COMMISSION REGULATION (EU) 2016/631

of 14 April 2016

establishing a network code on requirements for grid connection of generators

(Text with EEA relevance)

THE EUROPEAN COMMISSION,

Having regard to the Treaty on the Functioning of the European Union,

Having regard to Regulation (EC) No 714/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the network for cross-border exchanges in electricity and repealing Regulation (EC) No 1228/2003 (1), and in particular Article 6(11) thereof,

Whereas:

[…]

(s1)Equally, electricity storage plays a key role in the system as different energy storage technologies have a dual behaviour of being able to consume electricity from or inject electricity into the grid at different times and scales. For this reason, and due to the specific characteristics of storage and impact on the system, it is necessary to introduce requirements for the grid connection of electricity storage modules. The requirements on electricity storage are considered to be the same as those on power generation modules unless explicitly stated otherwise in this Regulation. In the case of electrical equipment such as synchronous compensators, flywheels and regenerative braking systems which do not fall onto the definition of a power generating module or electricity storage module, the relevant TSO may define the technical requirements that apply.

(s2) For the purpose of this regulation, electricity storage includes electric vehicles that comply with the definition of electricity storage.

[…]

TITLE I
GENERAL PROVISIONS

Article 1

Subject matter

This Regulation establishes a network code which lays down the requirements for grid connection of power-generating facilities, namely synchronous power-generating modules, power park modules, electricity storage modules (which can inject and consume electrical energy to and from the network) and offshore power park modules, to the interconnected system. It, therefore, helps to ensure fair conditions of competition

in the internal electricity market, to ensure system security and the integration of renewable electricity sources, and to facilitate Union-wide trade in electricity.

This regulation also lays down the obligations for ensuring that system operators make appropriate use of the power-generating facilities' capabilities in a transparent and non-discriminatory manner to provide a level playing field throughout the Union.

Article 2

Definitions

[…]

(66) ‘electricity storage’ means the conversion of electrical energy into a form of energy which can be stored, the storing of that energy, and the subsequent reconversion of that energy back into electrical energy;

(67) ‘electricity storage module’ or ‘ESM’ means a synchronous power-generating module or a power park module which can inject and consume active power to and from the network for electricity storage, excluding pump-storage power-generating modules. A V2G electric vehicle and associated V2G electric vehicle charging point or installation with a bidirectional functionality is regarded as an electricity storage module;

(68) 'maximum consumption capacity’ means the maximum continuous active power which a~~n~~ demand unit or electricity storage module can consume, less any demand or losses associated solely with facilitating the operation of that demand unit or electricity storage module, as specified in the connection agreement or as agreed between the relevant system operator and the demand facility owner or power-generating facility owner, or determined by other appropriate means, where an agreement is not required.

[…]

Article 6

Application to power-generating modules, pump-storage power-generating modules, electricity storage modules, V2G electric vehicles and associated V2G electric vehicle charging points or installations, combined heat and power facilities~~,~~ and industrial sites

[…]

6. Electricity storage modules and V2G electric vehicles and associated V2G electric vehicle charging points or installations shall be capable of satisfying the requirements of this Regulation both when the electricity storage module or V2G electric vehicle charging points or installations injects and consumes active power to and from the network.

[…]

General requirements

Article 13

General requirements for type A power-generating modules

1. […]

(b) ~~With regard to the rate of change of frequency withstand capability, a power-generating module shall be capable of staying connected to the network and operate at rates of change of frequency up to a value specified by the relevant TSO, unless disconnection was triggered by rate-of-change-of-frequency-type loss of mains protection. The relevant system operator, in coordination with the relevant TSO, shall specify this rate-of-change-of-frequency-type loss of mains protection.~~

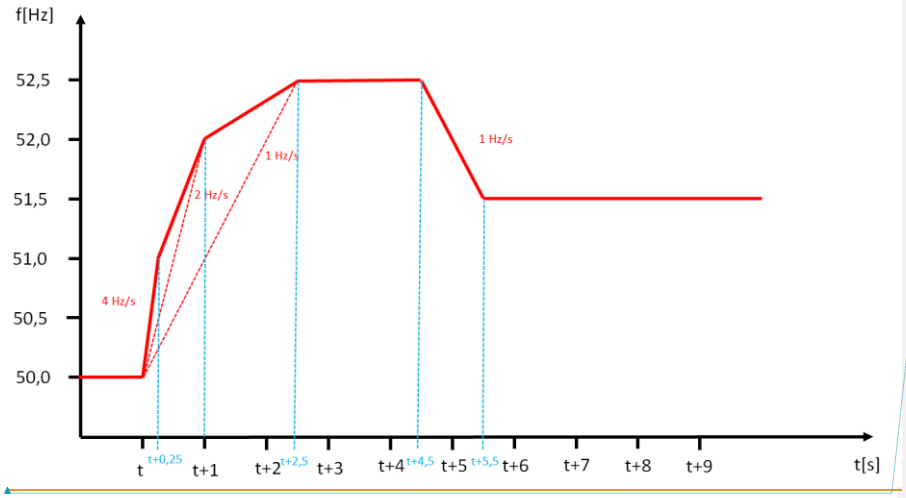
With regard to the rate-of-change-of-frequency withstand capability:

(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 0,25 s,
- ±2,0 Hz/s over a period of 0,5 s,
- ±1,5 Hz/s over a period of 1 s, and
- ±1,25 Hz/s over a period of 2 s;

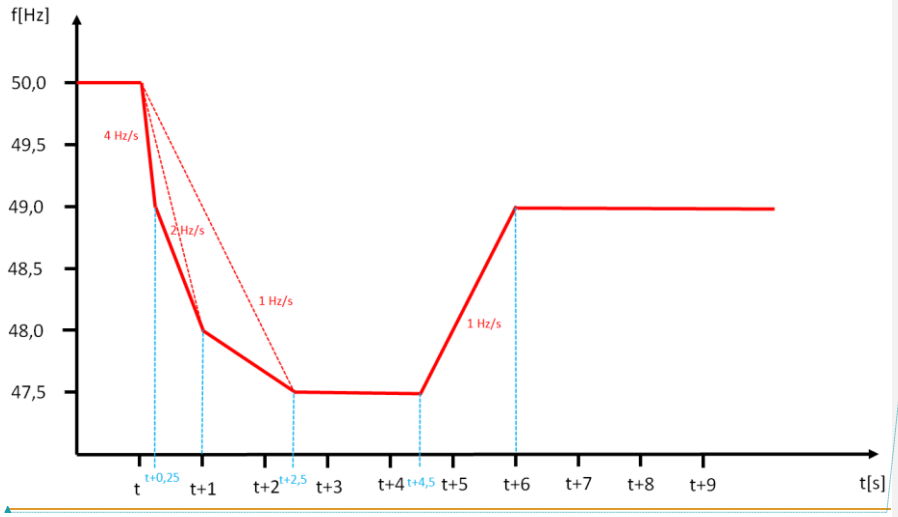
(ii) Without prejudice to ~~Article 13(a)~~point (i), a power-generating module shall be capable of staying connected to the network and operate at the sequence of rates-of-change-of-frequencies which are defined considering the overfrequency against time profiles given in ~~f~~Figure XX.a and the underfrequency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

Figure XX.a



Field Code Changed

Figure XX.b



Field Code Changed

(iiic) 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 ~~paragraph~~point (i) ~~13(1)(b)~~.

(c) The protection schemes shall not jeopardise frequency-ride-through performance specified in paragraph (b).

[…]

2. With regard to the limited frequency sensitive mode — overfrequency (LFSM-O), the following shall apply, 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:

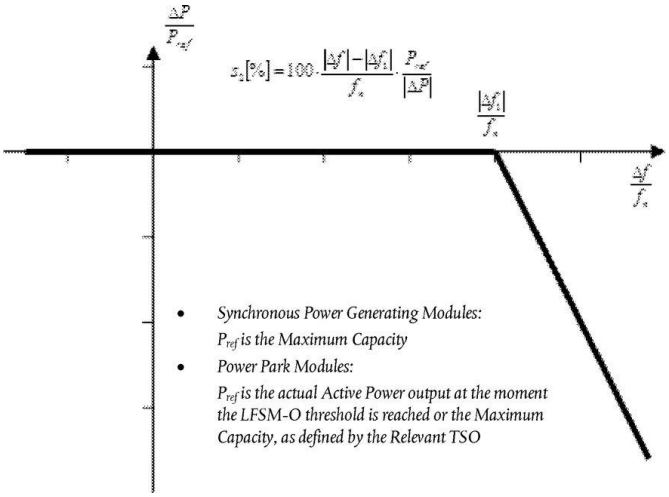
[…]

(h)An electricity storage module, regardless whether it is consuming or injecting active power during an overfrequency event, shall increase the level of active power consumed according to the LFSM-O characteristic, to the extent that is technically feasible. The electricity storage module shall consume power up to filling the maximum energy that it is able to store, then it may cease consumption.

The relevant TSO may define a different characteristic or establish that the electricity storage module, when consuming active power, will maintain the consumption level even during the overfrequency event.

Figure 1

Active power frequency response capability of power-generating modules in LFSM-O



P_{ref} is the reference active power to which ΔP is related and may be specified differently for synchronous power-generating modules and power park modules. ΔP is the change in active power output from the power-generating module. f_n is the nominal frequency (50 Hz) in the network and Δf is the frequency deviation in the network. At overfrequencies where Δf is above Δf_1, the power-generating module has to provide a negative active power output change according to the droop S_2.

In the case of electricity storage modules, P_{ref} could be the actual active power at the moment the LFSM-O threshold is reached or the maximum capacity or maximum consumption capacity, as agreed with the relevant system operator.

[…]

6. […]

The electricity storage modules shall be capable of modulating, without undue delay, active power output and input following an instruction being received at the input port.

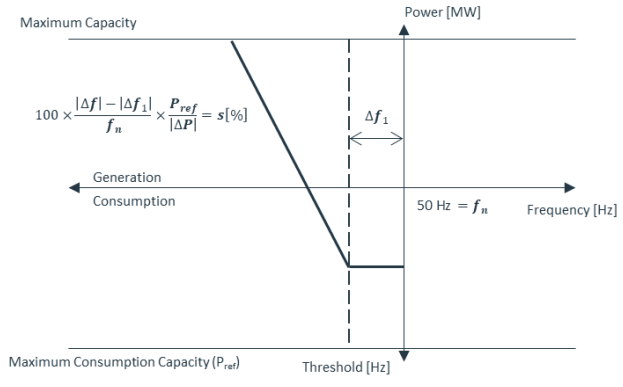
[…]

9. The following requirements shall apply to electricity storage modules with regard to limited frequency sensitive mode – underfrequency (LFSM-U-ESM):

(a) An electricity storage module shall be capable of activating the provision of active power frequency response from the current active power input/output automatically up

to the maximum capacity according to the indicative Figure YY. The relevant TSO has the right to specify a frequency threshold and a droop setting.

Figure YY



(b) The droop shall be adjustable between 0,2% to 5%. The default droop s shall be 1%.

(c) The frequency threshold shall be adjustable between 49,8 Hz and 49,5 Hz inclusive. The default frequency threshold shall be 50 Hz reduced by Δf1 where Δf1 is defined in Table X of Article 15.2.d.

(d) The electricity storage module shall stay and operate stably in this specific mode as long as the frequency is below the frequency threshold according to its content of energy. If the frequency recovers the electricity storage module shall follow the same power-frequency characteristic until it is back to its prior state of active power input/output.

(e) Instead of the capability referred to in paragraph (a), the relevant TSO may choose to allow electricity storage modules of Type A in consumption mode within its control area automatic disconnection at randomized frequencies, ideally uniformly distributed, between the frequency threshold and 49 Hz.

(f) the initial delay time T_{id} (Figure xx in Article 13.2) by the electricity storage modules shall not be intentionally delayed.

(g) The response time T_{resp} (Figure xx in Article 13.2) for LFSM-U-ESM shall be as described below:

— for SPGM: less or equal to 8 s for an active power setpoint change of 1 pu of capacity excluding the time for switching from consumption to generation or vice versa.

— for PPM: less or equal to 0,5 s for an active power setpoint change of 1 pu of capacity excluding the time for switching from consumption to generation or vice versa.

Switching from consumption to generation and vice versa should be as fast as technically feasible. The relevant system operator has the right to request the demonstration of technical evidence of the required switching time.

10. With regard to voltage stability, unless otherwise provided in this Regulation, the power-generating module shall be capable of staying connected to the network and operate continuously within the range of 0,85 pu - 1,1 pu at the connection point should that be at or below 400V. Conversely, the power-generating module shall be capable of staying connected to the network and operate continuously within the range of 0,9 pu - 1,1 pu at the connection point should that be above 400V and below 110 kV.

[…]

Article 15

General requirements for type C power-generating modules

[…]

2. Type C power-generating modules shall fulfil the following requirements relating to frequency stability:

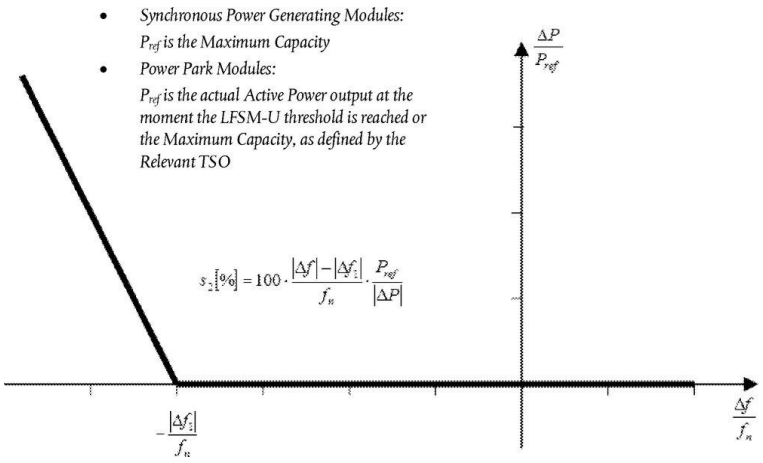
[…]

(c) In addition to Article 13(2), the following requirements shall apply to type C power-generating modules with regard to limited frequency sensitive mode — underfrequency (LFSM-U):

[…]

Figure 4

Active power frequency response capability of power-generating modules in LFSM-U



P_{ref} is the reference active power to which ΔP is related and may be specified differently for synchronous power-generating modules and power park modules. ΔP is the change in active power output from the power-generating module. f_n is the nominal frequency (50 Hz) in the network and Δf is the frequency deviation in the network. At underfrequencies where Δf is below Δf_1 the power-generating module has to provide a positive active power output change according to the droop S_2. In the case of electricity storage modules, P_{ref} could be the maximum capacity or the maximum consumption capacity at the moment the LFSM-U threshold is reached or the maximum capacity or maximum consumption capacity as agreed with the relevant system operator.

(d) in addition to point (c) of paragraph 2, the following shall apply cumulatively when frequency sensitive mode ('FSM') is operating:

(i) the power-generating module shall be capable of providing active power frequency response in accordance with the parameters specified by each relevant TSO within the ranges shown in Table 4. In specifying those parameters, the relevant TSO shall take account of the following facts:

—in case of overfrequency, the active power frequency response is limited by the minimum regulating level. In case of electricity storage modules, the active power frequency response is limited by the minimum regulating level or maximum consumption capacity, or the maximum energy content (as declared by the manufacturer) that the electricity storage module can store in its operative condition or as agreed between the power generating facility and the relevant TSO irrespective to whether the electricity storage module is independently connected to the transmission or distribution network or within a power park module sharing a single network connection with other power generating modules of lower energy content or of lower export power capacity,

—in case of underfrequency, the active power frequency response is limited by maximum capacity, and, in case of electricity storage modules, also by the maximum consumption capacity or maximum energy content of the electricity storage module in its operative condition (as declared by manufacturer) or as agreed between the power generating facility and the relevant TSO irrespective to whether the electricity storage module is independently connected to the transmission or distribution network or within a power park module sharing a single network connection with other power generating modules or demand of lower energy content or maximum consumption capacity,

—the actual delivery of active power frequency response depends on the operating and ambient conditions, as well as, on the underlying energy storage technology, of the power-generating module when this response is triggered, in particular, but not limited to, limitations on operation near maximum capacity at low frequencies according to paragraphs 4 and 5 of Article 13 and available primary energy sources;

- the TSO shall take into account the time needed for some technologies of electricity storage modules to switch from consumption mode to generating mode or vice versa and also the fact that the droop primary

frequency control characteristic in consumption and generating mode could be different;

Table 4

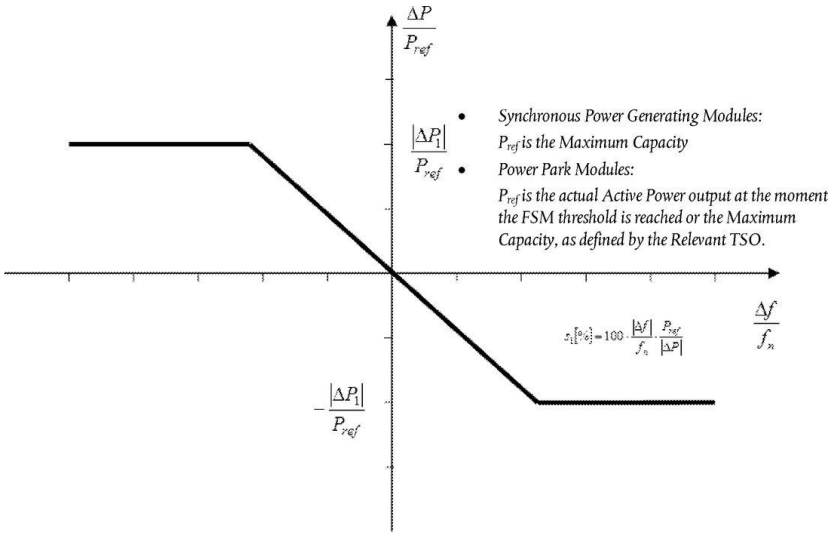
Parameters for active power frequency response in FSM (explanation for Figure 5)

Parameters	Ranges
Active power range related to maximum capacity $\frac{\lvert\Delta P_1\rvert}{P_{max}}$	1,5-10 %, except for electricity storage module. 1,5-100% for electricity storage module.

[...]

Figure 5

Active power frequency response capability of power-generating modules in FSM illustrating the case of zero deadband and insensitivity



P_{ref} is the reference active power to which ΔP is related. ΔP is the change in active power output from the power-generating module. f_n is the nominal frequency (50

Hz) in the network and Δf is the frequency deviation in the network. In case of electricity storage module, P_{ref} could be the maximum capacity or the maximum consumption capacity at the moment the FSM threshold is reached or the maximum capacity or maximum consumption capacity as agreed with the relevant system operator.

[…]

(v) the power-generating module shall be capable of providing full active power frequency response for a period of between 15 and 30 minutes as specified by the relevant TSO in coordination with the TSOs of the same synchronous area. ~~In specifying the period, the TSO shall have regard to active power headroom and~~ Unless, where agreed between the relevant TSO and the power-generating facility owner, contribution is limited only by the maximum energy content of the electricity storage module or primary energy source of the power-generating module;

[…]

(f) with regard to disconnection due to underfrequency, power-generating facilities capable of acting as a load, including ~~hydro~~ pump-storage power-generating ~~facilities~~modules and electricity storage modules, shall be capable of disconnecting their load in case of underfrequency. The requirement referred to in this point does not extend to auxiliary supply;

[…]

CHAPTER 2

Requirements for synchronous power-generating modules

[…]

Article 19

Requirements for type D synchronous power-generating modules

[…]

4. With regard to frequency stability:

(a) requirement laid down in Article 13(1)(b) shall not apply to a synchronous power-generating modules with maximum capacity larger than or equal to XXX MW;

(b) synchronous power-generating modules with maximum capacity larger than or equal to XXX MW shall be capable of staying connected to the network and operate at rate-of-change-of-frequency up to ±1,0 Hz/s over a period of 0,5 s;

(c) if the rate-of-change-of-frequency is used for loss of mains protection, the rate-of-change-of-frequency threshold shall be set at higher values than the one defined in paragraph (b).

CHAPTER 3

Requirements for power park modules

Article Y

Requirements for type A power park modules

[…]

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.

7. By way of derogation from Article 4(2), for the purposes of grid forming capabilities, a power park module shall be considered existing if:

(a) it is already connected to the network on the date of entry into force of this Regulation; or

(b) the power-generating facility owner has concluded a final and binding contract for the purchase of the main generating plant by three years after the entry into force of the Regulation.

8. The relevant system operator may specify in the connection agreement that the activation of grid forming mode is subject to necessary adaptations to the system operator's network and operating and maintenance procedures. The Member State or the entity designated by the Member State may provide the formal and substantive conditions under which the relevant system operator may conduct such specification.

9. Power park modules shall be capable of providing grid forming capability at the connection point as listed below.

(a) Within the power park module current and energy limits, the power park module shall be capable of behaving at the terminals of the individual unit(s) as a voltage source behind an internal impedance (Thevenin source), during normal operating conditions (non-disturbed grid conditions) and upon inception of a grid disturbance (including voltage, frequency and voltage phase angle disturbance). The Thevenin source is characterized by its internal voltage amplitude, voltage phase angle, frequency and internal impedance.

(b) Upon inception of a grid disturbance and while the power park module capabilities and current limits are not exceeded, the instantaneous AC voltage characteristics of the internal Thevenin source according to paragraph (a) shall be capable of not changing its amplitude and voltage phase angle while voltage phase angle steps or voltage magnitude steps are occurring at the connection point. The current exchanged between the power park module and the network shall flow naturally according to the main generating plant and converter impedances and the voltage difference between the internal Thevenin source and the voltage at the connection point.

(c) After inception of a network disturbance in voltage magnitude, frequency or voltage phase angle, the following shall apply with regard to the power park module's grid forming capability, including current limits and inherent energy storage capabilities of each individual unit. Inherent energy storage means an energy reserve available in physical components of a power park module, which has not necessarily been designed to suit the grid forming requirements of this article, but may be used for such purposes, without effecting the design of the physical components of individual units.

(i) The relevant system operator in coordination with the TSO shall predefine the dynamic performance regarding voltage control and specify the temporal parameters thereof.

(ii) Where current limitation is necessary from a transmission or distribution system operator point of view, the relevant system operator may specify additional requirements regarding contribution of active and reactive power at the point of connection.

(iii) The power park module shall be capable of stable operation when reaching the power park module current limits, without interruption, in a continuous manner and returning to the behaviour described in paragraph (b) as soon as the limitations are no longer active. If reaching the current limit, the grid forming behaviour must be maintained for responses as specified in (b) for disturbances that require the current to vary in the opposite direction of the current limitation.

(d) The power park module shall have the capability to activate or deactivate grid-forming mode.

Article 20

Requirements for type B power park modules

1. Type B power park modules shall fulfil the requirements laid down in Articles 13, except for Article 13(2)(b), and Article 14 and Article Y(7), (8) and (9).

2. Type B power park modules shall fulfil the following additional requirements in relation to voltage stability:

[...]

~~(b) the relevant system operator in coordination with the relevant TSO shall have the right to specify that a power park module be capable of providing fast fault current at the connection point in case of symmetrical (3-phase) faults, under the following conditions:~~

~~(i) the power park module shall be capable of activating the supply of fast fault current either by:~~

~~— ensuring the supply of the fast fault current at the connection point, or~~

~~— measuring voltage deviations at the terminals of the individual units of the power park module and providing a fast fault current at the terminals of these units;~~

~~(ii) the relevant system operator in coordination with the relevant TSO shall specify:~~

~~— how and when a voltage deviation is to be determined as well as the end of the voltage deviation,~~

~~— the characteristics of the fast fault current, including the time domain for measuring the voltage deviation and fast fault current, for which current and voltage may be measured differently from the method specified in Article 2,~~

~~— the timing and accuracy of the fast fault current, which may include several stages during a fault and after its clearance;~~

~~(c)with regard to the supply of fast fault current in case of asymmetrical (1-phase or 2-phase) faults, the relevant system operator in coordination with the relevant TSO shall have the right to specify a requirement for asymmetrical current injection.~~

[…]

4. With regard to grid forming capability:

(a) Type B power park modules shall fulfil the following additional requirements in relation to grid forming capability. The TSO in coordination with the relevant system operator shall specify the contribution to synthetic inertia. Where specified, the power park module shall be capable of contributing to limiting the transient frequency deviation under high frequency conditions. Additionally where specified, the ~~power park~~electricity storage module shall be capable of contributing to limiting the transient frequency deviation under low frequency conditions~~any frequency deviations from the nominal value~~.

(b) The dynamic performance according to Article Y(8)(c)(i) shall reflect this specified synthetic inertia.

Article 21

Requirements for type C power park modules

1. Type C power park modules shall fulfil the requirements listed in Articles 13, except for Article 13(2)(b) and (6), Article 14, except for Article 14(2), Article 15, Article Y(7), (8) and (9), and Article 20, except for Article 20(2)(a), unless referred to otherwise in point (v) of paragraph 3(d).

[…]

4. With regard to grid forming capability, type C power park modules shall fulfil the following additional requirements:

(a) The TSO in coordination with the relevant system operator shall specify the contribution to synthetic inertia. Where specified the power park module shall be capable of contributing to limiting the transient frequency deviation under high and low frequency conditions.

(b) For the provision of additional energy above the inherent energy storage the relevant TSO may apply to the NRA for the right to require the provision of additional energy beyond the inherent energy storage in coordination with the relevant system operator.

Article 22

Requirements for type D power park modules

1. Type D power park modules shall fulfil the requirements listed in Articles 13, except for Article 13(2)(b), (6) and (7), Article 14, except for Article 14(2), Article 15, except

for Article 15(3), Article 16, Article Y(7), (8) and (9), Article 20 except for Article 20(2)(a) and Article 21.

[…]

Compliance testing for power park modules

[...]

Article 48

Compliance tests for type C power park modules

[…]

4. With regard to the FSM response test the following requirements shall apply:

(a) the power park module's technical capability to continuously modulate active power over the full operating range between maximum capacity and minimum regulating level to contribute to frequency control shall be demonstrated. In the case of an electricity storage module, the full operating range, depending on the energy stored, is between maximum consumption capacity and maximum capacity. The steady-state parameters of regulations, such as insensitivity, droop, deadband and range of regulation, as well as dynamic parameters, including frequency step change response shall be verified;

[…]