. Frequency variations caused by the disconnection of large mechanical inertia



Cernavoda Nuclear Power Plant
2 x 700 MW

CNPP_ev1: 1st June 2017

- One unit was under planned maintenance (half inertia available)
- Sudden full disconnection of the unit (no inertia remained)
- The instant of perturbation:
  - 18% wind generation
  - 17% power export

CNPP_ev2: 16 August 2018

- Both units in operation
- Sudden full disconnection of the unit
- The instant of perturbation:
  - 4.4% wind generation
  - 6% power export

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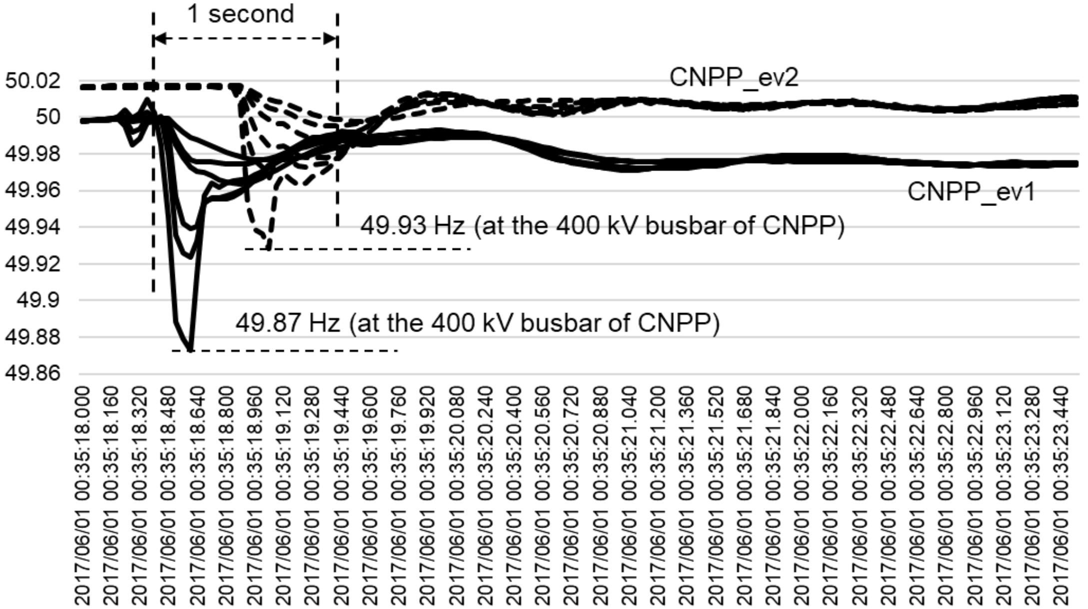
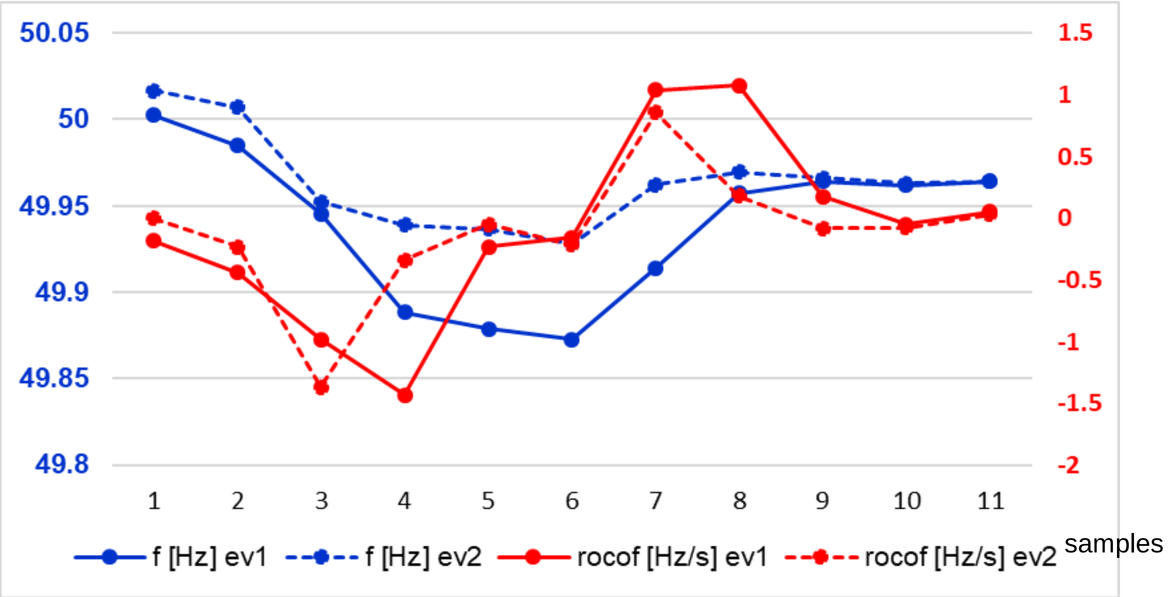
B. Frequency variations caused by the disconnection of large mechanical inertia

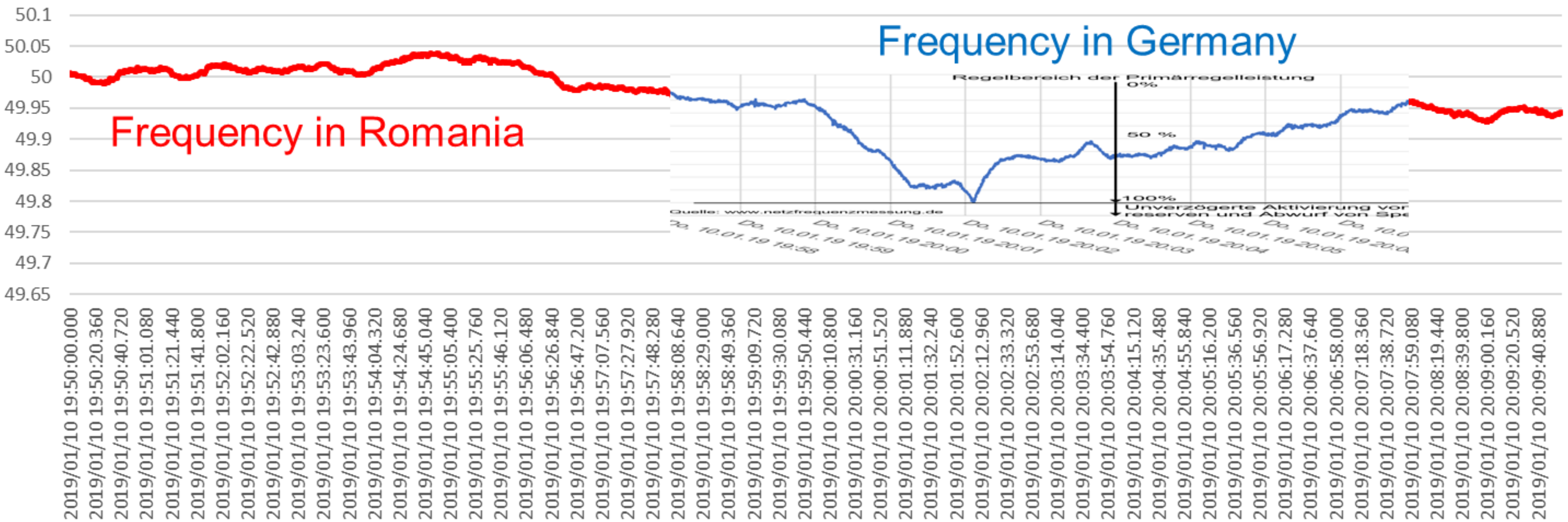




- The local mechanical inertia determines the frequency dip, which is double when both units of CNPP are disconnected
- The frequency is stabilized within 1 second, earlier than the time delay specific to the primary frequency control
- the frequency reaches the nadir value after 5 reporting intervals (200 ms), then the frequency is stabilized after 10 reporting intervals (400 ms).
- The mechanical inertia is deployed after 2-3 reporting intervals (80-120 ms), when RoCoF starts decreasing

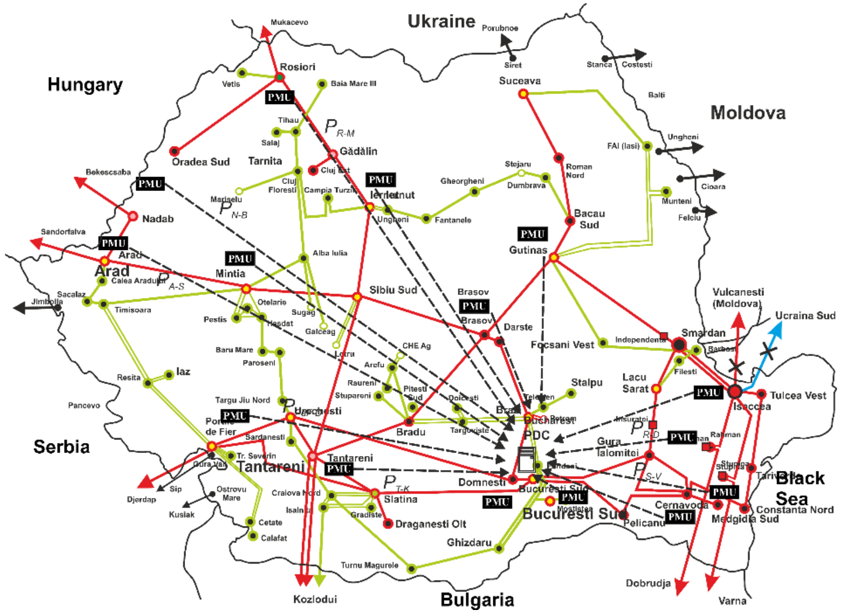
C. Frequency variations caused by slow long-term unbalances

- On 10 January 2019, 21:02 CET, a new critical situation was recorded in the Continental Europe power system. The frequency dropped to 49.8 Hz for nine seconds, as compared to 49.0 Hz in 2006, during the desynchronization of the ENTSO-E power system.
- The frequency was almost identical in both Germany and Romania showing that, under the current operating conditions of the European Continental power system, with large mechanical inertia available across the system, the generators maintain synchronism with each other.

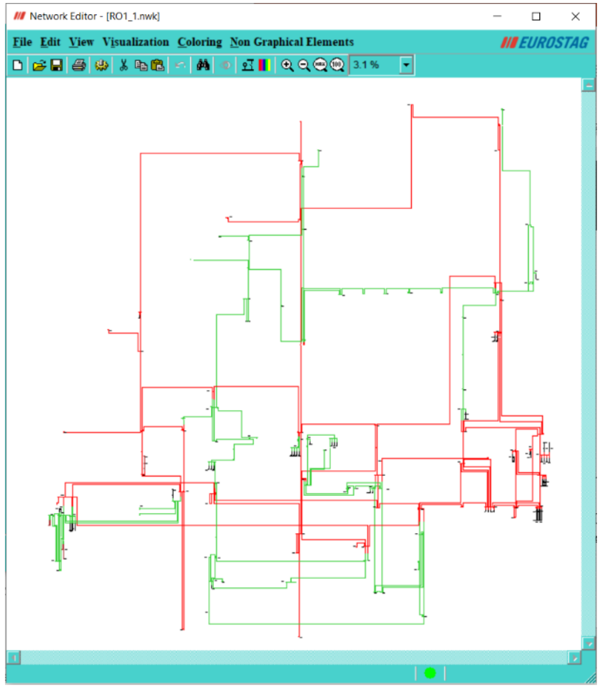


D. Simulations with the Eurostag Software

Romanian Transmission System



One-line diagram in Eurostag



Load-flow general report

AREA INTERCHANGE

AREA	ACTIVE POWER (MW)			
	GENERATION	LOAD	LOSSES	EXPORT
11	0.00	1117.98	2.84	-1120.82
44	8466.37	7142.32	203.23	1120.82
TOTAL	8466.37	8260.30	206.08	-0.01

- The dynamic models of the fossil fueled power plants have been removed
- Only the dynamic models of the hydro, nuclear, and RES have been considered

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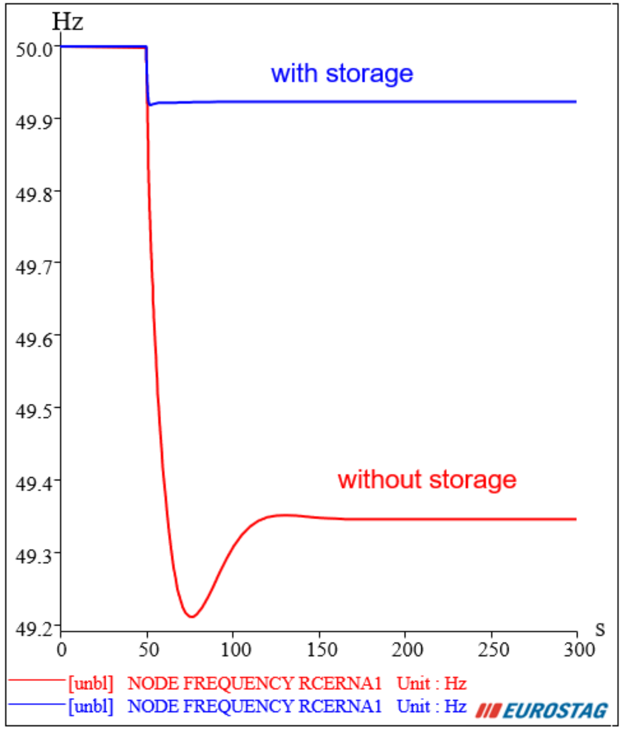
D. Simulations with the Eurostag Software

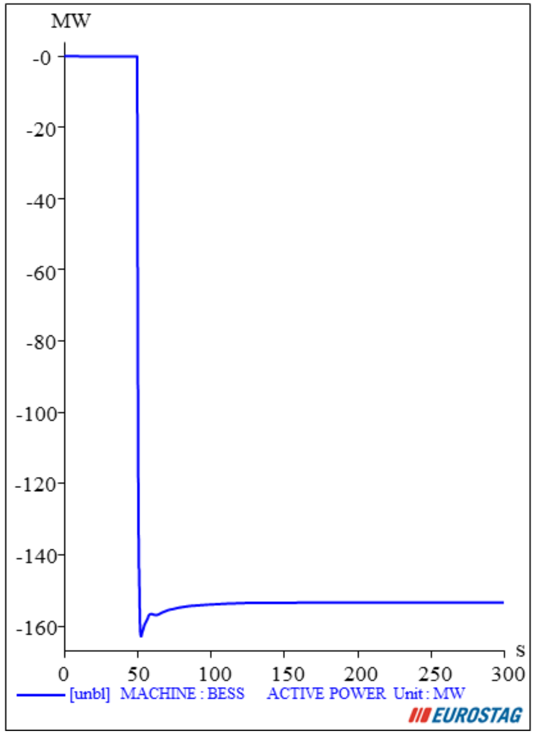
D.1. Frequency variation caused by load change

- Sudden load connection of 245 MW, representing 2.97% of the total generation
- The BESS is modeled as a simple derivative function with 100 ms delay

Frequency variation



BESS power contribution



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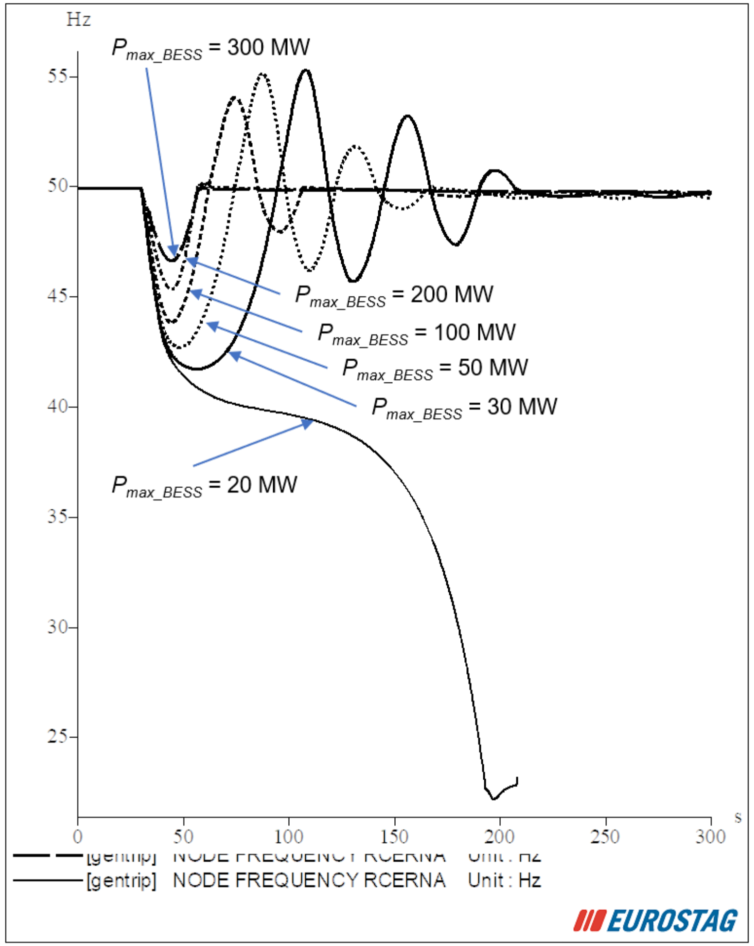
D. Simulations with the Eurostag Software

D.2. Frequency variation caused by losing a large power plant

- One nuclear unit, that injects 660 MW into the transmission system is suddenly disconnected, together with its associated dynamic models.
- BESSs of various powers, from 20 MW (instability) to 300 MW, have been considered for frequency stabilization.
- The frequency nadir is large because mechanical inertia at CNPP is also lost
- Stability can be maintained by rapid power compensation to restore the power balance.



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Conclusions

- This paper aimed at analyzing the frequency behavior in the Romanian power system upon major disturbances using PMU measurements
- The power system engineers are concerned about frequency stability in the future low-inertia power systems. This is because frequency instability can evolve very quickly, with large RoCoF values, and very low frequency values that can trigger the protection systems.
- In the case of sudden lose of the largest generation unit in Romania, together with its mechanical inertia, the lowest frequency value is reached within 120 ms. Currently most of the RoCoF algorithms recommend a time interval of 500 ms for calculating the RoCoF value, which is higher than the natural behavior.

Conclusions

- The nuclear units host the largest mechanical inertia. The mechanical inertia available in hydraulic units is low, while their governors exhibits a delay in the frequency response.
- Slow power unbalances are not causing visible differences in frequency values over the continental network of ENTSO-E. Frequency measurements in Romania and Germany showed strong interconnection.
- Battery Energy Storage Systems are solutions sought by power system specialists for many problems, including the compensation of the mechanical inertia for frequency stability. Short term stability is more concerned with the rapid time response. Various BESS technologies and other solutions can be combined to ensure both short-term and long-term stability.

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