Potential for System Services and expected Connection Requirements for P2H2

November 2023, presented by Ioannis Theologitis and Manuel Froschauer

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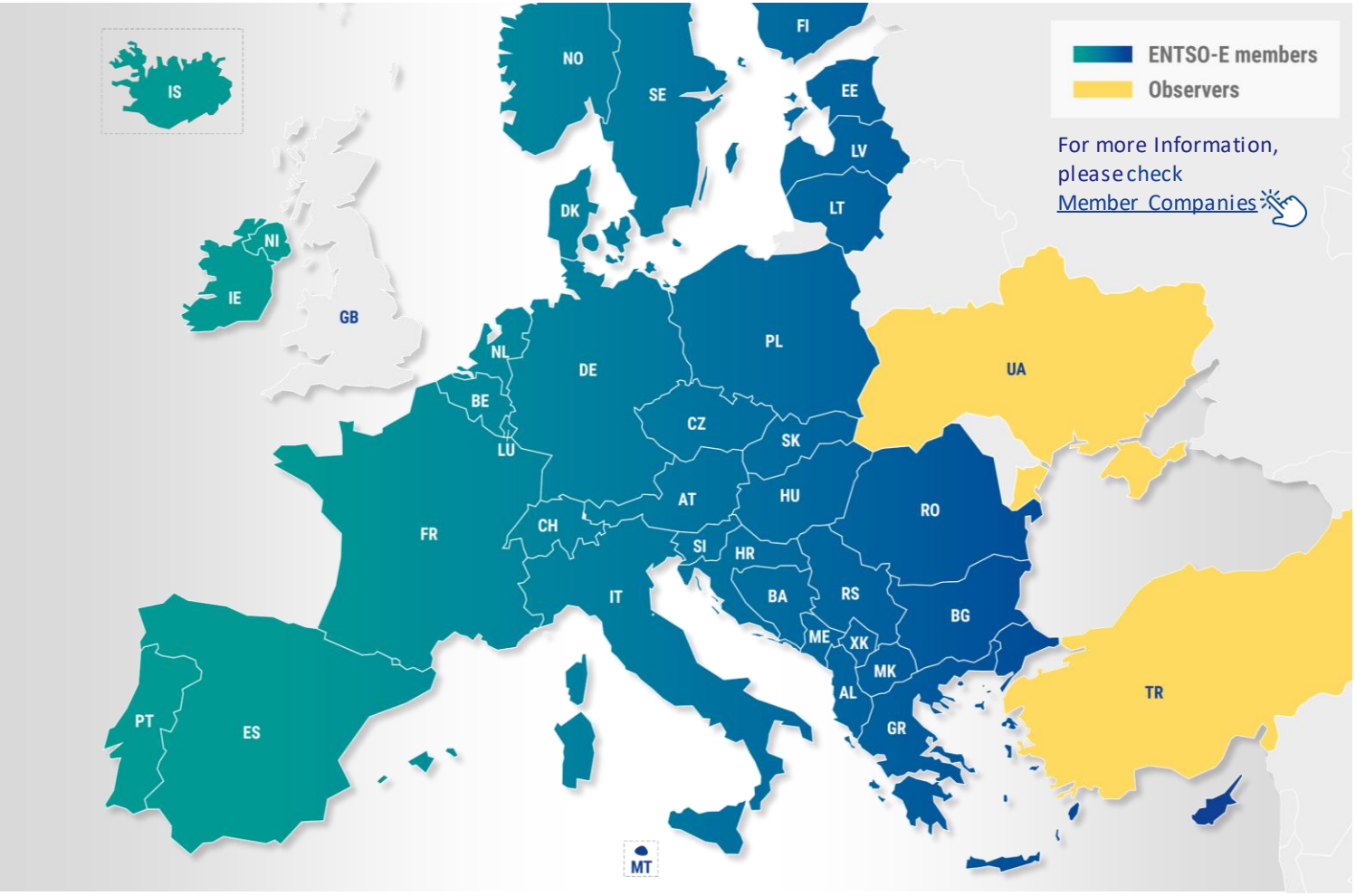
entsoe
Reliable Sustainable Connected

ENTSO-E:
39 TSOs operating one of the world's largest interconnected grids

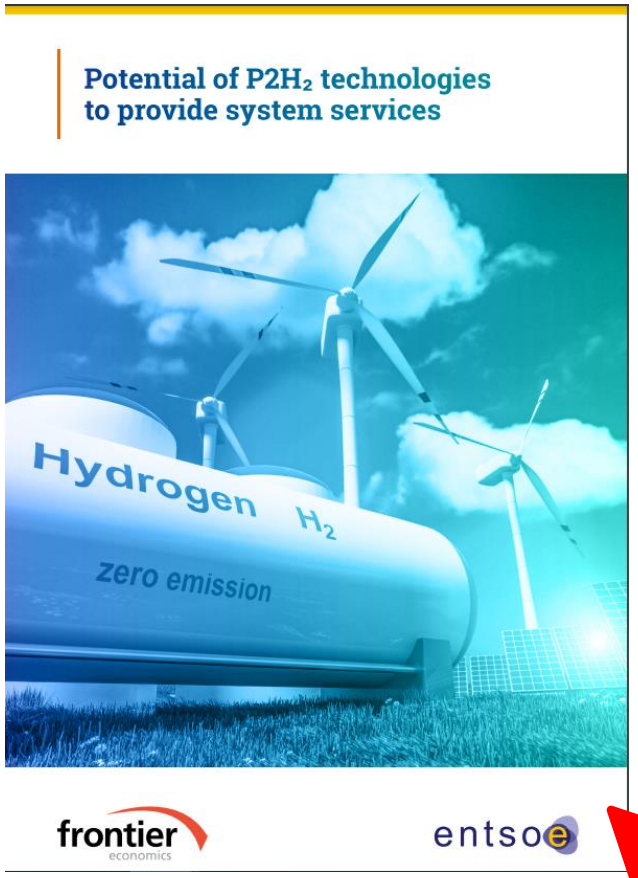


- ENTSO-E is the association for the **cooperation** of the European transmission system operators (TSOs).
- 39 member TSOs, representing 35 countries and serving about 500 million citizens, responsible for the **secure and coordinated operation** of Europe's electricity system.
- ENTSO-E is also the **common voice of TSOs in Europe**.
- ENTSO-E **serves the interests of society by optimising social welfare** in its dimensions of safety, economy, environment, and performance.

* Figures date from 2018

Potential for System Services

ENTSO-E Study on potential of P2H2



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Technical characteristics of electrolysers technology

We analysed three different P2H2 technologies – not all are at the same level of technological maturity

	Alkaline	PEM	SOEC
Cost, lifetime and efficiency*	▪ Typical capex is in the range of 700 €/kWe today and is expected to decrease slightly. ▪ Efficiency ranges from 63-70% and is expected to increase slightly over the next decade.	▪ Typical capex is c. 1,200 €/kWe today but is anticipated to fall and be broadly similar to AEL costs by 2030. ▪ Efficiency is in the range of 61-70% and is expected to increase slightly over the next decade.	▪ Typical capex is c. 3,000 €/kWe and is expected to fall by more than 40%. ▪ Efficiency is in the range of 74-91% and is anticipated to increase further over the next decade.
Plant size	▪ Currently, Toshiba operates the largest alkaline electrolyser of **10 MW.** Future plant capacity is expected to increase up to **200 MW**.	▪ Air Liquide recently inaugurated a **20 MW** PEM electrolyser**.** Future plant capacity is expected to increase up to **200 MW**.	▪ Currently, the largest SOEC electrolyser has a capacity of **225 kW**. Future plants are anticipated to reach a capacity of **100 MW.**
Flexibility	▪ The start-up time is in the range **of 1 to 10 minutes.** ▪ Ramp-up / down response is **0.2 – 20 % / second**	▪ The start-up time is in the range of **1 second to 5 minutes.** ▪ Ramp-up / down response is **100% / second.**	▪ There is very limited information on SOEC electrolysers' characteristics with respect to flexibility.

Size and flexibility are the main characteristics that influence electrolysers' capability to provide system services

*Efficiency is defined as the energy output in H2 as a percentage of energy input in electricity

Electrolysers capabilities of providing system services

Identification of system services and their technical requirements

We have identified a set of system services. Then, for these services, we have listed some of the key technical features.

	Full Activation Time	Minimum Bid Size	Symmetry
Frequency Containment Reserves (FCR)	▪ 30 seconds	▪ 1 MW	▪ Yes
Automatic Frequency Restoration Reserves (aFRR)	▪ 5 minutes	▪ 1 MW	▪ No
Manual Frequency Restoration Reserves (mFRR)	▪ 12.5 minutes	▪ 1 MW	▪ No
Reserve Restoration (RR)	▪ 30 minutes	▪ 1 MW	▪ No
Voltage Control	▪ Few seconds to 15 minutes	▪ NA	▪ No
Services for Congestion Management	▪ 15 minutes	▪ 1 to 10 MW	▪ No

Electrolysers capabilities of providing system services

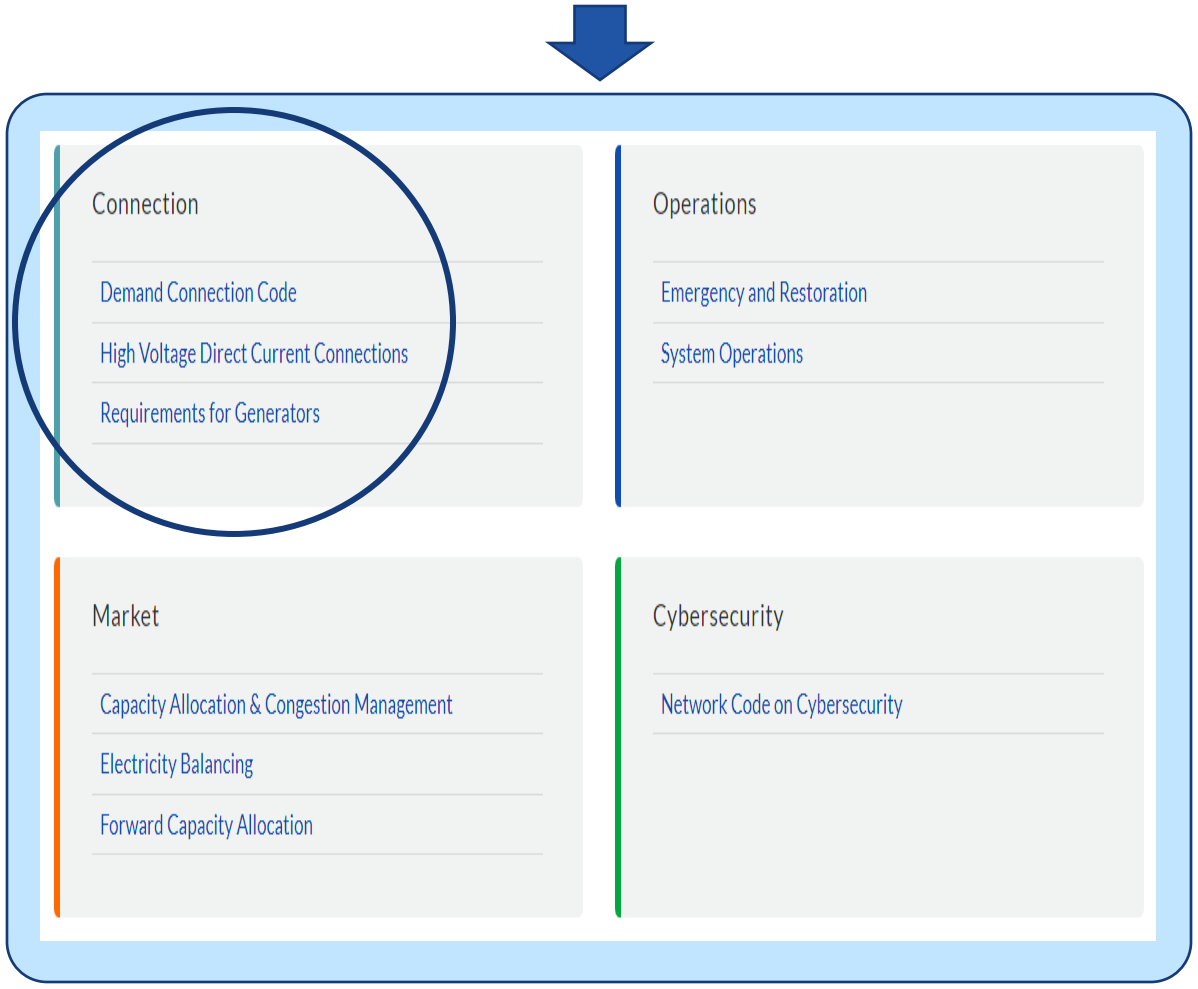
In theory, electrolysers could provide most system services

	Alkaline		PEM		SOEC	
	Today	2030	Today	2030	Today	2030
FCR	Yes with limits	Yes with limits	Yes with limits	Yes with limits	No	Uncertainty about flexibility
aFRR	Yes with limits	Yes with limits	Yes	Yes	No	Uncertainty about flexibility
mFRR	Yes	Yes	Yes	Yes	No	Uncertainty about flexibility
RR	Yes	Yes	Yes	Yes	No	Uncertainty about flexibility
Voltage control	Electrolysers can provide reactive power if they are equipped with self-commuted rectifiers					
Congestion management	Yes	Yes	Yes	Yes	No	Uncertainty about flexibility

Expected Connection Requirements

About Connection Network Codes

Network Codes (NC)



Connection NC:

CNC is the **regulatory platform** at European level which define the necessary **technical capabilities** of power generating modules, distribution systems connected to transmission systems, demand facilities, and HVDC systems during normal and disturbed system operating conditions.

- NC RfG
- NC DC
- NC HVDC

National regulation on connection codes

Detailed project specification and connection agreement is based on CNCs

ACER-Draft

- Electromobility, heat pumps, P2G demand units are expected to be connected *en masse* in the future
- Currently, the connection rules for these units follow on the divergent national approaches
- Harmonisation at the EU level can provide for the economies of scale and the level-playing field

P2G

Power-to-Gas demand units

New Article in NC DC – exhaustive requirements:

- Frequency and voltage ranges
- RoCoF withstand capability
- LFSM-UC
- FRT

Additional national requirements possible

Workshop 17 April_final.pdf (europa.eu)

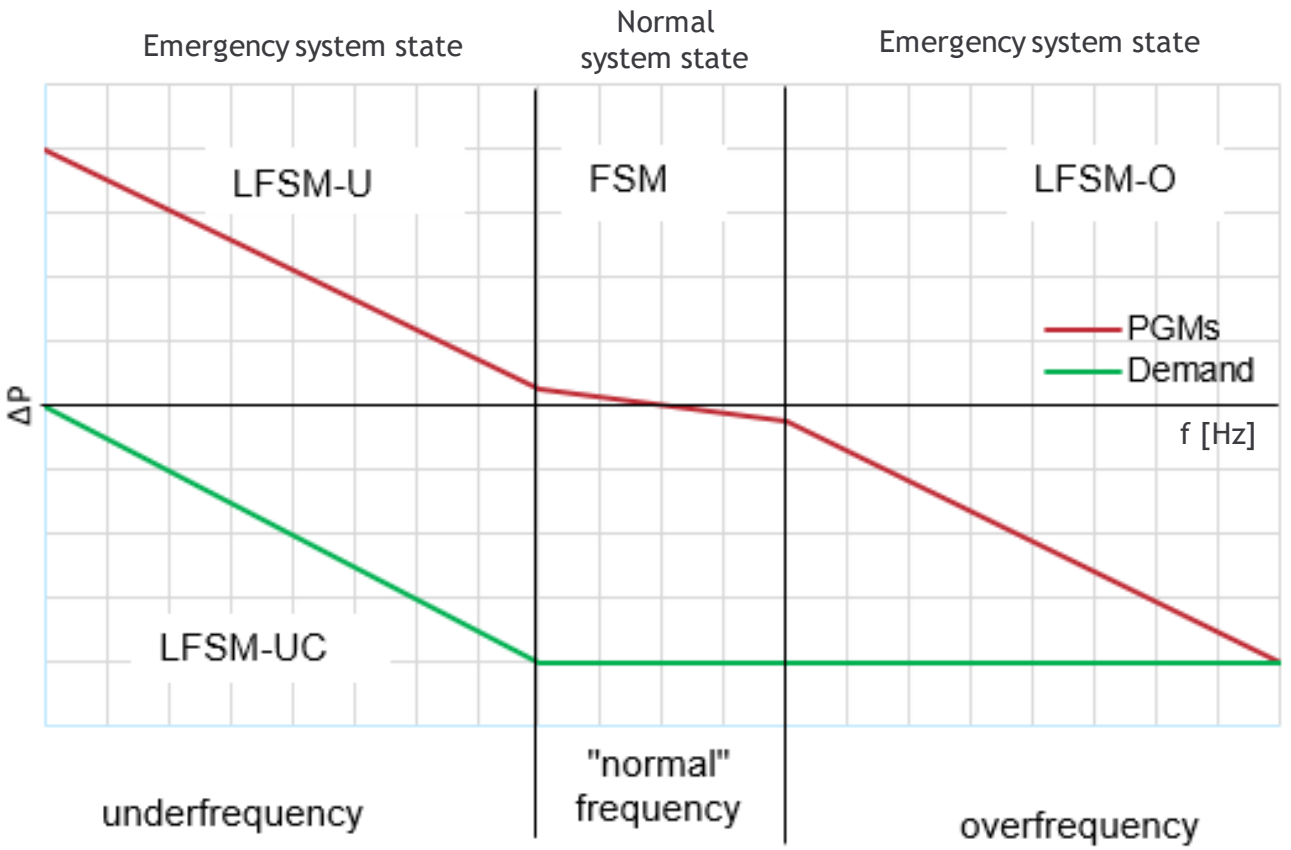
ACER: NC DC Draft

Threats // Mitigation Measures

Decreasing LFDD potential due to DER	**LFSM-UC**: Limited frequency sensitive modes apply in underfrequency system states on demand facilities.
System splits	**RoCoF**: Rate-of-Change-of-Frequency withstand capability
Mass disconnections in fault conditions	**FRT:** Fault-Ride-Through capability

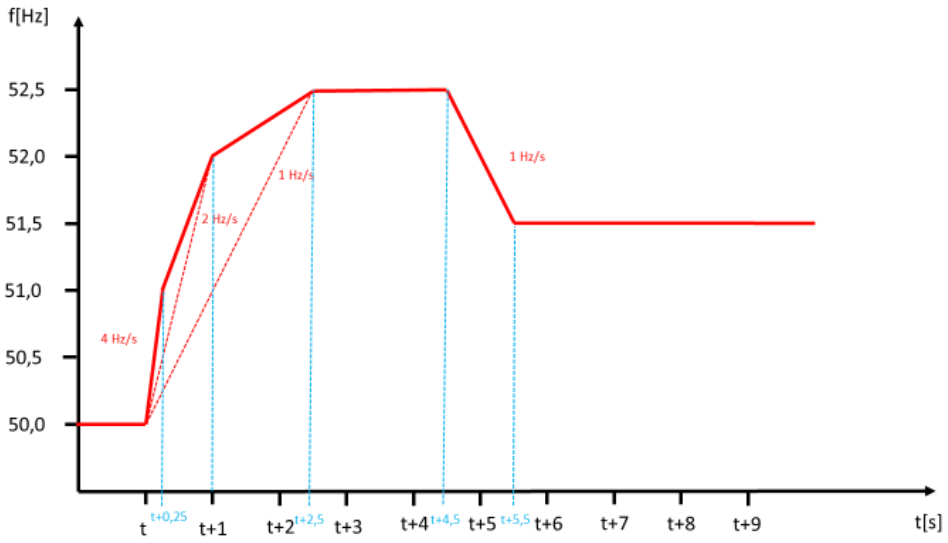
What does LFSM-UC mean and why is needed?

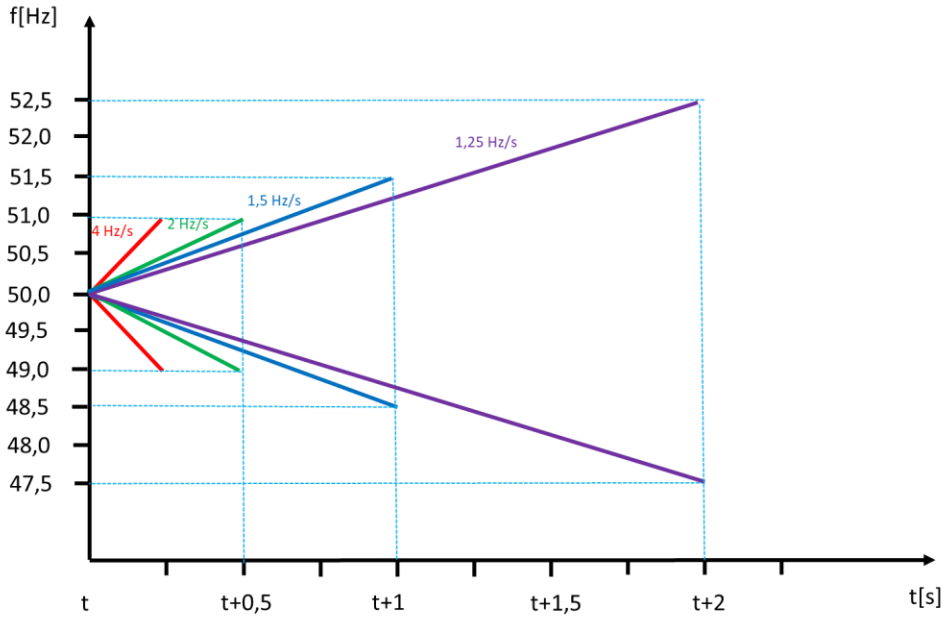
- LFSM-UC means „Limited frequency sensitive mode - underfrequency in consumption“
- Regular LFSM modes are required for power-generating modules (NC RfG)
- LFSM-UC capability works in a similar way as LFSM-O/U are required for PGMs but with modification related to demand facilities
- LFSM modes are applied autonomously when the frequency exceeds set thresholds (emergency system state)

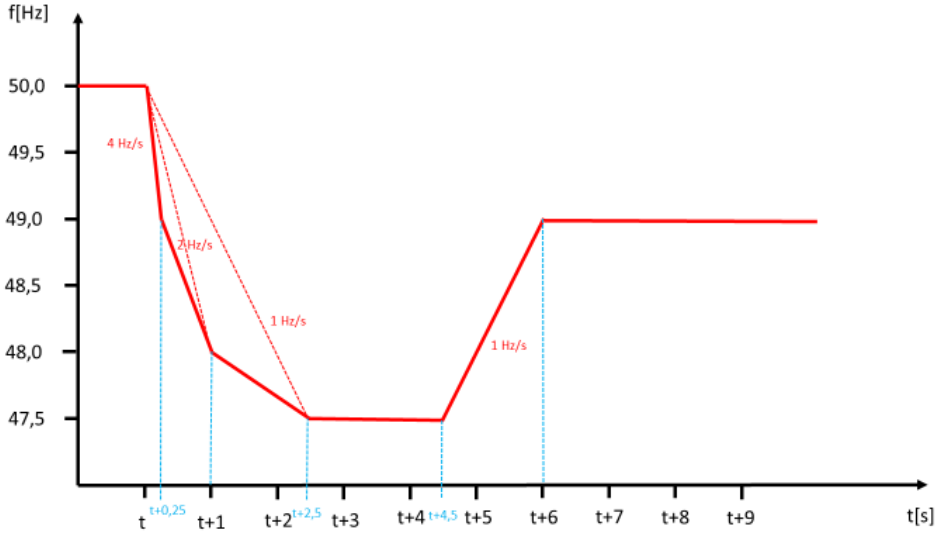


RoCoF whithstand capability for P2G

- Withstand high Rates-of-Change-of-Frequency
- The control scheme must cope with it stably

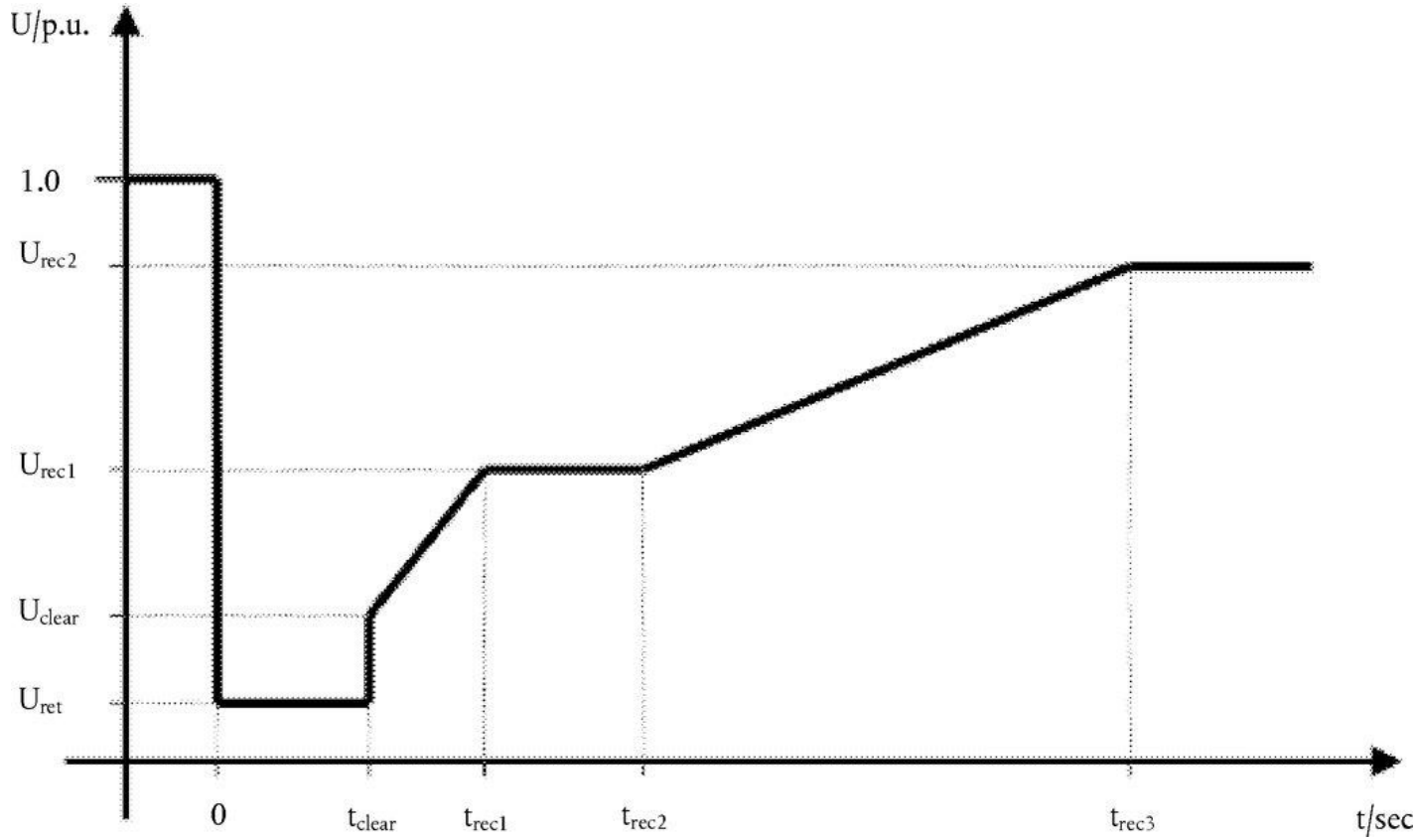






FRT - Requirement

- P2G shall stay connected to the network and continue to operate stably after the power system has been disturbed by faults



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