ENTSO-E views on RoCoF and Grid Forming capabilities related amendments of the Connection Network Codes

10 May 2023, presented by Hans Abele and Adrian Gonzalez

entsoe

Reliable Sustainable Connected

In which situations a Rate of Change of Frequency (RoCof) appears?

If the balance of load and generation is suddenly disturbed

Disturbances leading to relatively small RoCoF values:

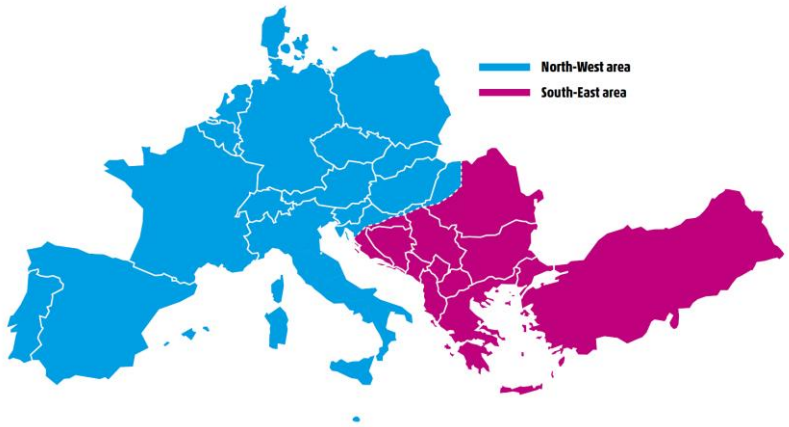
- Loss of load, generation or HVDC links to other synchronous areas
- Causes higher RoCoF values in smaller systems than in larger systems

Disturbances leading to high RoCoF values:

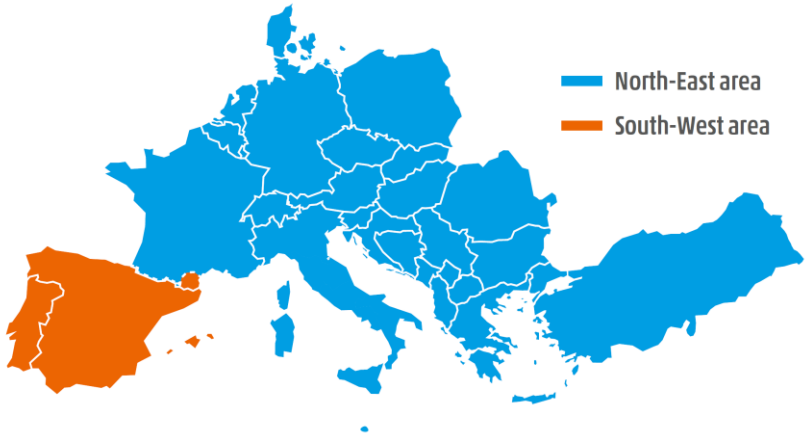
- System Splits

Proposed RoCoF requirement is targeting system splits

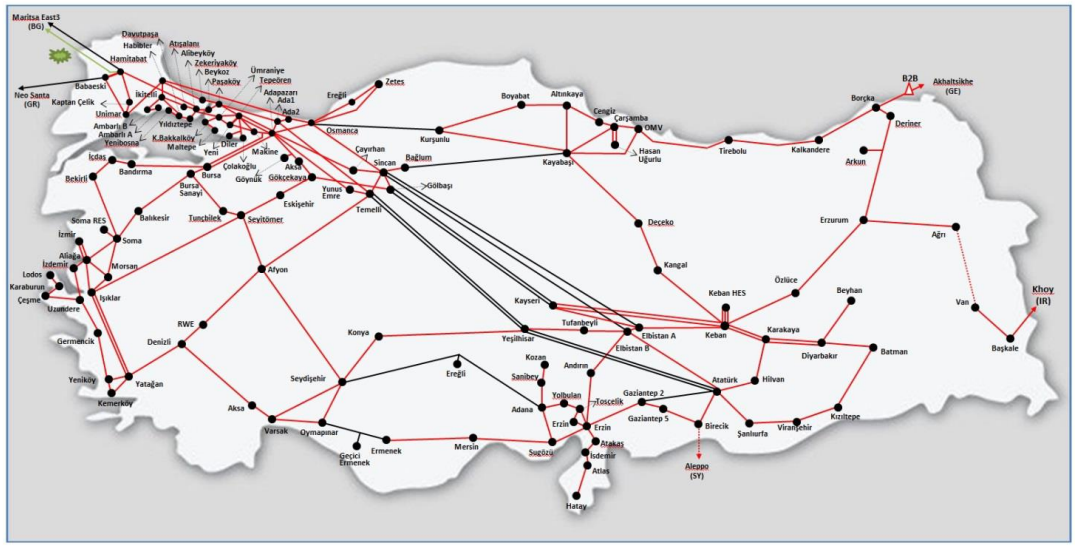
System Splits – are they real?



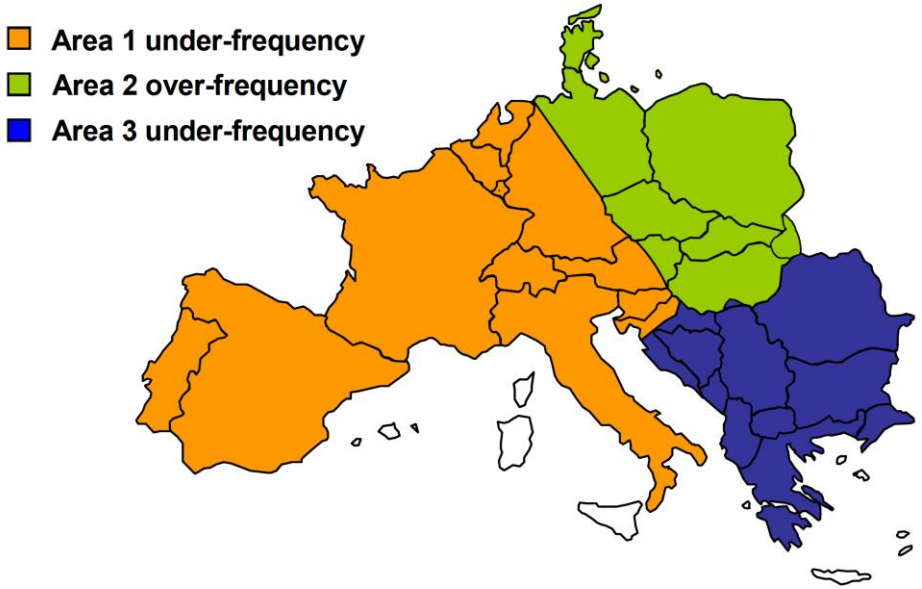
ENTSO-E, "Continental Europe Synchronous Area Separation on 08 January 2021 " Final Report 2022.



ENTSO-E, "Continental Europe Synchronous Area Separation on 24 July 2021 " Final Report "," 2022.



ENTSO-E, "Report on Blackout in Turkey on 31st March 2015, 21 September 2015



UCTE "System Disturbance on 4 November 2006" Final report

RoCoF values of the real system splits

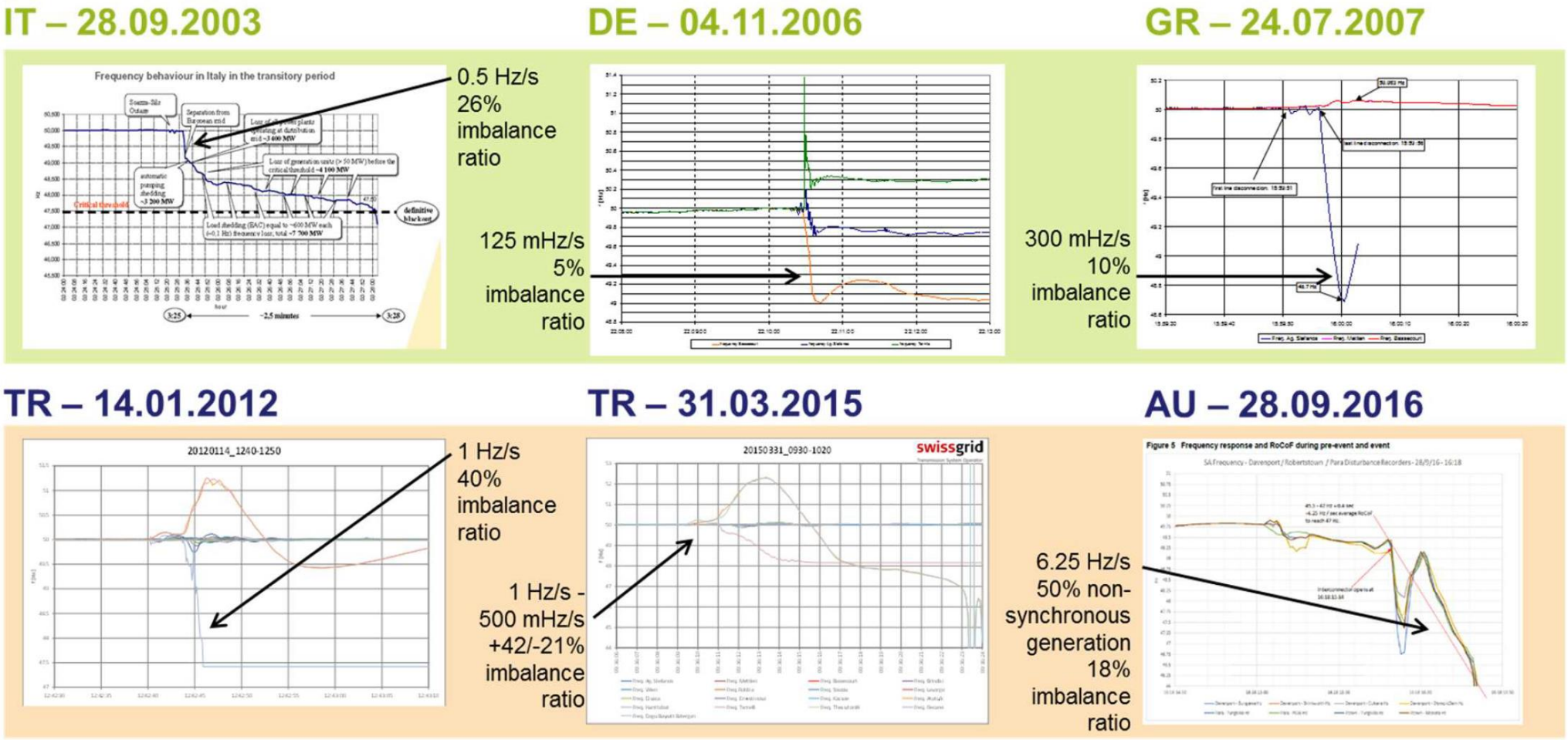


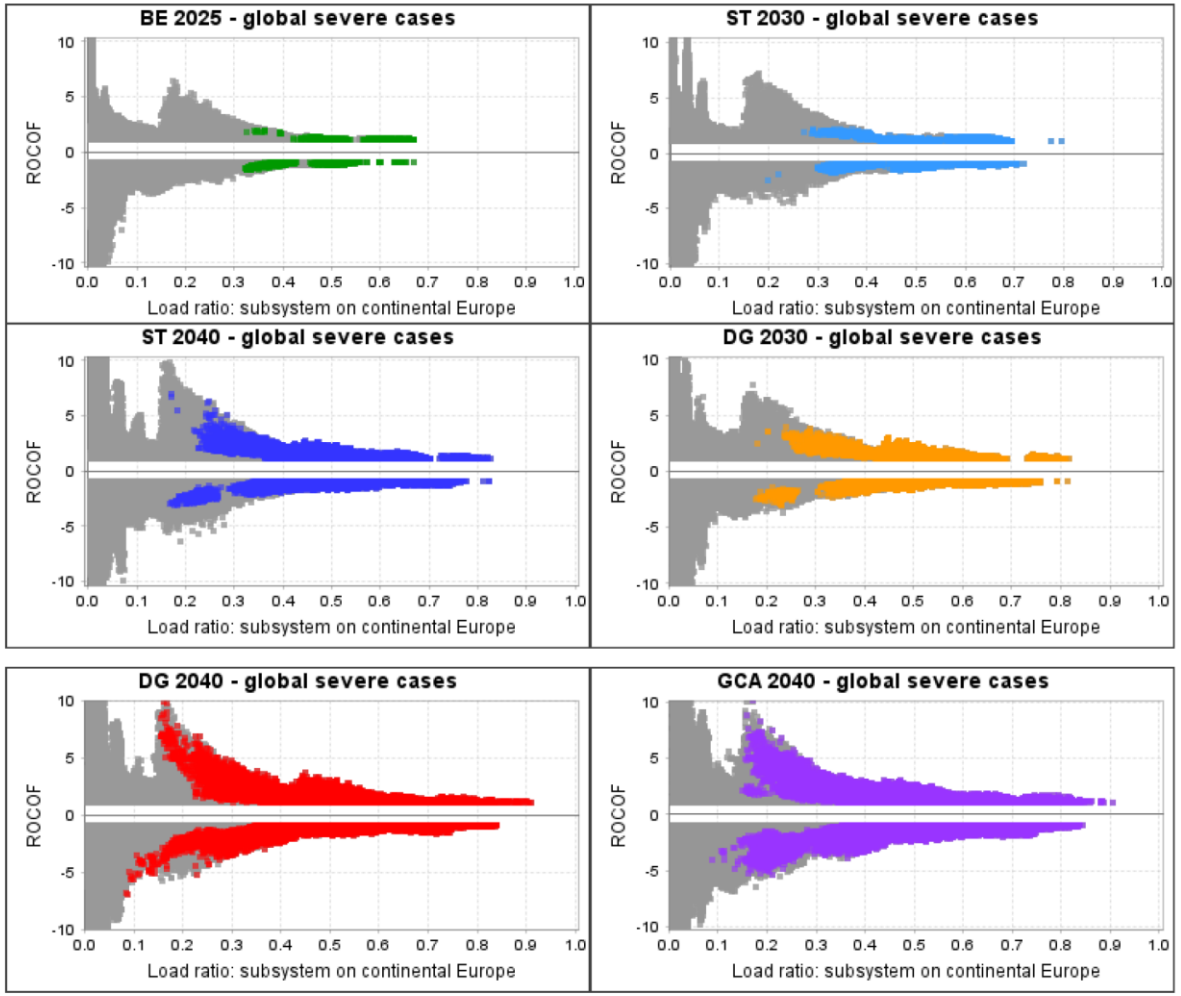
Figure 24 – Worldwide serious events

Will it become better in future?

- In the case of a system split, high RoCoF values anticipated in future (all dots)
- Even high RoCoF values in both islands after the system split (coloured dots)
  - Risk of both islands blacking out
  - Makes the restoration process difficult
  - → Global severe system splits

- **Robustness of grid users against RoCoF is a system need - now and in future -**

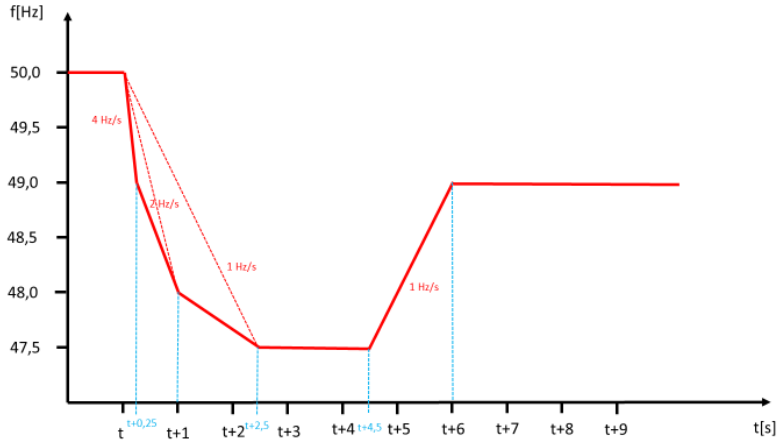
- **Harmonization across Europe is needed**

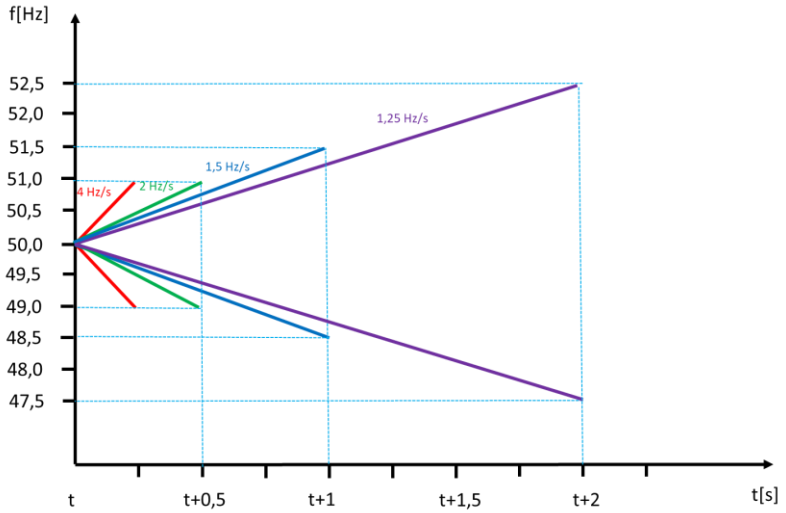


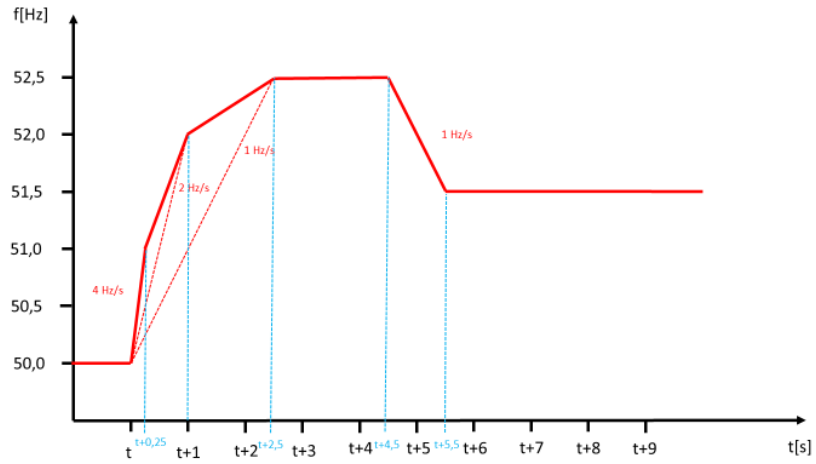
ENTSO-E, "Frequency Stability in Long Term Scenarios and relevant Requirements", 3 December 2021

RoCoF whithstand capability for PGMs

- The control scheme must cope with it stably
- Control scheme must avoid loss of synchronism
- Compliance verification via simulation







RoCoF withstand capability for PGMs: Conclusions

- ENTSO-E sees the inclusion of up-to-date parameters of RoCoF withstand capability in the CNCs as one of the main reliability measures to overcome system splits in the future.

- ENTSO-E understands that promoting harmonization of RoCoF parameters is beneficial whenever it does not jeopardise system robustness.

- ENTSO-E welcomes and supports ACER's willingness of including RoCoF withstand capability exhaustively in the CNCs, and the changes proposed in Article 13 (1) RfG NC and the new Article XX (2) in DC NC.

- ENTSO-E is against exemptions not based in physical constraints, in line with the non-discriminatory basis of the Regulation.

RoCoF withstand capability: Limitations of high inertia SPGMs

- ENTSO-E acknowledges that loss of synchronism is a physical problem for high inertia machines.
- Loss of synchronism is more related to the inertia constant (H) of a machine than to its size in MW. Therefore, ENTSO-E is not in favor of the ACER proposal for implementing a MW threshold, but to base it in the inertia constant.
- EU Turbines, ENTSO-E and other stakeholders have been continued the collaboration, approaching a solution:
  - Boundary conditions for simulations have been fixed.
  - Dedicated explanatory meeting on 27 April 2023.
  - Aim: Identifying an inertia constant (H) for which different RoCoF requirements shall apply and define them.
  - ENTSO-E is confident that a constructive solution can be found.

ENTSO-E is against the proposed changes in Article 19 (4) of RfG NC implying that big SPGMs would exclusively withstand RoCoF up to 1Hz/s over a period of 0,5s. This would increase the risk of blackouts in system split events.

Boundary conditions, proposed by ENTSO-E following GC ESC request, for stakeholder's simulations:

Short circuit ratio: $S_{k\ (connection\ point)}''/P_{r(generator)}=6$
X/R ratio= 10
PSS: Off
Voltage: $U=U_r$
Operating point:

- $P=P_{max}$,
- $Q/P_{max}=0,33$ (underexcited) **at the connection point** (with a realistic transformer).
- $Q/P_{max}=0$ (neutral) at the generator **at the connection point** (with a realistic transformer).

ENTSO-E's proposal to accommodate the outcome of the simulations ("HHH", ""TTT") in the amendment for RfG NC:

With regard to the rate of change of frequency withstand capability for synchronous power generating modules having an inertia constant above **HHH**,

(i) a power-generating module shall be capable of staying connected to the network and operate at rates of change of frequency up to the following values:

- ±4,0 Hz/s over a period of **TTT** s
- ±2,0 Hz/s over a period of **TTT** s
- ±1,5 Hz/s over a period of **TTT** s
- ±1,25 Hz/s over a period of **TTT** s
- ±1 Hz/s over a period of **TTT** s

(ii) Without prejudice to article 13.a.i, a power-generating module shall be capable of staying connected to the network and operate at the sequence of rates of change of frequencies which are defined considering the overfrequency against time profiles given in figure XX.a and the underfrequency against time profiles given in figure XX.b.

RoCoF withstand capability and island detection

- In some countries, RoCoF is used for island detection in distribution grids
- Commonly used thresholds are lower than the proposed values for immunity
- ENTSO-E-proposal:
  - Need for development towards other methods for island detection
  - Have the immunity of the grid users through a Network Code requirement
  - During transition period “overrule” it with the island detection
  - After transition, disable island detection via RoCoF

ACER’s proposal: Acceptable for ENTSO-E

“(iii) If the rate-of-change-of-frequency (RoCoF) is used for loss of mains protection, the rate-of-change-of-frequency threshold shall be set at higher values than the ones defined in point (i).”

Alternative proposal (compromise-solution agreed between ENTSO-E and EU DSO Entity)

“(iii) If rate-of-change-of-frequency (RoCoF) is used for loss of mains protection, the relevant system operator, in coordination with the relevant TSO and adjacent TSOs, shall specify the threshold of this rate-of-change-of-frequency-type loss of mains protection.”

Linked with alternative proposal for Grid Forming Capability for type B, towards a roadmap for adaptation of the distribution grids

Grid Forming Capability: Generalities

- ENTSO-E sees the introduction of grid forming capabilities as a key element in the energy transition.
- ENTSO-E welcomes and supports ACER's willingness for including grid forming capabilities into the NC RfG.
- ENTSO-E welcomes ACER's approach of taking the legal text proposal of EG ACPPM as a basis.
- ENTSO-E is aware of the challenge implicit in adopting the requirement as non-exhaustive, so is already working towards the development of an IGD together with manufacturers and interested stakeholders during 2024.

Grid forming capabilities for Type A

ACER's proposal:

- Non mandatory requirement
- Activation and deactivation of the grid forming capability possible
- Exhaustive transition period of 3 years

ENTSO-E's opinion

✓ Non mandatory requirement

× Activation and deactivation of the grid forming capability **shall be excluded** because: i) the system needs the capability continuously, ii) switching would cause implementation and reliability issues and, iii)implies unjustified additional costs for manufacturers.

! Non-exhaustive transition period may be needed to allow the necessary adaptation of the distribution grids. This implies that the ability of deactivation of grid forming can be avoided.

Compromise-solution proposal agreed between ENTSO-E and EU DSO Entity:

✓ *"6. The relevant TSO in coordination with the relevant system operators may specify that type A power park modules be capable of providing grid forming capability at the connection point."*

Changes proposed in article Y:

➢ ~~*(d) The power park module shall have the capability to activate or deactivate grid forming mode*~~

➢ Applicability of the requirement depends on when it is specified by the relevant TSO and relevant system operators (not from the consideration of new or existing –3 years-).

Grid forming capabilities for Type B

ACER's proposal:

- Mandatory requirement
- Inertia contribution for overfrequency regime
- Exhaustive transition period of 3 years

ENTSO-E's opinion

✓ Mandatory requirement

✓ Inertia contribution for overfrequency regime

× Lack of inertia contribution for underfrequency regime

! Non-exhaustive transition period may be needed to allow the necessary adaptation of the distribution grids. This implies that the ability of deactivation of grid forming can be avoided.

Compromise-solution proposal agreed between ENTSO-E and EU DSO Entity:

Change proposed in article 20:

- *"4. (a) After a transition period, proposed by the relevant TSO in coordination with the relevant system operator and adjacent TSOs, a type B PPM shall be capable of providing grid forming."*
  - Aim: Bind relevant system operator and relevant TSO to define a period after which the requirement becomes mandatory, considering the different needs of time for adaptations of the distribution grids.

Grid forming capabilities for Type C and Type D

ACER's proposal:

- Mandatory requirement
- Inertia contribution for overfrequency and underfrequency regimes
- Exhaustive transition period of 3 years
- Possibility of additional energy above the inherent energy storage

ENTSO-E's opinion

- ✓ Mandatory requirement
- ✓ Inertia contribution for overfrequency and underfrequency regimes
- ✓ Exhaustive transition period of 3 years
- ✓ Possibility of additional energy above the inherent energy storage

Thank you very much for your attention

Our values define who we are, what we stand for and how we behave.
We all play a part in bringing them to life.

EXCELLENCE

We deliver to the highest standardss. We provide an environment in which people can develop to their full potential.

TRUST

We trust each other, we are transparent and we empower people. We respect diversity.

INTEGRITY

We act in the interest of ENTSO-E

TEAM

We care about people. We work transversal and we support each other. We celebrate success.

FUTURE THINKING

We are a learning organisation. We explore new paths and solutions.

We are ENTSO-E