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Technical regulation 3.3.1

TECHNICAL REGULATION 3.3.1 – REVISION 5 REQUIREMENTS FOR ENERGY STORAGE FACILITIES

EFFECTIVE FROM 15 FEBRUARY 2024

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TECHNICAL REGULATION 3.3.1

REQUIREMENTS FOR ENERGY STORAGE FACILITIES

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TECHNICAL REGULATION 3.3.1

REQUIREMENTS FOR ENERGY STORAGE FACILITIES

Pursuant to section 26(2) and (3) of the Danish Electricity Supply Act, cf. Danish Executive Order No. 1248 of 24 October 2023, and pursuant to authorisation in section 7(1), no. 1 and 2 of Danish Executive Order No. 1358 of 24 November 2023 on transmission system operation and the use of the electricity transmission system etc., the following is stipulated:

Part 1
Scope and definitions

1. (1) This regulation lays down requirements for energy storage facilities that are connected to the electricity supply system as of the effective date of this regulation. The regulation applies to energy storage facilities that are connected independently or together with other electrical facilities. The requirements in the regulation apply both when the energy storage facility is in production mode and consumption mode, unless otherwise stated in the requirement. Compliance with the requirements is dependent on the availability of the energy storage facility's energy source. Energy storage facilities subject to the requirements of this regulation are listed in subsection (2) below, and include, but are not limited to, facilities that are connected to the distribution system or transmission system that:

a) store electrical energy reversibly and are operated in such a way that the frequency of the generated voltage, the rotational speed of the generator and the frequency in the electricity supply system are synchronised (synchronous energy storage facilities)
b) store electrical energy reversibly and are either non-synchronously connected to the electricity supply system or are connected using power electronics (non-synchronous energy storage facilities)
c) store electrical energy reversibly in electrically powered transport, including electric vehicles and ferries, where all of the following criteria are met:
    i. energy is stored via a charging station and an electrically powered transport unit that supports bi-directional charging (V2G),
    ii. energy is stored in the electrically powered transport,
    iii. the electrical energy is primarily used to propel the electrically powered transport,
    iv. conversion takes place either within the charging station or the electrically powered transport,
    v. the electrically powered transport is required to have a registration certificate through the relevant registration authority, and
    vi. the electrically powered transport is used to transport passengers and/or goods.

   When connecting electrically powered transport under this item (c), the requirements of this regulation must be observed by either the owner of the charging station or of the electrically powered transport, depending on where conversion takes place.

(2) Energy storage facilities covered by this regulation are facilities that meet all of the following requirements:

a) The design or characteristics of the facility allow for reversible electrical energy storage in a fixed installation, and the energy storage:
    i. postpones the final use of electricity to a time later than when the electricity was generated, and
    ii. converts electrical energy into a storable form, stores the energy, and later reconverts the energy into electrical energy.
b) The facility is not subject to the requirements in Commission Regulation (EU) 2016/631 of 14 April 2016 establishing a network code on requirements for grid connection of generators (NC RfG), Commission Regulation (EU) 2016/1388 of 17 August 2016 establishing a network code on demand connection (NC DC), and/or Commission Regulation (EU) 2016/1447 of 26 August 2016 establishing a network code on requirements for grid connection of high voltage direct current systems and direct current-connected power park modules (NC HVDC).
c) The facility has not been installed with the aim of providing emergency supply and operates in parallel with the electricity supply system for less than five minutes per calendar month when the system is in its normal state. Parallel operation in connection with maintenance or commissioning testing is not included in the five minutes.

(3) The following facilities are not covered by this regulation (not exhaustive):

a) Electrically powered transport for which the energy storage facility only supports charging,
b) Regenerative demand facilities, which are demand facilities with a system design and operating pattern that allow them to return an unspecified amount of energy to the connection point.

(4) Existing energy storage facilities are not subject to the requirements in this regulation, except in the following cases:

a) A type C or D energy storage facility connected to the distribution system is modified so extensively that its electrical and dynamic grid interaction is significantly changed. Before such a change may be made, the facility owner must follow the procedure below:
    i. Facility owners who wish to modify an energy storage facility or replace equipment that affects the electrical characteristics of the facility must notify the DSO in advance.
    ii. If the DSO deems the change or replacement of equipment to be significant, it must report the change to Energinet.
    iii. Energinet decides which requirements in this regulation will apply to the significantly modified facility.
b) An energy storage facility connected to the transmission system is modified so extensively that its electrical and dynamic grid interaction is significantly changed. Before the change is made, the following procedure must be followed:
    i. Facility owners who wish to modify an energy storage facility or replace equipment that affects the electrical characteristics of the facility must notify Energinet in advance.
    ii. If Energinet deems the change or replacement of equipment to be significant, it will decide which requirements of this regulation will apply to the significantly modified facility.

(5) An energy storage facility is considered to be 'existing' under this regulation if:

a) the facility is already connected to the electricity supply system and has been issued an ION by the relevant system operator at the time when this regulation enters into force, or
b) the facility owner has entered into a final and binding agreement for the purchase of a significant proportion of the energy storage facility and has notified and sent the agreement to Energinet no later than six months after this regulation enters into force. Energinet will then decide which requirements in this regulation will apply.

(6) Expenses incurred in complying with the provisions of this regulation must be paid by the given facility owner.

(7) Where matters in this regulation have to be agreed between the facility owner and the relevant system operator, an agreement must be sought within six months of the facility owner's request.

(8) Appendix 1 lists definitions used in this regulation.

2. (1) The requirements in this regulation are categorised for the following facility types based on the energy storage facility's P_n:

a) Type A is energy storage facilities up to 125 kW
b) Type B is energy storage facilities from and including 125 kW to 3 MW
c) Type C is energy storage facilities from and including 3 MW to 25 MW
d) Type D is energy storage facilities from and including 25 MW, or energy storage facilities connected at voltages above 110 kV.

(2) If the energy storage facility's P_{nl} and P_{no} do not result in the same facility type under subsection (1), the facility type will be determined in accordance with subsection (1) based on the energy storage facility's P_{nl}.

(3) All requirements must be assessed in relation to the energy storage facility's P_n. All requirements apply at the point of connection, unless otherwise stated in the given requirement.

Part 2

Type A energy storage facilities

Reporting facility information

3. (1) Owners of energy storage facilities must provide the following facility information to the relevant system operator:

a) The energy storage facility's P_{no} and P_{nl}
b) The usable energy storage capacity (kWh) for the storage medium used
c) The make of the storage medium used or, if this is not possible, a description of the storage medium
d) The model number of the storage medium used or, if this is not possible, a description of the storage medium, and
e) the CE declaration of conformity.

(2) Owners of energy storage facilities covered by section 1(1)(c) must provide the following facility information to the relevant system operator instead of the information in subsection (1) above:

a) The charging station's P_n, or if P_{no} and P_{nl} er asymmetric, the charging station's P_{no} and P_{nl}
b) The make of the charging station
c) The model number of the charging station

d) Whether the energy conversion takes place in the charging station or in the electrically powered transport

e) The CE declaration of conformity for the charging station.

(3) Energinet may stipulate that DSOs must submit the information specified in subsection (1) to Energinet in a format etc. specified by Energinet.

Single or multiphase connection

4. (1) Energy storage facilities must have a multiphase connection when either P_{no} or P_{nl} exceeds 3.68 kW ≈ 16 A.

(2) If the phase current of the energy storage facility exceeds 16 A, there must be an equal distribution of total power across two or three phases (see, however, section 14).

Normal frequency and voltage operating range – below 0.8 kW - connected at up to 1 kV

5. (1) Energy storage facilities smaller than 0.8 kW connected at up to 1 kV must be capable of continuous operation at voltages between 0.85-1.1 of U_n within the frequency, voltage, and time intervals specified in Table 1, Table 2 and Figure 1.

Frequency range [Hz]	Time [minutes]
49.0-51.0	Unlimited

Table 1 Normal frequency operating range – below 0.8 kW, connected at up to 1 kV.

Voltage range [U_n]	Time [minutes]
0.85/1.1	Unlimited

Table 2 Normal voltage operating range – below 0.8 kW, connected at up to 1 kV.

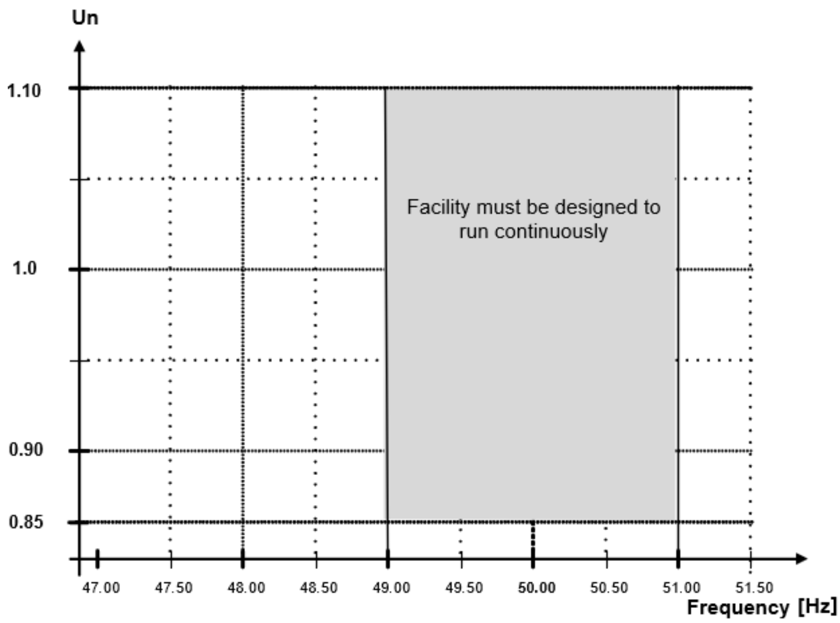


Figure 1 Normal frequency and voltage operating range – below 0.8 kW, connected at up to 1 kV.

6. (1) Energy storage facilities of 0.8 kW or larger connected at up to 1 kV must be capable of continuous operation at voltages between 0.85-1.1 of U_n within the frequency, voltage and time intervals specified in Table 3, Table 4 and Figure 2. However, total operation time below 49.0 Hz must not exceed 60 minutes.

Frequency range [Hz]	Time [minutes]
47.5-48.5	30
48.5-49.0	30
49.0-51.0	Unlimited
51.0-51.5	30

Table 3 Normal frequency operating range – 0.8 kW or larger, connected at up to 1 kV.

Voltage range [U_n]	Time [minutes]
0.85/1.1	Unlimited

Table 4 Normal voltage operating range – 0.8 kW or larger, connected at up to 1 kV.

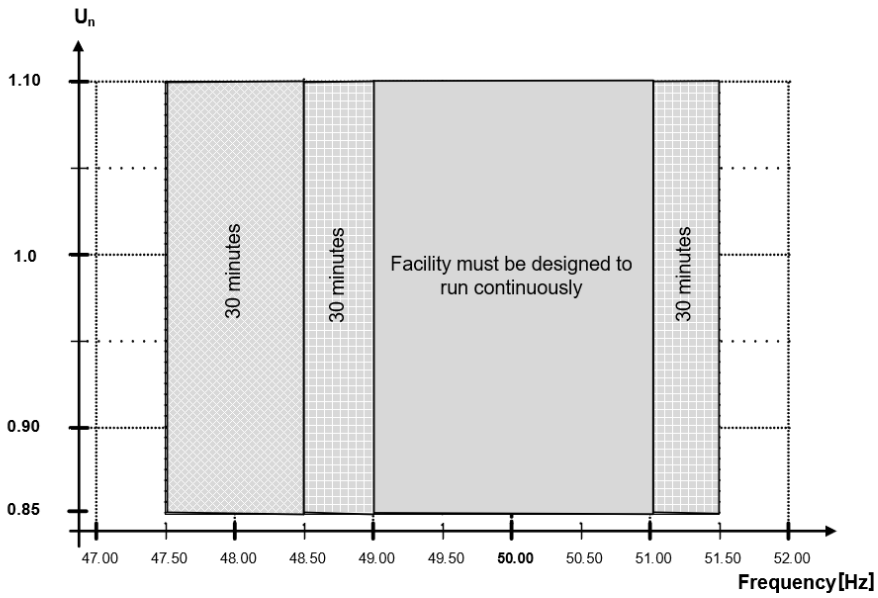


Figure 2 Normal frequency and voltage operating range – 0.8 kW or larger, connected at up to 1 kV.

Automatic closing or reclosing within FSM band – 0.8 kW or larger

7. (1) Energy storage facilities of 0.8 kW or larger may not reclose automatically until at least three minutes after the voltage has come within the tolerance range for the normal operating voltage, and the grid frequency is within the range indicated by f_1 and f_2 (Frequency Sensitive Mode, FSM) in Table 5 (the FSM band).

FSM band	DK1		DK2	
	f_1	f_2	f_1	f_2
Hz	49.80	50.20	49.50	50.50

Table 5 Automatic closing and reclosing within FSM band – 0.8 kW or larger

(2) Energy storage facilities of 0.8 kW or larger may not reclose automatically until at least three minutes after the voltage has come within the tolerance range for the normal operating voltage, and the grid frequency is within the range indicated by f_1 and f_2 in Table 5.

(3) Energy storage facilities covered by section 1(1)(c) are not subject to the three-minute delay requirement for automatic closing under subsection (1) above.

Active power gradient for automatic closing and reclosing – 0.8 kW or larger

8. (1) During automatic closing and reclosing, energy storage facilities of 0.8 kW or larger must set the active power gradient to 20% of P_n per min., subject to a maximum of 1 MW per second.

(2) The active power gradient for automatic closing and reclosing under subsection (1) must be set with:

a) a resolution for set points for active power of at least 1% of P_{nl} and P_{no}.

(3) The ramp rate requirement under subsection (1) above does not apply to the supply of ancillary services or the activation of a required technical property in the energy storage facility, including LFSM-U and LFSM-O.

Absolute power constraint function – 0.8 kW or larger

9. (1) An energy storage facility of 0.8 kW or larger must be equipped with absolute power limiting functions to limit active power, to ensure stable operation based on a selected operating point.

(2) It must be possible to set the absolute power limiting function under subsection (1) above so that:

a) any orders to change the set point are implemented within 10 seconds of receipt.

(3) The absolute power limiting function under subsection (1) above must be set with:

a) a precision for a completed or continuous adjustment not exceeding 2% of P_n, measured over a 1-minute period

b) a resolution for set points for active power of at least 1% of P_{nl} and P_{no}.

Phase jumps – 0.8 kW or larger

10. (1) Energy storage facilities of 0.8 kW or larger must be able to withstand transitory phase jumps of up to 20° in the point of connection without disconnecting from the point of connection and without shutting down.

Rate of Change of Frequency (RoCoF) – 0.8 kW or larger

11. (1) Energy storage facilities of 0.8 kW or larger must be able to withstand transient frequency gradients (RoCoF), calculated according to the method in Figure 3, of up to ±2 Hz/s in the point of connection, without disconnecting from the point of connection and without shutting down.

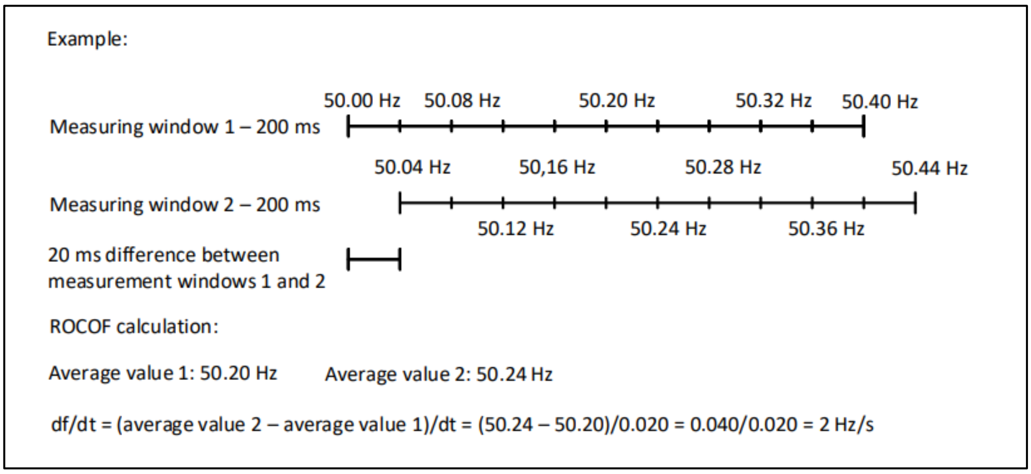


Figure 3 Method for calculating compliance with the RoCoF requirement – 0.8 kW or larger.

Permissible reduction in active power at underfrequency – 0.8 kW or larger

12. (1) Energy storage facilities of 0.8 kW or larger must maintain active power in the event of underfrequency, but where the frequency drops to 49 Hz or below, they may reduce active power linearly by up to 6% of P_n per Hz, as indicated by the shaded area in Figure 4.

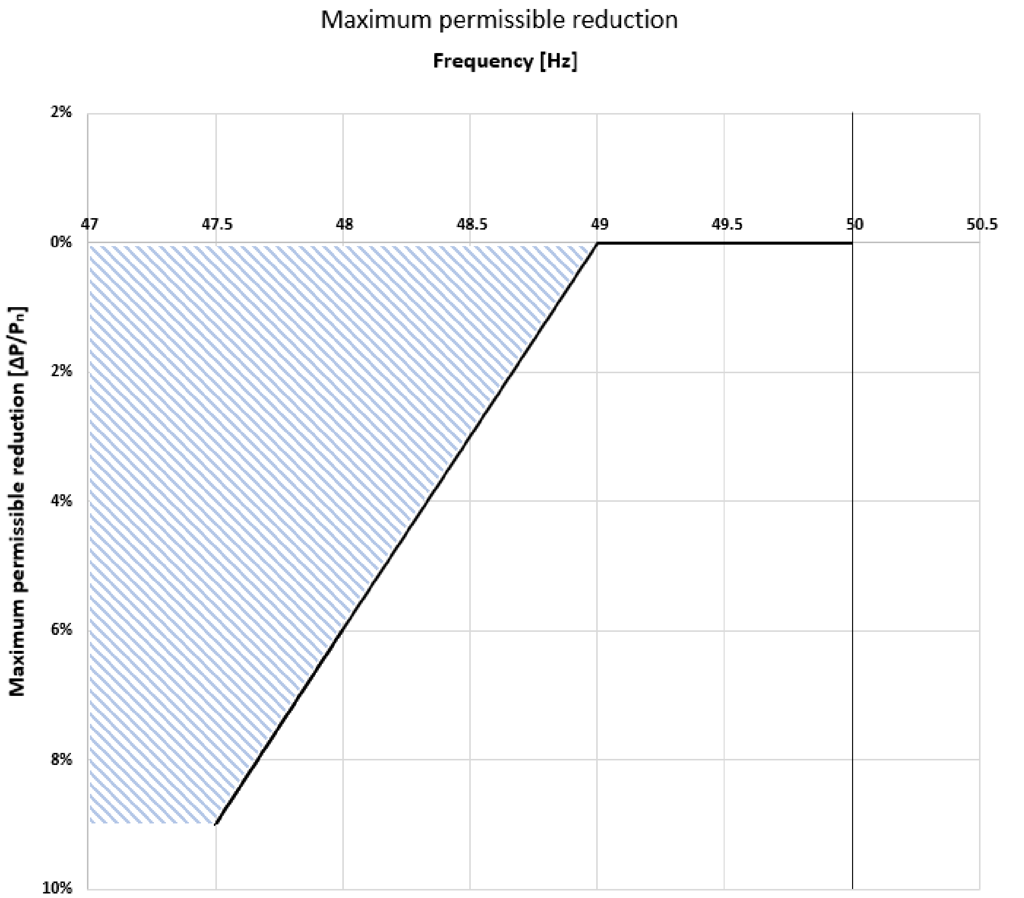


Figure 4 Permissible reduction in active power at underfrequency – 0.8 kW or larger.

Power quality

13. (1) Energy storage facilities connected to the distribution system must comply with the power quality requirements in sections 14-18. Energy storage facilities above 50 kW in size connected to the distribution system must comply with the requirements in sections 19-20 in addition to those in sections 14-18.

(2) The power quality requirements in sections 16-18 are deemed to be met if the energy storage units in an energy storage facility up to 50 kW meet the requirements specified in paragraphs (a) to (c) below:

a) the relevant product standards, and/or
b) for facilities up to 11 kW: DS/EN 61000-3-2 and DS/EN 61000-3-3, and/or
c) for facilities 11 kW or more in size: DS/EN 61000-3-11 and DS/EN 61000-3-12.

14. (1) Energy storage facilities connected to the distribution system must limit the injection of DC current into the distribution system to a value below 0.5% of the energy storage facility's nominal current.

(2) If the energy storage facility is connected through a facility transformer, the requirement in subsection (1) above is deemed to be met.

15. (1) Energy storage facilities connected at up to 1 kV, with P_n of up to 11 kW, must have a maximum current imbalance of 16 A between the three phases. Energy storage facilities connected at up to 1 kV, with P_n above 11 kW, must be balanced in relation to current on all three phases.

16. (1) Energy storage facilities connected to the distribution system must not cause rapid voltage changes greater than the limit value specified in Table 6.

	Limit value
U ≤ 33 kV	d (%) = 4 %
U > 33 kV	d (%) = 3 %

Table 6 Limit value for rapid voltage changes as a percentage of Un.

17. (1) Energy storage facilities connected to the distribution system must not contribute to flicker that exceeds the limit values for short-term and long-term flicker specified in Table 7.

	Short-term flicker (P_{st})	Long-term flicker (P_{lt})
U ≤ 1 kV	0.35/0.45/0.55*	0.25/0.30/0.40*
U > 1 kV	0.3	0.2
* The limit values apply if 4+/2/1 energy storage facilities and/or generation facilities, respectively, are already connected in the same substation.		

Table 7 Limit value for short-term and long-term flicker.

18. (1) An energy storage facility connected to the distribution system must not emit harmonic currents (I_h) higher than the limit values in Table 8 for the individual harmonics, which are stated as percentages of the energy storage facility's nominal current (I_n), i.e. I_h/I_n (%). The limit values depend on the short-circuit ratio (SCR) between the energy storage facility's S_n and the short-circuit power (S_k) in the energy storage facility's point of connection.

	SCR	Odd harmonic order h							Even harmonic order h					
		3	5	7	9	11	13	15	2	4	6	8	10	12
U ≤ 1 kV	<33	3.4	3.8	2.5	0.5	1.2	0.7	0.35	0.5	0.5	1.0	0.8	0.6	0.5
	≥33	3.5	4.1	2.7	0.5	1.3	0.7	0.37	0.5	0.5	1.0	0.8	0.6	0.5
	≥66	3.9	5.2	3.4	0.6	1.8	1.0	0.43	0.5	0.5	1.0	0.8	0.6	0.5
	≥120	4.6	7.1	4.6	0.8	2.5	1.5	0.5	0.5	0.5	1.0	0.8	0.6	0.5
	≥250	6.3	11.6	7.3	1.3	4.4	2.7	0.8	0.5	0.5	1.0	0.8	0.6	0.5
	≥350	7.5	15.0	9.5	1.6	5.7	3.7	1.0	0.5	0.5	1.0	0.8	0.6	0.5
U > 1 kV	-	3.4	3.8	2.5	0.5	1.2	0.7	0.35	0.5	0.5	1.0	0.8	0.6	0.5

Table 8 Limit values for harmonic currents Ih/In (% of In).

(2) In addition to the limit values for the individual harmonics, there are also limit values for the sum of all harmonics. Limit values for the total harmonic distortion (THD_I) and partial weighted harmonic distortion ($PWHD_I$) are specified in Table 9.

	SCR	THD_I	$PWHD_I$
U ≤ 1 kV	<33	4.4	4.4
	≥33	4.7	4.7
	≥66	6.1	6.1
	≥120	8.4	8.4
	≥250	13.8	13.8
	≥350	18.0	18.0
U > 1 kV	-	4.4	4.4

Table 9 Limit values for THDI and PWHDI in current (% of In).

19. (1) An energy storage facility connected to the distribution system must observe the limit values, specified in current, for all interharmonics specified in Table 10.

	SCR	Frequency (Hz)		
		75 Hz	125 Hz	> 175 Hz
U ≤ 1 kV	<33	0.4	0.6	$\frac{75}{f}*$
	≥33	0.5	0.7	$\frac{83}{f}*$
	≥66	0.6	0.8	$\frac{104}{f}*$
	≥120	0.7	1.1	$\frac{139}{f}*$
	≥250	1.2	1.8	$\frac{224}{f}*$
	≥350	1.5	2.3	$\frac{289}{f}*$
U > 1 kV	-	0.44	0.66	$\frac{83}{f}*$
	* However, not less than the measuring uncertainty.			

Table 10 Limit values for interharmonics in current (% of In).

(2) If harmonics have been measured with grouping activated (see measuring method), no separate requirements for interharmonics are stipulated, as these are included in the harmonics if so.

20. (1) Energy storage facilities connected to the distribution system must not exceed a limit value, specified in current, of 0.2% of I_n for all 200 Hz frequency groups in the 2-9 kHz range.

21. (1) The DSO must inform the facility owner of the amount of three-phase short-circuit power, $S_{k,\text{ power quality}} = \frac{S_{k,maks}+S_{k,min}}{2}$ and the related impedance angle (ψ_k) in the point of connection, which the facility owner must use for calculating power quality.

22. (1) Compliance with the power quality requirements can be verified by measurement or calculation.

(2) Power quality parameters must be measured in accordance with the European standard DS/EN 61000-4-30 (class A).

(3) Harmonic distortion of voltage and current must be measured as defined in IEC 61000-4-7, in line with the principles (harmonic subgroup) and with the precisions specified for class I.

(4) Interharmonic distortion up to 2 kHz must be measured as defined in IEC 61000-4-7 Annex A and must be measured as interharmonic subgroups.

(5) Alternatively, it is permitted to measure harmonic distortion up to 2 kHz with grouping activated (harmonic groups) as specified in IEC 61000-4-7 and with the precisions specified for class I. If harmonic distortion up to 2 kHz is measured with grouping activated, measuring interharmonic distortion up to 2 kHz separately is not required.

(6) Distortions in the 2-9 kHz range must be measured in accordance with IEC 61000-4-7 Annex B, and in 200 Hz windows with centre frequencies from 2100 Hz to 8900 Hz.

Limited Frequency Sensitive Mode – Overfrequency (LFSM-O) – 0.8 kW or larger

23. (1) Energy storage facilities must be able to provide frequency response in the event of overfrequency (Limited Frequency Sensitive Mode – Overfrequency, LFSM-O) by following the droop specified in Figure 5 (DK1) and Figure 6 (DK2). If frequency subsequently stabilises and drops, the droop must still be followed until system frequency is once again below the breakpoint for LFSM-O.

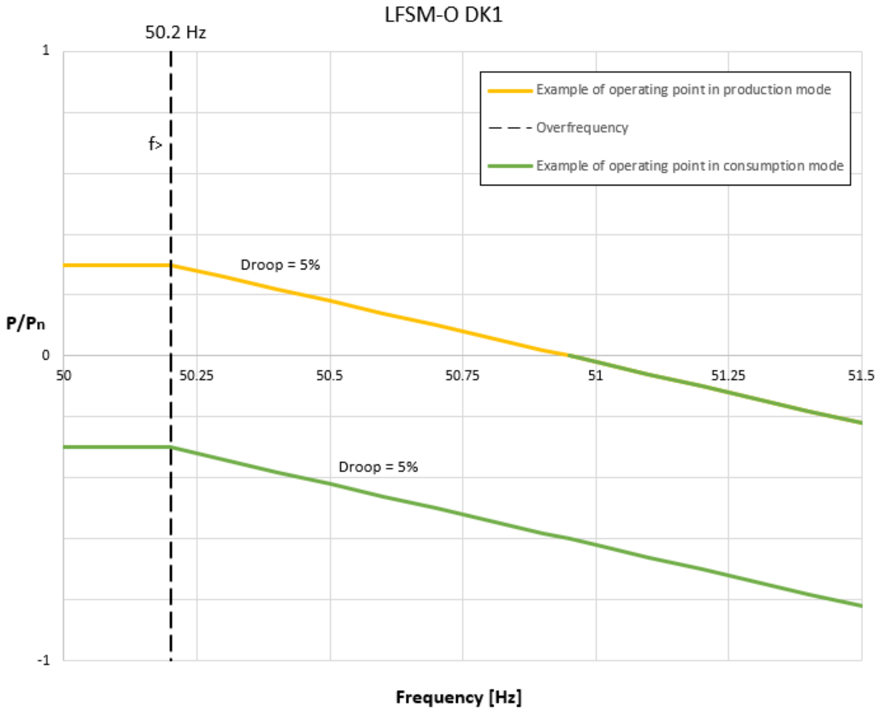


Figure 5 LFSM-O requirements for DK1 – 0.8 kW or larger.

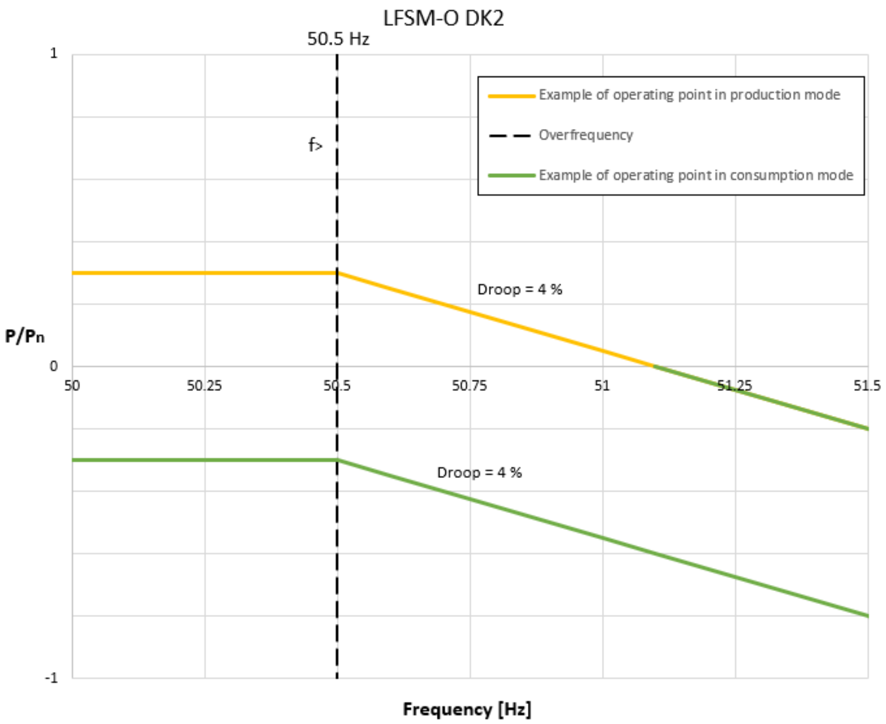


Figure 6 LFSM-O requirements for DK2 – 0.8 kW or larger.

(2) The LFSM-O function under subsection (1) above must:

a) be able to be set to any value in the 47.50-51.50 Hz range with a maximum resolution of 10 mHz

b) be set to 50.20 Hz for DK1 and 50.50 Hz for DK2, unless otherwise stipulated by Energinet

c) be set with a droop of 5% for DK1 and 4% for DK2

d) have a resolution for the droop of 1 percentage point, and it must be possible to set the droop in the 2-12% range
e) have a maximum control imprecision of 5% of P_n, where precision is measured over a period of more than 1 minute
f) have frequency measurement precision of 10 mHz or less
g) have control function sensitivity of 10 mHz or less
h) be commenced no later than 2 seconds after the frequency change is detected. If the initial activation of the frequency response for active power is longer than 2 seconds, technical documentation must be provided showing why more time is needed
i) be fully supplied within 30 seconds.

(3) Energy storage facilities connected to the distribution system must not commence downward adjustment of active power until 500 ms have elapsed, to allow detection of island operation.

(4) If the frequency change results in the energy storage facility changing power flow, the energy storage facility must follow the droop in the opposite power flow.

Protection

24. (1) Energy storage facilities must be equipped with protection to protect the energy storage facility and ensure stability in the electricity supply system.

(2) The protection under subsection (1) above must observe the following requirements:

a) Energy storage facilities that have cut out due to a fault in the electricity supply system must not reclose automatically until at least 3 minutes after the voltage and frequency have returned to the energy storage facility's normal operating range.
b) An energy storage facility which has been cut out by an external signal prior to a fault occurring in the electricity supply system must not be energised until the external signal is no longer active, and voltage and frequency are once again within the energy storage facility's normal operating range.
c) In addition to relay protection, the energy storage facility must have protection specifically aimed at internal faults in the energy storage facility or installation, including short-circuits etc. The protection must not cut out the energy storage facility in case of short circuits or rerouting in the electricity supply system.
d) In case of internal faults in the energy storage facility, the energy storage facility's protection must be selective with the grid protection. Short circuits in energy storage facilities connected to the distribution system must trip within 100 milliseconds.

(3) The DSO or Energinet may require changes to the settings for protection functions after the energy storage facility is in operation. The changes must not exceed the energy storage facility's design requirements.

(4) At the facility owner's request, the DSO or Energinet must state the highest and lowest short-circuit current that can be expected in the point of connection, as well as any other information about the electricity supply system that is necessary to set the energy storage facility's protection functions.

25. (1) Energy storage facilities must comply with the following requirements for protection functions and associated settings:

a) The energy storage facility's protection and associated settings and trip time are specified in Table 11 (stated as RMS values):

Protection function	Symbol	Setting		Trip time
Overvoltage (step 2)	$U_{>>}$	$1.15 \cdot U_n$	V	200 ms
Overvoltage (step 1)	$U_{>}$	$1.10 \cdot U_n$	V	60 s
Undervoltage (step 1)	$U_{<}$	$0.85 \cdot U_n$	V	50 s
Undervoltage (step 2)	$U_{<<}$	$0.80 \cdot U_n$	V	200 ms
Overfrequency	$f_{>}$	51.5	Hz	200 ms
Underfrequency	$f_{<}$	47.5	Hz	200 ms
Frequency change	df/dt	±2.5	Hz/s	80 ms

Table 11 Requirements for protection functions and associated settings.

b) The energy storage facility may implement the functions for both undervoltage (step 2) and frequency change, but must implement at least one of the functions.
c) Compliance with the RoCoF requirement under section 11 takes precedence over the frequency change protection requirement (df/dt, ±2.5 Hz/s, 80 ms). Compliance with the frequency change protection requirement is calculated using the method in section 11.
d) The trip time stated is the measuring period during which the trip condition must constantly be met before the protection function can release a trip signal.
e) The use of vector jump relays as protection against island operation/loss of mains is not allowed.
f) If voltage is measured on the high-voltage side, the setting value must be determined by converting nominal voltage on the low-voltage side to the high-voltage side of the facility transformer.
g) Voltage and frequency must be measured for all three phases as line-to-line voltage in multi-phase facilities. Alternatively, if the measuring point is located on the low-voltage side of the facility transformer, voltage can be measured between the three phases and ground. Frequency must be measured simultaneously on all three phases.
h) For single-phase connections, voltage is measured between phase and zero. Frequency is measured on the phase being used.
i) The relevant system operator must approve the defined relay settings.

(2) The DSO and/or Energinet may allow settings to be used that deviate from the setting values specified in Table 11.

Order of priority for protection and control functions

26. (1) Energy storage facilities must prioritise protection and control functions in the following order:

a) protection of the grid and energy storage facility
b) synthetic inertia, where relevant
c) frequency control (adjustment of active power)
d) power constraint and
e) power gradient constraint.

Information exchange

27. (1) Energy storage facilities 0.8 kW or larger must exchange signals in PCOM as specified in Table 12:

Stop signal
Hold signal

Table 12 Signal list – 0.8 kW or larger.

(2) The energy storage facility must be equipped with a logic interface (input port) so it can respond to a command received via the input port. The relevant system operator is entitled to set requirements for the equipment so that this function can be controlled remotely.

(3) The relevant system operator determines the location of PCOM, and the information exchange must be available to the relevant system operator in PCOM.

28. (1) Energy storage facilities must comply with the information exchange requirements in this regulation until regulations 5.8.10 and 5.8.12 are approved and replace these requirements.

29. (1) If the energy storage facility is established and connected with online communication in PCOM, and if the communication equipment is replaced, the facility owner must establish communication equipment for the exchange of real-time data in line with the IEC 61850 standard.

(2) If relevant security requirements are met, the plant owner may make the same PCOM available to the DSO, Energinet, the balance-responsible party and other parties relevant to the facility owner.

Part 3
Energy storage facilities of type B

30. (1) Type B energy storage facilities must meet the requirements in Part 2 and this Part 3, with the exception of:

a) protection settings and trip times in section 25(1)(a) and (b)
b) the communication interface requirements in section 27(2).

Normal operating range for frequencies and voltages when connected to the distribution system at above 1 kV

31. (1) Energy storage facilities connected to the distribution system at above 1 kV must be capable of continuous operation at voltages between 0.9-1.1 of U_n within the frequency, voltage and time ranges specified in Table 13, Table 14 and Figure 7. However, total operation time below 49.0 Hz must not exceed 60 minutes.

Frequency range [Hz]	Time [minutes]
47.5-48.5	30
48.5-49.0	30
49.0-51.0	Unlimited
51.0-51.5	30

Table 13 Normal frequency operating range – connected at above 1 kV.

Voltage range [U_c]	Time [minutes]
0.9-1.1	Unlimited

Table 14 Normal voltage operating range – connected at above 1 kV.

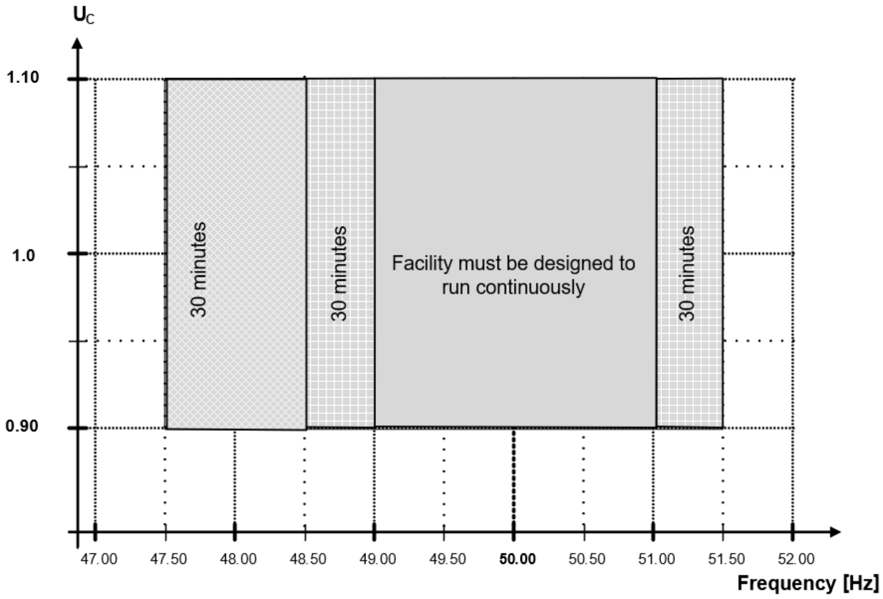


Figure 7 Normal operating range for frequency and voltage – connected at above 1 kV.

Ramp rate constraint function

32. (1) The energy storage facility must be equipped with a ramp rate constraint function that can be used for both upward and downward adjustment of active power and can be set to any value within the ramp rate ranges specified in Table 15.

Minimum [%/min]	1
Maximum [%/min]	20
Maximum [MW/s]	1

Table 15 Ramp rate constraint.

(2) The energy storage facility must normally apply the maximum gradient under subsection (1) unless the relevant system operator stipulates a lower gradient.

(3) The ramp rate requirement under subsection (1) above does not apply to the supply of ancillary services or the activation of a required technical property in the energy storage facility.

Overvoltage Fault-Ride-Through (OV-FRT)

33. (1) Energy storage facilities connected to the distribution system must be able to withstand a voltage rise in the point of connection without disconnecting (OV-FRT), as specified in Table 16:

Voltage	Duration [s]
1.15 * U_c	60
1.20 * U_c	5

Table 16 Requirements for OV-FRT.

Exchange and control of reactive power

34. (1) The energy storage facility must be able to exchange reactive power with the electricity supply system. The relevant system operator decides which of the control functions in this regulation must be activated, and the specific settings for the activated control function.

Q control

35. (1) The energy storage facility must be able to exchange a fixed reactive power with the electricity supply system (Q control).

(2) It must be possible to adjust the Q control under subsection (1) above such that:

a) orders to change the set point can be applied within 2 seconds of receipt
b) adjustment to a new set point begins within 2 seconds of receiving an order to change the set point
c) adjustment to a new set point is complete within 30 seconds of receiving an order to change the set point.

(3) The Q control under subsection (1) above must be adjustable with:

a) a maximum imprecision of ±2% of the energy storage facility's S_n, where precision is measured over a period of more than 1 minute, and
b) a resolution of 1% of the energy storage facility's S_n or better.

(4) If the production of active power is less than 10% of the energy storage facility's S_n, the control imprecision under subsection (3)(a) above may exceed ±2% of the energy storage facility's S_n. However, the exchange of uncontrolled reactive power must not exceed 10% of the energy storage facility's S_n in this case.

Power factor control

36. (1) Energy storage facilities must be able to control active and reactive power with the electricity supply system with a fixed power factor (power factor control).

(2) It must be possible to adjust the power factor control under subsection (1) above such that:

a) orders to change the set point can be applied within 2 seconds of receipt
b) adjustment to a new set point begins within 2 seconds of receiving an order to change the set point
c) adjustment to a new set point is complete within 30 seconds of receiving an order to change the set point.

(3) The Q control under subsection (1) above must be adjustable with:

a) a maximum imprecision of ±2% of the energy storage facility's S_n, where precision is measured over a period of more than 1 minute, and
b) a resolution of 0.01 or better.

(4) If the production of active power is less than 10% of the energy storage facility's S_n, the control imprecision under subsection (3)(a) above may exceed ±2% of the energy storage facility's S_n. However, the exchange of uncontrolled reactive power must not exceed 10% of the energy storage facility's S_n in this case.

Automatic power factor control (production mode)

37. (1) In production mode, the energy storage facility must be able to automatically activate and deactivate the Q control and power factor control functions at voltage levels in the voltage reference point as determined by the relevant system operator. Adjustment to reactive power must be complete within 10 seconds after the active power has stabilised.

(2) Unless specified otherwise by the relevant system operator, the default settings for automatic power factor control specified in Table 17 are used with the following setting levels:

a) Energy storage facilities connected at up to 1 kV are set with an activation level for the function of 105% of U_n and a deactivation level of 100% of U_n.
b) Energy storage facilities connected at above 1 kV are set with an activation level for the function of 105% of U_c and a deactivation level of 100% of U_c.

Point	P/P_{nl}	Power factor
1	0.0	1.0
2	0.5	1.0
3	1	0.9 in

Table 17 Default setting for automatic power factor control.

Supply of reactive power with units out for service or in case of breakdowns

38. (1) If one or more units in an energy storage facility are out for service or in the event of a breakdown, the energy storage facility's supply of reactive power may be reduced, pro rata, in proportion to the number of units that are out of operation.

Protection

39. (1) Requirements for the energy storage facility's protection and associated settings and trip time are specified in Table 18 for connection at up to 1 kV and in Table 19 for connection at above 1kV (stated as RMS values):

Protection function	Symbol	Setting		Trip time
Overvoltage (step 2)	$U_{>>}$	$1.15 \cdot U_n$	V	200 ms
Overvoltage (step 1)	$U_{>}$	$1.10 \cdot U_n$	V	60 s
Undervoltage (step 1)	$U_{<}$	$0.85 \cdot U_n$	V	60 s
Overfrequency	$f_{>}$	51.5	Hz	200 ms
Underfrequency	$f_{<}$	47.5	Hz	200 ms
Frequency change	df/dt	±2.5	Hz/s	80 ms

Table 18 Requirements for protection functions and associated settings – connected at up to 1 kV.

Protection function	Symbol	Setting		Trip time
Overvoltage (step 2)	$U_{>>}$	$1.15 \cdot U_c$	V	200 ms
Overvoltage (step 1)	$U_{>}$	$1.10 \cdot U_c$	V	60 s
Undervoltage (step 1)	$U_{<}$	$0.90 \cdot U_c$	V	60 s
Overfrequency	$f_{>}$	51.5	Hz	200 ms
Underfrequency	$f_{<}$	47.5	Hz	200 ms
Frequency change	df/dt	±2.5	Hz/s	80 ms

Table 19 Requirements for protection functions and associated settings – connected at above 1 kV.

(2) The DSO and/or Energinet may allow settings to be used that deviate from the setting values specified in Table 18 and Table 19.

Power quality

40. (1) An energy storage facility connected at above 1 kV must be balanced three-phase so that the energy storage facility does not cause voltage unbalances.

Control and regulation – 1 MW or larger

41. (1) Energy storage facilities 1 MW or larger must record all set point changes and the order issuer. Records must be kept for at least the last 100 changes and for at least three months. Upon request, the relevant system operator must be granted access to logged and relevant recorded information in COMTRADE format.

42. (1) Energy storage facilities 1 MW or larger must timestamp all set point changes or orders for operational changes with a precision of 10 ms or less and with reference to UTC.

Information exchange

43. (1) In addition to the signals in section 27(1) above, energy storage facilities 1 MW or larger must be set up to exchange the following signals in PCOM:

Grid connection circuit breaker/switch gear status in the facility's point of connection
Energy storage circuit breaker (switch gear status in the energy storage's point of connection – the relevant system operator decides whether to exchange the signal).
Active power kW (measured in the point of connection)
Active power control (absolute constraint)
Active power control (requisite maximum active power in production mode)
Active power control (requisite maximum active power in consumption mode)
Active power control (current measured in point of connection)
Reactive power control (MVAr measured in point of connection)
Reactive power control (activated/deactivated)
Reactive power control (requisite MVAr in point of connection)
Power factor control (cos (phi) measured in point of connection)
Power factor control (activated/deactivated)
Power factor control (requisite cos (phi) in point of connection)

Table 20 Signal list – 1 MW or larger.

(2) Energy storage facilities 1 MW or larger must be set up for online communication and able to exchange information with the relevant system operator and/or Energinet in real time or periodically, with timestamps as determined by the relevant system operator or Energinet.

(3) Timestamps must refer to UTC with a 10 millisecond resolution and ±1 millisecond accuracy or higher.

(4) Energy storage facilities must meet the following precision requirements:

Measurement category	Overall precision	Smallest measurement range
MW	1.0 %	Possible Operating range
MVAr	2.0%	Possible Operating range
Other measurements	1.5 %	

Table 21 Requirements for measurement precision.

44. (1) Type B energy storage facilities, 1 MW or larger, connected to the distribution system, must exchange data with the DSO and Energinet via the DSO, or temporarily – by agreement with the DSO – directly to Energinet.

45. (1) Type B energy storage facilities, 1 MW or larger, starting production or consumption after 1 January 2026 must set up communication equipment for the exchange of real-time data in line with the IEC 61850 standard.

(2) Energinet may set a longer deadline for implementation of the IEC 61850 standard, in part to ensure that the deadline is consistent with the deadline set in the transition scheme in regulation 5.8.12.

Part 4
Energy storage facilities of type C

46. (1) Type C energy storage facilities must meet the requirements in Parts 2 and 3 and in this Part 4, with the exception of:

a) normal frequency and voltage operating range up to and including 1 kV in section 5 above
b) protection settings and trip times in section 25(1)(a) and (b) and section 39
c) current imbalance in section 15
d) flicker contribution in section 17
e) harmonics in section 18
f) interharmonics in section 19
g) distortions in the 2-9 kHz range in section 20
h) the communication interface requirements in section 27(2)
i) Q control in section 35
j) power factor control in section 36
k) automatic power factor control in section 37
l) transition scheme for information exchange requirements in section 45.

Power quality

47. (1) Energy storage facilities must observe the flicker limit values set by the relevant system operator.

48. (1) Energy storage facilities must observe the voltage limit values for emission of harmonics set by the relevant system operator.

49. (1) Energy storage facilities must observe the voltage limit values for interharmonics set by the relevant system operator.

50. (1) Energy storage facilities must observe the voltage limit values for distortions in the 2-9 kHz frequency range set by the relevant system operator.

51. (1) The DSO and Energinet must jointly assess whether an energy storage facility has a significant impact on the electricity supply system.

(2) If an energy storage facility has a significant impact on the electricity supply system in line with subsection (1) above:

a) the relevant system operator supplies frequency-dependent impedance characteristics for the calculation of power quality

b) the facility owner provides a harmonic simulation model of the energy storage facility in line with the relevant requirements in NC RfG, which must be approved by Energinet.

Limited Frequency Sensitive Mode – Underfrequency (LFSM-U)

52. (1) Energy storage facilities must be able to provide frequency response in the event of underfrequency (Limited Frequency Sensitive Mode – Underfrequency, LFSM-U) by following the droop in Figure 8 (DK1) and Figure 9 (DK2). If frequency subsequently stabilises and rises, the droop must still be followed until system frequency is once again above the breakpoint for LFSM-U.

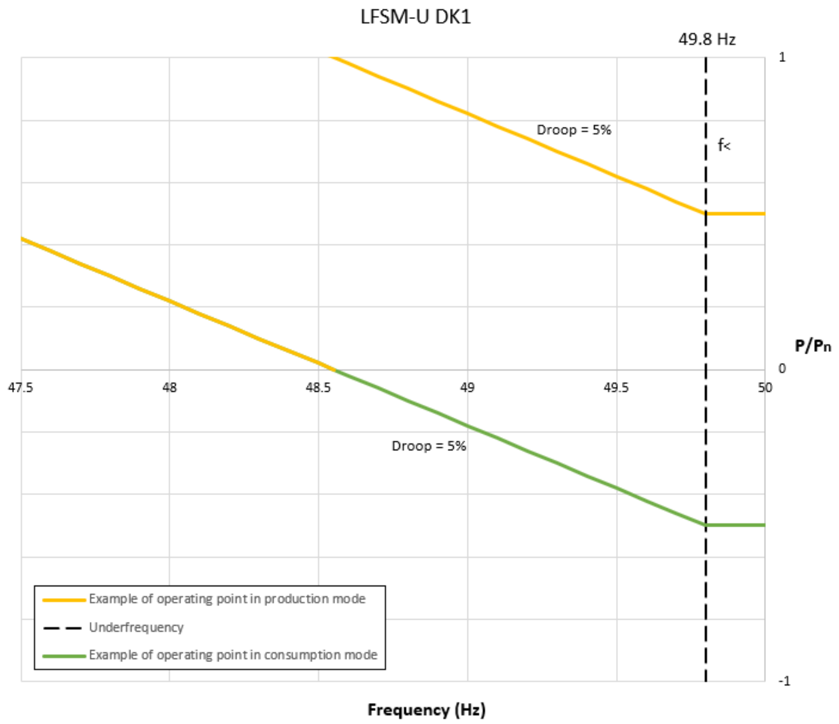


Figure 8 Requirements for LFSM-U for DK1.

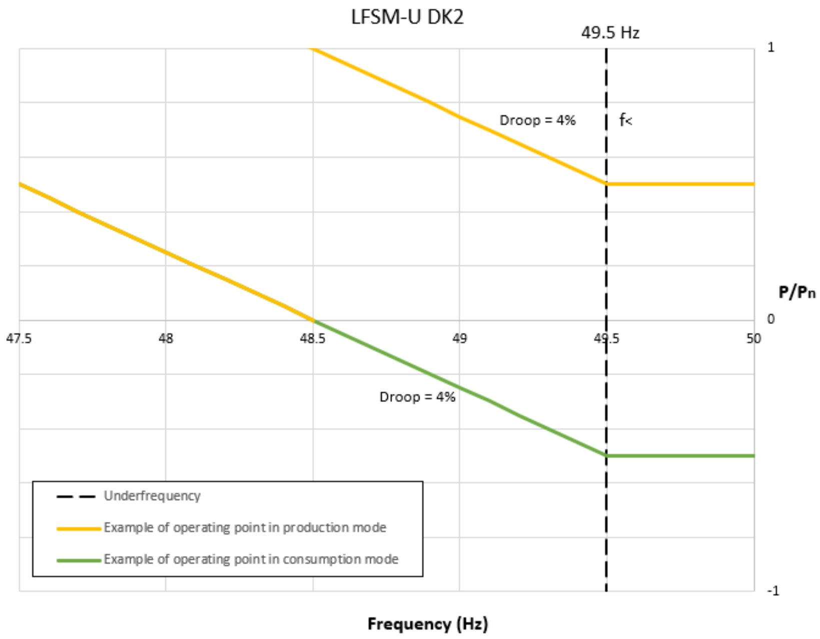


Figure 9 Requirements for LFSM-U for DK2.

(2) The LFSM-U function under subsection (1) above must:

a) be able to be set to any value in the 47.50-51.50 Hz range with a maximum resolution of 10 mHz

b) be set to 49.80 Hz for DK1 and 49.50 Hz for DK2, unless otherwise specifically stipulated by Energinet

c) be set with a droop of 5% for DK1 and 4% for DK2

d) have a resolution for the droop of 1 percentage point, and it must be possible to set the droop in the 2-12% range

e) have a maximum control imprecision of 5% of P_n, where precision is measured over a period of more 1 minute

f) have frequency measurement precision of 10 mHz or less

g) have control function sensitivity of 10 mHz or less

h) be commenced no later than 2 seconds after the frequency change is detected. If the initial activation of the frequency response for active power is longer than 2 seconds, technical documentation must be provided showing why more time is needed

i) be fully supplied within 30 seconds.

(3) Energy storage facilities connected to the distribution system must not commence downward adjustment of active power until 500 ms have elapsed, to allow detection of island operation.

(4) If the frequency change results in the energy storage facility changing power flow, the energy storage facility must follow the droop in the opposite power flow.

(5) In case of underfrequency, energy storage facilities which cannot reverse their state from consumption mode to production mode must disconnect from the electricity supply system as specified in Table 1.

	DK1	DK2
Hz	49.00	48.80

Table 22 Frequency for plants which cannot reverse mode to disconnect.

Frequency Sensitivity Mode (FSM)

53. (1) In the event of frequency deviations in the electricity supply system, energy storage facilities must have control functions that can provide frequency control to stabilise the frequency (Frequency Sensitivity Mode, FSM), depending on the synchronous area, as specified in Table 23:

FSM band	DK1		DK2	
	f_1	f_2	f_1	f_2
Hz	49.80	50.20	49.50	50.50

Table 23 FSM band.

(2) The FSM control function under subsection (1) above must:

a) be able to set the range for active power from 1.5% to 10% as a minimum
b) have a resolution for the droop of 1 percentage point, and it must be possible to set the droop in the 2-12% range
c) have a sensitivity of 10 mHz or less.

Reactive power in facility infrastructure

54. (1) The facility owner must compensate for the facility infrastructure's reactive power in situations where the electricity storage facility is disconnected or is not producing or consuming active power.

(2) The facility owner may arrange with the relevant system operator that compensation for the facility infrastructure's reactive power under subsection (1) above takes place in the electricity supply system.

Q control

55. (1) Energy storage facilities must be able to supply and absorb a fixed level of reactive power in the point of connection (Q control).

(2) It must be possible to adjust the Q control under subsection (1) above such that:

a) orders to change the set point can be applied within 2 seconds of receipt
b) adjustment to a new set point begins within 2 seconds of receiving an order to change the set point
c) adjustment to a new set point is complete within 30 seconds of receiving an order to change the set point.

(3) The Q control under subsection (1) above must be adjustable with:

a) a maximum imprecision of ±3% of the energy storage facility's Q_n, where precision is measured over a period of 1 minute, and
b) a step resolution of 100 kvar or better.

Power factor control

56. (1) Energy storage facilities must be able to supply and absorb active and reactive power with a power factor in the point of connection (power factor control).

(2) It must be possible to adjust the power factor control under subsection (1) above such that:

a) orders to change the set point can be applied within 2 seconds of receipt
b) adjustment to a new set point begins within 2 seconds of receiving an order to change the set point

c) adjustment to a new set point is complete within 30 seconds of receiving an order to change the set point.

(3) The power Factor control under subsection (1) above must be adjustable with:

a) a maximum imprecision of ±3% of the energy storage facility's Q_n, where precision is measured over a period of 1 minute, and
b) a resolution of 0.01 or better.

Voltage control

57. (1) The energy storage facility must be able to supply and absorb reactive power and thereby maintain a stable and constant voltage in the point of connection (voltage control).

(2) Voltage control in line with subsection (1) above must be able to effect 90% of the set point change within 1 second, and the remaining 10% (up to 100%) within 5 seconds of receiving an order to change the set point. The voltage control must be set with:

a) a maximum imprecision of ±3% of the energy storage facility's Q_n, where precision is measured over a period of 1 minute
b) a resolution for droop of 0.5% or better. It must be possible to set the droop in the 2-7% range
c) a step size for the dead band that can be set in the range ±5% of U_{ref} with a step size not exceeding 0.5% of U_{ref}, and must be symmetrical around the set point for voltage control
d) a set point decided by the relevant system operator within the normal operating voltage range.

System protection

58. (1) Energy storage facilities must be equipped with system protection which can adjust the facility's active power to predefined set points decided by the relevant system operator during commissioning.

(2) The system protection must adjust the energy storage facility's active power to one or more predefined set points in both production and consumption mode, in response to an order received from the relevant system operator, Energinet or an autonomous signal from one or more relays installed in the electricity supply system.

(3) The energy storage facility must have at least five configurable control levels in both production and consumption mode, which are set to the following levels, unless specified otherwise by the relevant system operator:

a) 70% of nominal power
b) 50% of nominal power
c) 40% of nominal power
d) 10% of nominal power
e) 0% of nominal power, without being disconnected from the electricity supply system.

(4) Control in line with subsection (3) above must:

a) begin within 1 second, and
b) be fully effected within 10 seconds.

(5) The precision for a completed or continuous adjustment must not deviate by more than 1% of the set point, measured over a period of 1 minute.

Protection

59. (1) Requirements for the energy storage facility's protection and associated settings and trip time are specified in Table 24 (stated as RMS values).

Protection function	Symbol	Setting		Trip time
Overvoltage (step 3)	$U_{>>>}$	$1.20 \cdot U_c$	V	100 ms
Overvoltage (step 2)	$U_{>>}$	$1.15 \cdot U_c$	V	200 ms
Overvoltage (step 1)	$U_{>}$	$1.10 \cdot U_c$	V	60 s
Undervoltage (step 1)	$U_{<}$	$0.90 \cdot U_c$	V	60 s
Overfrequency	$f_{>}$	51.5	Hz	200 ms
Underfrequency	$f_{<}$	47.5	Hz	200 ms
Frequency change	df/dt	±2.5	Hz/s	80 ms

Table 24 Requirements for protection functions and associated settings.

(2) The DSO and/or Energinet may allow settings to be used that deviate from the setting values specified in Table 24.

Information exchange

60. (1) In addition to the signals in sections 26(1) and 38 above, energy storage facilities must be set up to exchange the following signals in PCOM:

Planned active power (shows current set point) in both production and consumption mode
Voltage measured in point of connection
Voltage control (activated/deactivated)
Droop for voltage control
Requisite voltage in voltage reference point
System protection

Table 25 Signal list.

(4) In addition to the requirements in section 43(4), energy storage facilities must meet the following precision requirements:

Measurement category	Overall precision	Smallest measurement range
kV	1.0 %	0-120 %

Table 26 Requirements for measurement precision.

61. (1) Type C energy storage facilities starting production or consumption after 1 January 2026 must set up communication equipment for the exchange of real-time data in line with the IEC 61850 standard.

(2) Energinet may set a longer deadline for implementation of the IEC 61850 standard, in part to ensure that the deadline is consistent with the deadline set in the transition scheme in regulation 5.8.12.

Fault incident recording (Transient Fault Recorder, TFR)

62. (1) Logging must be performed using electronic equipment that can be configured, as a minimum, to log relevant incidents for the signals below in the point of connection in the event of faults in the electricity supply system and connected facilities.

(2) The facility owner must install logging equipment capable of recording (as a minimum):

a) voltage for each phase for the facility
b) current for each phase for the facility
c) active power for the facility (can be computed value)
d) reactive power for the facility (can be computed value)
e) frequency for the plant (can be computed value and can be rotor speed (synchronous generator))
f) activation of internal protection functions.

(3) Specific requirements for measurement, including logging initiation, can be described in the grid connection agreement.

(4) Logging must be performed as a cohesive time series of measured values, specifying the time before (-) and after (+) the incident.

(5) Incident logging is differentiated based on the facility's nominal power.

(6) The following logs/files must be supplied upon request. However, fast scan only has to log voltages and currents:

Nominal power [MW]	Time series [s]	Type	Sample frequency
3 ≤ P < 10	-10 to +60	Slow scan	50 Hz, RMS values
10 ≤ P < 25	-10 to +60	Slow scan	50 Hz, RMS values
10 ≤ P < 25	-0.25 to +2.75	Fast scan	Minimum 1 kHz
P ≥ 25	-10 to +60	Slow scan	50 Hz, RMS values
P ≥ 25	-3 to +60	Fast scan	Minimum 1 kHz

Table 27 Logging requirements.

(7) All measurements and data to be collected must be logged with a timestamp and an accuracy ensuring that such measurements and data can be correlated with each other and with similar recordings in the electricity supply system.

(8) Timestamps for incidents and data must refer to UTC with a 10-millisecond accuracy or higher.

(9) Logs must be filed for at least three months from the time of the fault situation, up to a maximum of 100 incidents.

(10) The relevant DSO and/or Energinet must be granted access to logged and relevant recorded information upon request. The relevant system operator and/or Energinet specify which measurements and calculations must be exchanged.

Part 5

Energy storage facilities of type D

63. (1) Type D energy storage facilities must meet the requirements in Parts 2, 3 and 4 and in this Part 5, with the exception of:

a) normal frequency and voltage operating range, connected at up to 1 kV, in section 5 above
b) requirements for automatic reconnection in section 7(2)
c) protection settings and trip times in section 25(1)(a) and (b) and section 39
d) current imbalance in section 15
e) flicker contribution in section 17
f) harmonics in section 18
g) interharmonics in section 19
h) distortions in the 2-9 kHz range in section 20

i) the communication interface requirements in section 27(2)
j) Q control in section 35
k) power factor control in section 36
l) automatic power factor control in section 37
m) transition scheme for information exchange requirements in sections 45 and 61.

Permission to reclose

64. (1) Energy storage facilities must not automatically reclose unless the relevant system operator has authorised this. Automatic closing or reclosing is only permitted within the range specified in Table 5. The relevant system operator decides the specific conditions of authorisation.

Information exchange

65. (1) In addition to the signals in sections 27(1), 43 and 60 above, energy storage facilities must be set up to exchange the following signals in PCOM:

Possible active power control properties – up
Possible active power control properties – down
Possible reactive power control properties – up
Possible reactive power control properties – down

Table 28 Signal list.

(2) Energy storage facilities must meet the following precision requirements:

Measurement category	Overall precision	Smallest measurement range
MW	0.5%	Possible Operating range
MVAr	1.0 %	Possible Operating range
kV	0.5%	0-120 %

Table 29 Requirements for measurement precision.

Transition scheme for type D energy storage facilities

66. (1) Type D energy storage facilities connected to the distribution system, starting production after 1 January 2026 must set up communication equipment for the exchange of real-time data in line with the IEC 61850 standard.

(2) Energinet may set a longer deadline for implementation of the IEC 61850 standard, in part to ensure that the deadline is consistent with the deadline set in the transition scheme in regulation 5.8.12.

Part 6
Energy storage facilities connected to the transmission system

67. (1) Energy storage facilities which are connected to the transmission system must meet the requirements in Parts 2, 3, 4 and 5 and in this Part 6, with the exception of:

a) normal frequency and voltage operating range in sections 5 and 31 above
b) requirements for automatic reconnection in section 7(2)
c) protection settings and trip times in section 25(1)(a) and (b) and section 39
d) the power quality requirements in sections 13-22 and 47-51

e) the communication interface requirements in section 27(2)
f) Q control, power factor control and automatic power factor control functions in sections 35-37
g) Q control, power factor control and voltage control functions in sections 55-57.

Normal operating range for frequencies and voltages when connected at 110-300 kV in DK1

68. (1) Energy storage facilities connected at 110-300 kV in DK1 must be able to continuously operate at voltages and frequencies specified in Table 30, Table 31 and Figure 10. However, total operation time below 49.0 Hz must not exceed 60 minutes.

Frequency range [Hz]	Time [minutes]
47.5-48.5	30
48.5-49.0	30
49.0-51.0	Unlimited
51.0-51.5	30

Table 30 Normal operating range for frequencies when connected at 110-300 kV in DK1.

Voltage range [pu]	Time [minutes]
0.85-0.9	60
0.9-1.118	Unlimited
1.118-1.15	60

Table 31 Normal operating range for voltages when connected at 110-300 kV in DK1.

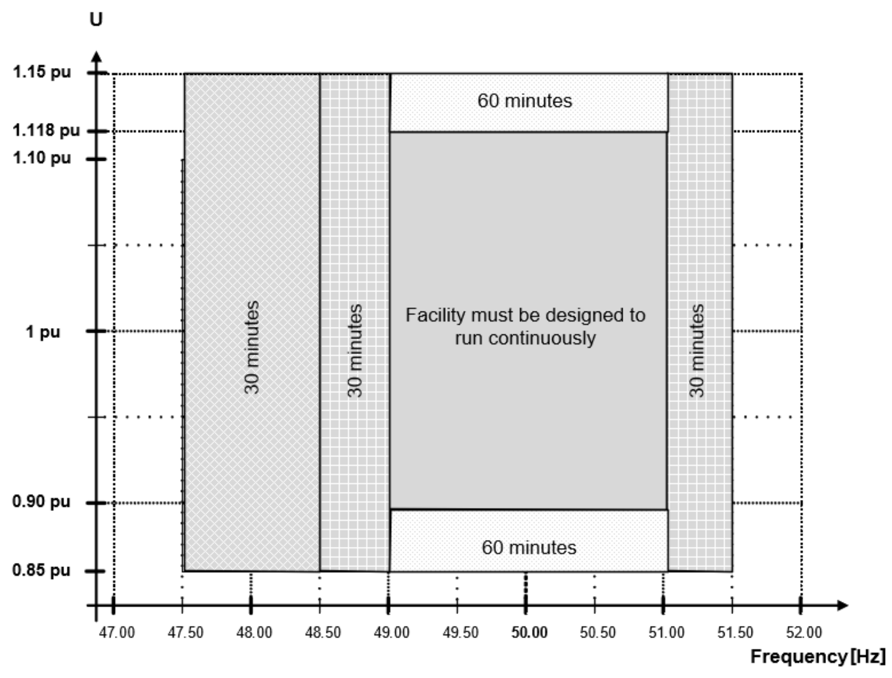


Figure 10 Normal operating range for frequencies and voltages when connected at 110-300 kV in DK1.

Normal operating range for frequencies and voltages when connected at above 300 kV in DK1

69. (1) Energy storage facilities connected at above 300 kV in DK1 must be able to continuously operate at voltages and frequencies specified in Table 32, Table 33 and Figure 11. However, total operation time below 49.0 Hz must not exceed 60 minutes.

Frequency range [Hz]	Time [minutes]
47.5-48.0	30
48.0-49.0	30
49.0-51.0	Unlimited
51.0-51.5	30

Table 32 Normal operating range for frequencies when connected at above 300 kV in DK1.

Voltage range [pu]	Time [minutes]
0.85-0.9	60
0.9-1.10	Unlimited
1.05-1.10	60

Table 33 Normal operating range for voltages when connected at above 300 kV in DK1.

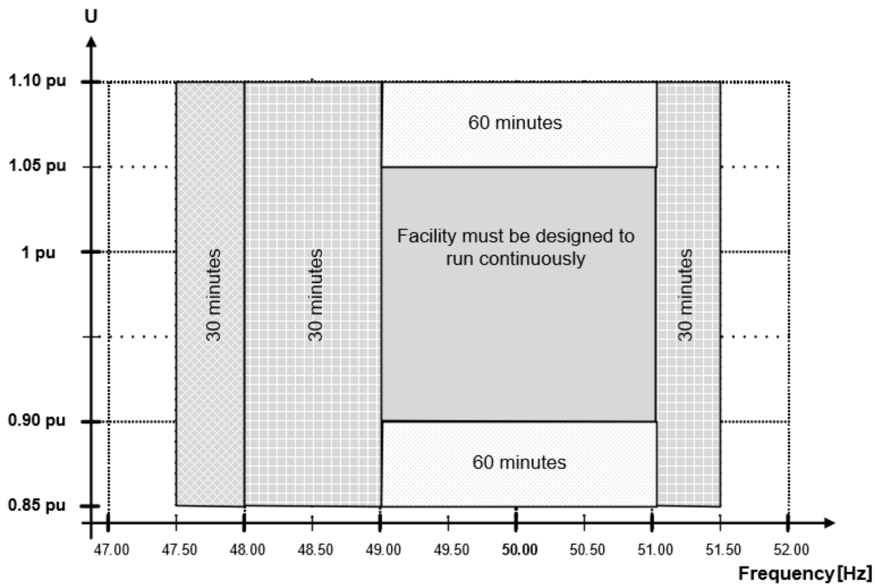


Figure 11 Normal operating range for frequencies and voltages when connected at above 300 kV in DK1.

Normal operating range for frequencies and voltages when connected at 110-300 kV in DK2

70. (1) Energy storage facilities connected at 110-300 kV in DK2 must be able to continuously operate at voltages and frequencies specified in Table 34, Table 35 and Figure 12. However, total operation time below 49.0 Hz must not exceed 60 minutes.

Frequency range [Hz]	Time [minutes]
47.5-48.0	30
48.0-49.0	30
49.0-51.0	Unlimited
51.0-51.5	30

Table 34 Normal operating range for frequencies when connected at 110-300 kV in DK2.

Voltage range [pu]	Time [minutes]
0.9-1.05	Unlimited
1.05-1.10	60

Table 35 Normal operating range for voltages when connected at 110-300 kV in DK2.

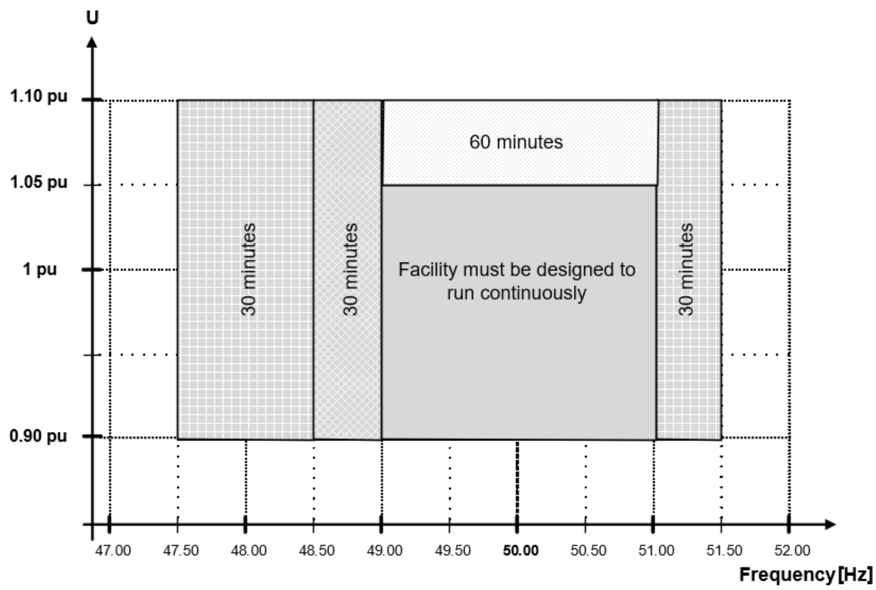


Figure 12 Normal operating range for frequencies and voltages when connected at 110-300 kV in DK2.

Normal operating range for frequencies and voltages when connected at above 300 kV in DK2

71. (1) Energy storage facilities connected at above 300 kV in DK2 must be able to continuously operate at voltages and frequencies specified in Table 36, Table 37 and Figure 13. However, total operation time below 49.0 Hz must not exceed 60 minutes.

Frequency range [Hz]	Time [minutes]
47.5-48.0	30
48.0-49.0	30
49.0-51.0	Unlimited
51.0-51.5	30

Table 36 Normal operating range for frequencies when connected at above 300 kV in DK2.

Voltage range [pu]	Time [minutes]
0.9-1.05	Unlimited
1.05-1.10	60

Table 37 Normal operating range for voltages when connected at above 300 kV in DK2.

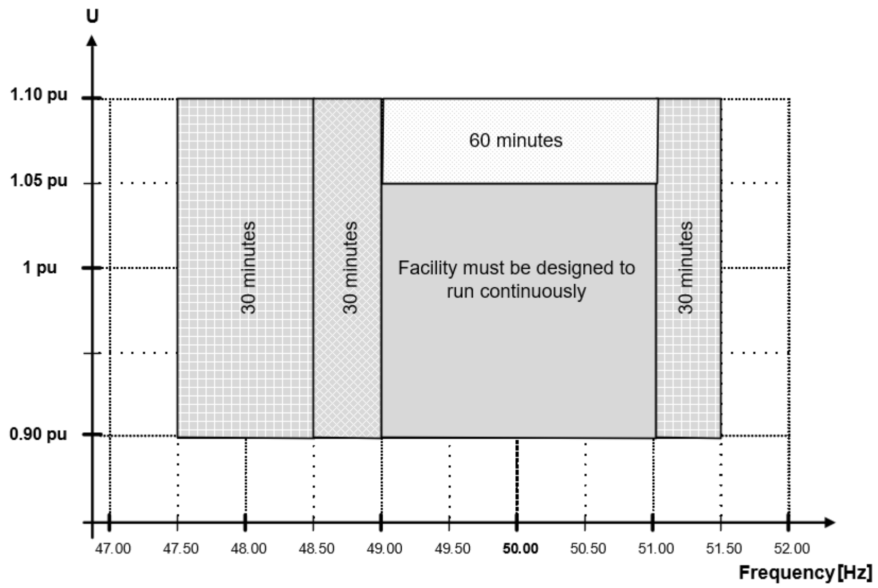


Figure 13 Normal operating range for frequencies and voltages when connected at above 300 kV in DK2.

Overvoltage Fault-Ride-Through (OV-FRT)

72. (1) Energy storage facilities must be able to withstand a voltage rise in the point of connection without disconnecting (OV-FRT), as specified in Table 38. The highest phase-to-phase or phase-to-earth voltage (root mean square (RMS) value) must be used for the voltage evaluation.

Voltage	Duration [s]
1.30 pu	0.1
1.20 pu	30

Table 38 Requirements for OV-FRT.

Power quality

73. (1) Energy storage facilities must observe Energinet's power quality requirements corresponding to facilities connected to the transmission system in technical regulation 3.2.7 'Requirements for voltage quality for generation facility connections to the transmission grid', and NC DC and nationally requirements pursuant thereto.

Manual load-shedding

74. (1) Energy storage facilities in consumption mode must comply with Energinet's requirements for manual load-shedding corresponding to demand facilities connected to the transmission system in technical regulation 3.4.2 'Manual load-shedding of transmission-connected demand facilities'.

Requirement to limit voltage variations in static state

75. (1) Energy storage facilities must be able to limit voltage variations during voltage restoration and connection of the energy storage facility in static state before and after connection.

(2) During voltage restoration and connection of the energy storage facility, the properties designed to limit voltage variations in static state before and after connection must observe the following requirements, as a minimum:

a) During normal operation +/- 3% of the previous operating voltage before connection
b) During special events +/- 4% of the previous operating voltage before connection.

Point on wave

76. (1) If Energinet deems there to be a risk that the energy storage facility's transformers may generate temporary overvoltages due to interaction with the transmission system which could cause damage to Energinet's equipment, Energinet may demand controlled circuit breaker switching during transformer energisation, by the energy storage facility's transformers being equipped with circuit breaker synchronisation (point on wave) for controlled connection. The controlled connection must be configured to minimise inrush current. The facility owner must inform Energinet about the size and type of the transformers without undue delay after becoming aware of this information, so that Energinet can make the assessment.

Zero-miss

77. (1) If the energy storage facility consists of equipment which is to be energised through Energinet's circuit breakers, the facility owner must document that the energy storage facility cannot introduce zero-miss into Energinet's circuit breakers, to ensure this phenomenon is avoided. The documentation must include electro-technology arguments showing why zero-miss cannot or will not occur in Energinet's circuit breakers. The documentation must be submitted to and approved by Energinet before the energy storage facility can be issued an EON.

Simulation models

78. (1) Facility owners must prepare and submit simulation models equivalent to those for generation facilities connected to the transmission system, pursuant to the applicable simulation model requirements in NC RfG and NC DC and national requirements pursuant thereto.

Protection

79. (1) The facility owner of energy storage facilities connected to the transmission system must complete stability and selectivity studies to determine the facility unit's protection, and to ensure that the energy storage facility complies with the protection requirements and that the protection does not impede the energy storage facility from complying with other requirements. Energinet has to approve the relay settings.

Information exchange

80. (1) Players and facility owners of energy storage facilities connected to the transmission system must exchange real-time data with Energinet.

81. (1) Energy storage facilities connected to the transmission system, starting production or consumption after this regulation enters into force, must set up communication equipment for the exchange of real-time data in line with the IEC 61850 standard.

Part 7
Synchronous energy storage facilities of type A

82. (1) A synchronous type A energy storage facility must comply with the requirements in Part 2.

83. (1) The energy storage facility must be capable of absorbing reactive power in the point of connection within the Operating range specified in Figure 14, unless the relevant system operator has defined an inductive power factor greater than 0.95.

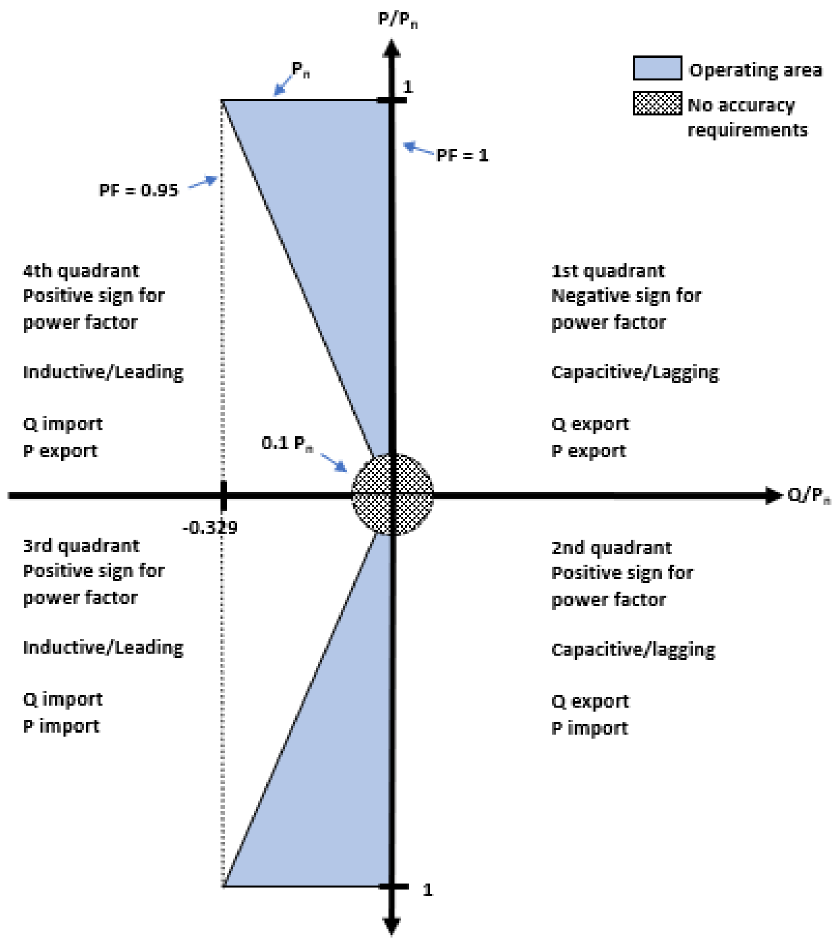


Figure 14 Operating range requirements for P/P_n.

(2) There are no precision requirements in cases where P is less than 10% of P_n. However, the exchange of uncontrolled reactive power must not exceed 10% of the energy storage facility's P_n in this case.

Part 8
Synchronous energy storage facilities of type B

84. (1) Synchronous type B energy storage facilities must comply with the requirements in Parts 2, 3, 7 and this Part 8, taking into account the exceptions in these parts, with the exception of:

a) operating range requirements for P/P_n in section 83.

Operating range for U/U_n – connected at up to 1 kV

85. (1) Energy storage facilities connected at up to 1 kV must, at maximum active power output, be capable of supplying and absorbing reactive power in the point of connection within the operating range specified in Figure 15.

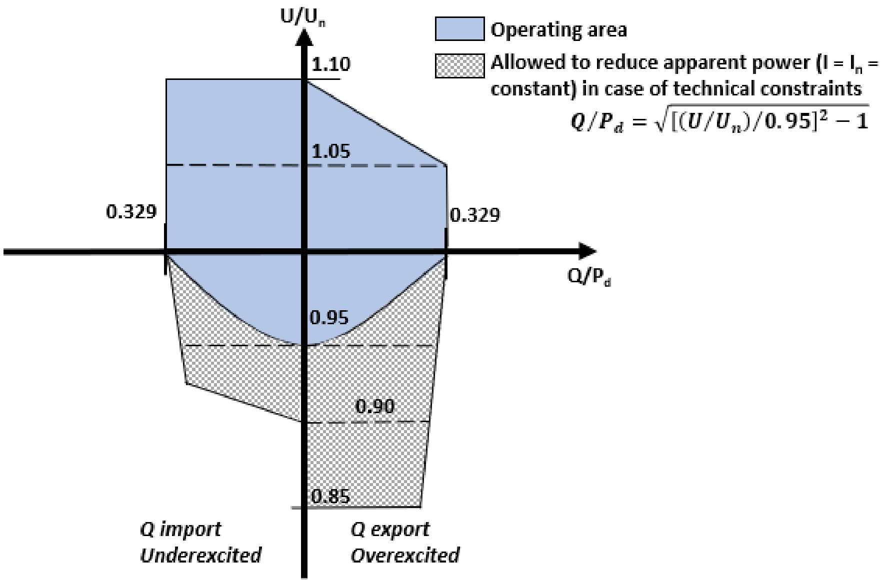


Figure 15 Operating range for U/U_n – connected at up to 1 kV.

Operating range for P/S_n – connected at up to 1 kV

86. (1) Energy storage facilities connected at up to 1 kV must be capable of supplying and absorbing reactive power in the point of connection within the operating range specified in Figure 15.

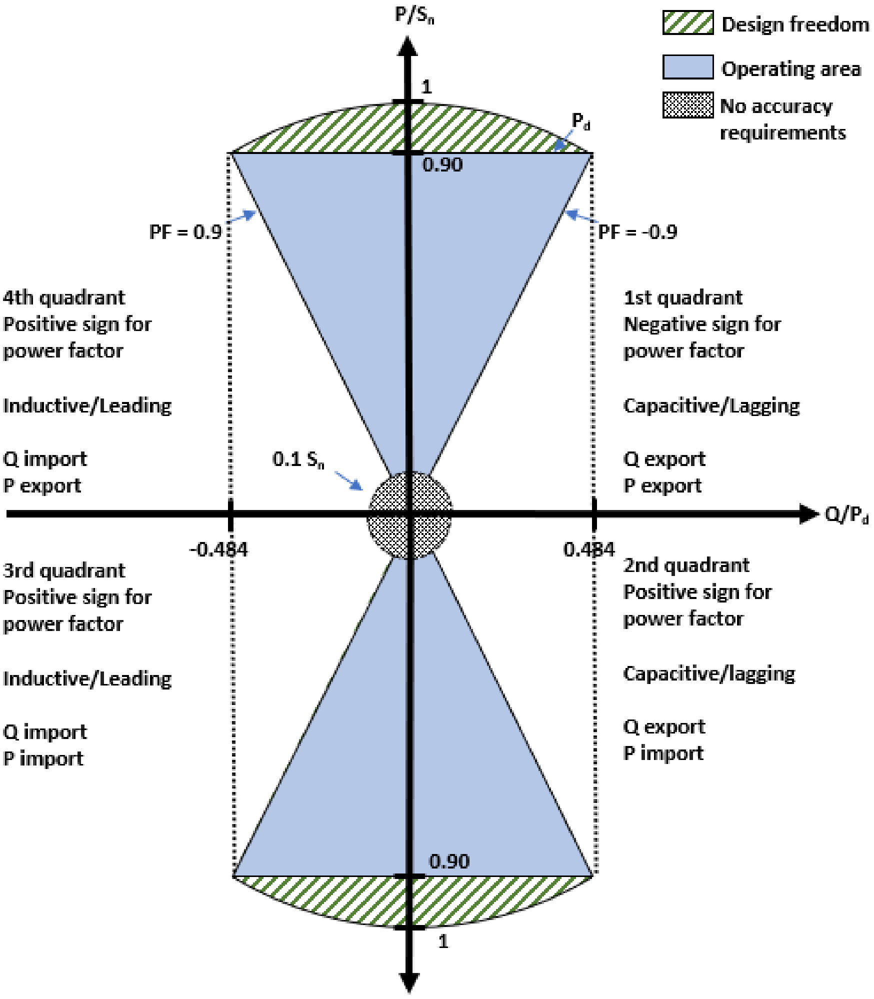


Figure 16 Operating range for P/S_n – connected at up to 1 kV.
Quadrant numbering follows the generator convention.

(2) There are no precision requirements in cases where P is less than 10% of S_n. However, the exchange of uncontrolled reactive power must not exceed 10% of the energy storage facility's S_n in this case.

Operating range for U/U_c – connected at above 1 kV

87. (1) Energy storage facilities connected at above 1 kV must, at maximum active power output, be capable of supplying and absorbing reactive power in the point of connection within the operating range specified in Figure 17.

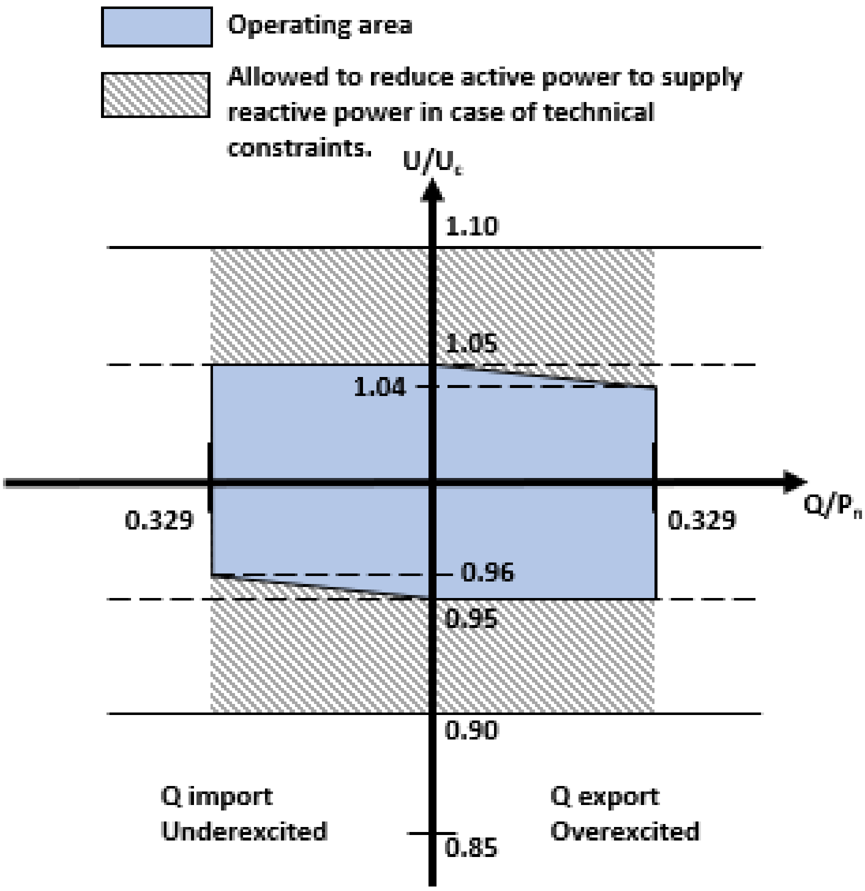


Figure 17 Operating range for U/U_c – connected at above 1 kV.

Operating range for P/P_n – connected at above 1 kV

88. (1) Energy storage facilities connected at above 1 kV must be capable of supplying and absorbing reactive power in the point of connection within the operating range specified in Figure 18.

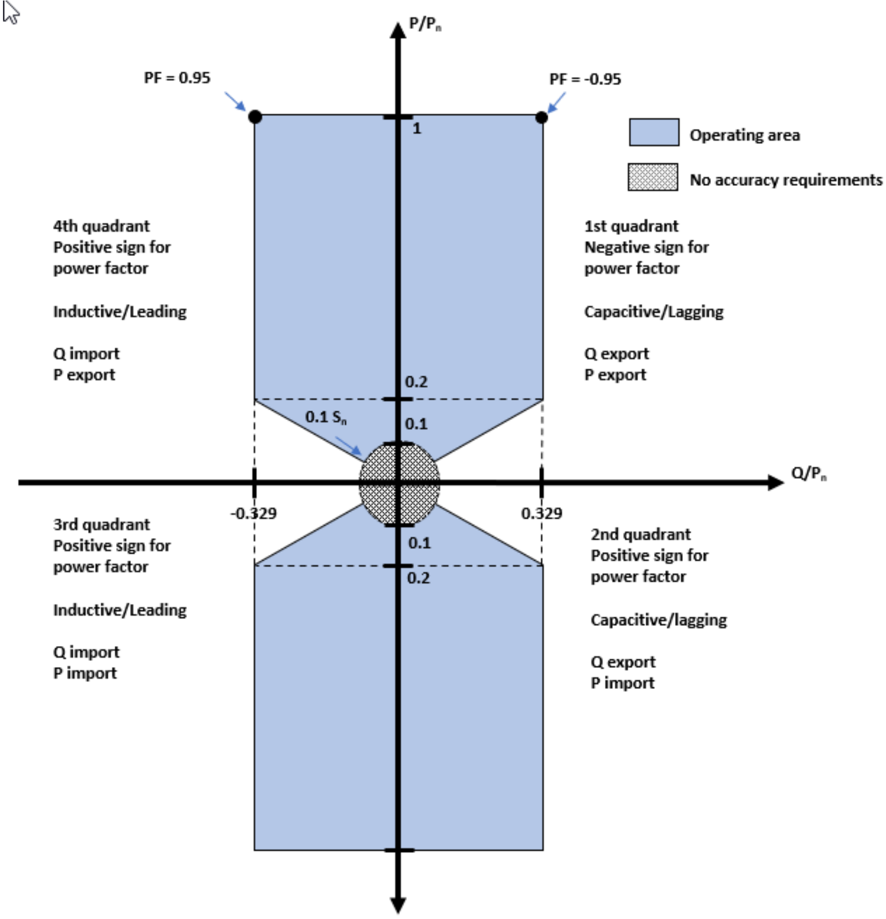


Figure 18 Operating range for P/P_n – connected at above 1 kV.
Quadrant numbering follows the generator convention.

(2) There are no precision requirements in cases where P is less than 10% of P_n. However, the exchange of uncontrolled reactive power must not exceed 10% of the energy storage facility's P_n in this case.

Automatic voltage regulator (AVR)

89. (1) Energy storage facilities must be equipped with a continuously functioning excitation system (Automatic Voltage Regulator, AVR) capable of supplying a stable and constant voltage in the point of connection.

Undervoltage Fault-Ride-Through (UV-FRT)

90. (1) Energy storage facilities must be able to withstand a voltage dip in the point of connection without disconnecting (UV-FRT), as specified in Table 39 for connections at up to 1 kV and Table 40 for connections at above 1 kV and as shown in Figure 19.

	Voltage [U_n]		Duration [s]
U_{ret}	0.3	T_{clear}	0.25
U_{clear}	0.7	T_{rec1}	0.25
U_{rec1}	0.7	T_{rec2}	0.70
U_{rec2}	0.9	T_{rec3}	1.50

Table 39 Requirements for UV-FRT – connected at up to 1 kV.

	Voltage [U_c]		Duration [s]
U_{ret}	0.3	T_{clear}	0.25
U_{clear}	0.7	T_{rec1}	0.25
U_{rec1}	0.7	T_{rec2}	0.70
U_{rec2}	0.9	T_{rec3}	1.50

Table 40 Requirements for UV-FRT – connected at above 1 kV.

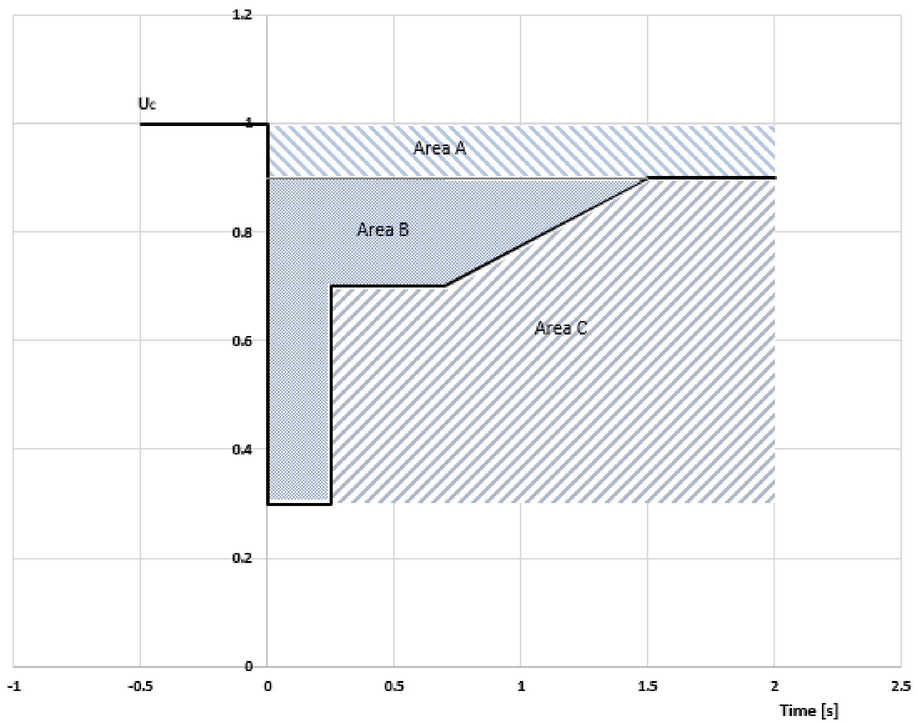


Figure 19 Requirements for UV-FRT – for connections at up to 1 kV, U_c equals U_n.

(2) If, during a fault sequence, the voltage in the point of connection reverts after 1.5 seconds to at least 0.9 U_n for connections at up to 1 kV and 0.9 U_c for connections at above 1 kV, any new voltage dip must be regarded as a new fault situation.

(3) If several successive fault sequences within area B cause the facility to enter area C time-wise, disconnection of the facility is permitted.

91. (1) Energy storage facilities must be able to restore normal active power production following a fault as soon as possible after the voltage and frequency have returned to the normal operating range. The natural ability of the synchronous energy storage facility to restore active power production must not be artificially or unnecessarily limited.

Part 9
Synchronous energy storage facilities of type C

92. (1) Synchronous type C energy storage facilities must comply with the requirements in Parts 2, 3, 4, 7, 8 and this Part 9, taking into account the exceptions in these parts, with the exception of:

a) operating range requirements for P/P_n in section 83
b) operating range requirements for U/U_n in section 85

c) operating range requirements for P/S_n in section 86
d) operating range requirements for U/U_c in section 87
e) operating range requirements for P/P_n in section 88.

Operating range for U/U_c

93. (1) Energy storage facilities must, at maximum active power output, be able to supply and absorb reactive power in the point of connection within the operating range specified in Figure 20.

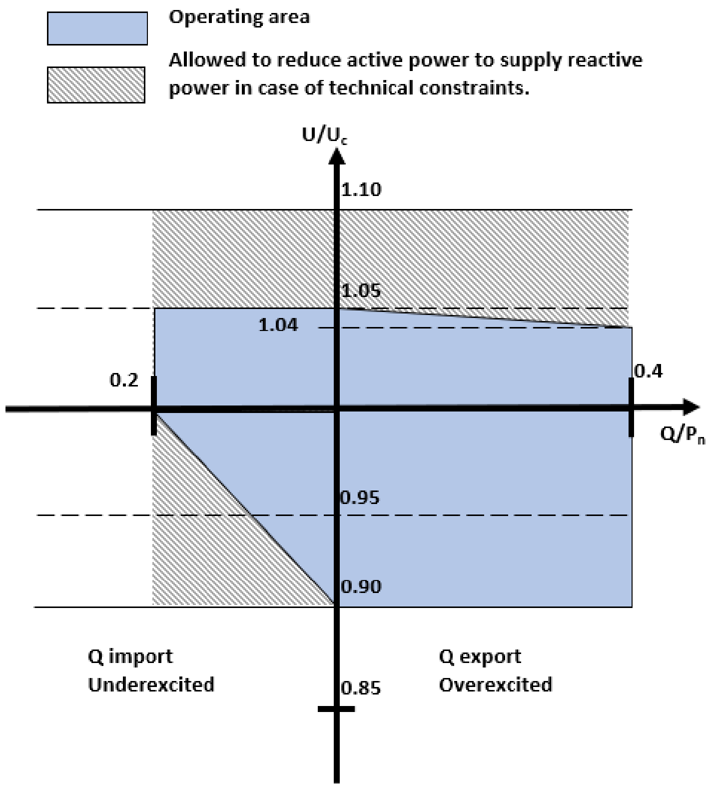


Figure 20 Operating range for U/U_c.

(2) The energy storage facility must have a maximum imprecision of ±2% of the energy storage facility's S_n, where precision is measured over a period of 1 minute.

(3) In the hatched area in Figure 20, where it is permissible to reduce active power to supply reactive power in the event of technical limitations, the energy storage facility must be able to supply stable reactive power in line with the chosen control method, which must only be limited by the technical capabilities of the unit, including in the event of saturation or undercompensation.

(4) When producing active power below maximum capacity, the energy storage facility must be able to operate at any point within the energy storage facility's P-Q capability curve (PQ diagram).

Part 10
Synchronous energy storage facilities of type D

94. (1) Synchronous type D energy storage facilities must comply with the requirements in Parts 2, 3, 4, 5, 7, 8, 9 and this Part 10, taking into account the exceptions in these parts, with the exception of:

a) operating range requirements for P/P_n in section 83

b) operating range requirements for U/U_n in section 85
c) operating range requirements for P/S_n in section 86
d) operating range requirements for U/U_c in section 87
e) operating range requirements for P/P_n in section 88
f) operating range requirements for U/U_c in section 93.

Operating range for U/U_c

95. (1) Energy storage facilities must, at maximum active power output, be able to supply and absorb reactive power in the point of connection within the operating range specified in Figure 21.

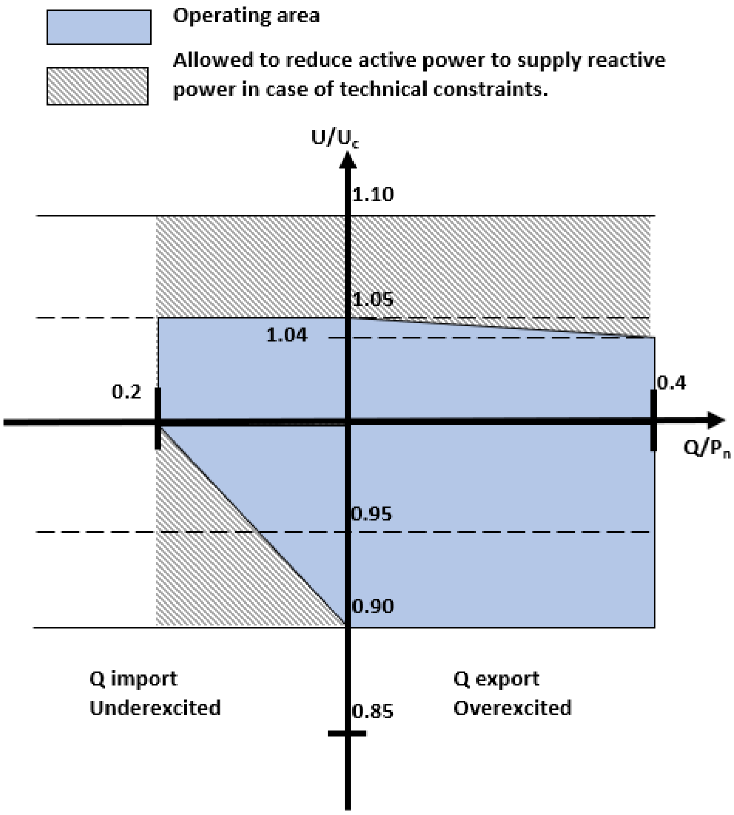


Figure 21 Operating range for U/U_c.

(2) The energy storage facility must have a maximum imprecision of ±2% of the energy storage facility's S_n, where precision is measured over a period of 1 minute.

(3) In the hatched area in Figure 21, where it is permissible to reduce active power to supply reactive power in the event of technical limitations, the energy storage facility must be able to supply stable reactive power in line with the chosen control method, which must only be limited by the technical capabilities of the unit, including in the event of saturation or undercompensation.

(4) When producing active power below maximum capacity, the energy storage facility must be able to operate at any point within the synchronous energy storage facility's P-Q capability curve (PQ diagram).

Using tap changers for reactive power control properties

96. (1) The owner of an energy storage facility connected to the distribution system may use the tap changer on the step-up transformer to comply with requirements for reactive power control properties if this is accepted by the relevant system operator.

Automatic voltage regulator (AVR)

97. (1) The energy storage facility must be equipped with a continuously functioning automatic excitation system (Automatic Voltage Regulator, AVR).

(2) The excitation system must be designed in conformity with European standard DS/EN 60034-16-1:2011 'Rotating electrical machines – Part 16: Excitation systems for synchronous machines – Chapter 1: Definitions' and DS/CLC/TR 60034-16-3:2004 'Rotating electrical machines – Part 16: Excitation systems for synchronous machines – Section 3: Dynamic performance'.

(3) In the event of grid disturbances resulting in voltage reduction, it must be possible to overexcite the generator for at least 10 seconds to 1.6 times the excitation current and voltage at nominal output and tgϕ = 0.4 in the point of connection and normal operating voltage. If the overexcitation property depends on voltage in the point of connection, this property must be available at reduced grid voltages in the point of connection down to 0.6 pu.

(4) The generator's overexcitation protection and other types of protection must be designed and set so that the generator's capacity for temporary overload can be utilised without overriding the generator's thermal limits.

(5) The excitation system's limit functions must be selective with the facility's protective functions, thereby allowing for a brief utilisation of overload characteristics without the facility being disconnected.

(6) The excitation system's time response (measured at the generator terminals) during idling (generator disconnected from the grid and operated at nominal RPM) for a momentary 10% change to the reference voltage must be non-oscillatory and have a maximum rise time, as defined in DS/CLC/TR 60034-16-3:2004, of 0.3 seconds for a static excitation system. For a rotating excitation system ('rotating exciter'), a time response of up to 0.5 seconds for a positive 10% change to the reference voltage is permitted, and correspondingly, up to 0.8 seconds for a negative 10% change to the reference voltage.

(7) The excitation system's overshoot, measured at the generator terminals, as defined in DS/CLC/TR 60034-16-3:2004, must not exceed 15% of the change during a momentary 10% change in the reference voltage.

Power System Stabiliser (PSS)

98. (1) The energy storage facility must be equipped with a power system stabiliser (PSS). The relevant system operator decides the specific requirements and settings for the PSS based on a specific analysis.

(2) The PSS function must comply with the following requirements:

a) The PSS function must use input from rotor speed/grid frequency and active power (dual input) to derive the stability signal, where damping equipment of type IEEE PSS2B, see IEEE 421.5, is normative.
b) The PSS function must be adjusted to achieve a significant damping in the 0.2-0.7 Hz frequency range.
c) The phase of the supplied damping signal produced by the PSS function must be in phase with the change in speed for the generator rotor in the 0.2-2 Hz frequency range. Deviations of up to -30 degrees (undercompensated) are acceptable.
d) With the PSS function activated, damping of the facility's power oscillations (exponentially declining function) must be faster than 1 second at all set points and for any distortion.
e) The energy storage facility's natural damping of 'local mode' power oscillations must not be adversely affected by the PSS function.

f) The PSS function must be set so that changes to the facility's set point (active power) during normal operation, or in the event of a fault, including faults in a turbine regulator, boiler facility, feedwater facility or other auxiliary power facility do not cause the voltage on the high-voltage side of the generator transformer to change by more than 1%.
g) The PSS output signal must be limited so that activation of the PSS function does not lead to a change in generator voltage greater than ±5% of the generator's nominal voltage. Limits may be automatically and dynamically reduced by the voltage regulator, including when the excitation system's limit functions are activated.
h) The PSS function must be deactivated automatically when generated active power is less than 20% of nominal output. It must be possible to connect and disconnect the PSS function. When the PSS function is disconnected, an alarm must be set off.

Part 11
Synchronous energy storage facilities connected to the transmission system

99. (1) Synchronous energy storage facilities connected to the transmission system must comply with the requirements in Parts 2, 3, 4, 5, 6, 7, 8, 9, 10 and this Part 11, taking into account the exceptions in these parts, with the exception of:

a) operating range requirements for P/P_n in section 83
b) operating range requirements for U/U_n in section 85
c) operating range requirements for P/S_n in section 86
d) operating range requirements for U/U_c in section 87
e) operating range requirements for P/P_n in section 88
f) requirements for UV-FRT in section 90
g) operating range requirements for U/U_c in section 93
h) operating range requirements for U/U_c in section 95.

Operating range for U-Q/P_n

100. (1) At maximum production and consumption of active power, energy storage facilities must be able to supply and absorb reactive power in the point of connection as a function of the voltage in the point of connection (U_{POC}), as shown for connections at 110-300 kV in Figure 22 for DK1 and Figure 23 for DK2, and for connections at 300-400 kV in Figure 24.

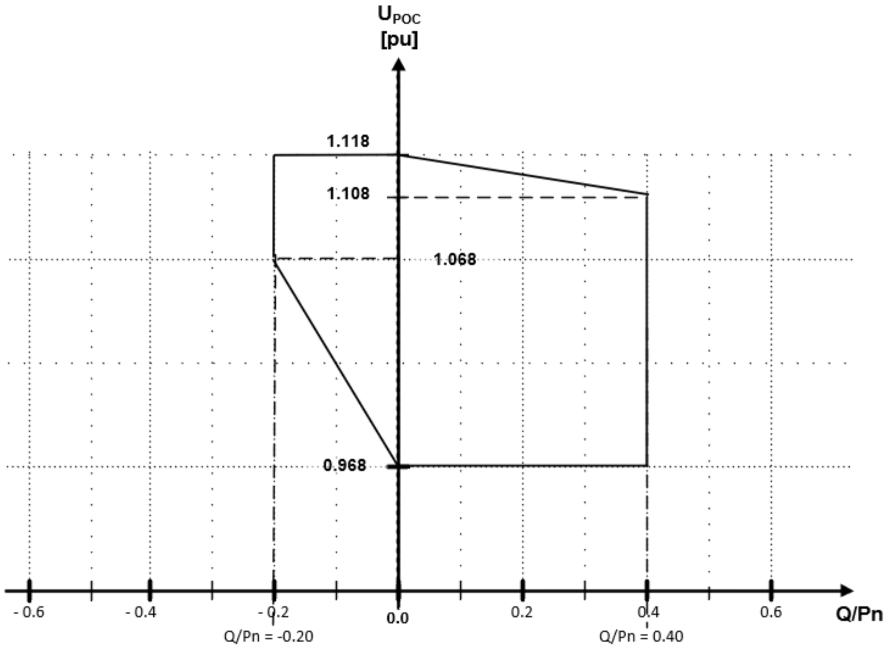


Figure 22 Operating range for U-Q/P_n when connected at 110-300 kV in DK1.

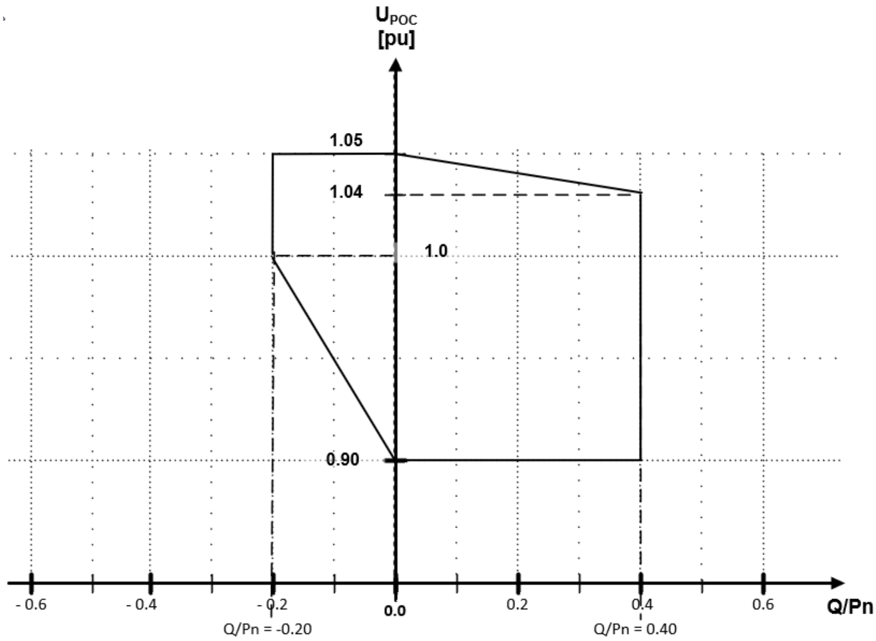


Figure 23 Operating range for U-Q/P_n when connected at 110-300 kV in DK2.

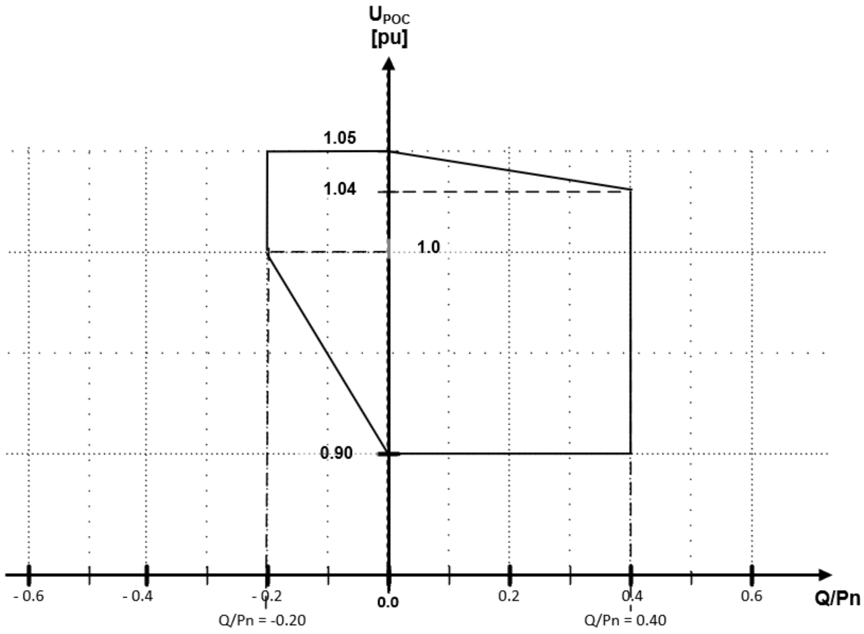


Figure 24 Operating range for U-Q/P_n when connected at 300-400 kV.

Undervoltage Fault-Ride-Through (UV-FRT) for DK1

101. (1) Energy storage facilities must be able to withstand a voltage dip in the point of connection without disconnecting (UV-FRT), as specified in Table 41 and shown in Figure 25.

	Voltage		Duration [s]
U_{ret}	0	T_{clear}	0.15
U_{clear}	0.6	T_{rec1}	0.15
U_{rec1}	0.6	T_{rec2}	0.75
U_{rec2}	0.85	T_{rec3}	1.50

Table 41 Requirements for UV-FRT for DK1.

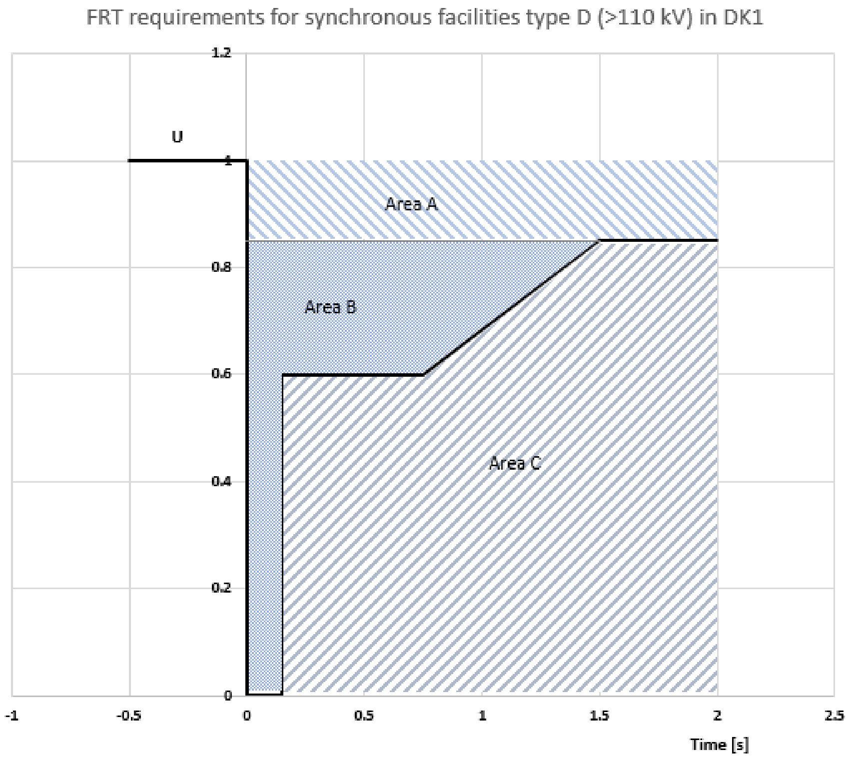


Figure 25 Requirements for UV-FRT for DK1.

(2) If, during a fault sequence, the voltage in the point of connection reverts after 1.5 seconds to at least 0.85 pu, any new voltage dip must be regarded as a new fault situation.

(3) If several successive fault sequences within area B cause the facility to enter area C time-wise, disconnection of the facility is permitted.

Undervoltage Fault-Ride-Through (UV-FRT) for DK2

102. (1) Energy storage facilities must be able to withstand a voltage dip in the point of connection without disconnecting (UV-FRT), as specified in Table 42 and shown in Figure 26.

	Voltage		Duration [s]
U_{ret}	0	T_{clear}	0.15
U_{clear}	0.6	T_{rec1}	0.15
U_{rec1}	0.6	T_{rec2}	0.75
U_{rec2}	0.9	T_{rec3}	1.50

Table 42 Requirements for UV-FRT for DK2.

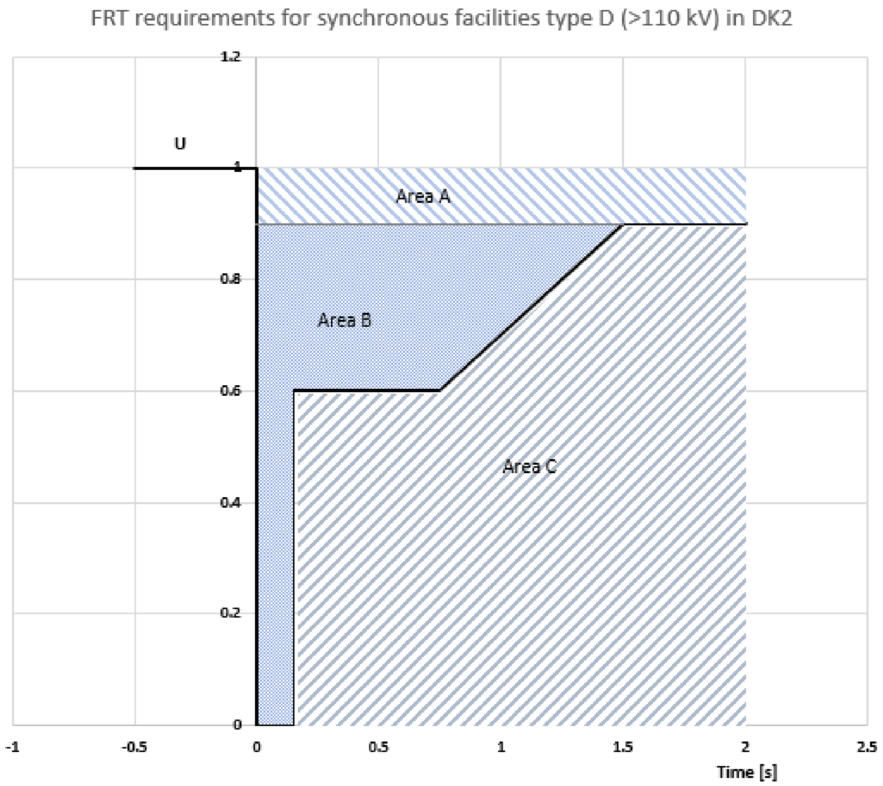


Figure 26 Requirements for UV-FRT for DK2.

(2) If, during a fault sequence, the voltage in the point of connection reverts after 1.5 seconds to at least 0.90 pu, any new voltage dip must be regarded as a new fault situation.

(3) If several successive fault sequences within area B cause the facility to enter area C time-wise, disconnection of the facility is permitted.

Q control

103. (1) Energy storage facilities must be able to supply and absorb a fixed level of reactive power in the point of connection (Q control).

(2) It must be possible to adjust the Q control under subsection (1) above such that:

a) orders to change the set point can be applied within 2 seconds of receipt

b) adjustment to a new set point begins within 2 seconds of receiving an order to change the set point

c) adjustment to a new set point is complete within 30 seconds of receiving an order to change the set point.

(3) The Q control under subsection (1) above must be adjustable with:

a) a maximum imprecision of ±3% of the energy storage facility's Q_n, where precision is measured over a period of 1 minute, and

b) a resolution of 100 kvar or better.

Power factor control

104. (1) Energy storage facilities must be able to supply and absorb active and reactive power with a power factor in the point of connection (power factor control).

(2) It must be possible to adjust the power factor control under subsection (1) above such that:

a) orders to change the set point can be applied within 2 seconds of receipt

b) adjustment to a new set point begins within 2 seconds of receiving an order to change the set point
c) adjustment to a new set point is complete within 30 seconds of receiving an order to change the set point.

(3) The power Factor control under subsection (1) above must be adjustable with:
a) a maximum imprecision of ±3% of the energy storage facility's Q_n, where precision is measured over a period of 1 minute, and
b) a resolution of 0.01 or better.

Voltage control

105. (1) Energy storage facilities must be able to supply and absorb reactive power and thereby maintain a stable and constant voltage in the point of connection (voltage control).

(2) The voltage control must be set with:
a) a maximum imprecision of 0.5% of the energy storage facility's U_{ref}, where precision is measured over a period of 1 minute
b) a resolution for droop of 0.1 kV or better. It must be possible to set the droop in the 2-8% range
c) a step size for the dead band that can be set in the range ±5% of U_{ref} with a step size not exceeding 0.25% for 220/400 kV and 0.5% for 132/150 kV, and must be symmetrical around the set point for voltage control
d) a set point decided by the relevant system operator within the normal operating voltage range.

Using tap changers for reactive power control properties

106. (1) The owner of an energy storage facility connected to the transmission system may use the tap changer on the step-up transformer to comply with requirements for reactive power control properties if this is accepted by the relevant system operator. However, requirements for time and dynamic properties must still be observed when using the tap changer.

Part 12

Non-synchronous energy storage facilities of type A

107. (1) Non-synchronous type A energy storage facilities must comply with the requirements in Part 2 and this Part 12, taking into account the exceptions in these parts.

Operating range for P/P_n

108. (1) The energy storage facility must be capable of absorbing reactive power in the point of connection as specified in Figure 27, unless the relevant system operator has defined an inductive power factor greater than 0.95.

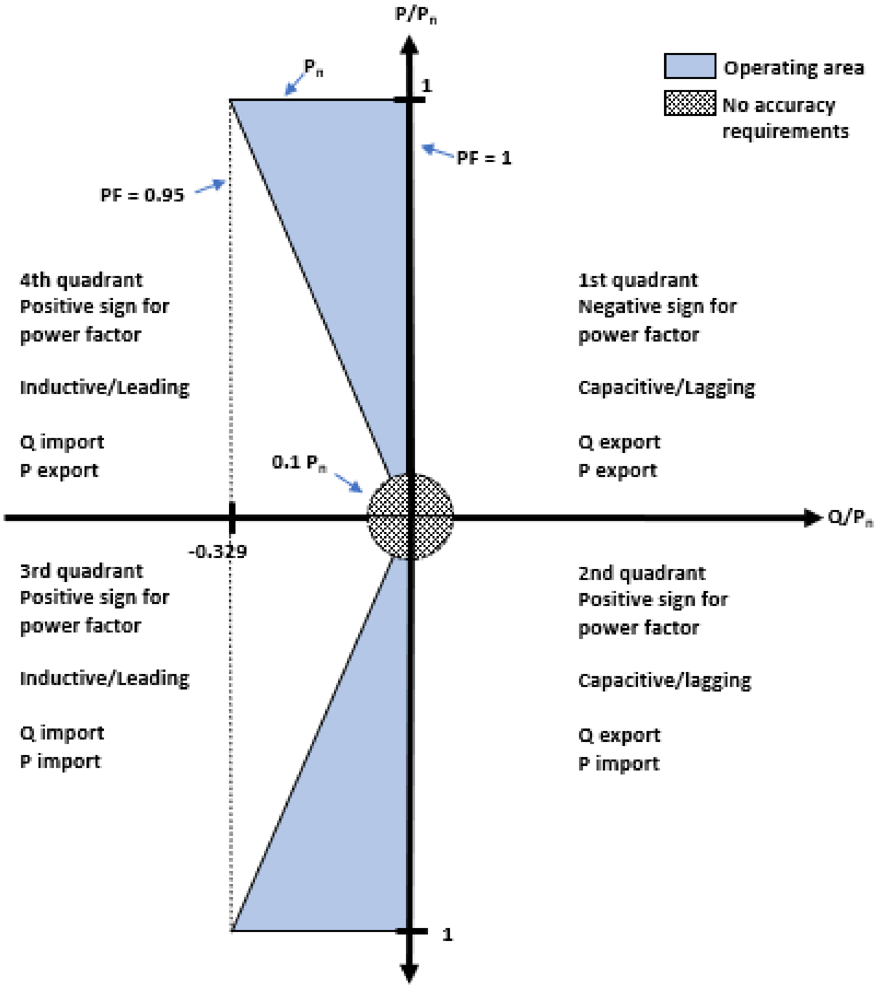


Figure 27 Operating range requirements for P/P_n.

(2) There are no precision requirements in cases where P is less than 10% of P_n. However, the exchange of uncontrolled reactive power must not exceed 10% of the energy storage facility's P_n in this case.

Part 13

Non-synchronous energy storage facilities of type B

109. (1) Non-synchronous type B energy storage facilities must comply with the requirements in Parts 2, 3, 12 and this Part 13, taking into account the exceptions in these parts, with the exception of:

a) operating range for P/P_n in section 108.

Operating range as a function of P/S_n – connected at up to 1 kV

110. (1) Energy storage facilities connected at up to 1 kV must be capable of supplying and absorbing reactive power in the point of connection within the operating range specified in Figure 28.

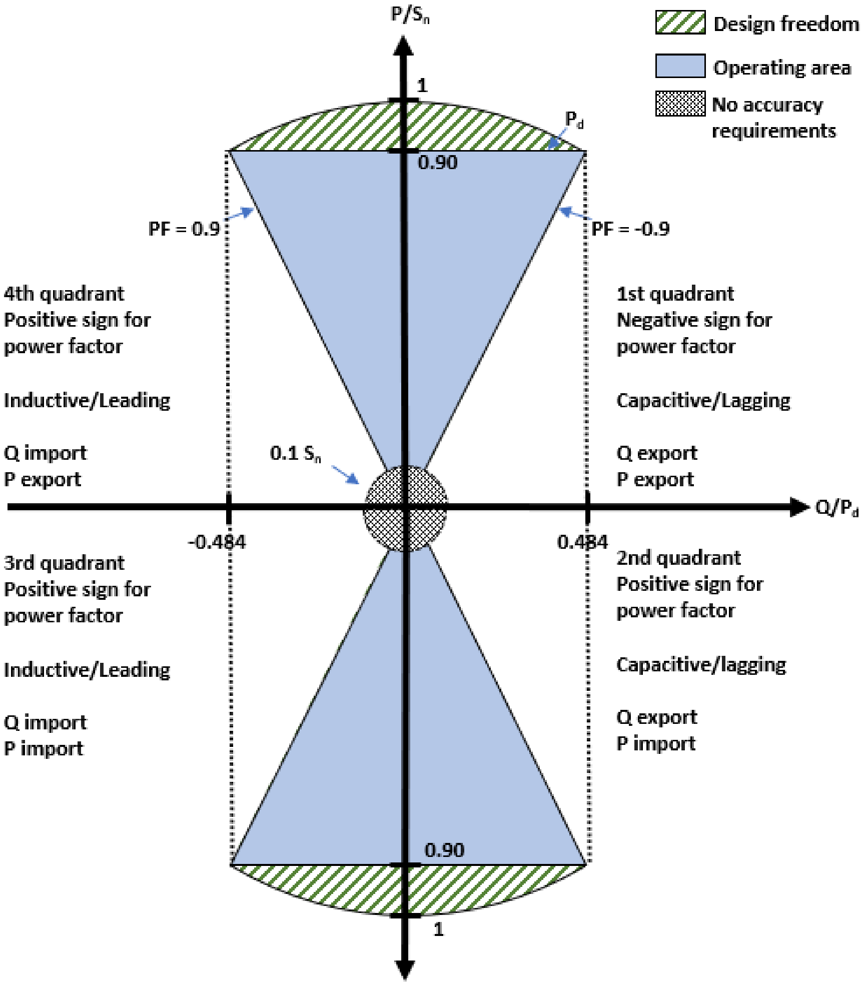


Figure 28 Operating range for P/S_n – connected at up to 1 kV.
Quadrant numbering follows the generator convention.

(2) There are no precision requirements in cases where P is less than 10% of S_n. However, the exchange of uncontrolled reactive power must not exceed 10% of the energy storage facility's S_n in this case.

Operating range for U/U_n – connected at up to 1 kV

111. (1) Energy storage facilities connected at less than 1 kV must, at maximum active power output (P_d), be able to supply and absorb reactive power in the point of connection within the operating range specified in Figure 29.

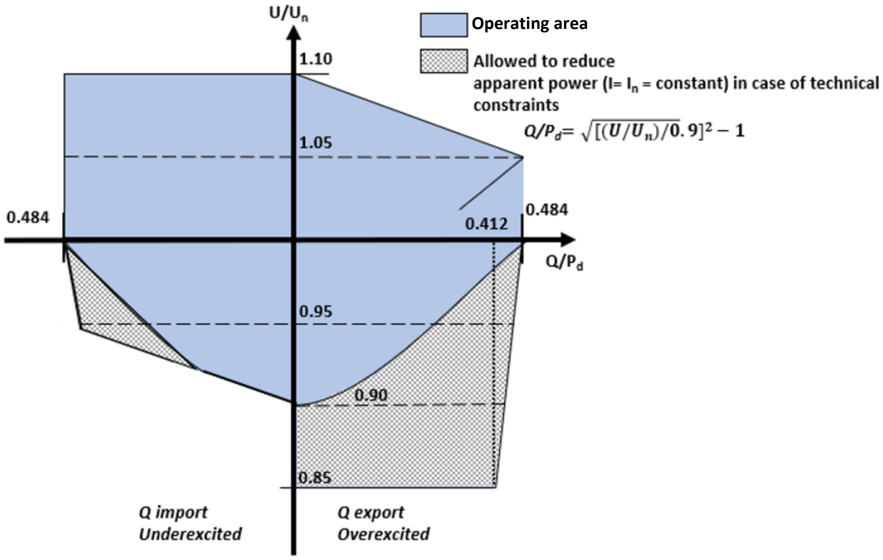


Figure 29 Operating range for U/U_n – connected at up to 1 kV.

Operating range for P/P_n – connected at above 1 kV

112. (1) Energy storage facilities connected at above 1 kV must be capable of supplying and absorbing reactive power in the point of connection within the operating range specified in Figure 30.

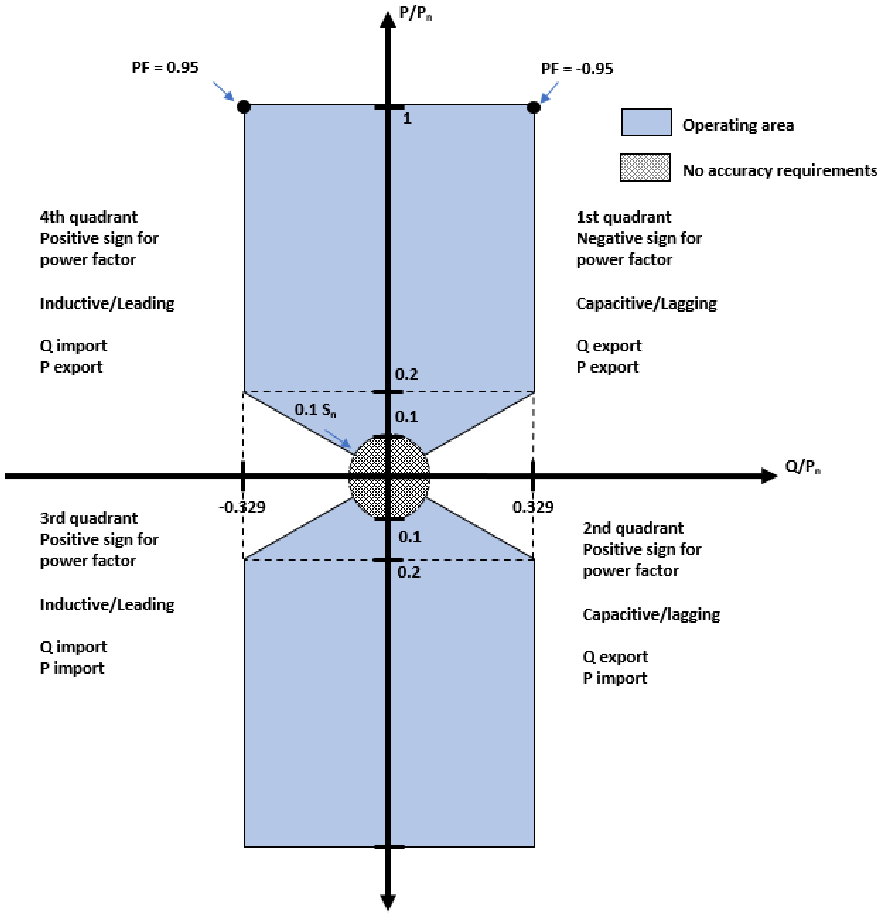


Figure 30 Operating range for P/P_n – connected at above 1 kV.
Quadrant numbering follows the generator convention.

(2) There are no precision requirements in cases where P is less than 10% of S_n. However, the exchange of uncontrolled reactive power must not exceed 10% of the energy storage facility's S_n in this case.

Operating range for U/U_c – connected at above 1 kV

113. (1) Energy storage facilities connected at above 1 kV must, at maximum active power output, be able to supply and absorb reactive power in the point of connection within the operating range specified in Figure 31.

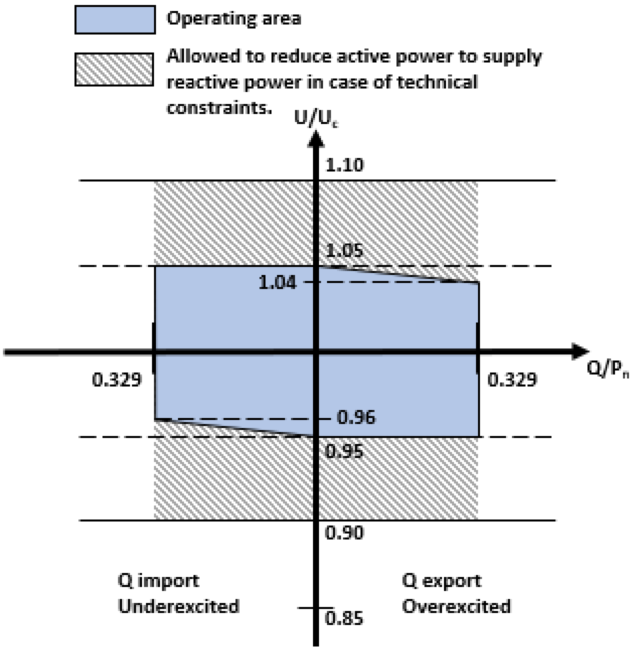


Figure 31 Operating range for U/U_c – connected at above 1 kV.

(2) In the hatched area in Figure 31, where it is permissible to reduce active power to supply reactive power in the event of technical limitations, energy storage facilities must be able to supply stable reactive power in line with the chosen control method, which must only be limited by the technical capabilities of the unit, including in the event of saturation or under-compensation.

Undervoltage Fault-Ride-Through (UV-FRT)

114. (1) Energy storage facilities must be able to withstand a voltage dip in the point of connection without disconnecting (UV-FRT), as specified in Table 43 for connections at up to 1 kV and Table 44 for connections at above 1 kV and shown in Figure 32.

	Voltage [U_n]		Duration [s]
U_{ret}	0.15	T_{clear}	0.25
U_{clear}	0.15	T_{rec1}	0.25
U_{rec1}	0.15	T_{rec2}	0.25
U_{rec2}	0.90	T_{rec3}	1.50

Table 43 Requirements for UV-FRT – connected at up to 1 kV.

	Voltage [U_c]		Duration [s]
U_{ret}	0.15	T_{clear}	0.25
U_{clear}	0.15	T_{rec1}	0.25
U_{rec1}	0.15	T_{rec2}	0.25
U_{rec2}	0.90	T_{rec3}	1.50

Table 44 Requirements for UV-FRT – connected at above 1 kV.

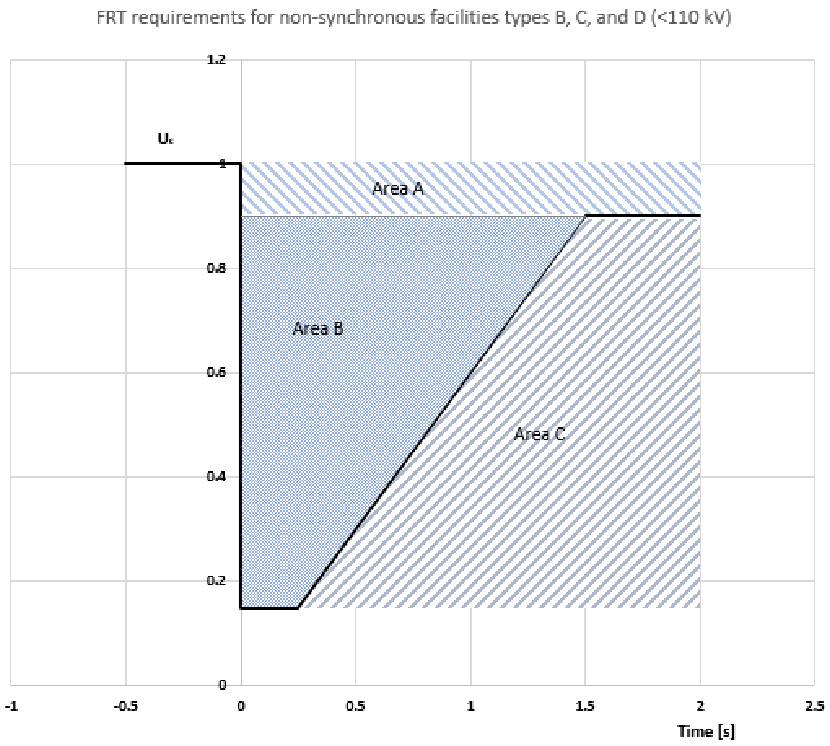


Figure 32 Requirements for UV-FRT – for connections at up to 1 kV, U_c equals U_n.

(2) If, during a fault sequence, the voltage in the point of connection reverts after 1.5 seconds to at least 0.9 U_n for connections at up to 1 kV and 0.9 U_c for connections at above 1 kV, any new voltage dip must be regarded as a new fault situation.

(3) If several successive fault sequences within area B cause the facility to enter area C time-wise, disconnection of the facility is permitted.

Fast Fault Current (FFC)

115. (1) Energy storage facilities must have a control function capable of controlling the positive sequence of the reactive current during a fault sequence (Fast Fault Current, FFC), as specified in Figure 33.

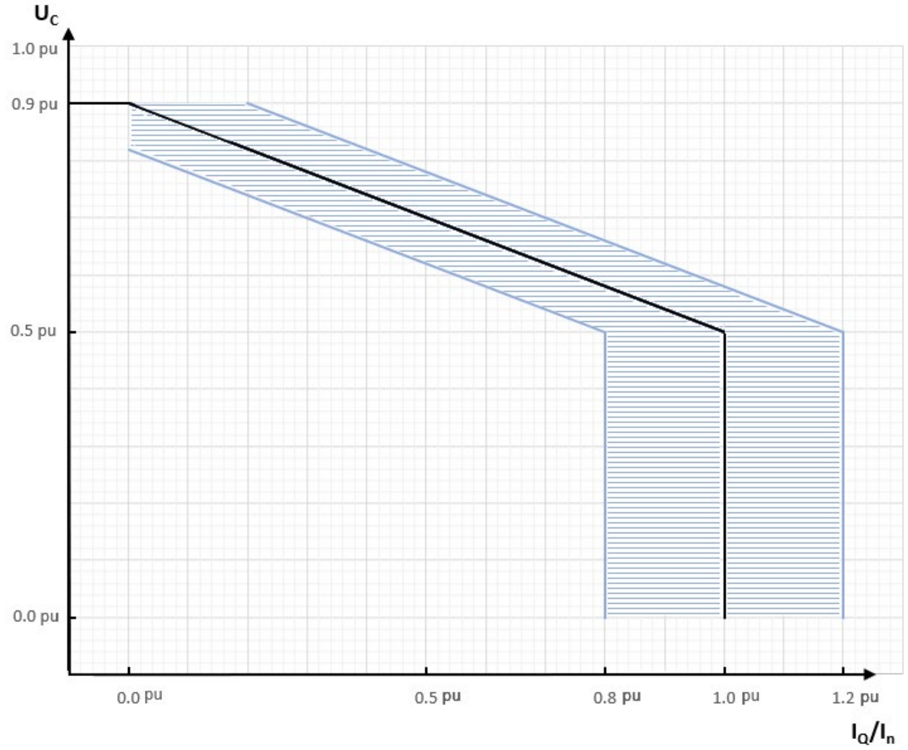


Figure 33 FFC requirements.

(2) Control in line with subsection (1) above must:

a) commence within 100 ms after the voltage dip, and
b) follow the characteristics in Figure 33, starting from 0.9 U_n to 0.5 U_n for connections up to 1 kV and 0.9 U_c to 0.5 U_c for connections above 1 kV, with a tolerance of ±20% of I_n.

Function for delayed exit from FRT state

116. (1) To prevent toggling between FFC and PFAPR activation, the energy storage facility must have a function for delayed exit from FRT state, so that the FFC control function remains active for a limited time after the operating conditions in the point of connection have returned to the normal frequency and voltage operating range.

(2) The delayed exit from FRT state property under subsection (1) above must meet the following requirements:

a) It must be possible to set the function to between 100-500 ms.
b) It must be possible to deactivate the function.
c) Energy storage facilities connected to the distribution system must have the function enabled and set to 250 ms, unless otherwise specified by Energinet.
d) Energinet decides the specific requirements and settings for energy storage facilities connected to the transmission system.

Post Fault Active Power Recovery (PFAPR)

117. (1) Energy storage facilities must be able to return to normal operation following a voltage dip in the electricity supply system, once the operating conditions in the point of connection have returned to the normal operating range (Post Fault Active Power Recovery, PFAPR), as shown in Figure 34.

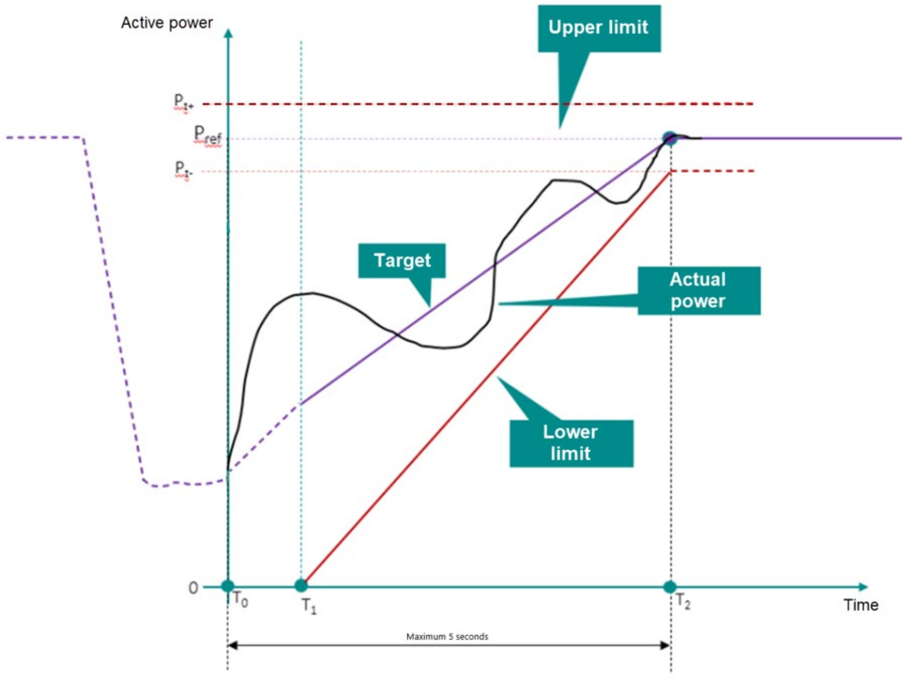


Figure 34 PFAPR requirements. The purple line (target) and black line (actual power) are examples to illustrate.

(2) The PFAPR property under subsection (1) above must observe the following requirements:

a) After a period of oscillation, the energy storage facility must resume its pre-fault operating point within 5 seconds after the operating conditions in the point of connection have returned to the normal frequency and voltage operating range.

b) Power control must follow an approximately constant gradient, and active power must lie within the range indicated in Figure 34 during the oscillation period, where:

i. T_0 is the time when the operating conditions return to the normal operating range for frequencies and voltages

ii. T_0 to T_1 is between 100-500 milliseconds and indicates when the energy storage facility leaves FRT state when the function for delayed exit from FRT state is used, in line with this section 117. If the function for delayed exit from FRT state is not used, then $T_0 = T_1$

iii. T_2 is the time when the energy storage facility has resumed its pre-fault operating point (up to 5 seconds after T_0)

iv. P_{ref} is the energy storage facility's pre-fault operating point.

v. P_{t+} and P_{t-} are P_{ref} ±5% of P_n.

c) The precision of a completed control sequence must be ±5% of P_n, except in the event of changes to the availability of the primary energy source.

Part 14

Non-synchronous energy storage facilities of type C

118. (1) Non-synchronous type C energy storage facilities must comply with the requirements in Parts 2, 3, 4, 12, 13 and this Part 14, taking into account the exceptions in these parts, with the exception of:

a) operating range requirements for P/P_n in section 108

b) operating range requirements for P/S_n in section 110

c) operating range requirements for U/U_n in section 111
d) operating range requirements for P/P_n in section 112
e) operating range requirements for U/U_c in section 113.

Operating range for P/P_n

119. (1) Energy storage facilities must be capable of supplying and absorbing reactive power in the point of connection within the operating range specified in Figure 35.

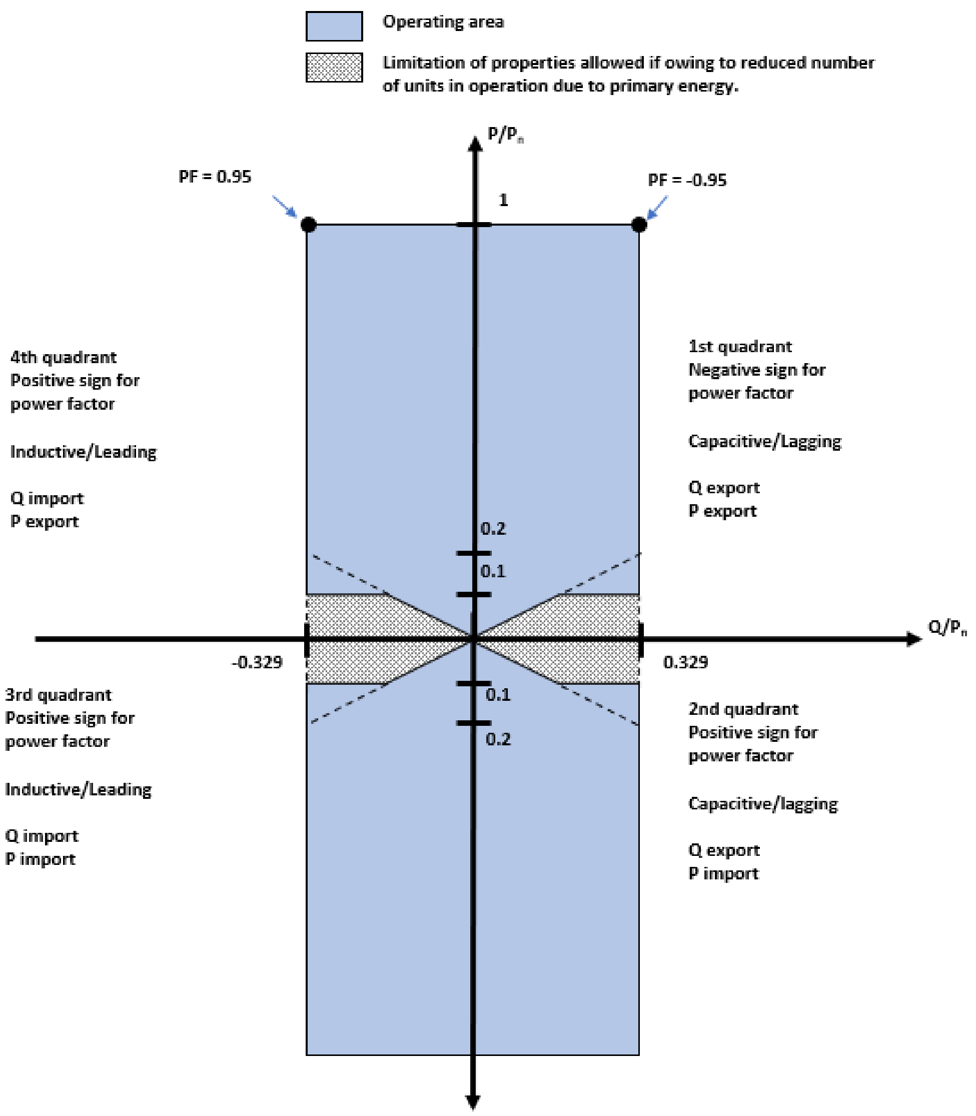


Figure 35 Operating range for P/P_n.
Quadrant numbering follows the generator convention.

Operating range for U/U_c

120. (1) Energy storage facilities must, at maximum active power output, be able to supply and absorb reactive power in the point of connection within the operating range specified in Figure 36.

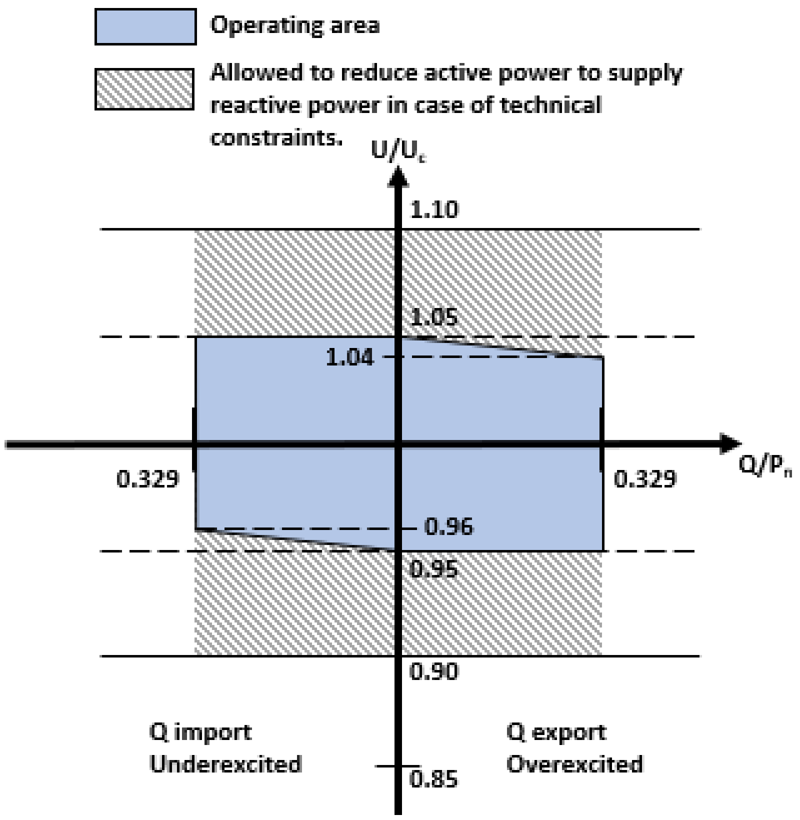


Figure 36 Operating range for U/U_c.

Power Oscillation Damping (POD)

121. (1) Energy storage facilities must be able to perform Power Oscillation Damping (POD).

(2) The POD property under subsection (1) above must observe the following requirements:

a) Active power oscillations generated by the energy storage facility, with frequencies equal to and above 0.1 Hz up to 50.0 Hz, must not exceed the least restrictive of:
   i. ±0.5% of current power production or consumption
   ii. ±0.25% of P_n.
b) Power oscillations which exceed the limit under para (a) above must be damped to within the limit values within 180 seconds of the limit being exceeded.
c) The property for damping power oscillations applies to all voltages within the normal operating range for voltages and frequency and within the time-limited operating voltage range.
d) The requirement applies and is verified for normal, stable conditions in the point of connection and after individual incidents outside the energy storage facility. If there are repeated incidents in the electricity supply system, the facility's power oscillations must be damped to be within the limit values within 180 seconds after the last incident in the electricity supply system.

Part 15
Non-synchronous energy storage facilities of type D

122. (1) Non-synchronous type D energy storage facilities must comply with the requirements in Parts 2, 3, 4, 5, 12, 13, 14 and this Part 15, taking into account the exceptions in these parts, with the exception of:

a) operating range requirements for P/P_n in section 108
b) operating range requirements for P/S_n in section 110
c) operating range requirements for U/U_n in section 111
d) operating range requirements for P/P_n in section 112
e) operating range requirements for U/U_c in section 113
f) operating range requirements for U/U_c in section 120.

Operating range for U/U_c

123. (1) Energy storage facilities must, at maximum active power output, be able to supply and absorb reactive power in the point of connection within the operating range specified in Figure 37.

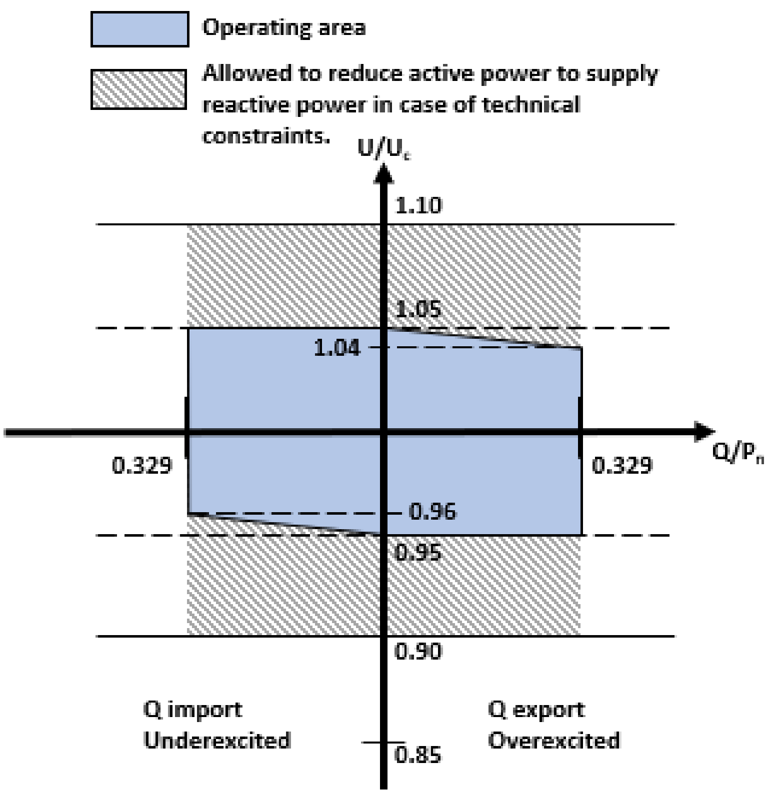


Figure 37 Operating range for U/U_c.

Extended Post Fault Active Power Recovery (extended PFAPR)

124. (1) Energy storage facilities must be able to return to normal operation in an extended process following a voltage dip in the electricity supply system, once the operating conditions in the point of connection have returned to the normal operating range for frequency and voltage (extended PFAPR), as shown in Figure 38.

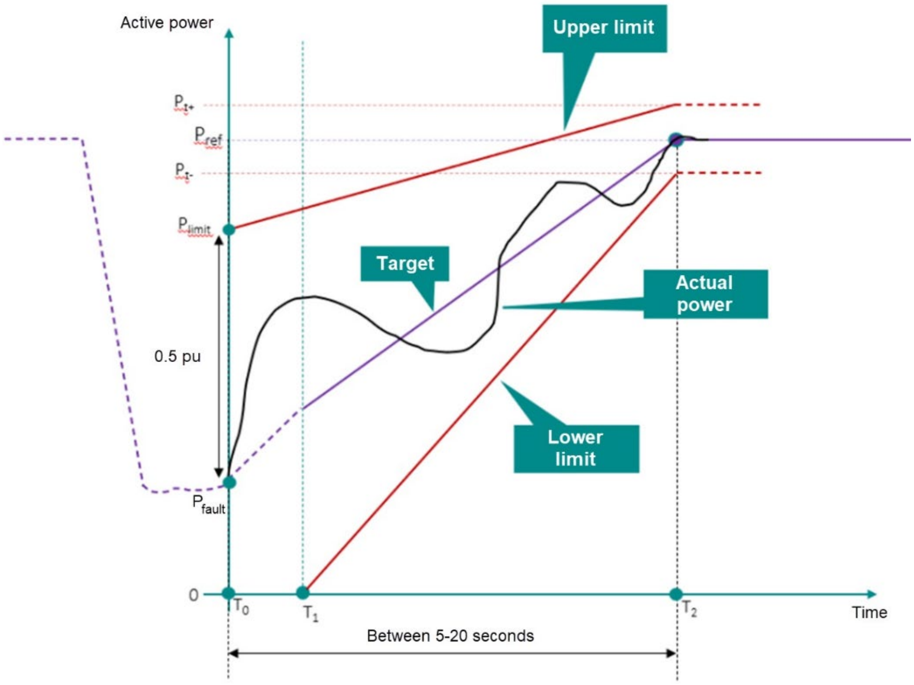


Figure 38 Requirements for extended PFAPR. The purple line (target) and black line (actual power) are examples to illustrate.

(2) The extended PFAPR property under subsection (1) above must observe the following requirements:

a) After a period of oscillation, the energy storage facility must resume its pre-fault operating point within 20 seconds after the operating conditions in the point of connection have returned to the normal frequency and voltage operating range.

b) It must be possible to set time T_2, when the active power is back to the pre-fault operating point, in the range 5-20 seconds with a resolution of 1 second.

c) The active power must lie within the upper and lower bounds shown in Figure 38. The upper bound is the line from P_{limit} at T_0 to P_{t+} at T_2, where P_{limit} is P_{fault} + 0.5 pu and P_{fault} is active power up to time T_0. The lower bound is the line from P = 0 at T_1 to P_{t-} at T_2.

d) The ramp rate during the adjustment (between T_0 and T_2) must not exceed 25% of P_n per second, and must lie within the range shown in Figure 38, where:

  i. T_0 is the time when the operating conditions return to the normal operating range for frequencies and voltages

  ii. T_0 to T_1 is between 100-500 milliseconds and indicates when the energy storage facility leaves FRT state when the function for delayed exit from FRT state is used, in line with this section 117. If the function for delayed exit from FRT state is not used, then $T_0 = T_1$

  iii. T_2 is the time when the energy storage facility has resumed its pre-fault operating point (up to 20 seconds after T_0)

  iv. P_{ref} is the energy storage facility's pre-fault operating point

  v. P_{t+} and P_{t-} are P_{ref} ±5% of P_n.

e) The precision of a completed control sequence must be ±5% of P_n, except in the event of changes to the availability of the primary energy source.

(3) The relevant system operator decides whether the function for PFAPR or extended PFAPR should be active.

Part 16
Non-synchronous energy storage facilities connected to the transmission system

125. (1) Non-synchronous energy storage facilities connected to the transmission system must comply with the requirements in Parts 2, 3, 4, 5, 6, 12, 13, 14, 15 and this Part 16, taking into account the exceptions in these parts, with the exception of:

a) operating range requirements for P/P_n in section 108
b) operating range requirements for P/S_n in section 110
c) operating range requirements for U/U_n in section 111
d) operating range requirements for P/P_n in section 112
e) operating range requirements for U/U_c in section 113
f) requirements for UV-FRT in section 114
g) requirements for FFC in section 115
h) operating range requirements for P/P_n in section 119
i) operating range requirements for U/U_c in section 120
j) operating range requirements for U/U_c in section 123.

Operating range for P/P_n

126. (1) Energy storage facilities must be capable of supplying and absorbing reactive power in the point of connection within the operating range specified in Figure 39.

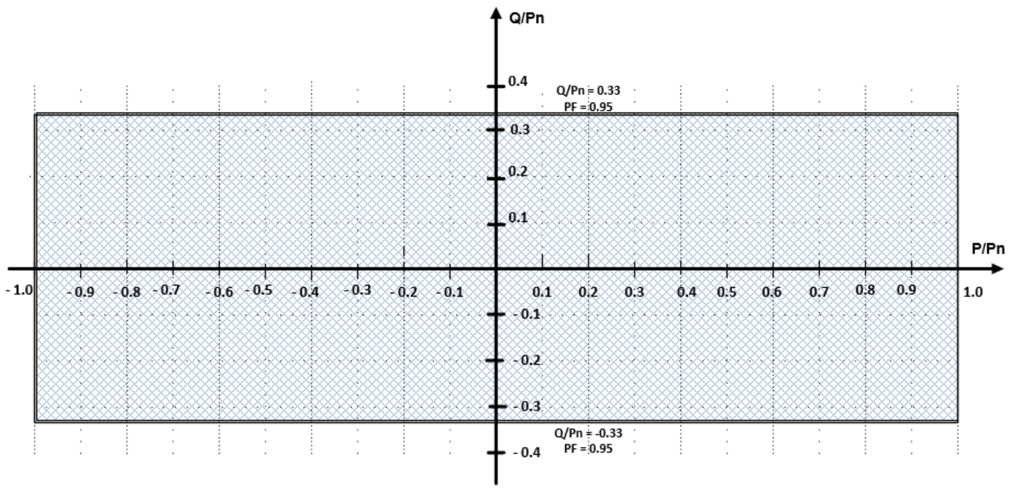


Figure 39 Operating range for P/P_n.

Operating range for $U\text{-}Q/P_n$

127. (1) At maximum production and consumption of active power, energy storage facilities must be able to supply and absorb reactive power in the point of connection within the operating range, as shown for connections at 110-300 kV in Figure 40 for DK1 and Figure 41 for DK2, and for connections at 300-400 kV in Figure 42.

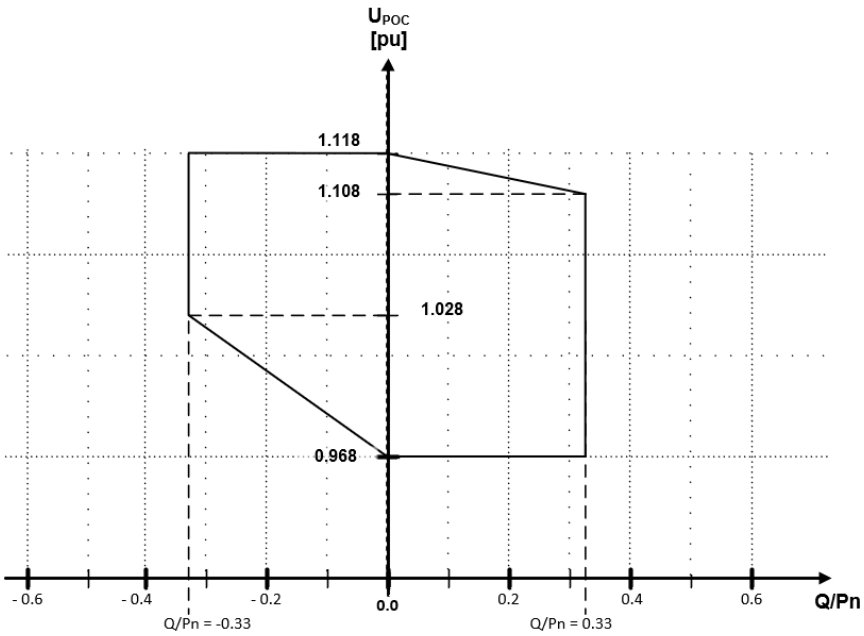


Figure 40 Operating range for U-Q/P_n when connected at 110-300 kV in DK1.

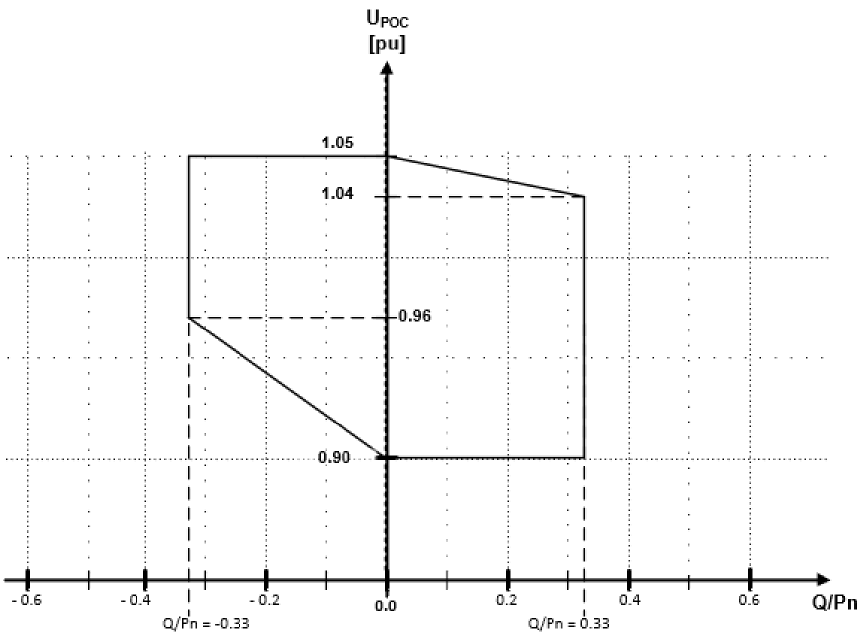


Figure 41 Operating range for U-Q/P_n when connected at 110-300 kV in DK2.

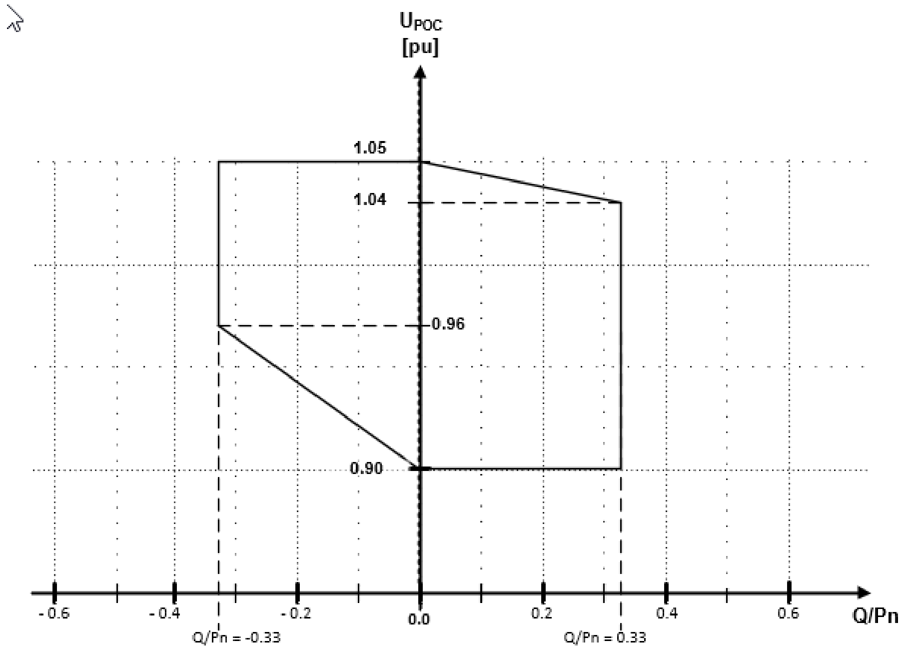


Figure 42 Operating range for U-Q/P_n when connected at 300-400 kV.

Undervoltage Fault-Ride-Through (UV-FRT) in DK1

128. (1) Energy storage facilities connected in DK1 must be able to withstand a voltage dip in the point of connection without disconnecting (UV-FRT), as specified in Table 45 and shown in Figure 43.

	Voltage		Duration [s]
U_{ret}	0	T_{clear}	0.15
U_{clear}	0	T_{rec1}	0.15
U_{rec1}	0	T_{rec2}	0.15
U_{rec2}	0.85	T_{rec3}	1.50

Table 45 Requirements for UV-FRT.

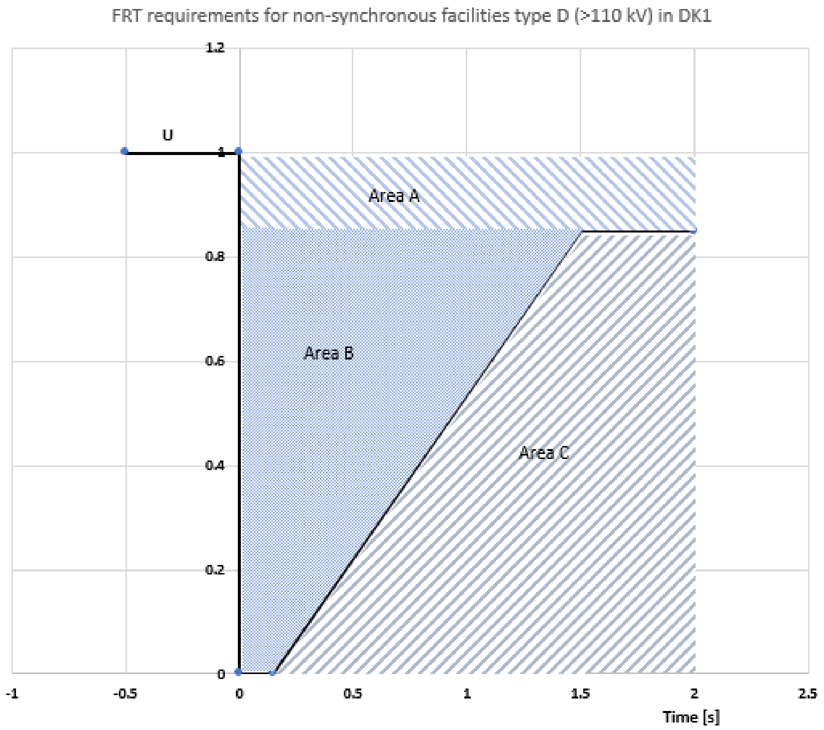


Figure 43 Requirements for UV-FRT in DK1.

(2) If, during a fault sequence, the voltage in the point of connection reverts after 1.5 seconds to at least 0.85 pu, any new voltage dip must be regarded as a new fault situation.

(3) If several successive fault sequences within area B cause the facility to enter area C time-wise, disconnection of the facility is permitted.

Undervoltage Fault-Ride-Through (UV-FRT) in DK2

129. (1) Energy storage facilities connected in DK2 must be able to withstand a voltage dip in the point of connection without disconnecting (UV-FRT), as specified in Table 46 and shown in Figure 44.

	Voltage		Duration [s]
U_{ret}	0	T_{clear}	0.15
U_{clear}	0	T_{rec1}	0.15
U_{rec1}	0	T_{rec2}	0.15
U_{rec2}	0.90	T_{rec3}	1.50

Table 46 Requirements for UV-FRT.

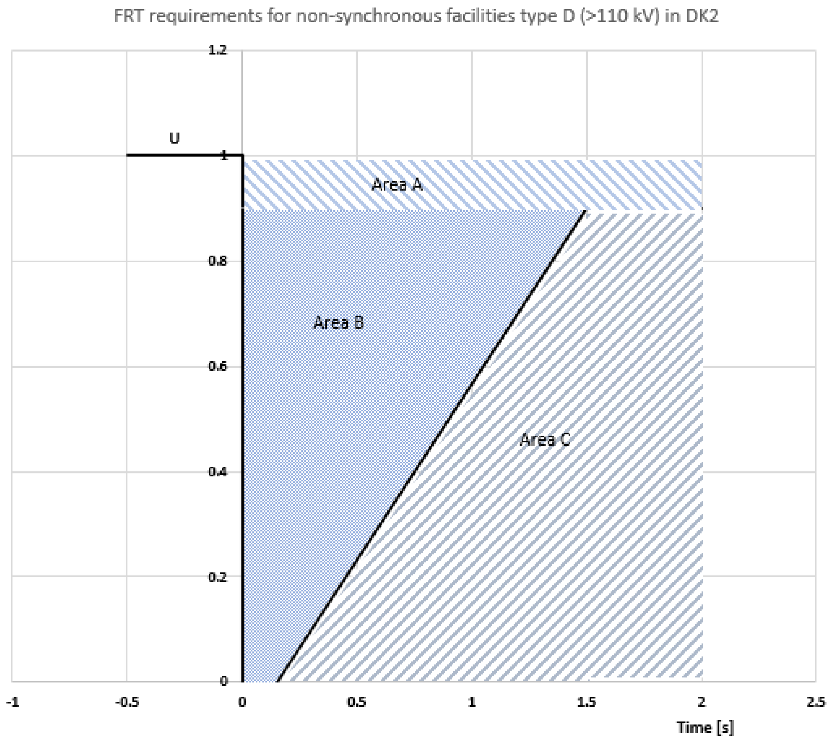


Figure 44 Requirements for UV-FRT in DK2.

(2) If, during a fault sequence, the voltage in the point of connection reverts after 1.5 seconds to at least 0.90 pu, any new voltage dip must be regarded as a new fault situation.

(3) If several successive fault sequences within area B cause the facility to enter area C time-wise, disconnection of the facility is permitted.

Q control

130. (1) Energy storage facilities must be able to supply and absorb a fixed level of reactive power in the point of connection (Q control).

(2) It must be possible to adjust the Q control under subsection (1) above such that:

a) orders to change the set point can be applied within 2 seconds of receipt
b) adjustment to a new set point begins within 2 seconds of receiving an order to change the set point
c) adjustment to a new set point is complete within 30 seconds of receiving an order to change the set point.

(3) The Q control under subsection (1) above must be adjustable with:

a) a maximum imprecision of 5 MVAr or 5% of Q_n (the lesser of the two), where precision is measured over a period of 1 minute, and
b) a resolution of 5 MVAr or 5% of Q_n (the lesser of the two) or better.

Power factor control

131. (1) Energy storage facilities must be able to supply and absorb active and reactive power with a power factor in the point of connection (power factor control).

(2) It must be possible to adjust the power factor control under subsection (1) above such that:

a) orders to change the set point can be applied within 2 seconds of receipt

b) adjustment to a new set point begins within 2 seconds of receiving an order to change the set point

c) adjustment to a new set point is complete within 30 seconds of receiving an order to change the set point.

(3) The power Factor control under subsection (1) above must be adjustable with:

a) a maximum imprecision of ±2% of the energy storage facility's Q_n, where precision is measured over a period of 1 minute, and

b) a resolution of 0.01 or better.

Voltage control

132. (1) Energy storage facilities must be able to supply and absorb reactive power and thereby maintain a stable and constant voltage in the point of connection (voltage control).

(2) Voltage control in line with subsection (1) above must be able to effect 90% of the set point change within 1 second, and the remaining 10% (up to 100%) within 5 seconds of receiving an order to change the set point. The voltage control must be set with:

a) a maximum imprecision of ±5% of the energy storage facility's Q_n, where precision is measured over a period of 1 minute

b) a resolution for droop of 0.5% or better. It must be possible to set the droop in the 2-7% range

c) a step size for the dead band that can be set in the range ±5% of U_{ref} with a step size not exceeding 0.25% for 220/400 kV and 0.5% for 132/150 kV, and must be symmetrical around the set point for voltage control

d) a set point decided by the relevant system operator within the normal operating voltage range.

Fast Fault Current (FFC) for DK1

133. (1) Energy storage facilities must have a control function capable of controlling the positive sequence of the reactive current during a fault sequence (Fast Fault Current, FFC), as specified in Figure 45.

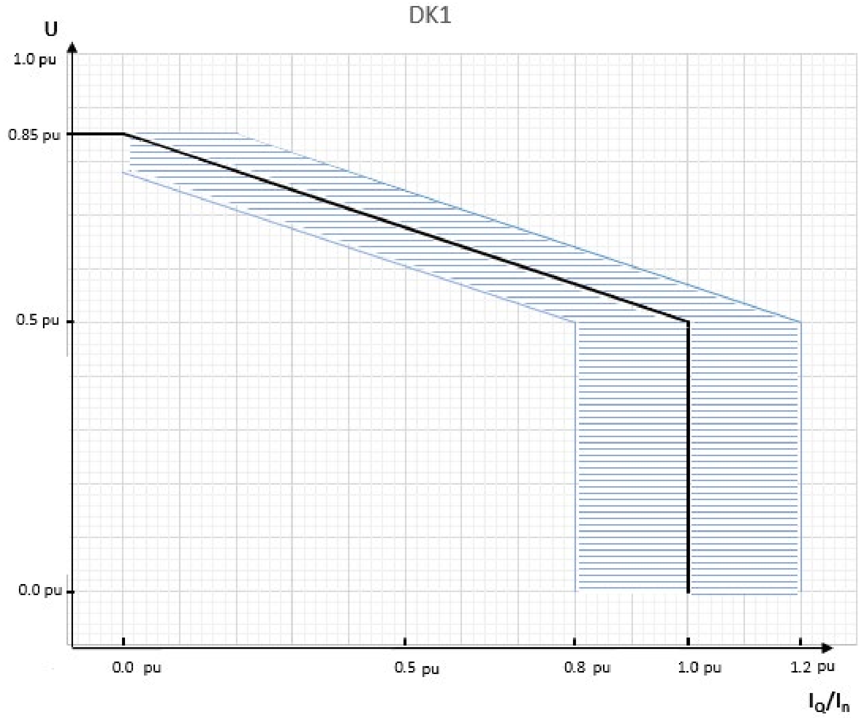


Figure 45 FFC requirements in DK1.

(2) Control in line with subsection (1) above must:

a) commence within 100 ms after the voltage dip, and
b) follow the characteristic in Figure 45, starting from 0.9 pu to 0.5 pu with a tolerance of ±20% of I_n.

Fast Fault Current (FFC) for DK2

134. (1) Energy storage facilities connected to the transmission system must have a control function capable of controlling the positive sequence of the reactive current during a fault sequence (Fast Fault Current, FFC), as specified in Figure 46.

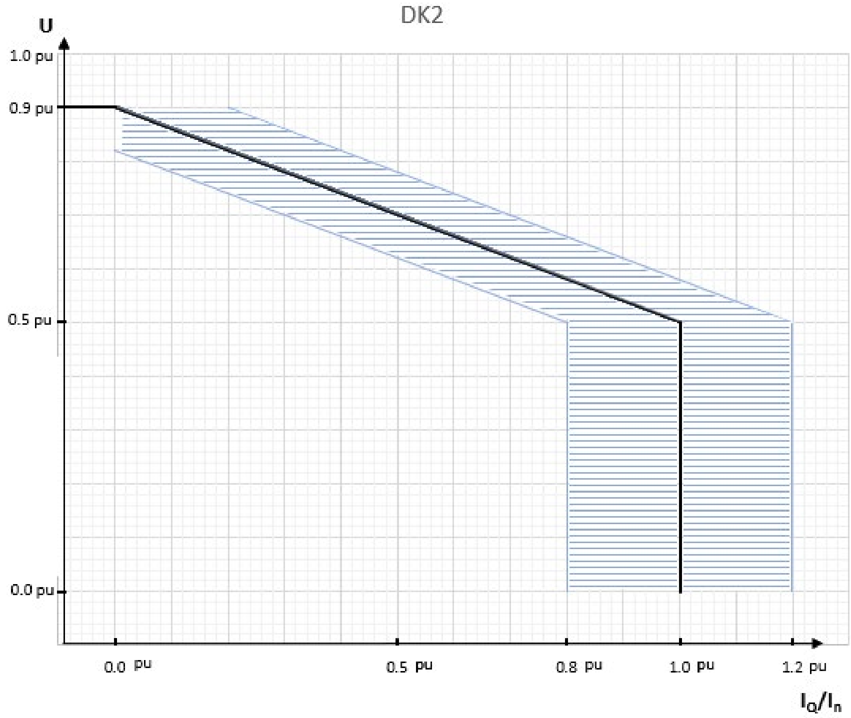


Figure 46 FFC requirements in DK2.

(2) Control in line with subsection (1) above must:

a) commence within 100 ms after the voltage dip, and
b) follow the characteristic in Figure 46, starting from 0.9 pu to 0.5 pu with a tolerance of ±20% of I_n.

Part 17
Compliance with requirements

Facility owner's responsibility

135. (1) The facility owner must ensure that the energy storage facility meets the requirements of this regulation throughout the service life of the facility.

(2) The facility owner must notify the relevant system operator in advance of any planned modifications to the technical properties of the energy storage facility that could affect compliance with the requirements in this regulation.

(3) The facility owner must notify the relevant system operator of any incident related to the operation of or a fault in the energy storage facility that affects compliance with the requirements in this regulation, immediately after such an incident occurs.

(4) The facility owner must notify the relevant system operator of planned testing and procedures to be followed in connection with verifying the energy storage facility's compliance with the requirements in this regulation, well in advance of initiating these. The relevant system operator must approve the planned testing and procedures beforehand. The relevant system operator must approve these within a reasonable time period, without undue delay.

(5) The relevant system operator must have the opportunity to participate in testing and record the performance of the energy storage facility.

Duties of the relevant system operator

136. (1) The relevant system operator assesses an energy storage facility's compliance with the requirements in this regulation throughout the service life of the facility. The facility owner is notified of the result of this assessment.

(2) The relevant system operator may request that the facility owner perform compliance testing and simulations according to a repeat schedule or general plan, or immediately after a fault, modification or equipment replacement that could affect the energy storage facility's compliance with the requirements in this regulation. The facility owner is notified of the result of these compliance tests and simulations.

(3) The relevant system operator publishes a list of information and documents facility owners must submit, and the requirements to be met in the compliance process. This list must contain the following information, documents, and requirements, as a minimum:

a) documentation and certificates the facility owner must submit
b) detailed technical information about the energy storage facility relevant to grid connection
c) requirements for the models to be used when investigating systems in static and dynamic state
d) a schedule for submitting system data for use in the investigations
e) investigations to be carried out by the facility owner to demonstrate expected performance in static and dynamic state, in line with the requirements in Part 18
f) the conditions and procedures, including scope, that apply to registering product certificates, and
g) the conditions and procedures that apply to the facility owner's use of relevant product certificates issued by an approved certification body.

(4) The relevant system operator publishes the division of responsibilities between the facility owner and the system operator with regard to compliance testing, simulations, and monitoring.

(5) The relevant system operator may delegate, in full or in part, performance of its compliance monitoring tasks to third parties. If this is the case, the relevant system operator must ensure ongoing compliance with confidentiality requirements.

(6) If compliance testing or simulations cannot be performed as agreed between the relevant system operator and the facility owner for reasons attributable to the relevant system operator, the relevant system operator must not unduly withhold the grid connection permit discussed in Part 18.

Part 18
Compliance testing and simulation

Common provisions on compliance testing

137. (1) The purpose of energy storage facility performance testing is to demonstrate that the requirements in this regulation are met.

(2) Without affecting the minimum requirements for compliance testing in this regulation, the relevant system operator is entitled to:

a) permit the facility owner to perform alternative tests, provided that these tests can effectively and sufficiently demonstrate that the energy storage facility meets the requirements in this regulation
b) require the facility owner to carry out additional or alternative testing if the information the relevant system operator receives in connection with compliance testing

under Part 18 is not sufficient to demonstrate that the requirements in this regulation are met

c) require the facility owner to conduct appropriate tests to demonstrate the performance of the energy storage facility during operation based on alternative fuels or fuel mixes. The relevant system operator and facility owner agree on the types of fuel to be tested.

(3) The facility owner is responsible for performing testing in line with the conditions in Part 18. The relevant system operator cooperates and does not unnecessarily delay performance of the tests.

(4) The relevant system operator must be able to participate in compliance testing, either on site or by a remote connecting to the system operator's control centre. To this end, the facility owner must provide the necessary monitoring equipment to record all relevant test signals and measurements and ensure that its necessary representatives are available on site throughout the test period. Signals defined by the relevant system operator must be provided if the system operator wants to use its own equipment to record performance for selected tests. It is up to the relevant system operator to decide whether or not to participate.

Common provisions on compliance simulation

138. (1) The purpose of energy storage facility performance simulation is to demonstrate that the requirements in this regulation are met.

(2) Without affecting the minimum requirements for compliance simulation in this regulation, the relevant system operator may:

a) permit the facility owner to perform alternative simulations, provided that these simulations are suitable and sufficiently demonstrate that the energy storage facility meets the requirements in this regulation or other applicable requirements

b) require the facility owner to carry out additional or alternative simulations if the information the relevant system operator receives in connection with compliance simulations under Part 18 is not sufficient to demonstrate that the requirements in this regulation are met.

(3) To demonstrate compliance with the requirements in this regulation, the facility owner must submit a report containing the results of the simulations for the energy storage facility. The relevant system operator must approve the facility owner's compliance simulation method.

(4) The relevant system operator is entitled to verify that the energy storage facility meets the requirements in this regulation by conducting its own compliance simulations, based on the simulation reports, simulation models and compliance test measurements submitted.

(5) The relevant system operator provides the facility owner with technical information and a grid simulation model where these are necessary to perform the required simulations.

Compliance testing for type B synchronous energy storage facilities

139. (1) Facility owners conduct LFSM-O state compliance testing for type B synchronous energy storage facilities. Instead of conducting the relevant tests, the facility owner may choose to rely on product certificates issued by an approved certification body to demonstrate compliance with this requirement. These product certificates must be submitted to the relevant system operator if so.

(2) The following requirements apply to testing LFSM-O state:

a) The energy storage facility's technical capacity to constantly modulate active power to contribute to frequency control in the event of a major rise in system frequency must be demonstrated. Static state control parameters, such as parameters for droop (negative slope) and dead band, and dynamic parameters, including response to changes in frequency steps, must be verified.

b) The testing is conducted by simulating frequency steps and ramps large enough to trigger a change in maximum active power of at least 10%, taking into account the droop settings for negative slope and dead band. If necessary, simulated frequency deviation signals must be sent simultaneously to both the speed regulator and the load control in the control system, taking into account the given control system scheme.

c) The testing is deemed to be successful if the following conditions are met:

i. The test results for both the dynamic and the static parameters meet the requirements for LFSM-O.

ii. No undamped oscillations occur following the response to step change.

Compliance testing for type C synchronous energy storage facilities

140. (1) In addition to compliance testing for type B synchronous energy storage facilities, facility owners must conduct the compliance tests set out in subsections (2), (3), (4) and (6) below for type C synchronous energy storage facilities. If an energy storage facility is capable of starting up from a dead grid, the facility owner must also perform the tests in subsection (5) below. Instead of conducting the relevant testing, the facility owner may choose to rely on product certificates issued by an approved certification body to demonstrate compliance with this requirement. These product certificates must be submitted to the relevant system operator if so.

(2) The following requirements apply to testing LFSM-U state:

a) The energy storage facility's technical capacity to constantly modulate active power at operating points below maximum power to contribute to frequency control in the event of a major drop in system frequency must be demonstrated.

b) The testing is conducted by simulating suitable reference points for active power at low frequency steps and ramps that are large enough to trigger a change of at least 10% in maximum active power, taking into account the droop settings for negative slope and dead band. If necessary, simulated frequency deviation signals must be sent simultaneously to both the speed regulator and load control references.

c) The testing is deemed to be successful if the following conditions are met:

i. The test results for both the dynamic and the static parameters meet the requirements for LFSM-U.

ii. No undamped oscillations occur following the response to step change.

(3) The following requirements apply to testing FSM state:

a) The energy storage facility's technical capacity to constantly modulate active power in the full operating range between maximum power and the lower limit for control to contribute to frequency control must be demonstrated. Static state control parameters, such as parameters for droop (negative slope) and dead band, and dynamic parameters, including robust response to deviations in frequency steps and large, rapid changes in frequency, must be verified.

b) The testing is conducted by simulating frequency steps and ramps large enough to trigger the entire range for frequency response for active power, taking into account the droop settings for negative slope, dead band, and the ability to actually increase or decrease active power in relation to the given operating point. If necessary, simulated frequency deviation signals must be sent simultaneously to both the speed regulator and the load control in the unit's or the facility's control system

c) The testing is deemed to be successful if the following conditions are met:

i. The time until full activation of the frequency response range for active power as a result of the frequency step change does not exceed the time set for the FSM control function.
ii. No undamped oscillations occur following the response to step change.
iii. The initial delay complies with the provisions for the FSM control function.
iv. The droop settings for negative slope are available within the set interval for LFSM, and the dead band (threshold) does not exceed the value set for the FSM control function.
v. The frequency response for active power insensitivity at any relevant operating point does not exceed the requirements set for the FSM control function.

(4) The following requirements apply to frequency restoration control testing:

a) The energy storage facility's technical capacity to participate in frequency restoration control must be demonstrated, and cooperation between FSM state and frequency restoration control must be checked.
b) The testing is deemed to be successful if the results for both the dynamic and the static parameters meet the requirements for LFSM.

(5) The following requirements apply to testing the capability to start up from a dead grid:

a) If an energy storage facility is capable of starting up from a dead grid, this ability to start up after a shutdown without any external electrical energy supply must be demonstrated.
b) The test is deemed to be successful if the start-up time is kept within the timeframe specified in the tender for the system recovery reserve.

(6) The following requirements apply to testing capability to supply reactive power:

a) The energy storage facility's technical capacity to supply reactive power with positive and negative phase shifts in accordance with the energy storage facility's operating range must be demonstrated.
b) The testing is deemed to be successful if the following conditions are met:
    i. The energy storage facility operates at maximum reactive power, with both positive and negative phase shifts, for at least one hour at the lowest stable operating level, maximum power and an active power operating point that lies between these maximum and minimum levels.
    ii. The energy storage facility's ability to switch to any reactive power value within the agreed or defined reactive power range is demonstrated.

Compliance testing for type D synchronous energy storage facilities

141. (1) Type D synchronous energy storage facilities must perform the same compliance tests as synchronous type B and C energy storage facilities.

(2) Instead of conducting the relevant testing, the facility owner may choose to rely on product certificates issued by an approved certification body to demonstrate compliance with this requirement. These product certificates must be submitted to the relevant system operator if so.

Compliance testing for type B non-synchronous energy storage facilities

142. (1) Facility owners conduct LFSM-O state compliance testing for type B non-synchronous energy storage facilities. Instead of conducting the relevant testing, the facility owner may choose to rely on product certificates issued by an approved certification body to demonstrate compliance with this requirement. These product certificates must be submitted to the relevant system operator if so.

(2) For type B energy storage facilities, the LFSM-O state testing must reflect the relevant system operator's control scheme.

(3) The following requirements apply to testing LFSM-O state:

a) the energy storage facility’s technical capacity to constantly modulate active power to contribute to frequency control in the event of a rise in system frequency must be demonstrated. Static state control parameters, such as parameters for droop (negative slope) and dead band and dynamic parameters must be verified.
b) the testing is conducted by simulating frequency steps and ramps large enough to trigger a change in maximum active power of at least 10%, taking into account the droop settings for negative slope and dead band. To perform this testing, simulated frequency deviation signals must be sent simultaneously to the control system references
c) the testing is deemed to be successful if the results for both the dynamic and the static parameters meet the requirements for LFSM-O.

Compliance testing for type C non-synchronous energy storage facilities

143. (1) In addition to compliance testing for type B non-synchronous energy storage facilities, facility owners must conduct the compliance tests set out in subsections (2)-(9) below for type C non-synchronous energy storage facilities. Instead of conducting the relevant testing, the facility owner may choose to rely on product certificates issued by an approved certification body to demonstrate compliance with this requirement. These product certificates must be submitted to the relevant system operator if so.

(2) The following requirements apply to testing the controllability of active power and the range of control:

a) The technical capacity of the energy storage facility to operate at a load level below the reference point determined by the relevant system operator or Energinet must be demonstrated.
b) The testing is deemed to be successful if the following conditions are met:
   i. The energy storage facility’s load level is kept below the reference point.
   ii. The reference point is implemented in line with the requirements for the absolute power constraint function.
   iii. The control precision meets the requirements for the absolute power constraint function.

(3) The following requirements apply to testing LFSM-U state:

a) The energy storage facility’s technical capacity to constantly modulate active power to contribute to frequency control in the event of a major drop in system frequency must be demonstrated.
b) The testing is conducted by simulating frequency steps and ramps large enough to trigger a change in maximum active power of at least 10%, starting at 80% or less of the maximum power, taking into account the droop settings for negative slope and dead band.
c) The testing is deemed to be successful if the following conditions are met:
   i. The test results for both the dynamic and the static parameters meet the requirements for LFSM-U.
   ii. No undamped oscillations occur following the response to step change.

(4) The following requirements apply to testing FSM state:

a) The energy storage facility’s technical capacity to constantly modulate active power in the full operating range between maximum power and the lower limit for control to contribute to frequency control must be demonstrated. Static state control parameters, such as parameters for insensitivity, droop (negative slope), dead band and control range, and dynamic parameters, including response to changes in frequency steps, must be verified.

b) The testing is conducted by simulating frequency steps and ramps large enough to trigger the entire range for frequency response for active power, taking into account the droop settings for negative slope and dead band. Simulated frequency deviation signals must be sent.
c) The testing is deemed to be successful if the following conditions are met:
   i. The time until full activation of the frequency response range for active power as a result of the frequency step change does not exceed the time set in the FSM control function.
   ii. No undamped oscillations occur following the response to step change.
   iii. The initial delay meets the requirements for the FSM control function.
   iv. The droop settings for negative slope are available within the set intervals in the LFSM control function, and the dead band (threshold) does not exceed the value set for the FSM control function.
   v. The frequency response for active power insensitivity does not exceed the requirements set for the FSM control function.

(5) The following requirements apply to frequency restoration control testing:

a) The energy storage facility's technical capacity to participate in frequency restoration control must be demonstrated. The cooperation between FSM state and frequency restoration control must be checked.
b) The testing is deemed to be successful if the results for both the dynamic and the static parameters meet the requirements set in the tender for the system recovery reserve.

(6) The following requirements apply to testing capability to supply reactive power:

a) The energy storage facility's technical capacity to supply reactive power with positive and negative phase shifts in accordance with the energy storage facility's operating range must be demonstrated.
b) The testing is carried out at maximum reactive power, with both positive and negative phase shifts, and verifies the following parameters:
   i. operating above 60% of maximum power for 30 minutes or until the energy source is exhausted
   ii. operating in the 30-50% of maximum power range for 30 minutes or until the energy source is exhausted and
   iii. operating in the 10-20% of maximum power range for 60 minutes or until the energy source is exhausted.
c) The testing is deemed to be successful if the following conditions are met:
   i. The energy storage facility runs for at least the requested period at maximum reactive power, with both positive and negative phase shifts, in accordance with each of the parameters specified in para (b) above.
   ii. The energy storage facility's ability to switch to any reactive power value within the agreed or defined reactive power range is demonstrated.
   iii. No protective measures are taken within the operating limits set out in the reactive power diagram.

(7) The following requirements apply to testing voltage control state:

a) The energy storage facility's ability to operate in voltage control state, in line with the conditions for voltage control, must be demonstrated.
b) The voltage control state testing must verify the following parameters:
   i. the implemented droop (positive slope) and dead band
   ii. control precision
   iii. control insensitivity and
   iv. the time until reactive power is activated.

c) the testing is deemed to be successful if the following conditions are met:
   i. The control interval, the adjustable droop (negative slope) and the dead band observe the agreed or set parameter characteristics.
   ii. The voltage control requirements in the 0.95 to 1.05 pu range have been met in steps of 0.01 pu or less, in line with the set requirements for voltage control.
   iii. After a change in voltage step, 90% of the change in reactive power is reached within the time and tolerances set in the voltage control requirements.

(8) The following requirements apply to testing reactive power control state:

a) The energy storage facility's ability to operate in reactive power control state, in line with the conditions for Q control, must be demonstrated.
b) The reactive power control state testing must complement testing of the ability to supply reactive power.
c) The reactive power control state testing must verify the following parameters:
   i. range and rise for the reactive power reference point
   ii. control precision and
   iii. the time until reactive power is activated.
d) The testing is deemed to be successful if the following conditions are met:
   i. The interval and rise for the reactive power reference point are ensured to be in line with the requirements for Q control.
   ii. The control precision meets the requirements for Q control.

(9) The following requirements apply to testing power factor control state:

a) The energy storage facility's ability to operate in power factor control state, in line with the conditions for power factor control, must be demonstrated.
b) The power factor control state testing must verify the following parameters:
   i. the range for the power factor reference point
   ii. control precision and
   iii. the reactive power response to a step change in active power.
c) The testing is deemed to be successful if the following conditions are cumulatively met:
   i. The interval and rise for the power factor reference point are ensured to be in line with the requirements for power factor control.
   ii. The time until reactive power is activated as a result of a step change in active power does not exceed the power factor control requirement.
   iii. The control precision observes the value set for power factor control.

(10) For the testing referred to in subsections (7), (8) and (9) above, the relevant system operator may only select one of the three states for testing.

Compliance testing for type D non-synchronous energy storage facilities

144. (1) Type D non-synchronous energy storage facilities must perform the same compliance tests as non-synchronous type B and C energy storage facilities.

(2) Instead of conducting the relevant testing, the facility owner may choose to rely on product certificates issued by an approved certification body to demonstrate compliance with this requirement. These product certificates must be submitted to the relevant system operator if so.

Compliance simulation for type B synchronous energy storage facilities

145. (1) Facility owners perform LFSM-O state simulation for type B synchronous energy storage facilities. Instead of performing the relevant simulation, the facility owner may choose to rely on product certificates issued by an approved certification body to demonstrate compliance with this requirement. These product certificates must be submitted to the relevant system operator if so.

(2) The following requirements apply to simulating LFSM-O state:

a) The energy storage facility's ability to modulate active power at high frequencies, in line with the LFSM-O requirements, must be demonstrated through simulation.
b) The simulation is performed by simulating high frequency steps and ramps that reach the lower control limit, taking into account the droop settings for negative slope and dead band.
c) The simulation is deemed to be successful if:
   i. the energy storage facility's simulation model is validated in relation to the compliance tests for LFSM-O state, and
   ii. compliance with the requirements for LFSM-O is demonstrated.

(3) The following requirements apply to simulating tolerance of voltage faults for type B synchronous energy storage facilities:

a) The energy storage facility's tolerance of voltage faults, in line with the conditions for UV-FRT and OV-FRT, must be demonstrated through simulation.
b) The simulation is deemed to be successful if it is demonstrated that requirements for UV-FRT and OV-FRT are met.

(4) The following requirements apply to simulating active power restoration after a fault:

a) The energy storage facility's ability to restore active power after a fault, in line with the conditions for PFAPR, must be demonstrated.
b) The simulation is deemed to be successful if it is demonstrated that the PFAPR requirement is met.

Compliance simulation for type C synchronous energy storage facilities

146. (1) In addition to the compliance simulations for type B synchronous energy storage facilities, type C synchronous energy storage facilities must perform the compliance simulations described in subsections (2)-(4) below. Instead of performing some or all of these simulations, the facility owner may choose to rely on product certificates issued by an approved certification body, which must be submitted to the relevant system operator.

(2) The following requirements apply to simulating LFSM-U state:

a) The energy storage facility's ability to modulate active power at low frequencies, in line with the LFSM requirements, must be demonstrated.
b) The simulation is performed by simulating low frequency steps and ramps that reach maximum power, taking into account the droop settings for negative slope and dead band.
c) The simulation is deemed to be successful if:
   i. the energy storage facility's simulation model is validated in relation to the compliance tests for LFSM-U state, and
   ii. compliance with the requirements for LFSM is demonstrated.

(3) The following requirements apply to simulating FSM state:

a) The energy storage facility's ability to modulate active power in the full frequency range, in line with the FSM control function requirements, must be demonstrated.
b) The simulation is performed by simulating frequency steps and ramps large enough to trigger the entire range for frequency response for active power, taking into account the droop settings for negative slope and dead band.

c) The simulation is deemed to be successful if:
   i. the energy storage facility's simulation model is validated in relation to compliance testing for FSM state, and
   ii. compliance with the requirements for LFSM is demonstrated.

(4) The following requirements apply to simulating ability to supply reactive power:

a) The energy storage facility's ability to supply reactive power with positive and negative phase shifts in accordance with the energy storage facility's operating range must be demonstrated.
b) The simulation is deemed to be successful if:
   i. the energy storage facility's simulation model is validated in relation to the compliance tests for reactive power, and
   ii. it is demonstrated that the requirements set for the operating range are met.

Compliance simulation for type D synchronous energy storage facilities

147. (1) In addition to compliance simulations for type B and C synchronous energy storage facilities, with the exception of simulating tolerance of voltage faults that applies to type B synchronous energy storage facilities, type D synchronous energy storage facilities must perform the compliance simulations described in subsections (2) and (3) below. Instead of performing some or all of these simulations, the facility owner may choose to rely on product certificates issued by an approved certification body, which must be submitted to the relevant system operator.

(2) The following requirements apply to simulating damping of power fluctuations:

a) It must be demonstrated that the energy storage facility's control system (power system stabiliser) is capable of damping active power fluctuations, in line with the conditions for AVR and PSS.
b) The adjustment must result in better damping of the automatic voltage regulator's response for active power in combination with the power system stabiliser, compared to the automatic voltage regulator's response for active power alone.
c) The simulating is deemed to be successful if the following conditions are cumulatively met:
   i. The power system stabiliser damps the energy storage facility's existing active power fluctuations within a frequency range set by the relevant TSO. This frequency range must include the energy storage facility's local state frequencies and the expected grid fluctuations.
   ii. A sudden load reduction for the energy storage facility from 1 pu to 0.6 pu of maximum power does not lead to undamped oscillations of active or reactive power for the energy storage facility.

(3) The following requirements apply to simulating tolerance of voltage faults for type D synchronous energy storage facilities:

a) The energy storage facility's tolerance of voltage faults, in line with the conditions for UV-FRT and OV-FRT, must be demonstrated.
b) The simulation is deemed to be successful if it is demonstrated that requirements for UV-FRT and OV-FRT are met.

Compliance simulation for type B non-synchronous energy storage facilities

148. (1) Type B non-synchronous energy storage facilities must perform the compliance simulation in subsections (2)-(5) below. Instead of performing some or all of these simulations, the facility owner may choose to rely on product certificates issued by an approved certification body, which must be submitted to the relevant system operator.

(2) The following requirements apply to simulating LFSM-O state:

a) The energy storage facility's ability to modulate active power at high frequencies, in line with the LFSM-O requirements, must be demonstrated.
b) The simulation is performed by simulating high frequency steps and ramps that reach the lower control limit, taking into account the droop settings for negative slope and dead band.
c) The simulation is deemed to be successful if:
   i. the energy storage facility's simulation model is validated in relation to the compliance tests for LFSM-O state, and
   ii. compliance with the requirements for LFSM-O is demonstrated.

(3) The following requirements apply to simulating the supply of fast fault current:

a) The energy storage facility's ability to provide fast fault current in accordance with the conditions for FCC must be demonstrated.
b) The simulation is deemed to be successful if it is demonstrated that the FCC requirement is met.

(4) The following requirements apply to simulating tolerance of voltage faults for type B energy storage facilities:

a) The energy storage facility's tolerance of voltage faults, in line with the conditions for UV-FRT and OV-FRT, must be demonstrated through simulation.
b) The simulation is deemed to be successful if it is demonstrated that requirements for UV-FRT and OV-FRT are met.

(5) The following requirements apply to simulating active power restoration after a fault:

a) The energy storage facility's ability to restore active power after a fault, in line with the conditions for PFAPR, must be demonstrated.
b) The simulation is deemed to be successful if it is demonstrated that the PFAPR requirement is met.

Compliance simulation for type C non-synchronous energy storage facilities

149. (1) In addition to the compliance simulations for type B energy storage facilities, type C non-synchronous energy storage facilities must perform the compliance simulations described in subsections (2)-(5) below. Instead of performing some or all of these simulations, the facility owner may choose to rely on product certificates issued by an approved certification body, which must be submitted to the relevant system operator.

(2) The following requirements apply to simulating LFSM-U state:

a) The energy storage facility's ability to modulate active power at low frequencies, in line with the LFSM requirements, must be demonstrated.
b) The simulation is performed by simulating low frequency steps and ramps that reach maximum power, taking into account the droop settings for negative slope and dead band.
c) The simulation is deemed to be successful if:
   i. the energy storage facility's simulation model is validated in relation to the compliance tests for LFSM-U state, and
   ii. compliance with the requirements for LFSM-U is demonstrated.

(3) The following requirements apply to simulating FSM state:

a) The energy storage facility's ability to modulate active power in the full frequency range, in line with the FSM control function requirements, must be demonstrated.
b) The simulation is performed by simulating frequency steps and ramps large enough to trigger the entire range for frequency response for active power, taking into account the droop settings for negative slope and dead band.
c) The simulation is deemed to be successful if:

i. the energy storage facility's simulation model is validated in relation to compliance testing for FSM state, and
ii. it is demonstrated that the set requirement for the FSM control function is met.

(4) The following requirements apply to simulating ability to supply reactive power:

a) It must be demonstrated that the energy storage facility can supply reactive power with positive and negative phase shifts in accordance with the energy storage facility's operating range.
b) The simulating is deemed to be successful if the following conditions are cumulatively met:
   i. the energy storage facility's simulation model is validated in relation to the compliance tests for reactive power, and
   ii. it is demonstrated that the requirements set for the operating range are met.

(5) The following requirements apply to simulating damping of power fluctuations:

a) The model of the energy storage facility must demonstrate that it can provide damping of active power oscillations in line with the requirements for power oscillation damping (POD).
b) The simulation is deemed to be successful if the model demonstrates that the requirements for power oscillation damping (POD) are met.

Compliance simulation for type D non-synchronous energy storage facilities

150. (1) In addition to compliance simulations for type B and C non-synchronous energy storage facilities, with the exception of tolerance of voltage faults that applies to type B non-synchronous energy storage facilities, type D non-synchronous energy storage facilities must perform compliance simulation of the capacity for uninterrupted operation.

(2) Instead of performing some or all of the simulations noted in subsection (1) above, the facility owner may choose to rely on product certificates issued by an approved certification body, which must be submitted to the relevant system operator.

(3) The model of the energy storage facility must demonstrate that it can simulate tolerance of voltage faults, in line with the requirements for UV-FRT and OV-FRT.

(4) The simulation is deemed to be successful if the model demonstrates that the conditions for UV-FRT and OV-FRT are met.

Part 19
Procedure for grid connection and compliance with requirements

151. (1) The facility owner must demonstrate to the satisfaction of the relevant system operator that the requirements of this regulation are being met by successfully completing the grid connection permit procedure described in this chapter.

(2) The relevant system operator must specify the details of the grid connection permit procedure.

(3) Information and documentation must be submitted electronically to the relevant system operator and/or Energinet.

Grid connection permit for type A energy storage facilities

152. (1) When connecting a type A energy storage facility, the facility owner must submit an installation document to the DSO. The DSO decides the content of the installation document, which must include the following as a minimum:

a) location of the connection
b) date of connection
c) maximum power of the installation in kW
d) type of primary energy source
e) references to product certificates for equipment that is part of the installation, issued by an approved certification body
f) for any equipment being used for which no product certificate has been received, information must be provided in line with the DSO's instructions, and
g) contact details of the facility owner and installer and their signatures.

Grid connection permit for type B and C energy storage facilities

153. (1) When connecting a type B or C energy storage facility, the facility owner must submit a facility document, including a declaration of conformity, to the DSO. The DSO decides the content of the facility document, which may include the following:

a) documentation for an agreement on protection mechanisms and settings for the point of connection that concern the DSO and facility owner
b) a detailed declaration of conformity
c) detailed technical information about the energy storage facility relevant to grid connection, as determined by the DSO
d) product certificates issued by an approved certification body where these form part of the basis for the conformity documentation
e) required simulation models
f) required reports on compliance testing documenting static state and dynamic performance, including the use of actual values measured during testing, where the level of detail is determined by the DSO, and
g) required investigations documenting static state and dynamic performance, where the level of detail is determined by the DSO.

(2) After accepting a complete and adequate facility document, the DSO issues an FON (Final Operational Notification) for the energy storage facility.

Grid connection permit for type D energy storage facilities

154. (1) The grid connection permit procedure for type D energy storage facilities comprises:

a) EON (Energisation Operational Notification)
b) ION (Interim Operational Notification) and
c) FON (Final Operational Notification)

(2) The relevant system operator has the right to refuse to allow the energisation or operation of the energy storage facility if the permit is no longer valid.

155. (1) An EON entitles a facility owner to energise the internal grid and the energy storage facility's auxiliary supplies via the point of connection.

(2) An EON is issued by the relevant system operator once the preparations have been completed, including reaching an agreement on protection mechanisms and settings for the point of connection that concern the relevant system operator and the facility owner.

156. (1) An ION entitles the facility owner to operate the energy storage facility and produce or consume electricity using the grid connection for a limited period of time for the purpose of testing and verification.

(2) An ION is issued by the relevant system operator once the information and investigations specified by the relevant system operator have been submitted to it. These may comprise the following:

a) a detailed declaration of conformity
b) detailed technical information about the energy storage facility relevant to grid connection, as determined by the relevant system operator
c) product certificates for the energy storage facility issued by an approved certification body where these form part of the basis for the conformity documentation
d) simulation models, as determined and required by the relevant system operator and/or Energinet
e) investigations documenting static state and dynamic performance, and
f) details of the planned compliance testing.

(3) A facility owner can be issued with an ION for up to 24 months. The relevant system operator is entitled to set a shorter validity period for temporary grid connection permits. The validity period of an ION will only be extended if the facility owner has made significant progress towards full compliance. When an extension is requested, the outstanding points must be clearly stated.

(4) An extension beyond the 24-month limit stipulated in subsection (3) above may be granted by Energinet in line with the exemption procedure set out in Part 20. The facility owner must send a request to Energinet containing (as a minimum):

a) relevant information about the energy storage facility
b) background and reasons for the request
c) the relevant system operator's comments on the request.

157. (1) An FON entitles the facility owner to operate the energy storage facility using the grid connection.

(2) An FON is issued by the relevant system operator once all incompatibilities identified in connection with the ION have been eliminated, and the information and investigations specified by the relevant system operator have been submitted to it. These may comprise the following:

a) a declaration of conformity and
b) an update of applicable technical information, simulation models and investigations that formed the basis of the ION with actual values measured during testing.

158. (1) Facility owners that have been issued with an FON must immediately notify the relevant system operator in any of the following circumstances:

a) the facility is being significantly modified or has temporarily lost capacity which affects its performance, or
b) equipment faults lead to non-compliance with one or more relevant requirements.

(2) The facility owner must apply to the relevant system operator for an LON (Limited Operational Notification) if the facility owner can reasonably expect the circumstances described in subsection (1) above to last for more than three months.

(3) An LON is issued by the relevant system operator and includes the following information, which must be clearly stated:

a) the unresolved issues that gave rise to an LON
b) division of responsibilities and deadlines for expected resolution of the issues, and

c) the maximum validity period, which must not exceed 12 months. A shorter period may be stipulated initially, which can be extended if documentation is submitted demonstrating clear progress towards full compliance to the relevant system operator's satisfaction.

(4) The FON is suspended during the validity period of the LON with respect to the points to which the LON relates.

(5) An extension beyond the 12-month limit stipulated in subsection (3) above may be granted by Energinet in line with the exemption procedure set out in Part 20. The facility owner must send a request to Energinet containing (as a minimum):

a) relevant information about the energy storage facility
b) background and reasons for the request
c) the relevant system operator's comments on the request.

Part 20
Exemptions

159. (1) An owner or future owner of an energy storage facility may apply to Energinet for an exemption from parts or all of the requirements in this regulation.

(2) The following conditions must all be met for an exemption to be granted:

a) There must be special circumstances, or the facility owner must have entered into a final and binding agreement to purchase the main plant or primary equipment.
b) There must be a significant technical and/or socio-economic consideration.
c) The exemption must not cause a significant deterioration in the technical quality or balance of the electricity supply system – either locally or more broadly.
d) The exemption must not lead to greater burdens on other companies.
e) The exemption must not be disadvantageous from a socio-economic viewpoint.

(3) Applications for exemption must be sent to myndighed@energinet.dk and must include a description of what the exemption relates to and the reasons for applying (see subsection (2)(a)-(e) above).

Part 21
Enforcement and sanctions

160. (1) Energinet can issue an order to comply with this regulation to a player that blatantly or repeatedly disregards its obligations under this regulation. In the event of failure to comply with an order, Energinet can decide to impose fines, or that the player will be fully or partially excluded from using Energinet's services.

Part 22
Complaints etc.

161. (1) Complaints about the content of this regulation may be brought before the Danish Utility Regulator.

(2) Orders under section 160 may be appealed to the Danish Utility Regulator.

(3) Complaints about decisions made by Energinet pursuant to this regulation may be brought before the Danish Utility Regulator, in line with section 7(4) of the Executive Order on transmission system operation and the use of the electricity transmission grid, etc.

Part 23

Commencement

162. (1) This regulation enters into force on 15 February 2024.

Appendix 1 – Terminology and definitions

1. **Facility owner**
   The facility owner is the legal owner of the energy storage facility and must ensure that the energy storage facility meets the requirements in the regulation.

2. **Facility infrastructure**
   The facility infrastructure is the electrical infrastructure on the facility owner's side of the point of connection.

3. **Type of facility**
   Facilities are subdivided into types based on the energy storage facility's P_n:
   Type A is energy storage facilities up to 125 kW
   Type B is energy storage facilities 125 kW to 3 MW in size
   Type C is energy storage facilities 3 MW to 25 MW in size
   Type D is energy storage facilities 25 MW or larger or connected at voltages above 110 kV.

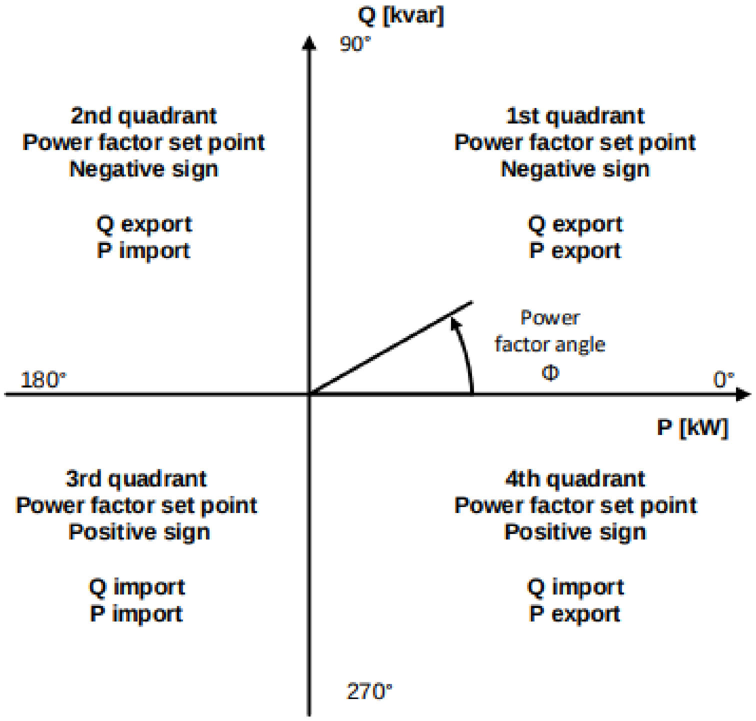
4. **DK1**
   DK1 refers to the West Denmark region, which is part of the Continental Europe (CE) synchronous area.

5. **DK2**
   DK2 refers to the East Denmark region, which is part of the Nordic (N) synchronous area.

6. **Energinet**
   Energinet is the transmission system operator in Denmark, entrusted with the overall responsibility for maintaining security of supply and ensuring the effective utilisation of an interconnected electricity supply system.

   If the energy storage facility is connected to the transmission system, Energinet is the relevant system operator.

7. **Generator Convention**
   Quadrant numbering is to be understood in line with the generator convention:



8. Public electricity supply system
Transmission and distribution systems that serve to transmit electricity for an indefinite group of electricity suppliers and consumers on terms laid down by public authorities.

The distribution system is defined as the public electricity supply system operated at voltages below 110 kV.

The transmission system is defined as the public electricity supply system operated at voltages of 110 kV or more.

9. Normal operating range
Normal operating range indicates the voltage and frequency range within which an energy storage facility must be able to continuously maintain operation in relation to the facility's P_n.

10. PCOM
PCOM (Point of Communication) is the point between the energy storage facility and the relevant system operator where data communication properties must be exchanged (made available and verified).

11. P_n
P_n (nominal active power) is the maximum continuous active power that an energy storage facility can absorb and supply as stated in the grid connection agreement, or as agreed between the relevant system operator and facility owner.

P_n is normally the energy storage facility's installed power in the point of connection, unless specified otherwise by the relevant system operator.

For energy storage facilities that absorb and supply symmetrically to and from the electricity supply system, the energy storage facility's nominal power is referred to as P_n. Where P_{nl} and P_{no} are asymmetric, P_n in production mode is understood as the energy storage facility's P_{nl}, and in consumption mode as the energy storage facility's P_{no}. If P_{nl} and P_{no} are asymmetric, these levels are set in connection with the grid connection agreement.

12. P_{nl}

P_{nl} (nominal active supplied power) is the maximum continuous active power that an energy storage facility can produce, as stated in the grid connection agreement, or as agreed between the relevant system operator and facility owner.

13. P_{no}

P_{no} (nominal active absorbed power) is the maximum continuous active power that an energy storage facility can consume, as stated in the grid connection agreement, or as agreed between the relevant system operator and facility owner.

14. Pu

Pu (per unit) is a value defined by the ratio between an actual value and a reference value in the same unit.

Voltages in the transmission system vary in relation to the two synchronous areas and the different voltage levels:

a) DK1 system voltage:
   i) 1 pu at 150 kV is 152 kV
   ii) 1 pu at 220 kV is 220 kV
   iii) 1 pu at 400 kV is 400 kV.

b) DK2 system voltage:
   i) 1 pu at 132 kV is 138 kV
   ii) 1 pu at 220 kV is 234 kV
   iii) 1 pu at 400 kV is 400 kV.

15. Q_n

Q_n (nominal reactive power) is the maximum continuous reactive power that an energy storage facility can absorb and supply, which is stated as a connection requirement in this regulation and derived from the energy storage facility's P_n.

For energy storage facilities that absorb and supply symmetrically to and from the electricity supply system, the energy storage facility's nominal power is referred to as Q_n. Where the maximum continuous reactive power for supply and for absorption are asymmetric, Q_n should be understood in production mode as the energy storage facility's maximum continuous reactive power for supply, and in consumption mode as the energy storage facility's maximum continuous reactive power for absorption. If the maximum continuous reactive power for supply and for absorption are asymmetric, these levels are set in connection with the grid connection agreement.

16. Relevant system operator
The relevant system operator is the transmission system operator (TSO) or distribution system operator (DSO) for the system to which an energy storage facility is or will be connected.

17. S_n
S_n (nominal apparent power) is the maximum continuous apparent power that an energy storage facility can absorb and supply as stated in the grid connection agreement, or as agreed between the relevant system operator and facility owner.

S_n is normally the energy storage facility's installed power in the point of connection, unless specified otherwise by the relevant system operator.

For energy storage facilities that absorb and supply symmetrically to and from the electricity supply system, the energy storage facility's nominal power is referred to as S_n. Where the maximum continuous apparent power for supply and for absorption are asymmetric, S_n should be understood in production mode as the energy storage facility's maximum continuous apparent power for supply, and in consumption mode as the energy storage facility's maximum continuous apparent power for absorption. If the maximum continuous apparent power for supply and for absorption are asymmetric, these levels are set in connection with the grid connection agreement.

18. Droop
Droop is the ratio between a frequency change in static state and the resulting change in active power in static state, expressed as a percentage. The frequency change is expressed in relation to the nominal frequency and the change in active power relative to maximum power or actual active power at the time when the relevant threshold is reached.

The formula for LFSM droop is shown below, where Δf is the current frequency, Δf_1 is the break frequency, f_n is 50 Hz, and ΔP is the change in active power:

$$Droop[\%] = 100 \cdot \frac{|\Delta f| - |\Delta f_1|}{f_n} \cdot \frac{P_n}{|\Delta P|}$$

$$|\Delta P| = 100 \cdot \frac{|\Delta f| - |\Delta f_1|}{f_n} \cdot \frac{P_n}{droop[\%]}$$

The formula for FSM droop is shown below, where Δf is the current frequency, f_n is 50 Hz, and ΔP is the change in active power:

$$Droop[\%] = 100 \cdot \frac{|\Delta f|}{f_n} \cdot \frac{P_n}{|\Delta P|}$$

19. Point of connection or POC
The point of connection (POC) is the point in the public electricity supply system where the energy storage facility is or can be connected and is determined by the relevant system operator.

20. U_c
U_c is the normal operating voltage in the point of connection, at which an energy storage facility must be able to continuously supply the specified nominal power. The normal operating voltage is determined by the relevant system operator. For low voltages, the voltage is measured between phase and zero. For medium and high voltages, the voltage is measured between phases.

21. U_n
U_n (nominal voltage) denotes the grid voltage level. For nominal voltages up to 1 kV, $U_c = U_n$.

22. U_{rec}
U_{rec1}, U_{rec2}, T_{rec1}, T_{rec2} and T_{rec3} specify lower limits for voltage recovery after a fault has been rectified.

23. U_{ret}
The U_{ret} is the remaining voltage in the point of connection during a fault

24. T_{clear}
T_{clear} is the moment when the fault was rectified.

25. UTC
UTC is an abbreviation for Coordinated Universal Time.