ENTSO-E position on the need for national connection requirements to ensure EU power system stability

Approved | 11 December 2025

From: System Development Committee

ENTSO-E Mission Statement

ENTSO-E, the European Network of Transmission System Operators for Electricity, **is the association of the European transmission system operators** (TSOs). The **40 member TSOs, representing 36 countries**, are responsible for the secure and coordinated operation of Europe's electricity system, the **largest interconnected electrical grid in the world**.

Before ENTSO-E was established in 2009, there was a long history of cooperation among European transmission operators, dating back to the creation of the electrical synchronous areas and interconnections which were established in the 1950s.

In its present form, ENTSO-E was founded to fulfil the common mission of the European TSO community: to power our society. At its core, European consumers rely upon a secure and efficient electricity system. Our electricity transmission grid, and its secure operation, is the backbone of the power system, thereby supporting the vitality of our society. ENTSO-E was created **to ensure the efficiency and security of the pan-European interconnected power system** across all time frames within the internal energy market and its extension to the interconnected countries.

ENTSO-E is working to secure a carbon-neutral future. The transition is a shared political objective throughout the continent and necessitates a much more electrified economy where sustainable, efficient and secure electricity becomes even more important. **Our Vision: "a power system for a carbon-neutral Europe"*** shows that this is within our reach, but additional work is necessary to make it a reality.

In its Strategic Roadmap presented in 2024, ENTSO-E has organised its activities around two interlinked pillars, reflecting this dual role:

- "Prepare for the future" to organise a power system for a carbon-neutral Europe; and
- "Manage the present" to ensure a secure and efficient power system for Europe.

ENTSO-E is ready to meet the ambitions of Net Zero, the challenges of today and those of the future for the benefit of consumers, by working together with all stakeholders and policymakers.

* https://vision.entsoe.eu/

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1 Position

In response to national and European initiatives for the green transition, Europe anticipates a significant amount of connection requests of new and modernized grid users to achieve the planned European energy mix. On the demand side, new technologies such as power-to-gas, data centres, electric vehicles and heat pumps are already being installed and, on the generation side, new technologies such as storage systems and control systems like grid forming are also being already installed. Their deployment, together with new HVDC systems, is expected to rapidly increase in the near future to reach the European Union (EU) and national objectives for already 2030. Connection agreements for these grid users are usually signed a few years before the realization of the projects, and a national implementation and technological adaptation period to new requirements is necessary. Although this position paper is not legally binding, its purpose is to highlight the importance of updating national connection requirements. [1]

In this context, in September 2022, the European Commission (EC) asked the EU Agency for the Cooperation of Energy Regulators (ACER) to propose amendments to the three Connection Network Codes (CNC). The purpose of these amendments was to enhance the Regulations by making them more "future-proof" and reflecting the latest developments in the electricity sector. After organizing several public consultations, firstly, ACER submitted its recommendation to the EC on the amended Network Code on Requirements for Generators (NC RfG[2]) and on the amended Network Code on Demand Connection (NC DC[3]) in December 2023; secondly, ACER submitted its proposal on the amended Network Code on High Voltage Direct Current (NC HVDC[4]) in December 2024.

The process of finalising the adoption of the updated regulations is now the responsibility of the EC for all CNC. According to the latest information shared by the EC at the Grid Connection European Stakeholders Committee[5] (GC ESC) chaired by ACER, the adoption of CNC 2.0 has been deprioritised, and no specific timeline has been communicated so far. Subsequently after EC approval and publication in the Official Journal of the EU, they will apply at the national level only after the relative national implementation, which makes them unlikely to influence the 2030 energy mix.

Given the rapid increase and size (in GW) of connection requests, the absence of updated and new technical requirements in the currently in force CNC will have an adverse impact on both national systems and cross-border operations. In more details, insufficient technical requirements for large-scale integration of power electronic interfaced devices, lacking necessary provisions for immunity and system-supportive behaviour, crucial for stability of the interconnected European power system, will be applied. Furthermore, some technologies such as electricity storage modules (except for pump-storage), electric vehicles, heat pumps, power-to-gas and data centres are excluded from

[1] *Please note that this position paper does not establish by itself any national requirements.*
[2] *https://www.acer.europa.eu/sites/default/files/documents/Recommendations_annex/ACER_Recommendation_03-2023_Annex_1_NC_RfG_clean.pdf*
[3] *https://www.acer.europa.eu/sites/default/files/documents/Recommendations_annex/ACER_Recommendation_03-2023_Annex_2_NC_DC_clean.pdf*
[4] *https://www.acer.europa.eu/sites/default/files/documents/Recommendations_annex/ACER_Recommendation_01-2024_NC_HVDC_Annex_1.pdf*
[5] *On 18 September 2025*

the currently in force requirements (except for demand facilities connected to the transmission network).

Given the above concerns, ENTSO-E asked the EC to do its utmost to ensure a fast entry into force of the new regulations. Moreover, some Member States and Transmission System Operators (TSOs) have already started implementing some draft CNC 2.0 proposals at national level, even prior to the EC adoption, in order to overcome the challenges of keeping the power system secure. For example, power-to-gas requirements, electricity storage requirements, and both NC RfG 2.0 and NC HVDC 2.0 grid forming requirements, are being introduced across national grid codes. While ENTSO-E recognises the need of updated connection requirements, a harmonized European framework will also support level playing field in the EU market.

In order to support the Clean Industrial Deal ambitions of a competitive, decarbonised and secure Europe, and to avoid the potential future need for retroactive application of requirements (which would lead to unreasonable technical and economical efforts), and large-scale integration of the new and modernized components of the energy mix, ensuring the necessary provisions for immunity and system-supportive behaviour, crucial for stability of the interconnected European power system,

- **ENTSO-E recommends TSOs to take actions to update national technical connection requirements as soon as possible to support EU-wide power system stability needs identified by ACER[6], the Grid Connection European Stakeholder Committee, and the EC-organized "roundtable discussions on sustainable integration of data centres in the energy system".**
- As this action may include involving the National Regulatory Authorities, Member States, and Distribution System Operators, **ENTSO-E encourages ACER and the Council of European Energy Regulators to convey this message towards the National Regulatory Authorities and - where needed - to ask them to support the TSOs for the above**.

Finally, it should be noted that these actions may fall within the scope of the Article 58(2)(d) of the Electricity Regulation when justified by system security needs aim at addressing the gap of lack of adequate requirements to meet the system needs, until EU regulations with amended connection requirements are adopted and implemented at the national level.

2 Recommendations

As mentioned before, ACER submitted recommendations to the EC to amend technical requirements for generators and demand connection in December 2023 and in December 2024 for

[6] *https://acer.europa.eu/sites/default/files/documents/Position%20Papers/260908%20ACER%20GCNCs%20Policy%20Paper_final.pdf*

HVDC technologies. Furthermore, following the 27 June 2024 GC ESC meeting, ACER announced the creation of workstreams[7] to help forming ACER views during the adoption phase of the amendments of RfG and DC network codes where ACER will advise the Commission. The resulting common views, published on the GC ESC website[8], propose wording improvements on the draft CNC 2.0.

Therefore, in order to support a secure and stable European power system, **ENTSO-E recommends an update of the national technical connection requirements based on the latest technical discussions[9] on the needed requirements to mitigate EU power system stability risks**. The published requirements can be found in the legal text recommendations from ACER to the EC on the three amended CNC[10] and the common views provided by the workstreams on CNC 2.0 within the GC ESC. Any national technical requirements adopted following this Position Paper should remain strictly proportionate, objectively justified by identified system-security needs, and non-discriminatory. Moreover, the ability of interconnected European synchronous areas to remain stable during severe grid disturbances is considered vital to avoid large power and energy imbalances. Against this background, the immunity of Power Generating Modules to survive high Rate-of-Change-of-Frequency is key for the system resilience. According to the above, ENTSO-E has provided its position on this matter during the ACER's public consultation on the NC RfG.[11] In addition, ENTSO-E also published an Implementation Guidance Document on RoCoF withstand capability.[12] While the recommendations of this position paper shall be understood as minimum interim measures to mitigate stability risks before the revised CNCs will enter into force, it shall not be interpreted as ENTSO-E abdicating from its previous position on amendments of the CNCs needed to ensure power system stability.

Additional and tailor-made connection requirements for data centres are being recommended by ENTSO-E (Annex A). The lack of specific requirements for this kind of demand units was raised by ENTSO-E in the public consultation on the NC DC 2.0, acknowledged by ACER and suggested to be included in the national legislations or in connection agreements.[13] **ENTSO-E is recommending a minimum set of common connection requirements for data centres as basis for national use, as well as for engaging with relevant stakeholders and OEMs.** ENTSO-E remains open for further discussion of the data centres connection requirements with stakeholders within a dedicated EC-acknowledged workstream. Any subsequent relevant updates will be communicated to TSOs to further guide the development of national connection requirements.

Finally, the above-mentioned technical recommendations are intended without prejudice to any further information or recommendations for CNC that may arise from the 28 April 2025 Incident

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[7] *On requirements for electric vehicles, heat pumps, power-to-gas demand units, and synchronous power generating modules.*
[8] *https://www.entsoe.eu/network_codes/esc/#gesc*
[9] *Including minor wording corrections and inconsistency issues*
[10] *Recommended by ACER to the EC in December 2023 (on NC RfG and NC DC) and in December 2024 (on NC HVDC).*
[11] *https://acer.europa.eu/public-consultation/pc2023e07-public-consultation-amendments-electricity-grid-connection-network-codes*
[12] *https://eepublicdownloads.entsoe.eu/clean-documents/Network%20codes%20documents/NC%20RfG/IGD_RoCoF_withstand_capability_final.pdf*
[13] *https://www.acer.europa.eu/sites/default/files/documents/Recommendations_annex/ACER_Recommendation_03-2023_Annex_7_Evaluation_PC_2023_E_07.pdf*

Final Report. Where appropriate, such recommendations could give another perspective to the amendment of the CNC.

Annex A Connection requirements for data centres

A.1 Introduction

A.1.1 Background

The already ongoing and further expected rise of connection of data centres, both in number and in size, will impact the EU power system including cross-border issues.

A.1.2 Justification

Data centres demand units are usually characterized by high and often unpredictable demand profiles, which can pose substantial risks to system operations if not properly integrated. Data centres typically operate with high-power consumption, often concentrated in relatively small geographic areas. The demand can range from tens to hundreds of MW and even up to a GW level and, unlike other more predictable loads, their consumption patterns are not always steady or predictable. This unpredictability stems from several factors, such as:

- Dynamic load: sudden spikes, drops and oscillatory patterns in power consumption linked to computing resources (such as Artificial Intelligence (AI) training cycles).

- Limited visibility and control: TSOs may lack real-time visibility into data centre operations, raising issue to anticipate and respond to the relative impact on grid stability.

- Tendency to switch to island operation mode during minor disturbances. This may potentially remove several GW of load and cause unbalances that are hard to manage for TSOs.

If these facilities are connected without adequate system-supporting and robust technical requirements, they can exacerbate system imbalances, such as:

- Frequency deviations, potentially leading to over-activation of frequency containment reserves[14]

- Voltage instability

[14] Moreover, sudden load dips or spikes will lead to over activation of the frequency reserves with related costs for the collective

- Overloading of transmission lines
- Increased need for reserve and balancing services
- Excitation of local and global oscillatory modes (such as inter-area oscillation or sub-synchronous torsional interactions)

Therefore, to mitigate these risks, the need of certain additional[15] connection requirements is essential to ensure a secure and stable operation of the power system via a clear and robust set of harmonized connection requirements for data centre demand facilities.

Figure **1** shows the expected energy demand from data centres from 2019 to 2050.[16] Taking 2019 as a reference, it is worth noting that the final energy demand of the data centres and Information and Communication Technology (ICT) sector[17] is expected to increase threefold by 2030.

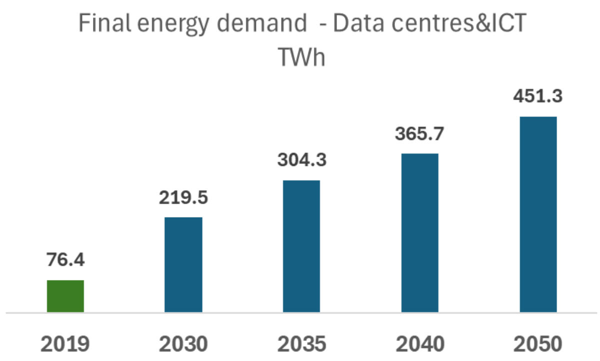

Figure 1. Final energy demand of data centres and ICT – 2019 actual data and future scenarios

A.1.3 Scope

The requirements for data centres reported in Section - shall apply to demand facilities that fall under the definition of data centres (as defined in Section A.2) that are connected above 1 kV.

A.2 Definitions

According to the Regulation (EC) No 1099/2008, *a data centre is defined as a structure or a group of structures used to house, connect and operate computer systems/servers and associated equipment for data storage, processing and/or distribution, as well as related activities.*

Notwithstanding the EC has adopted the Commission Delegated Regulation (EU) 2024/1364 on the rating scheme for data centres including in Article 2 the definitions on different types of data centres,

[15] *Compared to the ones included in the NC DC 2.0 recommendation which apply to all the transmission-connected demand facilities*
[16] *Published by ENTSO-E in June 2025 for consultation, based on the most up-to-date National Energy and Climate Plans and national/EU policies with the cut-off date of 24 December 2024: https://2026.entsos-tyndp-scenarios.eu/download/*
[17] *It encompasses all centralized ICT services. Its most notable components are data centres and telecom.*

such as ‘enterprise data centre’, ‘colocation data centre’ and ‘co-hosting data centre’, ENTSO-E suggests the following definition related to data centres to delimitate the scope of the proposed connection requirements:

- ‘Data centre’ means a demand unit, with the purpose of remote storage, processing, or distribution of large amounts of computing data. Connection requirements

ENTSO-E recommends TSOs introducing the following a minimum set of harmonized technical requirements for data centres. The requirements for power-to-gas demand units included in the draft NC DC 2.0 (Article XX) were considered as reference.

A.2.1 Current legal framework

Data centres connected to the transmission grid must currently comply with Title II of the NC DC, where the general requirements are defined from Article 12 to Article 21.

A.2.2 Voltage and frequency stability requirements

With regard to voltage ranges, data centres shall comply with the following requirements:

(a) Data centres with a voltage level at the connection point at or above 110 kV: requirements defined in the Article 13 of the draft NC DC 2.0.

(b) Data centres with a voltage level at the connection point above 1 kV and below 110 kV: they shall be capable of remaining connected to the network and operate continuously within the range of 0,9 pu - 1,1 pu at the connection point.

With regard to frequency ranges, data centres shall comply with the requirements defined in Article 12 of the draft NC DC 2.0.

A.2.3 Rate-of-change-of-frequency withstand capability

With regard to the rate-of-change-of-frequency withstand capability:

(a) A data centre shall be capable of remaining connected to the network and to operate continuously at rates-of-change-of-frequency up to the following values:

  – ±4,0 Hz/s over a period of 0,25s
  – ±2,0 Hz/s over a period of 0,5 s
  – ±1,5 Hz/s over a period of 1 s
  – ±1,25 Hz/s over a period of 2 s

(b) Without prejudice to point (a) of this paragraph, a data centre shall be capable of remaining connected to the network and continuing to operate stably at the sequence of rates of-change-of-frequencies which are defined considering the overfrequency against time profiles given in Figure **2** and the underfrequency against time profiles given in Figure **3**.

(c) With regard to the rate-of-change-of-frequency withstand capability defined in points (a) and (b) of this paragraph, a data centre shall be capable of staying connected to the network and continuing to operate stably, unless disconnection was triggered by the low frequency demand disconnection of the demand facility.

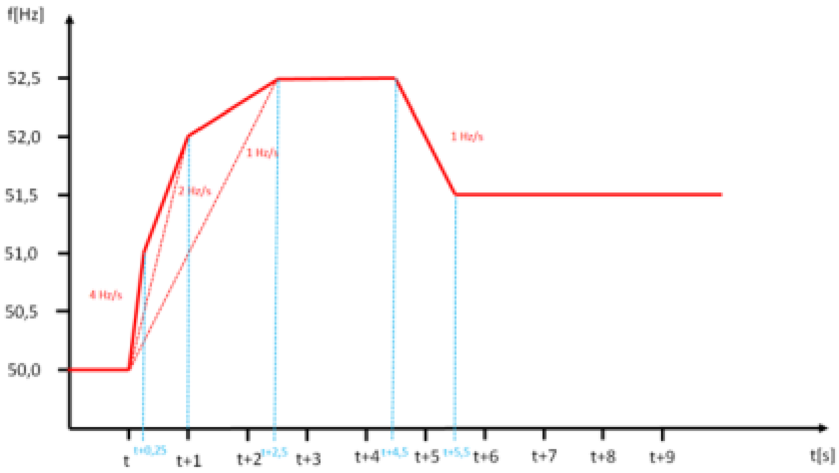

Figure 2. Overfrequency against time profiles at which data centres shall be capable of remaining connected to the network and continuing to operate stably

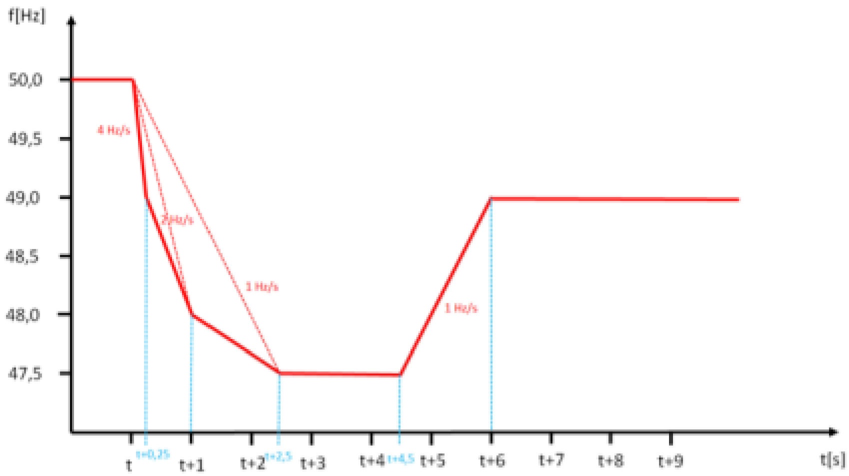

Figure 3. Underfrequency against time profiles at which data centres shall be capable of remaining connected to the network and continuing to operate stably

A.2.4 Undervoltage Fault Ride Through

With regard to undervoltage Fault-Ride-Through (FRT) capability, the data centre shall be capable of remaining connected to the network and continuing to operate stably after the power system has been disturbed by faults in the network, according to a voltage-against-time-profile in line with Figure **4** at the connection point. The RSO, in coordination with the relevant TSO, shall define longer times for operation, if it is required to preserve or to restore system security.

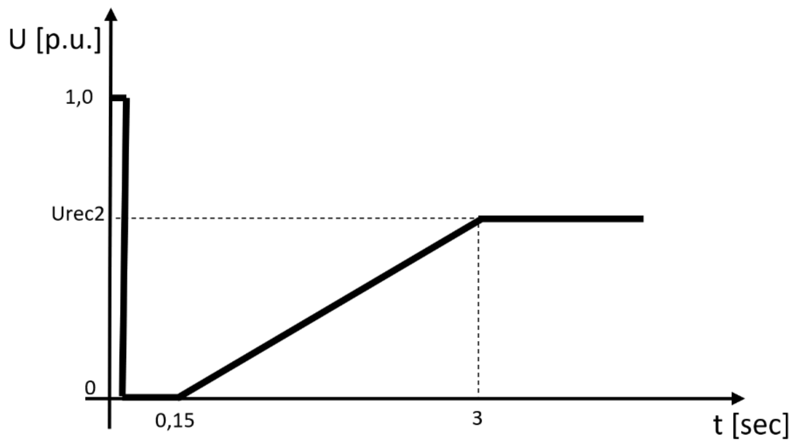

Figure 4. FRT profile proposed for data centres

The diagram represents the lower limit of a voltage-against-time profile of the voltage at the connection point, expressed as the ratio of its actual value and its reference 1 pu value before, during and after a fault.

The voltage-against-time-profile expresses a lower limit of the profile of the phase-to-phase voltages on the network voltage level during a symmetrical fault, as a function of time before, during and after the fault. Undervoltage FRT capabilities in case of asymmetrical faults shall be specified by the RSO.

A.2.5 Overvoltage Fault Ride Through

The data centre shall be capable of operating stably without disconnecting from the network, if none of the phase-to-phase voltages exceed the voltage-against-time-profile defined in Figure **5** at the connection point. The RSO, in coordination with the relevant TSO, shall define longer times for operation, if it is required to preserve or to restore system security.

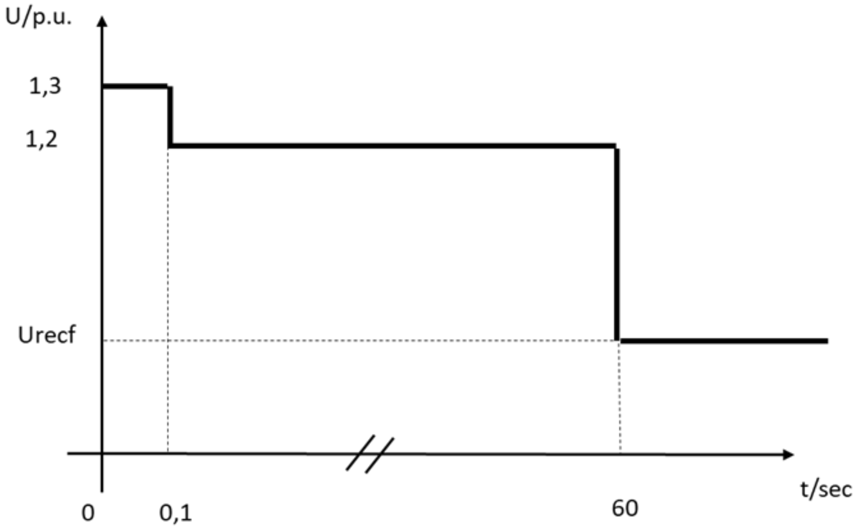

Figure 5. Overvoltage-ride-through profile proposed for data centres

Where *Urecf* is the maximum voltage specified in Section A.2.2 for unlimited time of operation.

Besides, FRT capabilities in case of asymmetrical faults shall be specified by the RSO.

A.2.6 Post-fault active power recovery

When the network voltage resumes, after the fault has been cleared, to a value within the voltage range specified in Section A.2.2 for unlimited time of operation, a data centre shall recover its active power consumption level at the connection point according to the specification of the relevant TSO. The relevant TSO shall define:

(i) A magnitude and accuracy within the range from 80% to 100% of the pre-disturbance active power consumption level

(ii) A recovery time in the range from 0.5 seconds to 5 seconds.

The relevant system operator, in coordination with the relevant TSO, shall define a longer recovery time for operation, if it is required to preserve or to restore system security.

A.2.7 Load-induced forced oscillations

The relevant TSO shall define the magnitude and accuracy of the allowed oscillations in the frequency range between 0.01 Hz to 50 Hz (rotating reference frame). Within the 0.01 Hz to 50 Hz range, the relevant TSO may define more than one frequency ranges and relative allowed oscillations.

A.2.8 Limited Frequency Sensitive Mode Underfrequency Control

With regards to Limited Frequency Sensitive Mode Underfrequency Control (LFSM-UC), the data centre shall be capable of reducing the consumption from the active power input automatically down to the minimum technical operational level according to the indicative Figure **6** below at a frequency threshold and with a droop setting. The relevant TSO shall define the reference of the active power input in terms of Pref, as the actual active power consumption at the moment the LFSM-UC threshold is reached, or Pmax, as the maximum capacity as defined by the relevant TSO.

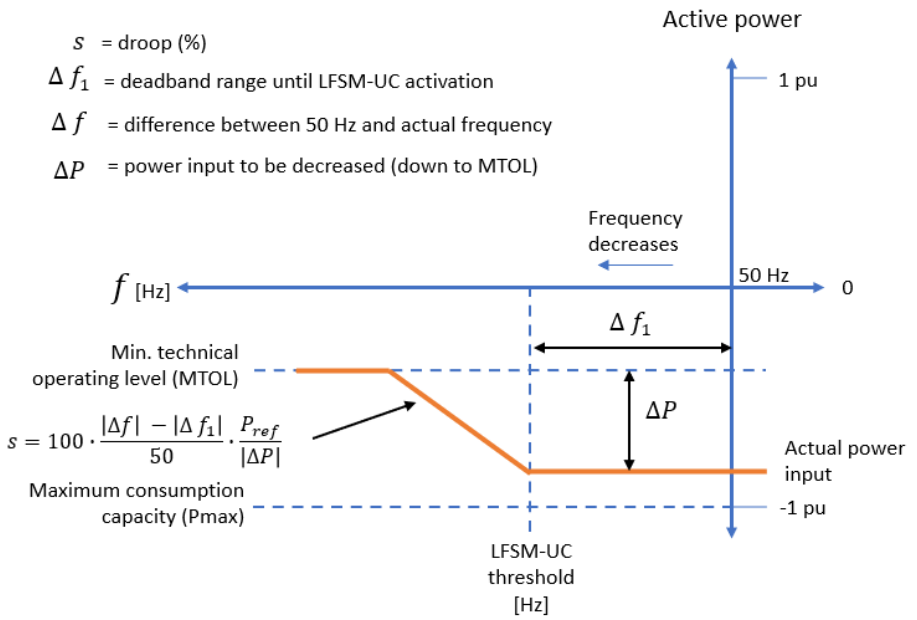

Figure 6. LFSM-UC profile proposed for data centres

Where:

- The droop settings shall be between 2 % and 12 %, as determined by the relevant TSO for its control area in coordination with the TSOs of the same synchronous area to ensure minimal impacts on neighbouring areas.
- The frequency threshold shall be 49,8 Hz (Δf_1 equal to 0,2 Hz), except for the synchronous areas Ireland and Nordic where the frequency threshold shall be 49,5 Hz (Δf_1 equal to 0,5 Hz).

The data centre shall stay in this specific mode as long as the frequency is below the frequency threshold. If the frequency recovers, the data centre shall follow the same power-frequency characteristic and the same response time until it is back to its prior state of active power consumption.

Requirements for frequency measurement:

- Measuring time window: 100 ms

– Accuracy: ± 30 mHz

Stable operation of the data centre during LFSM-UC operation shall be ensured. The response time for LFSM-UC shall be less or equal to 0,5 seconds.

When LFSM-UC is active, the LFSM-UC setpoint will prevail over any other active power setpoints which would result in an increase of active power consumption above the LFSM-UC setpoint.

A.2.9 Active power control

The relevant TSO shall be able to specify both up and down ramp limits for active power consumption.

A.2.10 Reactive power capability

With regards to reactive power capability, the relevant system operator shall specify the requirements in coordination with the relevant TSO.