ENERGINET

Technical regulation 3.3.1 for battery plants

This is a translation of the original Danish regulation text. In case of any discrepancies, the Danish version shall prevail.

1	Published UK edition	10.06.2017	22.06.2017	22.06.2017	23.06.2017	DATE
		FBN	JMI	KDJ	FBN	NAME
REV.	DESCRIPTION	PREPARED	CHECKED	REVIEWED	APPROVED	

15/01357-88

©Energinet

Revision view

Section no.	Text	Revision	Date
Figure 7	Editorial correction only (Danish-text figure removed)	-	28.09.2017
All sections	The regulation was updated following public consultation. This includes: Editorial errors were corrected. - Changes were made on the basis of public consultation responses	1	23.06.2017
5.3.5	Updated with new requirement to plant properties as regards reactive power	1	23.06.2017
7	Updated as regards communication	1	23.06.2017
All sections	Public consultation document	0	14.02.2017

Table of contents

List of figures and tables

List of figures:

List of tables:

Reading instructions

This regulation contains the technical and functional minimum requirements which *battery plants* included in the *battery plant* definition [section 1.2.6] must comply with if they are to be *connected* to the Danish grid.

The regulation is structured such that section 1 contains the terminology and definitions used, section 2 describes the regulatory provisions and relevant references, while sections 3 through 7 contain the technical and functional requirements. Section 8 contains the requirements for documentation of the different *plant categories*, and section 9 contains the requirements for the electrical simulation model.

The technical requirements of the regulation are divided into several *plant categories* as described in sections 1 and 2.2.

The regulation makes extensive use of terminology and definitions. The key ones are found in section 1. In the regulation, terminology and definitions are written in *italics*.

The regulation is also published in English. In case of any discrepancies, the Danish version shall prevail.

The regulation is published by the *transmission system operator* and is available at www.energinet.dk.

1. Terminology, abbreviations and definitions

1.1 Abbreviations

This section contains the abbreviations used in the document.

1.1.1 Ψ_k

Ψ_k is used as an abbreviation for the short-circuit angle in the *Point of Connection. Flicker* values are calculated for each *battery plant* using the ψ_k parameter.

1.1.2 df/dt

df/dt denotes *frequency change as a function of time*. See section 1.2.15 for more detail.

1.1.3 Dk1

Dk1 denotes Western Denmark and a part of the synchronous area 'Continental Europe'.

1.1.4 Dk2

Dk2 denotes Eastern Denmark and a part of the synchronous area 'Nordic region'.

1.1.5 $f_<$

$f_<$ denotes the operational setting for underfrequency in the relay protection. See section 5 for more detail.

1.1.6 $f_>$

$f_>$ denotes the operational setting for overfrequency in the relay protection. See section 5 for more detail.

1.1.7 f_{max}

f_{max} denotes the maximum frequency.

1.1.8 f_{min}

f_{min} denotes the minimum frequency.

1.1.9 f_x

f_x, where x may be 0 to 7 or minimum and maximum, are points used for *frequency control.* See section 5.2.2 for more detail.

1.1.10 G_{lt}

G_{lt} denotes the planning value of the *flicker* emission from a plant.

1.1.11 I_h

I_h denotes the sum of the individual harmonic currents.

1.1.12 I_k

I_k denotes the *short-circuit current*. See section 1.2.26 for more detail.

1.1.13 I_n

I_n denotes *rated current* which is the maximum continuous current a *battery plant* is designed to deliver or consume. See section 1.2.31 for more detail.

1.1.14 I_Q

I_Q denotes the reactive current delivered or absorbed by the *battery plant*.

1.1.15 k_u

k_u denotes the voltage change factor. The voltage change factor is calculated as a function of Ψ_k.

1.1.16 $P_{current}$

$P_{current}$ denotes the current level of active power.

1.1.17 P_{delta}

P_{delta} denotes a rolling reserve. P_{delta} is the power by which the available active power is reduced in order to provide frequency stabilisation (upward adjustment) in case of falling grid frequency.

1.1.18 $P_{deliver}$

$P_{deliver}$ denotes the current level and direction of the active power which at a given point in time is delivered by a *battery plant* to the *public electricity supply grid*.

1.1.19 P_{lt}

P_{lt} denotes the long-term *flicker* emission from a plant. P_{lt} stands for 'long term' and is assessed over a period of two hours. See IEC 61000-3-7 [ref. 20] for more detail.

1.1.20 P_{min}

P_{min} denotes the lower limit for active power control.

1.1.21 P_{nl}

P_{nl} indicates the *rated power delivered* which the *battery plant* 1.2.29 is designed to be able to continuously deliver to the *public electricity supply grid* and which appears from the type approval. See section 1.2.29 for more detail.

1.1.22 P_{no}

P_{no} indicates the *rated power absorbed* which the *battery plant* is designed to be able to continuously absorb from 1.2.30 the *public electricity supply grid* and which appears from the type approval. See section 1.2.30 for more detail.

1.1.23 P_{absorb}

P_{absorb} denotes the current level and direction of the active power which at a given point in time is absorbed by a *battery plant* from the *public electricity supply grid*.

1.1.24 P_{st}

P_{st} denotes the short-term *flicker* emission from a *plant*. P_{st} stands for 'short term' and is assessed over a period of 10 minutes. See IEC 61000-3-7 [ref. 20] for more detail.

1.1.25 PCC

Point of Common Coupling *(PCC)*. See section 1.2.27 for more detail.

1.1.26 PCI

Point of Connection in Installation 1.2.21 (PCI) is the point in the installation where the plant is connected and where consumption is connected. See section 1.2.21 for more detail.

1.1.27 PCOM

Point of Communication *(PCOM)*. See section 1.2.23 for a more detailed definition of PCOM.

1.1.28 PF

Power Factor (*PF*). See section 1.2.9 for more detail.

1.1.29 PGC

Point of Generator Connection (*PGC*) is the point defined by the supplier of a *battery plant* as the *battery plant's* terminals. See section 1.2.17 for more detail.

1.1.30 POC

Point of Connection *(POC).* See section 1.2.28 for a more detailed description of the POC.

1.1.31 P/P_n

P/P_n is the normalised ratio for rated power. P_n can be P_{no} or P_{nl}, respectively.

1.1.32 PWHD

Partial Weighted Harmonic Distortion *(PWHD)*. See section 1.2.37 for more detail.

1.1.33 Q_{max}

Q_{max} denotes the maximum level of reactive power that a *battery plant* can deliver.

1.1.34 Q_{min}

Q_{min} denotes the minimum level of reactive power that a *battery plant* can absorb.

1.1.35 Q_{nl}

Q_{nl} denotes the rated reactive *power delivered* for a *battery plant* which the battery plant is designed to continuously deliver and which appears from the type approval.

1.1.36 Q_{no}

Q_{no} denotes the rated reactive *power absorbed* for a *battery plant* which the battery plant is approved to continuously absorb in the Point of Common Coupling under normal operating conditions.

1.1.37 S_k

S_k denotes the *short-circuit power*. See section 1.2.24 for more detail.

1.1.38 S_n
S_n denotes the rated *apparent power* of a *battery plant*. See section 1.2.32 for more detail.

1.1.39 SCR
Short Circuit Ratio. The abbreviation for the *short-circuit ratio* at the *Point of Connection*.

1.1.40 THD
Total Harmonic Distortion (THD) The designation of the *total harmonic distortion*. See section 1.2.46 for more detail.

1.1.41 U_c
U_c denotes the *normal operating voltage*. See section 1.2.34 for more detail.

1.1.42 U_h
U_h denotes the sum of the harmonic voltages.

1.1.43 U_{max}
U_{max} denotes the maximum value of the *rated voltage* U_n that a *battery plant* may be exposed to.

1.1.44 U_{min}
U_{min} denotes the minimum value of the *rated voltage* U_n that a *battery plant* may be exposed to.

1.1.45 U_n
U_n denotes *rated voltage*. This voltage is measured phase to phase. See section 1.2.33 for more detail.

1.1.46 U_{PGC}
U_{PGC} denotes the voltage measured on the *battery plant's* terminals. See section 1.2.17 for more detail.

1.1.47 U_{POC}
U_{POC} denotes the *normal operating voltage* in the *POC*. See section 1.2.28 for more detail.

1.1.48 U_x
U_x where x indicates the relay configuration for undervoltage steps 1 (<) or 2 (<<) as well as overvoltage steps 1 (>), 2 (>>) or 3 (>>>). See section 6 for more detail.

1.1.49 UTC
UTC is the abbreviation for *Coordinated Universal Time* (*Universal Time, Coordinated*). In Danish, the term 'universal time' or 'world time' is also used.

1.2 Definitions

This section contains the definitions used in this document. Several of the definitions are derived from IEC 60050-415:1999 [ref. 16], but have been modified to fit this regulation.

1.2.1 Absolute power limit

Adjustment of active power to a maximum level is indicated by a set point. The +/- tolerance of the set point adjustment is referred to as the *absolute power limit.*
See section 5.2.3.1 for more detail.

1.2.2 Plant owner

The *plant owner* is the entity that legally owns the *battery plant*. In certain situations, the term company is used instead of *plant owner*. The *plant owner* may hand over operational responsibility to a *plant operator*.

1.2.3 Plant infrastructure

Plant infrastructure is the electrical infrastructure connecting the *Point of Generator Connection (PGC)* for the given *battery plant* in a plant and the *Point of Connection (POC).*

1.2.4 Plant category

Plant categories in relation to total *rated power* in the *Point of Connection*:

A1. *Battery plants* up to and including 11 kW
A2. *Battery plants* above 11 kW up to and including 50 kW
B. *Battery plants* above 50 kW up to and including 1.5 MW
C. *Battery plants* above 1.5 MW up to and including 25 MW
D. *Battery plants* above 25 MW or connected to over 100 kV.

1.2.5 Plant operator

The *plant operator* is the enterprise responsible for the operation of the *battery plant*, either through ownership or through contractual obligations.

1.2.6 Battery plants

A battery plant is a plant which can store and deliver electrical energy in one or more of the following ways:

1. - absorbing electrical energy from the *public electricity supply grid* and, at a given time, delivering it back it in the *Point of Connection*

2. - absorbing energy from the *public electricity supply grid* and, at a given time, delivering electrical energy back internally in the installation, i.e. not delivering it back in the *Point of Connection*

3. - absorbing electrical energy directly generated in the installation (RE generation), i.e. not absorbing energy from the *public electricity supply grid* and, at a given time, delivering electrical energy back internally in the installation, i.e. not delivering it back in the *Point of Connection*

4. - absorbing electrical energy directly generated in the installation (RE generation), i.e. not absorbing energy from the *public electricity supply*

grid and, at a given time, delivering electrical energy in the *Point of Connection*.

The *battery plant* definition covers both permanently and temporarily connected *battery plants*, including, for example, V2G electric vehicle charging stations. A *battery* may consist of several separate inverters and batteries.

The *rated powers* of a *battery plant* when either energy (P_{no}) is absorbed from or energy (P_{nl}) is delivered back to the *public electricity supply grid*, or internally in the installation*,* may differ.

A UPS system (uninterruptible power supply with batteries) is not defined as a *battery plant* and is therefore not covered by this technical regulation, because the function of a UPS is to maintain power supply locally in an installation or in a part of an installation in case of public electricity supply grid disturbances or failure.

Note 1: It is not within the scope of this technical regulation to consider whether the above-mentioned configurations conflict with any subsidy scheme.

1.2.7 Battery plant controller

A *battery plant controller* is a set of control functions that make it possible to control several units as a single *battery plant* in the *Point of Connection*.

The set of control functions must be part of the *battery plant* in a communicative context. This means that if the communication to a *battery plant* is interrupted, the *battery plant* must be able to continue operation as scheduled or carry out a controlled shutdown.

1.2.8 COMTRADE

COMTRADE (Common Format for Transient Data) is a standardised file format specified in IEEE C37.111-2013 [ref. 31]. The format is designed for the exchange of information on transient phenomena occurring in connection with faults and switching in electricity systems.

The standard includes a description of the required file types and the sources of transient data such as protective relays, fault recorders and simulation programs. The standard also defines sample rates, filters and the conversion of transient data to be exchanged.

1.2.9 Power Factor (PF)

The *Power Factor*, cosine φ*,* for AC power systems indicates the ratio of active power P to apparent power S, where P = S*cosine φ. Similarly, reactive power Q = S*sinus φ. The angle between current and voltage is denoted by φ.

1.2.10 Power Factor control

Power Factor control is the control of the reactive power proportionally to the active power generated. See section 5.3.2 for more detail.

1.2.11 Electricity supply undertaking

The *electricity supply undertaking* is the enterprise to whose grid a *battery plant* is electrically connected. Responsibilities in the *public electricity supply grid* are distributed across several grid companies and one transmission enterprise.

The grid company is the company licensed to operate the *public electricity supply grid* of **up to** 100 kV.

The transmission enterprise is the enterprise licensed to operate the *public electricity supply grid* **above** 100 kV.

1.2.12 Flicker

Flicker is visual perception of light flickering caused by *voltage fluctuations*. *Flicker* occurs if the luminance or the spectral distribution of light fluctuates with time. At a certain intensity, *flicker* becomes an irritant to the eye.

Flicker is measured as described in IEC 61000-4-15 [ref. 9].

1.2.13 Frequency control

The *frequency control* function controls active power with the aim of stabilising the grid frequency. See section 5.2.2 for a more detailed description.

Note 2: The following related terms are also used:

FSM, Frequency Sensitive Mode.
FSM is a *frequency control* state which is an operational mode in which a *battery plant* controls the active power in such a way that it contributes to stabilising the fundamental frequency.

FSM band:
The frequency control band in which *frequency control* can be performed. The purpose of the *frequency control* function is to control active power at grid frequencies between f_1 and f_2 as shown in Figure 11.

1.2.14 Frequency response

Frequency response is the automatic downward regulation of active power as a function of grid frequencies above a certain frequency f_R with a view to stabilising the grid frequency. See section 5.2.1 for a more detailed description.

Note 3: The following related terms are also used:
LFSM-O, Limited Frequency Sensitive Mode – Overfrequency:
The operational mode in which a *battery plant* reduces active power if the system frequency exceeds a set value.

LFSM-U, Limited Frequency Sensitive Mode – Underfrequency:
The operational mode in which a *battery plant* increases active power if the system frequency drops below a set value.

1.2.15 Frequency change as a function of time

df/dt denotes frequency change as a function of time.

Note 4: The frequency change, *df/dt*, is calculated according to the principle below or an equivalent principle. The frequency measurement used to calculate the frequency change is based on an 80-100 ms measuring period for which the mean value is calculated.

Frequency measurements must be made continuously, so that a new value is calculated every 20 ms.

df/dt must be calculated as the difference between the mean value frequency calculation just made and the mean value frequency calculation made 20-100 ms ago.

Note 5: Among other, the *df/dt* function is used in decentralised generation plants to detect situations of island operation where island operation occurs without a prior voltage dip.

1.2.16 Generator convention

The sign for active/reactive power indicates the power flow as seen from the generator. The consumption/import of active/reactive power is indicated by a negative sign, while the generation/export of active/reactive power is indicated by a positive sign.

The sign of the *Power Factor* set point is used to determine whether control should take place in the first or the fourth quadrant. For *Power Factor* set points, two pieces of information are thus combined into a single signal: a set point value and the choice of control quadrant.

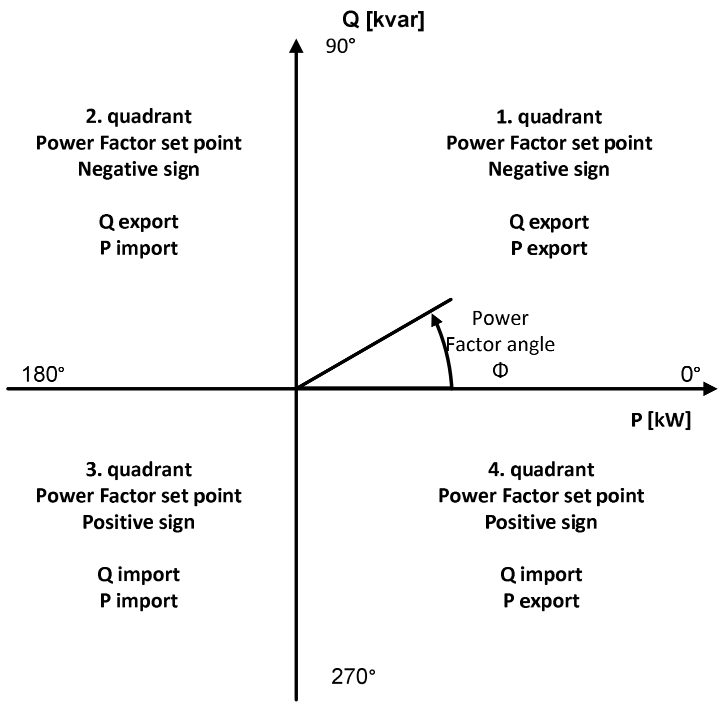

Figure 1 Definition of signs for active and reactive power and Power Factor set points [ref. 14 and 15].

1.2.17 Point of Generator Connection (PGC)

The *Point of Generator Connection* is the point in the *plant infrastructure* where the terminals/generator terminals for the *battery plant* are located. The *Point of Generator Connection* is the point defined by the manufacturer of a *battery plant* as the *battery plant's* terminals.

1.2.18 Ramp rate limit

The *ramp rate limit* controls the interval of active power using a set point-defined maximum increase/reduction (ramp rate) of active power. See section 5.2.3.2 for a more detailed description.

1.2.19 Harmonic distortions

Harmonic distortions are defined as electrical distortions caused by overharmonic currents and voltages. *Harmonic distortions* are also referred to as overtones, overharmonic tones, overharmonic distortion or simply harmonics. See section 4.6 for a more detailed description.

1.2.20 Rapid voltage changes

Rapid voltage change is defined as brief, isolated voltage dips (RMS). *Rapid voltage changes* are expressed as a percentage of *normal operating voltage*.

1.2.21 Point of Connection in Installation (PCI)

The *Point of Connection in Installation* (*PCI*) is the point in the installation where the *battery plant* in the installation is connected or can be connected, see Figure 2 for the typical location.

1.2.22 Public electricity supply grid

Transmission and distribution grids that serve to transmit electricity for an indefinite group of electricity suppliers and consumers on terms laid down by public authorities.

The distribution grid is defined as the *public electricity supply grid* with a **maximum** *rated voltage* of 100 kV.

The transmission grid is defined as the *public electricity supply grid* with a *rated voltage* **above** 100 kV.

1.2.23 Point of Communication (PCOM)

The *Point of Communication (PCOM)* is the point in a *battery plant* where the data communication properties specified in section 7 must be made available and verified.

1.2.24 Short-circuit power (S_k)

The *short-circuit power* (S_k) is the amount of power [VA] that the *public electricity supply grid* can deliver in the *Point of Connection* in the event of a short-circuit of the *battery plant's* terminals.

1.2.25 Short-circuit ratio (SCR)

The *short-circuit ratio (SCR)* is the ratio between the *short-circuit power* in the *Point of Connection* S_k and the *battery plant's rated apparent power* S_n.

1.2.26 Short-circuit current (I_k)

The *short circuit current* (I_k) is the amount of current [kA] that the *battery plant* can deliver in the *Point of Connection* in the event of a short circuit at the *battery plant's* terminals.

1.2.27 Point of Common Coupling (PCC)

The *Point of Common Coupling (PCC)* is the point in the *public electricity supply grid* where consumers are or can be connected.

The *Point of Common Coupling* and the *Point of Connection* may coincide electrically. The *Point of Common Coupling (PCC)* is always placed closest to the *public electricity supply grid*, see Figure 2 and Figure 3.

The *electricity supply undertaking* determines the *Point of Common Coupling*.

1.2.28 Point of Connection (POC)

The *Point of Connection (POC)* is the point in the *public electricity supply grid* where the *battery plant* is or can be connected, see Figure 2 and Figure 3 for the typical location.

All requirements specified in this regulation apply to the *Point of Connection*.

By agreement with the *electricity supply undertaking*, reactive compensation at no load can be placed elsewhere in the *public electricity supply grid*. The *electricity supply undertaking* determines the *Point of Connection*.

Figure 2 shows a typical installation connection of one or more *battery plants,* indicating the typical location of the *Point of Generator Connection (PGC), Point of Connection (POC), Point of Connection in Installation (PCI)* and *Point of Common Coupling (PCC)*. In the situation shown, the *Point of Common Coupling (PCC)* and the *Point of Connection (POC)* coincide.

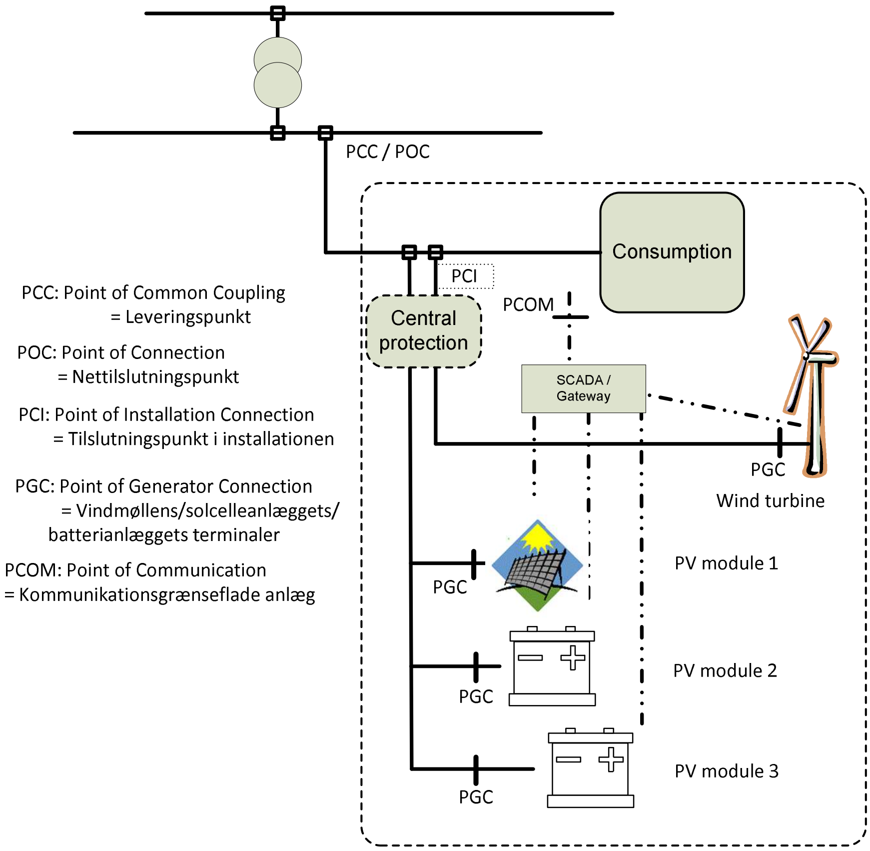

Figure 2 Example of installation connection of a plant.

Figure 3 shows a typical grid connection of several plants, indicating where the *Point of Generator Connection* (PGC), *Point of Connection* (POC), *Point of Common Coupling* (PCC) and the *voltage reference point* may be located. The *voltage reference point* is either in the *Point of Connection (POC)*, the *Point of Common Coupling (PCC)* or a point in between.

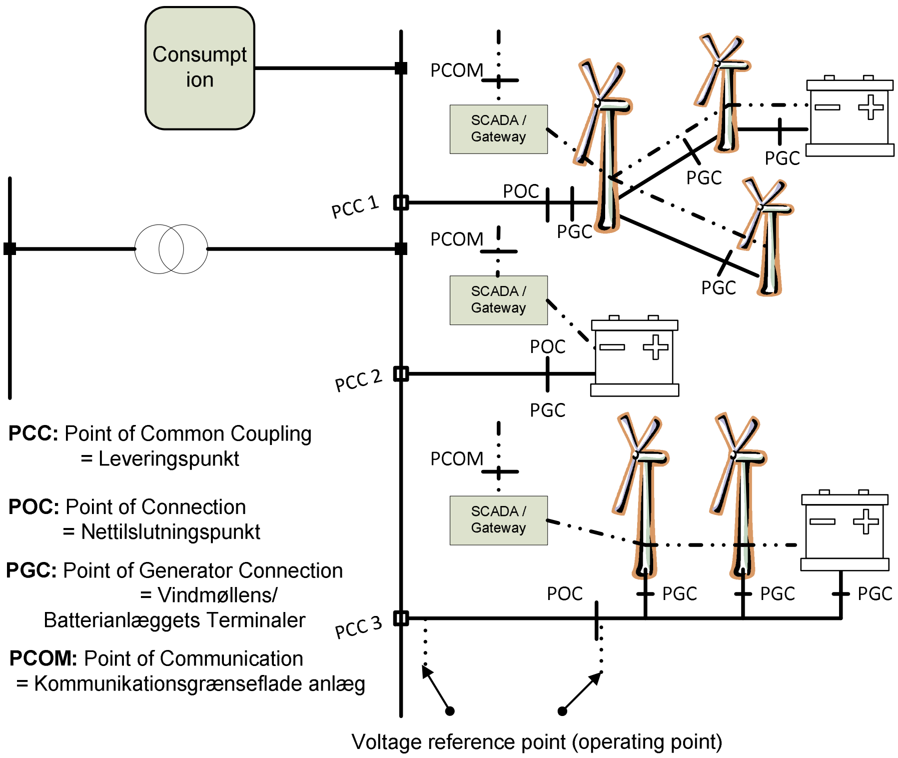

Figure 3 Example of grid connection of a plant.

1.2.29 Rated power delivered for a battery plant (P_{nl})

The *rated power delivered (Pnl)* for a *battery plant* is the highest active power output which the *battery plant* is designed to continuously deliver. It appears from the type approval.

1.2.30 Rated power absorbed for a battery plant (P_{no})

The *rated power absorbed* (P*no*) for a *battery plant* is the highest active power input which the *battery plant* is approved to continuously absorb in the *Point of Common Coupling* under normal operating conditions.

1.2.31 Rated current (I_n)

Rated current (I_n) is defined as the maximum continuous current a *battery plant* is designed to deliver under normal operating conditions.

1.2.32 Rated value for apparent power (S_n)

The *rated value for the apparent power* S_n is the highest power, consisting of both the active and reactive component, which the *battery plant* is designed to continuously deliver.

1.2.33 Rated voltage (U_n)

The voltage level at the *POC* for which a grid is defined and to which operational characteristics refer.

The internationally standardised voltage levels are shown in Table 1.

1.2.34 Normal operating voltage (U_c)

Normal operating voltage indicates the voltage range within which a *battery plant* must be able to continuously deliver the specified *rated power*, see sections 3.1 and 3.2. The *normal operating voltage* is determined by the *electricity supply undertaking*.

1.2.35 Normal operating range

Normal operating range indicates the voltage/frequency range within which a *battery plant* must be able to continuously maintain operation in relation to the specified rated power, see sections 3.1 and 3.2.

1.2.36 Power infrastructure

The *power infrastructure* is the part of the *public electricity supply grid* that connects the *POC* and *PCC*.

1.2.37 Partial Weighted Harmonic Distortion (PWHD)

The *partial weighted harmonic distortions* (PWHD) are defined as the ratio between the root-mean-square (RMS) value of the current I_h or the voltage U_h for the h'th harmonic of a selected group of higher harmonics (h: 14-40) harmonic and the root-mean-square (RMS) value of the current I_1 from the fundamental frequency. The general formula for *PWHD* is as follows:

$$PWHD = \sqrt{\sum_{h=14}^{h=40} h * \left(\frac{X_h}{X_1}\right)^2}$$ See IEC 61000-3-12 [ref. 22] for more detail,

where:

X represents either current or voltage
X_1 is the RMS value of the fundamental component
h is the harmonic order
X_h is the RMS value of the harmonic component of the h order.

1.2.38 Positive list

A so-called *positive list* for *battery plants* may have been prepared to facilitate the approval process for grid connection of *category* A1 and A2 *battery plants*.

1.2.39 Q control

Q control is the control of reactive power independent of active power generated.

1.2.40 Interconnected electricity supply system

The *public electricity supply grids* and associated plants in a large area which are interconnected for the purpose of joint operation are referred to as an *interconnected electricity supply system*.

1.2.41 Voltage fluctuation

A *voltage fluctuation* is a series of *rapid voltage changes* or a periodic variation of the root-mean-square (RMS) value of the voltage.

1.2.42 Voltage reference point

Metering point used for *voltage control*. The *voltage reference point* is either in the *Point of Connection*, the *Point of Common Coupling* or a point in between. *The voltage reference point* is defined by the electricity supply *undertaking*.

1.2.43 Voltage control

Voltage control is the control of the reactive power with the configured *droop* for the purpose of achieving the desired voltage in the *voltage reference point*.

1.2.44 Droop

Droop is the trajectory of a curve which a control function must follow.

1.2.45 Transmission system operator (TSO)

Enterprise entrusted with the overall responsibility for maintaining security of supply and ensuring the effective utilisation of an *interconnected electricity supply system*.

1.2.46 Total Harmonic Distortion (THD)

The *Total Harmonic Distortion* is defined as the ratio between the root-mean-square (RMS) value of the current I_h or the voltage U_h for the h'th (h: 2-40) harmonic and the root-mean-square (RMS) value of the current I_1 from the fundamental frequency. The general formula for *THD* is as follows:

$$THD_I = \sqrt{\sum_{h=2}^{h=H} \left(\frac{X_h}{X_1} \right)^2}$$ See IEC 61000-3-6 [ref. 19] for a more detailed specification,

where:

X represents either current or voltage
X_1 is the RMS value of the fundamental component
h is the harmonic order
X_h is the RMS value of the harmonic component of the h order
H is generally 40 or 50 depending on use.

2. Objective, scope of application and regulatory provisions

2.1 Objective

The objective of technical regulation TR 3.3.1 is to specify the minimum technical and functional requirements that a *battery plant* must comply with in the *Point of Connection* when the *battery plant* is connected to the *public electricity supply grid*.

In addition, *battery plants* must be registered with master data to ensure that data and information concerning the impact on the public electricity supply grid can be collected and used for development of the *battery plant* and the *public electricity supply grid*.

The regulation is issued pursuant to Section 7(1)(i), (iii) and (iv) of Danish Executive Order no. 891 of 17 August 2011 (Executive Order on transmission system operation and the use of the electricity transmission grid, etc. *(Systemansvarsbekendtgørelsen)*. Under Section 7(1) of the Executive Order on transmission system operation and the use of the electricity transmission grid, etc., this regulation has been prepared following discussions with market players and grid companies. It has also been subject to public consultation before being registered with the Danish Energy Regulatory Authority.

This regulation is effective within the framework of the Danish Electricity Supply Act (*Elforsyningsloven*), see Consolidated Act no. 1329 of 25 November 2013 as amended.

A *battery plant* must comply with Danish legislation, including the Danish Heavy Current Regulation (*Stærkstrømsbekendtgørelsen*) [ref. 4], [ref. 5], the Joint Regulation (*Fællesregulativet*) [ref. 3], the Machinery Directive (*Maskindirektivet*) [ref. 6], [ref. 7], and the grid connection and grid use agreement (*nettilslutnings- og netbenyttelsesaftalen*).

In areas which are not subject to Danish legislation, CENELEC standards (EN), IEC standards and CENELEC or IEC technical specifications apply.

2.2 Scope of application

A *battery plant* connected to the *public electricity supply grid* must comply with the provisions of this regulation throughout the *battery plant's* service life.

The technical requirements of the regulation are divided into the following *categories* based on the total *rated power* in the *Point of Connection*:

- A1. *Battery plants* up to and including 11 kW
- A2. *Battery plants* above 11 kW up to and including 50 kW
- B. *Battery plants* above 50 kW up to and including 1.5 MW
- C. *Battery plants* above 1.5 MW up to and including 25 MW
- D. *Battery plants* above 25 MW or connected to over 100 kV.

2.2.1 New battery plants

This regulation applies to all *battery plants* connected to the *public electricity supply grid* and commissioned as of the effective date of this regulation.

2.2.2 Existing battery plants

A *plant* which was connected to the *public electricity supply grid* before the effective date of this regulation must comply with the regulation in force at the time of its commissioning.

2.2.3 Modifications to existing battery plants

Existing *battery plants* to which substantial functional modifications are made must comply with the provisions of this regulation relating to such modifications.

A substantial modification is one that changes one or more vital plant components that may alter the properties of the *battery plant*.

In case of doubt, the *transmission system operator* decides whether a specific modification is substantial.

The documentation described in section 8 must be updated and submitted in a version indicating any modifications made using Appendix 1.

2.3 Delimitation

This technical regulation is part of the complete set of technical regulations issued by the Danish *transmission system operator*, Energinet.dk.

The technical regulations contain the technical minimum requirements that apply to *plant owners*, *plant operators* and *electricity supply undertakings* regarding the connection of plants to the *public electricity supply grid*.

Together with the market regulations, the technical regulations (including the system operation regulations) constitute the set of rules which *plant owners*, *plant operators* and *electricity supply undertakings* must comply with when operating plants*:*

- Technical regulation TR 5.8.1 'Måledata til systemdriftsformål' (Metering data for system operation purposes) [ref. 10]
- Technical regulation TR 5.9.1 'Systemtjenester' (Ancillary services) [ref. 11]
- Regulation D1 'Settlement metering' [ref. 12]
- Regulation D2 'Technical requirements for electricity metering' [ref. 13]
- Technical regulation TR 3.3.1 'Technical regulation for *battery plants*'.

In case of discrepancies between the requirements of the individual regulations, the *transmission system operator* decides which requirements should apply.

Current versions of the above-mentioned documents are available on Energinet.dk's website at www.energinet.dk.

Operational matters will be agreed between the *plant owner* and the *electricity supply undertaking*.

Any supply of ancillary services must be agreed between the *plant owner* and the *balance-responsible party for production*.

This regulation does not deal with the financial aspects of using control capabilities or settlement metering nor with the technical settlement metering requirements.

The *plant owner* must safeguard the *battery plant* against possible damaging impacts due to a lack of electricity supply from the *public electricity supply grid* for short or long periods of time.

2.3.1 Exceptions from minimum requirements

The following functionality is excepted from the minimum requirements.

The system protection requirement has not been included as a minimum requirement to be fulfilled in order to be granted grid connection. See section 5.4 for further details.

2.4 Statutory authority

This regulation is issued pursuant to:

- Section 26(1) of Consolidated Act no. 1329 of 25 November 2013 concerning the Danish Electricity Supply Act.
- Section 7(1)(i), (iii) and (iv) of Danish Executive Order no. 891 of 17 August 2011 (Executive Order on transmission system operation and the use of the electricity transmission grid, etc.).

2.5 Effective date

This regulation comes into force on **23 June 2017**.

Please direct questions and requests for additional information on this technical regulation to Energinet.dk. Contact information is available at https://www.energinet.dk/El/Rammer-og-regler/Forskrifter-For-Nettilslutning

The regulation was registered with the Danish Energy Regulatory Authority pursuant to the provisions of Section 26 of the Danish Electricity Supply Act and Section 7 of the Danish Executive Order on transmission system operation and the use of the electricity transmission grid, etc.

As regards *battery plants*, the construction of which was finally ordered in a binding written order before this regulation was registered with the Danish Energy Regulatory Authority, but which are scheduled to be commissioned after this regulation comes into force, an exemption can be applied for in accordance with section 2.9; any relevant documentation should be enclosed.

2.6 Complaints

Complaints in respect of this regulation may be lodged with the Danish Energy Regulatory Authority, www.energitilsynet.dk.

Complaints about the *transmission system operator's* enforcement of the provisions of the regulation may also be lodged with the Danish Energy Regulatory Authority.

Complaints about how the individual *electricity supply undertaking* enforces the provisions of the regulation may be lodged with the *transmission system operator*.

2.7 Breach

The *plant owner* shall ensure that the provisions of this regulation are complied with throughout the *battery plant's* service life.

The *battery plant* must be regularly maintained to ensure that the provisions of this regulation are complied with.

The *plant owner* must pay any expenses incurred to ensure compliance with the provisions of this regulation.

2.8 Sanctions

If a *battery plant* does not comply with the provisions of section 3 and onwards of this regulation, the *electricity supply undertaking* is entitled to cut off the grid connection to the *battery plant* as a last resort until the provisions are complied with.

2.9 Exemptions and unforeseen events

The *transmission system operator* may grant exemption from specific requirements in this regulation.

An exemption can only be granted if:

- special conditions exist, for instance of a local nature
- the deviation does not appreciably impair the technical quality and balance of the *public electricity supply grid*
- the deviation is not inappropriate from a socio-economic viewpoint

or

- the *battery plant* was ordered before this regulation was registered with the Danish Energy Regulatory Authority, see section 2.5.

To obtain an exemption, submit a written application to the *electricity supply undertaking*, stating which provisions the exemption concerns and the reason for the exemption.

The *electricity supply undertaking* has the right to comment on the application before it is submitted to the *transmission system operator*.

If events not foreseen in this technical regulation occur, the *transmission system operator* must consult the parties involved to agree on a course of action.

If an agreement cannot be reached, the *transmission system operator* must decide on a course of action.

The decision must be based on what is reasonable, taking the views of the parties involved into consideration where possible.

Complaints about the decisions of the *transmission system operator* can be lodged with the Danish Energy Regulatory Authority, see section 2.6.

2.10 References

The mentioned International Standards (IS), European Standards (EN), Technical Reports (TR) and Technical Specifications (TS) are only to be used within the topics mentioned in connection with the references in this regulation.

2.10.1 Normative references

1. **DS/EN 50160:2010**: Voltage characteristics of electricity supplied by public electricity networks.
   DS/EN 50160/Corr.:Dec 2011
   DS/EN 50160:2010/A1:2015
2. **DS/EN 60038:2011**: CENELEC standard voltages.
3. **Joint Regulation 2014:** 'Connection of electrical equipment and utility products'.
4. **Section 6 of the Danish Heavy Current Regulation:** 'Electrical installations', 2003.
5. **Section 2 of the Danish Heavy Current Regulation:** 'Design of electricity supply systems', 2003.
6. **DS/EN 60204-1:2006**: Safety of machines – Electrical equipment of machines.
   DS/EN 60204-1/Corr.:2010
7. **DS/EN 60204-11:2002**: Safety of machinery – Electrical equipment of machines – Part 11: Requirements for HV equipment for voltages above 1000 V a.c. or 1500 V d.c. and not exceeding 36 kV.
8. **IEC-60870-5-104:2006**: Telecontrol equipment and systems, Part 5-104.
9. **IEC 61000-4-15:2010**: Testing and measurement techniques – Section 15: Flickermeter – Functional and design specifications.
10. **Technical regulation TR 5.8.1:** 'Måledata til systemdriftsformål' (Metering data for system operation purposes) of 28 June 2011, version 3, document no. 17792-10.
11. **Technical regulation TR 5.9.1:** 'Systemtjenester' (Ancillary services), 6 July 2012, version 1.1 , document no. 91470-11.
12. **Regulation D1:** 'Settlement metering', March 2016, version 4.11, document no. 16/04092-18.
13. **Regulation D2:** 'Technical requirements for electricity metering', May 2007, version 1, document no. 171964-07.
14. **IEC 61850 series**
15. **IEEE 1459:2010**: Standard definitions for the measurement of electrical power quantities under sinusoidal, non-sinusoidal, balanced or unbalanced conditions.
16. **IEC 60050-415:1999**: International Electrotechnical Vocabulary.
17. **DS/EN 61000-3-2:2014**: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase).
18. Limits – Limitation of voltage changes, *voltage fluctuations* and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection.
19. **IEC/TR 61000-3-6:2008**: EMC limits. Limitation of emissions of harmonic currents for equipment connected to medium and high voltage power supply systems.
20. **IEC/TR 61000-3-7:2008**: EMC limits. Limitation of voltage fluctuations and flicker for equipment connected to medium and high voltage power supply systems.
21. **DS/EN 61000-3-11:2001**: Electromagnetic compatibility (EMC): Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems – Equipment with rated current </= 75A and subject to conditional connection.

22. **DS/EN 61000-3-12:2012**: Limits – Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current > 16 A and ≤ 75 A per phase.
23. **IEC/TR 61000-3-13:2008**: Electromagnetic compatibility (EMC): Limits – Assessment of emission limits for the connection of unbalanced installations to MV, HV and EHV power systems.
24. **IEC/TR 61000-3-14:2011**: Electromagnetic compatibility (EMC): Assessment of emission limits for harmonics, interharmonics, voltage fluctuations and unbalance for the connection of disturbing installations to LV power systems.
25. **IEC/TR 61000-3-15 Ed. 1.0:2011**: Limits – Assessment of low frequency electromagnetic immunity and emission requirements for dispersed generation systems in LV network.
26. **DS/CLC/TS 50549-1:2015**: Requirements for generating plants to be connected in parallel with distribution networks – Part 1: Generating plants connected to a LV distribution network and rated at more than 16 A per phase.
27. **DS/CLC/TS 50549-2:2015**: Requirements for generating plants to be connected in parallel with distribution networks – Part 2: Generating plants connected to a MV distribution network.

2.10.2 Informative references

28. **Research Association of the Danish Electric Utilities (DEFU) report RA-557:** 'Maximum emission of voltage distortions from wind power plant*s* with a power output above 11 kW'.
29. **Research Association of the Danish Electric Utilities (DEFU) recommendation no. 16**: Voltage quality in low-voltage grids, 4th edition, August 2011.
30. **Research Association of the Danish Electric Utilities (DEFU) recommendation no. 21**: Voltage quality in medium-voltage grids, 3rd edition, August 2011.
31. **IEEE C37.111-24:2013:** Measuring relays and protection equipment – Part 24: Common format for transient data exchange (COMTRADE) for power systems.
32. Guidelines on the calculation of power quality parameters – TR 3.2.2, 2014 November 27.

3. Tolerance of frequency and voltage deviations

All requirements outlined in the following sections are to be considered minimum requirements.

A *battery plant* must be able to withstand frequency and voltage deviations in the *Point of Connection* under normal and abnormal operating conditions while reducing the active power as little as possible.

Battery plants may be designed for single-phase connection when neither P_{no} nor P_{nl} exceeds 3.68 kW.

The *battery plant* must be designed for three-phase connection if neither P_{no} nor P_{nl} exceeds 3.68 kW.

For planning and grid expansion reasons, the *electricity supply undertaking* has the right to reject grid connection for non-three-phase plants.

3.1 Determination of voltage level

The following requirements apply to *battery plant* categories A1, A2, B, C and D.

The *electricity supply undertaking* determines the voltage level for the *battery plant's Point of Connection* within the voltage limits stated in Table 1.

The *normal operating voltage* may differ from location to location, and the *electricity supply undertaking* must therefore state the *normal operating voltage* U_c for the *Point of Connection*.

For rated voltages up to 1 kV, $U_c = U_n$.

The *electricity supply undertaking* must ensure that the maximum voltage stated in Table 1 is never exceeded.

If the normal voltage range, $U_c \pm 10\%$, is lower than the minimum voltage stated in Table 1, the output requirements in the event of frequency and voltage variations must be adjusted so as not to overload the *battery plant.*

For the 400 kV voltage level, the *normal operating voltage* range is defined as U_c +5%, -10%.

Voltage level descriptions	Rated voltage U_n [kV]	Minimum voltage U_{min} [kV]	Maximum voltage U_{max} [kV]
Extra high voltage (EH)	400	320	420
	220	-	245
High voltage (HV)	150	135	170
	132	119	145
	60	54.0	72.5
	50	45.0	60.0
Medium voltage (MV)	33	30.0	36.0
	30	27.0	36.0
	20	18.0	24.0
	15	13.5	17.5
	10	9.00	12.0
Low voltage (LV)	0.69	0.62	0.76
	0.40	0.36	0.44

Table 1 Definition of voltage levels used in this regulation

Maximum (U_{max}) and minimum (U_{min}) voltage limits are determined using the standards DS/EN 50160 (10-minute mean values) [ref. 1] and DS/EN60038 [ref. 2].

The *battery plant* must be able to briefly withstand voltages exceeding the maximum voltages within the required protective functions as specified in section 6.

3.2 Normal operating conditions

The following requirements apply to *battery plant categories* A1, A2, B, C and D.

Within the *normal operating* range, a *battery plant* must be able to start and operate continuously within the design specifications, restricted only by the settings of the protective functions as described in section 6 and/or other functions impacting the *battery plant's* operation.

Within the *normal operating* range, the typical operating voltage is U_c±10%, see section 3.2.1, and the frequency range is 47.00 to 52.00 Hz.

Automatic connection of a *battery plant* may at the earliest take place three minutes after the voltage has come within the tolerance range of the *normal operating voltage*, and the grid frequency is within the range indicated by f_1 and f_2.

Standard FSM band	Dk1		Dk2	
f_x	f_1	f_2	f_1	f_2
Hz	49.80	50.20	49.90 %	50.10 %

Table 2 Frequency band for automatic connection and standard FSM band

The setting of the frequency limits is determined by *the transmission system operator*.

3.2.1 Requirements for normal operating range

The overall requirements for the *normal operating range* of active power in the event of frequency and voltage deviations for a *battery plant* in the *Point of Connection* are shown in Figure 4.

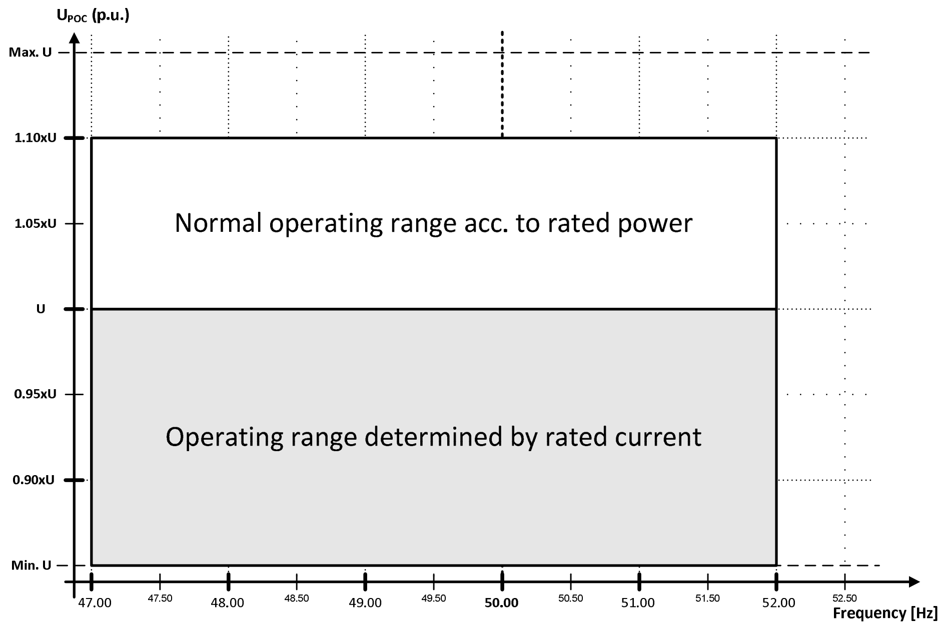

Figure 4 Requirements for rated power and rated current in the event of frequency and voltage deviations

The *battery plant* must remain connected to the *public electricity supply grid* in accordance with the required settings for protective functions as specified section 6.

3.3 Abnormal operating conditions

The following requirements apply to *battery plant categories* A1, A2, B, C and D.

The *battery plant* must be designed to withstand transitory (80-100 ms) phase jumps of up to 20 in the *Point of Connection* without outage and shutdown.

The *battery plant* must be able to withstand transient frequency gradients (*df/dt*) of up to ±2.5 Hz/s in the *Point of Connection* without disconnecting.

After a voltage dip, the *battery plant* must be able to return to *normal operation* no later than 5 seconds after the operating conditions in the *Point of Connection* have returned to the *normal operating* range.

3.3.1 Voltage dip tolerance

The following requirements apply to *battery plant categories* C and D.

In the *Point of Connection*, a *battery plant* must be designed to withstand voltage dips down to 10% of the voltage in the *Point of Connection* over a period of minimum 250 ms without disconnecting, as shown in Figure 5, and must be able to deliver additional reactive current during the fault sequence, as shown in Figure 6.

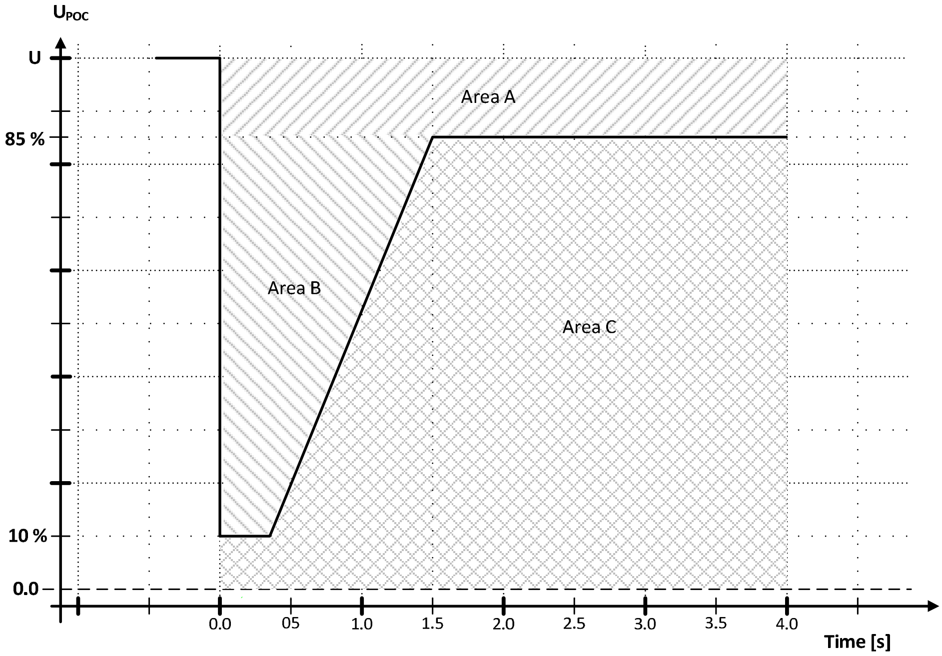

Figure 5 Voltage dip tolerance requirements for category C and D battery plants.

The following requirements must be complied with in the event of symmetrical and asymmetrical faults. This means that the requirements apply in the event of faults in three, two or a single phase:

- Area A: The *battery plant* must stay connected to the grid and maintain *normal operation*.
- Area B: The *battery plant* must stay connected to the grid. The *battery plant* must provide maximum voltage support by delivering a controlled amount of additional reactive current so as to ensure that the *battery plant* contributes to stabilising the voltage within the design framework offered by the current *battery plant* technology, see Figure 5.
- Area C: Disconnecting the *battery plant* is allowed.

If the voltage U_{POC} reverts to area A after 1.5 seconds during a fault sequence, a subsequent voltage dip will be regarded as a new fault situation, see section 3.3.2.

If several successive fault sequences occur within area B and continue into area C time-wise, disconnecting is allowed.

In connection with fault sequences in area B, the *battery plant* must have a *control function* capable of controlling the positive sequence of the reactive current as specified in Figure 6.

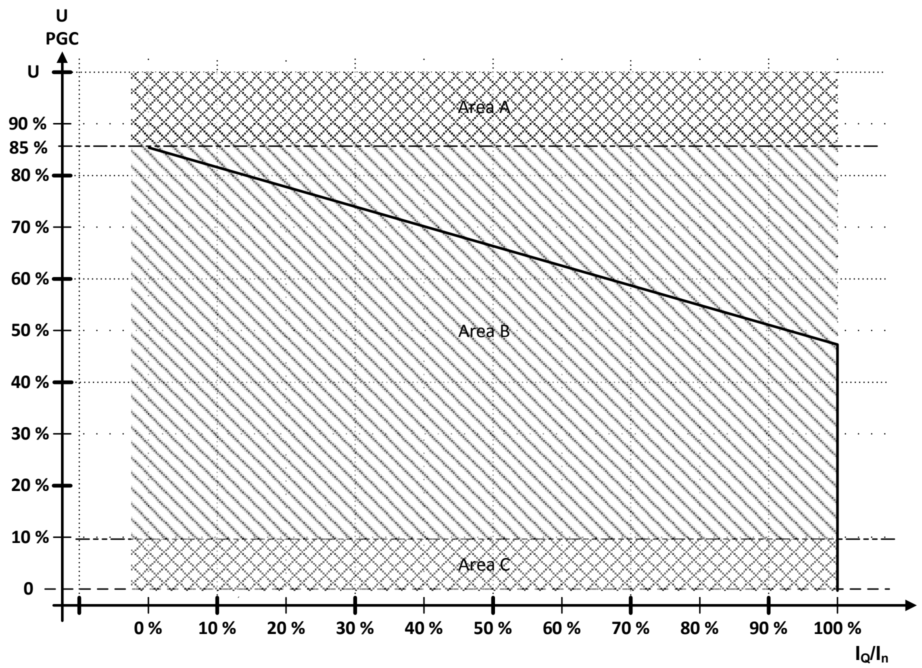

Figure 6 Requirements for the delivery of additional reactive current IQ during voltage dips for category C and D battery plants.

Control must follow Figure 6 so that the additional reactive current (positive sequence) follows the characteristic with a tolerance of ±20% after max. 100 ms.

In area B, the delivery of reactive current takes first priority, while the delivery of active power takes second priority.

3.3.2 Recurring faults in the public electricity supply grid

The following requirement applies to *battery plant* categories C and D.

This section describes the requirements to the plant's tolerance for repeated voltage dips in connection with intentional or unintentional voltage dips in the public electricity supply grid.

These requirements apply to the *Point of Connection*, but the fault sequence occurs at any point in the *public electricity supply grid*.

The *battery plant* and any compensation equipment must stay connected after faults have occurred in the *public electricity supply grid* as specified in 3.3.

Type	Duration of fault
Three-phase short circuit	Short circuit for 250 ms
Phase-to-phase-to-earth short circuit/phase-to-phase short circuit	Short circuit for 150 ms followed by a new short circuit 0.3-0.8 seconds later, also with a duration of 250 ms
Phase-to-earth short circuit	Phase-to-earth fault for 250 ms followed by a new phase-to-earth fault 0.3-0.8 seconds later, also with a duration of 250 ms

Table 3 Fault types and duration in the public electricity supply system.

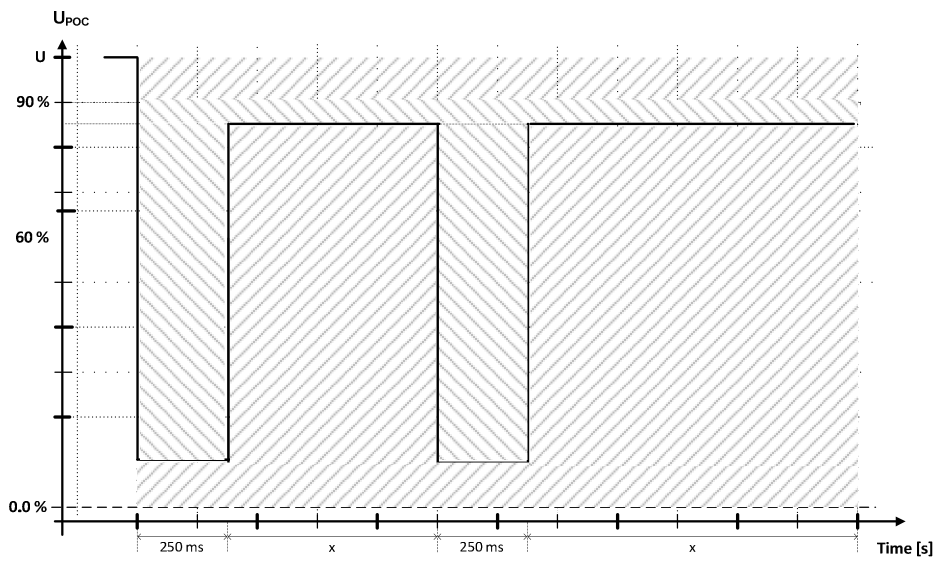

Figure 7 Tolerance for recurring faults

4. Power quality

4.1 General

When assessing a *battery plant's* impact on power quality, the various power quality parameters in the *Point of Connection* must be documented.

The emission limits apply to all the battery plant's operating conditions described in this technical regulation.

The table below lists the distortion requirements in individual *plant categories*.

Category Requirements	**A1**	**A2**	**B**	**C**	**D**
DC content (4.2)	X	X	X	X	X
Asymmetry (4.3)	X	X	X	X	X
Flicker (4.4)	X	X	X	X	X
Harmonic distortions (4.5)	X	X	X	X	X
Interharmonic distortions			X	X	X
Distortions 2-9 kHz (4.7)			X	X	X

Bracketed numbers indicate the sections that describe the respective requirements.

Table 4 Overview of power quality requirements for plant categories.

For each of the above distortion types, the following is specified:

- Data basis for calculations
- Emission limit values – plant requirements
- Methods for verifying compliance with limit values.

Applied power quality terminology and calculation methods are described in the following international standards: DS/EN 61000-3-2:2014 [ref. 17], DS/EN 61000-3-3:2013 [ref. 18], IEC/TR 61000-3-6:2008 [ref. 19], IEC/TR 61000-3-7:2008 [ref. 20], DS/EN 61000-3-11 [ref. 21], DS/EN 61000-3-12 [ref. 22], DS/EN 61000-3-13 [ref. 23], DS/EN 61000-3-14 [ref. 24] and DS/EN 61000-3-15 [ref. 25] as well as national recommendations [16] the Research Association of the Danish Electric Utilities (DEFU) recommendation no. 21 [ref. 32] and the Research Association of the Danish Electric Utilities (DEFU) recommendation no. 21 [ref. 29].

The *electricity supply undertaking* is responsible for setting emission limits in the *Point of Connection*.

The *electricity supply undertaking* must agree on a schedule for determining emission limits with grid connection applicants.

Generally, the *plant owner* must ensure that the *battery plant* is designed, constructed and configured in observance of the specified emission limits without grid reinforcements being required.

Under certain circumstances, the *plant owner* must purchase supplementary services from the *electricity supply undertaking* to ensure compliance with the specified limit values.

The *plant owner* must verify compliance with the emission limits in the *Point of Connection.*

4.1.1 Data basis

Data for the *battery plant* as well as the *public electricity supply grid* will be used to assess a *battery plant's* impact on power quality.

The plant owner must provide the data specified in section 4 to determine the emission of *flicker* and high-frequency distortions for the *battery plant.*

The *plant owner* must choose one of the following methods for determining the emission of *flicker* and high-frequency distortions.

1. The *plant owner* uses the results of the type test for each of the units that make up the *battery plant*. The type test must be performed in accordance with relevant standards.

   The plant owner calculates the total emissions as the sum of the contributions from each of the units that make up the *battery plant*.

2. The *plant owner* develops an emission model for the *battery plant*. The *plant owner* must thus document that this emission model can be used to determine the emission of high-frequency distortions from the entire plant.

   The plant emission model must include emission models for the *units* and the *plant infrastructure* in the *Point of Connection* for the relevant frequency range.

   The *transmission system operator* must approve the emission model.

The electricity supply undertaking supplies data for the public electricity supply grid in the Point of Connection. As regards the calculation of *voltage fluctuations* acc. to current international standards, the *public electricity supply grid* can be defined by the minimum, typical and maximum *short-circuit power* S_k and the corresponding grid impedance angle $\psi_{k,}$ in the *point of connection*.

The *electricity supply undertaking* must state the maximum and minimum S_k for the *Point of Connection*.

4.1.2 Limit values

The *electricity supply undertaking* is responsible for supplying limit values for the emission of the various types of distortions coming from the *battery plant* in the *Point of Connection* so as to ensure that the limit values for power quality in the *public electricity supply grid* are not exceeded.

The limit values specified in this regulation have been determined on the basis of the specifications in IEC/TR 61000-3-6 [ref. 19] IEC/TR 61000-3-7 [ref. 20], DS/EN 61000-3-12 [ref. 22] and DS/EN 61000-3-11 [ref. 21].

For *battery plants* which are electrically connected far from other consumers, the limit values may, however, be changed to values above the normal limits following acceptance from the *electricity supply undertaking*.

4.1.3 Verification

The *plant owner* must use calculations, simulations or measurements to verify that the *battery plant* complies with the limits defined in the *Point of Connection*.
The *electricity supply undertaking* must approve the *plant owner's* verification.

4.2 DC content

For all *plant categories*, the DC content of the supplied AC current in the *battery plant's Point of Connection (POC)* may not exceed 0.5% of the *rated current*, see IEC/TS 61000-3-15, section 7.5 [ref. 25].

4.3 Asymmetry

For all *plant categories*, the asymmetry between the phases at normal operation or in the event of faults in the *battery plant* may not exceed 16 A.

If the *battery plant* consists of multiple single-phase units, the necessary communication must be established to ensure that the above limit is not exceeded.

4.4 Flicker

4.4.1 Data basis

Flicker emission must be documented for continuous operation. Document the *flicker level* using data from type tests or emission models.

When calculating the *flicker* contribution at continuous operation, use the *flicker* coefficient $c_i\,(\psi_k)$ data that appear from the type test, where: $C_{i,}$ *i*: *battery plant* no. *i.*

4.4.2 Limit values

The *battery plant's* total *flicker* contribution must meet the requirements in the following sections in the *Point of Connection*.

4.4.2.1 Requirements for category A1 battery plants

All category A1 *battery plants* must meet the flicker emission limit value requirements in the Point of Connection, as described in DS/EN 61000-3-3, section 5 [ref. 18].

4.4.2.2 Requirements for category A2and B battery plants

All category A2 and B *battery plants* must meet the requirements to the flicker emission limit values in the Point of Connection, described in DS/EN 61000-3-11, section 5 [ref. 21].

4.4.2.3 Requirements for category C and D battery plants

The *electricity supply undertaking* determines the *flicker* emission limits in the *Point of Connection*, so that the maximum allowed *flicker* level G_{lt} and G_{st} at the same voltage level and under the same substation is not exceeded.

4.4.3 Verification

Verify that the *flicker* emission from continuous operation of the *battery plant* is below the limit value in the *Point of Connection*.

Determine the *flicker* coefficient on the basis of the current ψ_k for the *battery plant* through simple interpolation between the values for ψ_k specified in the type test.

The *flicker* emission for each *unit* that make up the *battery plant* is calculated as:

$$\mathrm{P}_{\mathrm{lt},i} = \mathrm{c}_i\left(\psi_{\mathrm{k}}\right) \cdot \frac{S_{n,i}}{S_k}$$

The emission from the entire *battery plant* is then calculated as:

$$\mathrm{P}_{\mathrm{lt}} = \sqrt[3]{\sum_i \left(\mathrm{P}_{\mathrm{lt},i}\right)^3}$$

Calculation examples can be found in 'Guidelines on the calculation of power quality parameters – TR 3.2.2' [ref. 32].

Alternatively, the verified emission model must be used.

4.4.3.1 Category A1, A2, B, C and D battery plants

Verify that the *flicker* emission from continuous operation of the *battery plant* is below the limit value in the *Point of Connection*.

4.5 Harmonic distortions

4.5.1 Data basis

Emission of *harmonic distortions* must be documented for the entire *battery plant*. Use data from type tests or emission models to document the emission level.

The type test specifies measured mean values for 2nd-40th harmonic contributions for 11 levels of generated active power from 0% to 100% of the *rated power* and with a *Power Factor* of 1. Measured mean values are stated as a percentage of the *rated current*.

4.5.2 Limit values

The *battery plant* is not allowed to emit *harmonic distortions* exceeding the limit values specified in this section.

For *battery plants* which are connected far from other consumers, the emission limits may, however, be changed to values above the normal emission limits following acceptance from *the electricity supply undertaking*.

In addition to limit values for the individual *harmonic distortions*, limit values for *THD* and *PWHD* are used.

For category C and D *battery plants*, limit values for the *harmonic distortions* are determined as voltage distortions in order to take into account local variations in the grid impedance. The size of the *battery plant* relative to the capacity in the grid is also taken into account.

4.5.2.1 Requirements for category A1 battery plants

All category A1 *battery plants* must meet the requirements to the harmonic distortion limit value in the Point of Connection, described in DS/EN 61000-3-2 [ref. 17].

4.5.2.2 Requirements for category A2 battery plants

All category A2 *battery plants* must meet the requirements to the harmonic distortion limit values in the Point of Connection, described in DS/EN 61000-3-12 [ref. 22].

4.5.2.3 Requirements for category B battery plants

The limit values for harmonic current emissions for different orders *h* appear from the following table.

Voltage level	SCR	Odd harmonic order *h* (not a multiple of 3)					Even harmonic order *h*		
		5	7	11	13	$17 \le h \le 39$	2	4	$8 \le h \le 40$
$U_c \le 1$ kV	<33	3.6	2.5	1.0	0.7	-	-	-	-
	≥33	4.1	2.8	1.1	0.8	-	-	-	-
	≥66	5.3	3.5	1.7	1.2	-	-	-	-
	≥120	7.2	4.6	2.6	1.6	-	-	-	-
	≥250	11.7	7.5	4.4	3.0	-	-	-	-
	≥350	15.2	9.6	5.9	4.1	-	-	-	-
$U_c > 1$ kV	-	4.0	4.0	2.0	2.0	$\frac{400}{h^2}$ *)	0.8	0.2	0.1

*) Though not less than 0.1%.
Note: Interpolation between the table values is required for *SCR* ≥33.

Table 5 Limit values for harmonic current Ih/In (% of In).

The limit values for total harmonic current distortion emissions appear from the table below.

Voltage level	SCR	THD_I	$PWHD_I$
$U_c \le 1$ kV	<33	4.5	7.9
	≥33	4.9	8.1
	≥66	6.0	9.0
	≥120	8.3	10.5
	≥250	13.9	14.3
	≥350	18.0	17.3
$U_c > 1$ kV	-	-	-

Table 6 Limit values for total harmonic current distortion (% of In) for all harmonic distortions.

4.5.2.4 Requirements for category C and D battery plants

The *electricity supply undertaking* determines the emission limits for harmonic voltages in the *Point of Connection*.

The purpose of the emission limits is to ensure that the total permissible noise level for the individual *harmonic distortions* and THD_U is not exceeded.

The limit values for total harmonic voltage distortion emissions appear from the table below.

Voltage level	THD_U
$U_n \le 35$ kV	6.5
$U_n > 35$ kV	3.0

Table 7 Limit values for total harmonic voltage distortion THDU (% of Un) for all harmonic distortions.

4.5.3 Verification

Verify that *battery plant* emissions are below the limit value in the *Point of Connection*.

Use the value from the level of generated active power at which the individual harmonic current is the greatest to verify observance of the limit values for harmonic currents for the individual harmonic currents *h*. Use the calculated current values to calculate THD_I and $PWHD_I$ for the verification of conformity with the limit values for THD_I and $PWHD_I$.

For current harmonic I_h, THD_I and $PWHD_I$ are defined as:

$$THD_I = \sqrt{\sum_{h=2}^{h=40}\left(\frac{I_h}{I_1}\right)^2}$$ [ref. 19] and $$PWHD_I = \sqrt{\sum_{h=14}^{h=40} h * \left(\frac{I_h}{I_1}\right)^2}$$ [ref. 22]

For voltage harmonic U_h, THD_U is defined as follows:

$$THD_U = \sqrt{\sum_{h=2}^{h=40}\left(\frac{U_h}{U_1}\right)^2}$$

For *battery plants* consisting of multiple units, the contributions from the individual units *i* may be summarised in accordance with the general summation law, see IEC/TR 61000-3-6 [ref. 19] and DS/EN 61000-3-11 [ref. 21] according to the following formula:

$$I_h = \sqrt[\alpha]{\sum_i I_{h,i}^{\alpha}}$$

Values for the exponent α appear from the table below.

Harmonic order	α (alfa)
h < 5	1
5 ≤ *h* ≤ 10	1.4
h > 10	2
h > 39	3

Table 8 Values for the exponent α.

Calculation examples can be found in 'Guidelines on the calculation of power quality parameters – TR 3.2.2' [ref. 32].

Alternatively, use the approved emission model to verify that limit values are met.

4.5.3.1 Category A1, A2, B, C and D battery plants:

Verify that limit values are observed at all levels of generated active power.

4.5.3.2 Category D battery plants
Verify that limit values are observed at all levels of generated active power.

Translate the sum of the individual harmonic currents I_h into harmonic voltages by multiplying the individual harmonic currents by the numerical value of the grid impedance at the individual frequencies as stated by the *electricity supply undertaking*.

4.6 Interharmonic distortions

4.6.1 Data basis
The type test specifies measured mean values for interharmonic contributions in the 75 Hz to 1975 Hz frequency range for 11 levels of generated active power from 0% to 100% of the *rated power* and with a *Power Factor* of 1.

Measured mean values are stated as a percentage of the *rated current* I_n.

4.6.2 Limit values
The *battery plant* is not allowed to emit interharmonic distortions exceeding the limit values specified in this section.

For *battery plants* which are connected far from other consumers, the emission limits may, however, be changed to values above the normal emission limits following acceptance from *the electricity supply undertaking*.

4.6.2.1 Requirements for category A1 and A2 battery plants
There are no interharmonic distortion emission requirements for plant categories A1 and A2.

4.6.2.2 Requirements for category B battery plants
The limit values for interharmonic current emissions appear from the table below which is based on RA557 [ref. 28] and scaling according to IEC/TR 61000-3-12 [ref. 22].

Voltage level	SCR	Frequency (Hz)		
		75 Hz	125 Hz	>175 Hz
$U_C \leq$ 1kV	<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_C > 1kV	-	0.44	0.66	$\frac{83}{f}$ *)

*) Minimum 0.1%.

Table 9 Limit values for interharmonic current emissions.

4.6.2.3 Requirements for category C and D battery plants

The *electricity supply undertaking* determines emission limits for interharmonic voltages from the *battery plant* in the *Point of Connection*.

The purpose of the emission limits is to ensure that the total permissible noise level for the individual *harmonic distortions* and THD_U is not exceeded.

4.6.3 Verification

4.6.3.1 Category A1 and A2 battery plants

For category A1 and A2 *battery plants*, no verification is required.

4.6.3.2 Category B and C battery plants

Verify that the *battery plant* complies with the limit values for interharmonic current emissions in the same way as for harmonic current emissions, see section 4.5.3.1. However, the exponent α=3 must be used if the summation rules are used.

4.6.3.3 Category D battery plants

Verify that the *battery plant* complies with the limit values for interharmonic voltage emissions in the same way as for harmonic voltage emissions, see section 4.5.3.2. However, the exponent α=3 must be used if the summation rules are used.

Alternatively, use the approved emission model to verify that limit values are met.

4.7 Distortions in the 2-9 kHz frequency range

4.7.1 Data basis

The type test specifies measured mean values for frequency components of the current in groups of 200 Hz width from 2 kHz to 9 kHz for 11 levels of generated active power from 0% to 100% of the *rated power* and a *Power Factor* of 1. Measured mean values are stated as a percentage of the *rated current* I_n.

4.7.2 Limit values

4.7.2.1 Requirements for category A1 and A2 battery plants

There are no requirements for emission of distortions above 2 kHz for *plant categories* A1 and A2.

4.7.2.2 Requirements for category B battery plants

The emission of currents with frequencies higher than 2 kHz must not exceed 0.2% of the *rated current* in any of the frequency groups measured.

4.7.2.3 Requirements for category C and D battery plants

The *electricity supply undertaking* determines emission limits for voltages from the *battery plant* in the *Point of Connection*.

The purpose of the emission limits is to ensure that the total permitted distortion for the individual frequency groups is not exceeded.

4.7.3 Verification

4.7.3.1 Category A1 and A2 battery plants

For *category* A1 and A2 *battery plants*, no verification is required.

4.7.3.2 Category B battery plants

Verify that the *battery plant* complies with the limit values for current emissions above 2 kHz in the same way as for harmonic current emissions. However, the exponent α=3 must be used if the summation rules are used.

4.7.3.3 Category C and D battery plants

Verify that the *battery plant* complies with the limit values for voltage emissions above 2 kHz in the same way as for harmonic voltage emissions. However, the exponent α=3 must be used if the summation rules are used.

Alternatively, use the approved emission model to verify that limit values are met.

5. Control

5.1 General requirements

The following requirements apply to *battery plant* categories A1, A2, B, C and D.

All control functions mentioned in the following sections refer to the *Point of Connection.*

The currently activated functions and parameter settings are determined by the *electricity supply undertaking* within the framework laid down by the *transmission system operator*.

In order to ensure security of supply, the *transmission system operator* must be able to activate or deactivate the specified control functions by agreement with the *plant owner.*

The signs used in all figures follow the *generator convention*.

The table below specifies the minimum control functionality requirements for a *battery plant* in *plant categories* A1, A2, B, C and D, see section 1.2.4.

Category / **Control function**	**A1**	**A2**	**B**	**C**	**D**
Frequency response – LFSM-O (5.2.1.3)	X	X	X	X	X
Frequency response – LFSM-U (5.2.1.5)	-	-	-	X	X
Frequency control **	-	-	-	X	X
Absolute power limit (5.2.3.1)	X	X	X	X	X
Ramp rate limit (5.2.3.2)	X	X	X	X	X
Q control (5.3.1)*)	X	X	X	X	X
Power Factor control (5.3.2)*)	X	X	X	X	X
Automatic Power Factor control (5.3.2) *)	X	X	-	-	-
Voltage control (5.3.3) *)	-	-	-	X	X
System protection (5.4)	-	-	-	(X)	(X)

Bracketed numbers indicate the sections that describe the respective functions.
*) A *plant* must not perform *Q control*, *Power Factor control or automatic Power Factor control* except by prior agreement with the *electricity supply undertaking*.
**) A *plant* must not perform *frequency control* or *voltage control* except by prior agreement with the *transmission system operator.*

Table 10 Control functions for battery plants.

The purpose of the various control functions is to ensure overall control and monitoring of the *battery plant's* operation.

The various control functions may be implemented in the individual unit, be combined into a single *battery plant controller* or a combination thereof, provided there is only one communication interface as shown in Figure 8.

This means that if any number of battery units are connected to the same POC, so that the *rated power* in the POC is the sum of the connected battery units, the connected units must thus function as one *battery plant*.

The sum of the rated power in the *POC* determines the *plant category* and thus the requirements for connection.

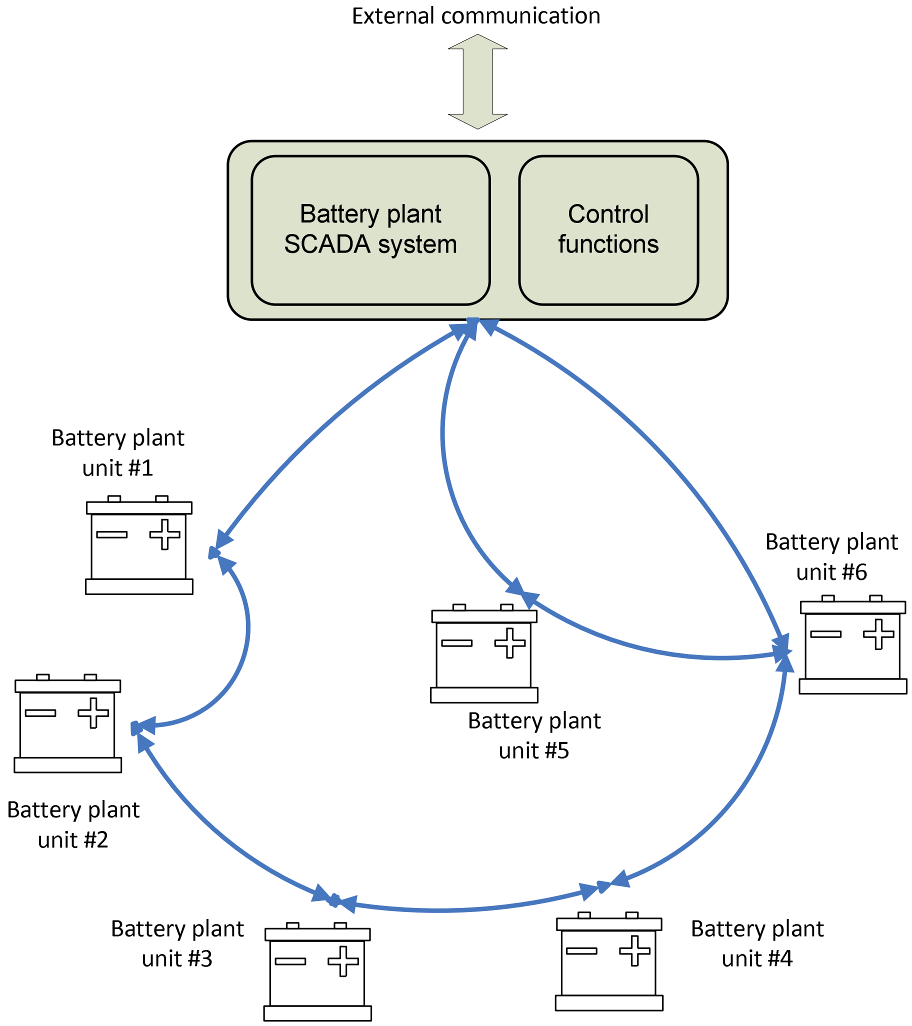

Figure 8 Drawing of a plant controller.

All set point changes must be registered with an identification of the party requesting the change.

All set point changes or orders for operational changes must be time stamped with a maximum accuracy of 10 ms and refer to *UTC*.

5.2 Active power and frequency control functions

The following requirements apply to *battery plant* categories A1, A2, B, C and D.

A *battery plant* must be equipped with control functions capable of controlling the active power delivered or absorbed in the *Point of Connection*.

It must be possible to specify set points for active power with a resolution of 1% of P_{no} or P_{nl} or higher.

Current parameter settings for activated active power control functions are determined by the *electricity supply undertaking* in collaboration with the *transmission system operator* before commissioning.

In addition to the general requirements in section 5.1, active power control functions must comply with the requirements outlined in the following sections.

5.2.1 Frequency response (LFSM-U and LFSM-O)

In the event of frequency deviations in the *public electricity supply grid*, the *battery plant* must contribute to ensuring frequency stability by automatically increasing or reducing active power at grid frequencies below or above the reference frequency f_1 and f_2. This is referred to as *frequency response* and is an autonomous function.

Regulation must be commenced no later than 2 seconds after a frequency change is detected and must be completed within 15 seconds.

The grid company in whose grid the *battery plant* is connected can coordinate initiation of the *frequency response* in relation to the trip time of island operation mode detection, and can thereby ensure optimal island operation mode detection functionality.

Frequency measurements must be carried out with 10 mHz accuracy or higher. The sensitivity of the control function must be 10 mHz or lower.

It must be possible to set the *frequency response* function's frequency points (response frequencies) indicated in Figure 9 to any value in the 47.00-52.00 Hz range with a resolution of maximum 10 mHz.

The setting value for the *frequency response* function's response frequencies is determined by the *transmission system operator*.

It must be possible to set the *droop* for the downward regulation to any value in the range 2 % to 12 % of P_n and to effect this with an accuracy of ±10 % of P_n. The standard value for *droop* is 4% of P_n.

In this context, *droop* is the change in active power as a function of the grid frequency. *Droop is* stated as a percentage of P_{no} and P_{nl} for the *battery plant*.

The *droop* for control between the various frequency points is shown in Figure 9 and Figure 10 for *battery plants* which can only absorb power from the grid and *battery plants* which can absorb power from and deliver power to the grid, respectively.

5.2.1.1 Power flow to battery plants

$P_{current}$ is a fictitious point illustrating a set point between P_{nl} and P_{no}.

P_{no} is the *battery plant's rated power absorbed* from the grid.

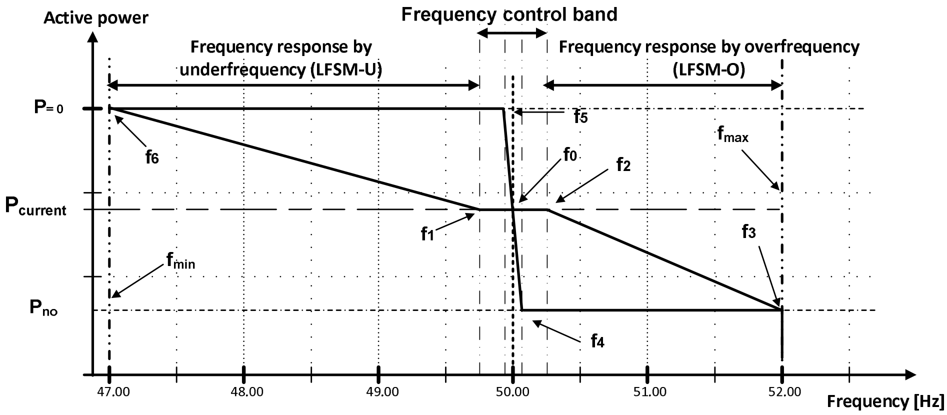

Figure 9 Frequency response for a battery plant which can only absorb power from the public electricity supply grid.

In the event of a frequency increase above f_2 (LFSM-O), the *droop* f_2 - f_3 must be followed, i.e. power in the direction from the grid is increased at increasing frequency. If the frequency is subsequently stabilised and decreases, the power must be maintained until the frequency has decreased to a *droop* value of f_4 - f_0. When the frequency is f_0, the *battery plant* switches to *frequency control* state (if this control method is activated).

In the event that frequency decreases to below f_1 (LFSM-U), the *droop* f_1 - f_6 must be followed, i.e. power in the direction from the grid is reduced at falling frequency. If the frequency is subsequently stabilised and increases, the power must be maintained until the frequency has increased to a *droop* value of f_5 - f_0. When the frequency is f_0, the *battery plant* switches state, i.e. the *battery plant* is out of *frequency response*.

5.2.1.2 Power flow to and from battery plants

$P_{current}$ is a fictitious point illustrating a set point between P_{nl} and P_{no}.
P_{no} is the *battery plant's rated power absorbed* from the grid.
P_{nl} is the *battery plant's rated power delivered* to the grid.

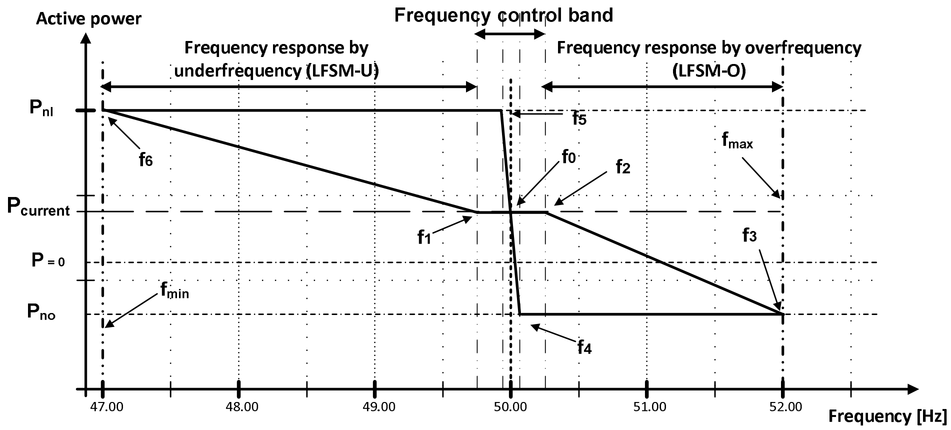

Figure 10 Frequency response from a battery plant which can deliver and absorb power from the public electricity supply grid.

In the event of a frequency increase above f_2 (LFSM-O), the *droop* f_2 - f_3 must be followed, i.e. the absorption of active power is increased at increasing frequency. If the frequency is subsequently stabilised and decreases, the power must be maintained until the frequency has decreased to a *droop* value of f_4 - f_0. When the frequency is f_0, the *battery plant* switches state, i.e. the *battery plant* is out of *frequency response*.

In the event that the frequency decreases below f_1 (LFSM-U), the *droop* f_1 - f_6 must be followed, i.e. the delivery of active power is increased at falling frequency. If the frequency is subsequently stabilised and increases, the power must be maintained until the frequency has increased to a *droop* value of f_5 - f_0. When the frequency is f_0, the *battery plant* switches state, i.e. the *battery plant* is out of *frequency response*.

The requirements for standard setting values are shown below in Table 11 and Table 12.

Standard frequency response setting values – Dk1									
f_x	f_{min}	f_{max}	f_0	f_1	f_2	f_3	f_4	f_5	f_6
Hz	47.00	52.00	50.00	49.80	50.20	52.00	50.05	49.95	47.00

Table 11 Standard frequency response setting values for Dk1.

Standard frequency response setting values – DK2									
f_x	f_{min}	f_{max}	f_0	f_1	f_2	f_3	f_4	f_5	f_6
Hz	47.00	52.00	50.00	49.50	50.10 %	52.00	50.05	49.95	47.00

Table 12 Standard frequency response setting values for Dk2.

5.2.1.3 Category A1, A2, B, C and D battery plants: requirements for LFSM-O

For *category* A1, A2, B, C and D *battery plants*, *frequency response* in accordance with Figure 9 or Figure 10 is required in case of overfrequency .

5.2.1.4 Category A1, A2 and B battery plants: requirements for LFSM-U

For *category* A1, A2 and B battery plants, there are no requirements for *frequency response* in case of underfrequency, LFSM-U.

5.2.1.5 Category C and D battery plants: requirements for LFSM-U

For *category* C and D *battery plants*, the *frequency response* functionality must be available in case of underfrequency, LFSM-U, in accordance with Figure 9 or Figure 10. Activation of the functionality is not required to obtain grid connection.

5.2.2 Frequency control (FSM)

In case of frequency deviations in the *public electricity supply grid*, the *battery plant* must have control functions that can provide *frequency control* in order to stabilise or restore the grid frequency (50.00 Hz).

The purpose of the *frequency control* function is to control active power at grid frequencies between f_1 and f_2 as shown in Figure 11.

The frequency measurement must be carried out with a ± 10 mHz accuracy or higher.

The accuracy of a completed *frequency control* regulation, including the accuracy at the set point, may not deviate by more than ±5% of the setpoint value or by ±0.5% of the *rated power,* depending on which yields the most stringent tolerances.

It must be possible to set the *frequency control* function in such a way that it is possible to set any frequency point in Figure 11 between the frequencies f_{min} and f_{max} (47.00-52.00 Hz range) with a 10 mHz accuracy.

The *droop* required for *frequency control* is shown in Figure 11.

In this context, *droop* is the change in active power as a function of the grid frequency. *Droop* is stated as a percentage of the *battery plant's rated power*.

Figure 11 illustrates the location of the various parameters and limits for the *frequency control* function.

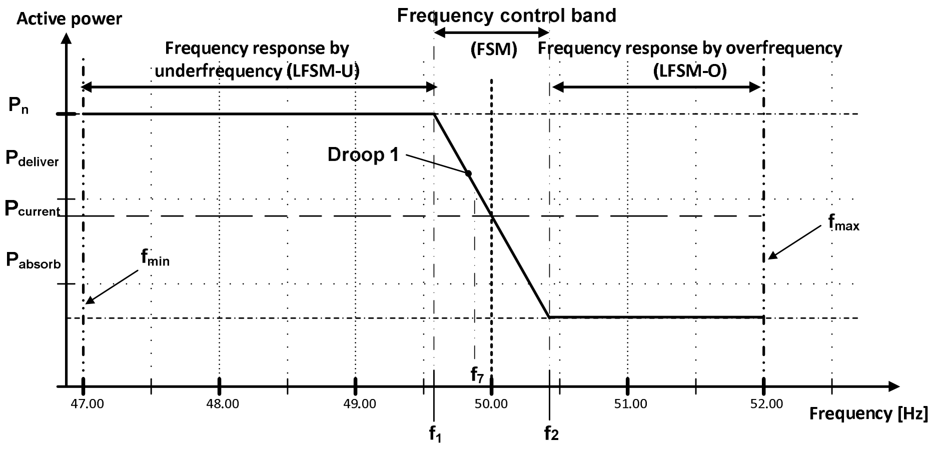

Figure 11 Frequency control curve for a battery plant.

It must be possible to activate the *frequency control* function in the f_{min} to f_{max} range.

Standard frequency control setting values – Dk1 (FCR)					
f_x	f_{min}	f_{max}	f_0	f_1	f_2
Hz	47.00	52.00	50.00	49.80	50.20

Table 13 Standard frequency control setting values Dk1

Standard frequency control setting values - Dk2 (FCR-N)					
f_x	f_{min}	f_{max}	f_0	f_1	f_2
Hz	47.00	52.00	50.00	49.90 %	50.10 %

Table 14 Standard frequency control setting values Dk2

Standard frequency control setting values - Dk2 (FCR-D)					
f_x	f_{min}	f_{max}	f_0	f_1	f_7
Hz	47.00	52.00	50.00	49.90 %	49.50

Table 15 Standard frequency control setting values Dk2

5.2.2.1 Category A1, A2 and B battery plants:

There are no requirements for the *frequency control* function in respect of *category* A1, A2 and B *battery plants*.

5.2.2.2 Category C and D battery plants:

For *category* C and D *battery plants,* the *frequency control* function with functionality in accordance with 5.2.2 is required.

Activation of the functionality is not required to obtain grid connection.

Frequency control using a new parameter set must be possible no later than 10 seconds from receipt of an order to change the parameter.

5.2.3 Limiter functions – active power control

A *plant* must be equipped with control functions (limiter functions) to control active power to ensure stable operation based on a selected operating point.

Examples of the use of these control functions are: load control based on a power schedule and secondary control based on centrally commanded control (FRR-a, FRR-m).

Control using a new parameter for the limiter functions must be commenced within 2 seconds and completed no later than 10 seconds after receipt of an order to change the parameter.

It must be possible to specify set points for active power with a resolution of minimum 1% of P_{nl} and P_{no} or better.

The accuracy of the control performed and of the set point may not deviate by more than ±5% of the set point value or by ±0.5% of the *rated power*, depending on which yields the highest tolerance.

The required limiter functions are specified in the following sections.

5.2.3.1 Absolute power limit (part load)

An a*bsolute power limit* is used to limit active power absorbed by or delivered to a *battery plant* to a set point-defined maximum power limit in the *Point of Connection*.

An absolute power limit is typically used to protect the *public electricity supply grid* against overload in critical situations, or to restrict the maximum active power absorbed or delivered by the *battery plant* as a result of legislation.

5.2.3.1.1 Category A1, A2, B, C and D battery plants

For *category* A1, A2, B, C and D *battery plants,* the *absolute power limit* limiter function is required.

The limiter function must as a minimum be set such that the plant never exceeds the plant's *rated power* in accordance with 1.2.29.

5.2.3.2 Ramp rate limit (load ramp rate – ramp function)

R*amp rate limit* is used to limit the maximum speed by which the active power can be changed in the event of changes in power or in the set points for a *battery plant*.

A *ramp rate limit* is typically used for reasons of system operation to prevent changes in active power from adversely impacting the stability of the *public electricity supply grid*.

5.2.3.2.1 Category A1, A2, B, C and D battery plants:

For *category* A1, A2, B, C and D *battery plants,* the *ramp rate limit* limiter function is required.

For frequencies in the frequency control band (FSM), the upward and downward adjustment of active power, applicable to both absorbed and delivered power, must adjust towards zero within minimum 30 seconds.

It must be possible to set the ramp rate to any value between 10 and 300 kW/s.
As a standard value for the *ramp rate power constraint is* used 100 kW/s.

5.3 Reactive power and voltage control functions

A *battery plant* must be equipped with reactive power and voltage control functions capable of controlling the reactive power in the *Point of Connection* and controlling the voltage in the *voltage reference point* via activation orders containing set points for the specified parameters.

The control functions for *Q control*, *Power Factor* and *voltage control* are mutually exclusive, which means that only one of the three functions can be activated at a time.

Before commissioning, the current control functions and the parameter settings for these must be determined by the *electricity supply undertaking* in collaboration with the *transmission system operator*.

In addition to fulfilling the general requirements stated in section 5.1, reactive power and voltage control functions must comply with the requirements outlined in the following sections.

The following table shows the minimum functionality requirements for reactive power control in the various *plant categories*.

Category Control function	A1	A2	B	C	D
Q control (5.3.1)*)	X	X	X	X	X
Power Factor control (5.3.2)*)	X	X	X	X	X
Voltage control (5.3.3) *)	-	-	-	X	X
Automatic Power Factor control (5.3.4) *)	X	X	-	-	-

Bracketed numbers indicate the sections that describe the respective functions.
*) By default, a *plant* must be configured with *Q control* and with a set point of 0 VAr. Any other method of reactive power control must be agreed with the *electricity supply undertaking*.

Table 16 Reactive power control functions.

5.3.1 Q control

The *Q control* function controls the reactive power independently of the grid voltage and the active power in the *Point of Connection*. This control function is shown as a horizontal line in Figure 12.

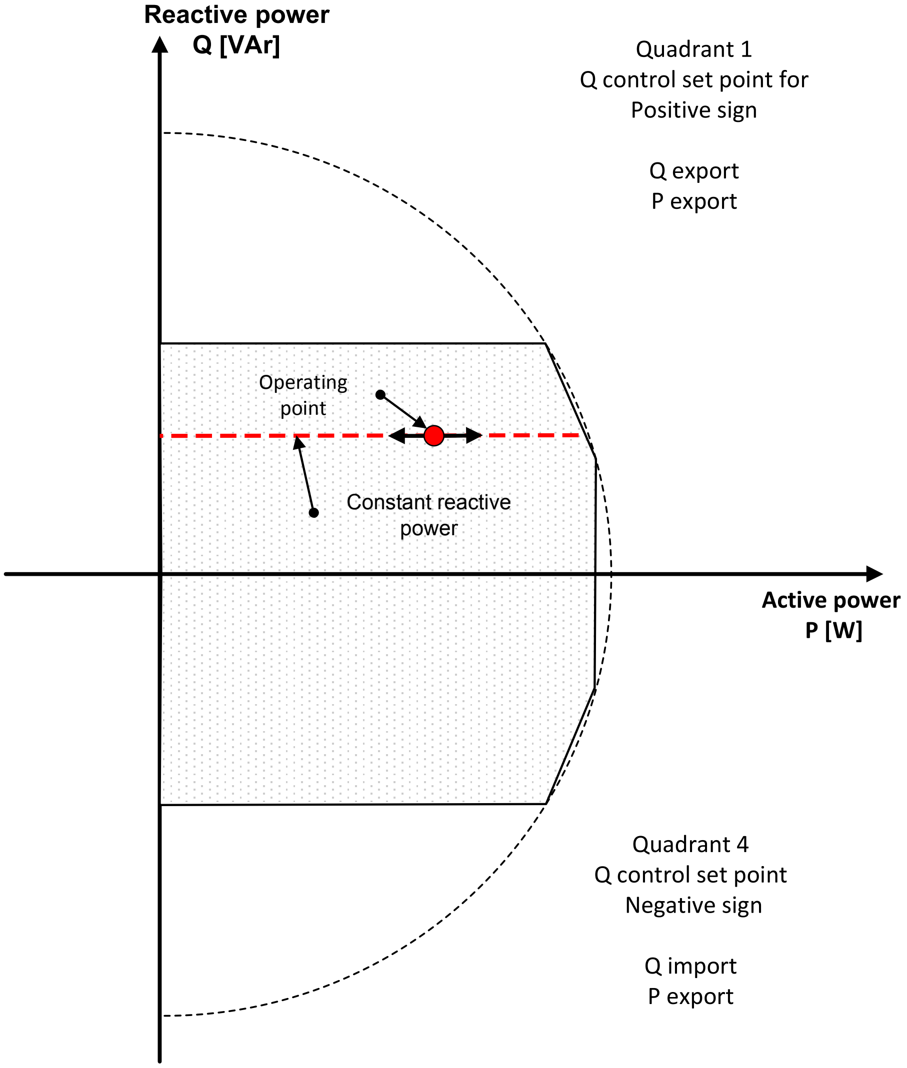

Figure 12 Reactive power control function for a battery plant.

Any change to the Q control set point must be commenced within 2 seconds and completed no later than 10 seconds after receipt of an order to change the set point.

For the control function, the accuracy of a completed or continuous control operation, including the accuracy at the set point, must not deviate by more than 1% of Q_n over a period of 1 minute.

It must be possible to specify set points for reactive power with a resolution of minimum 1% of Q_{nl} and Q_{no} or better.

5.3.1.1 Category A1, A2, B, C and D battery plants

Battery plants in *category* A1, A2, B, C and D must have the function *Q-control*.

5.3.2 Power Factor control

The *Power Factor control* function controls the reactive power proportionately (determined by the *droop*) to the active power in the *Point of Connection*, which is illustrated by a line with a constant gradient in Figure 13.

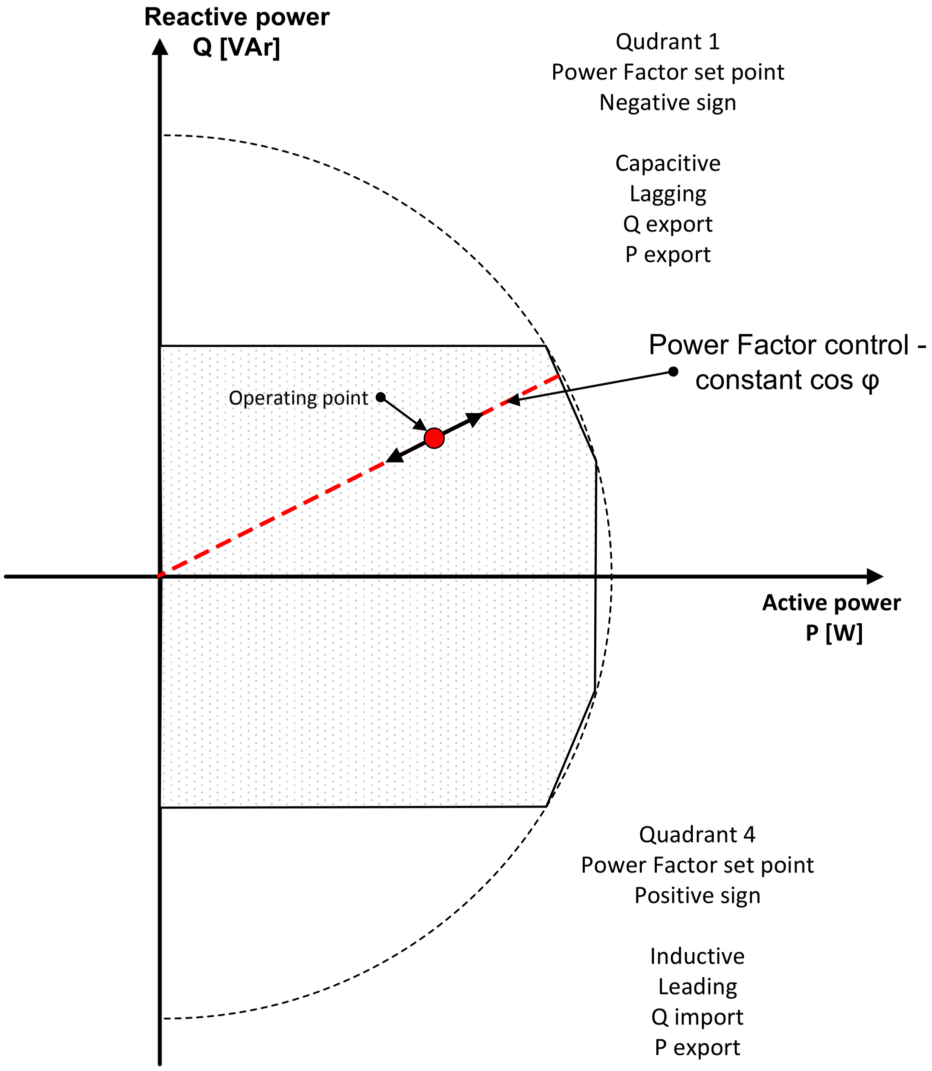

Figure 13 Power Factor control (PF) for a battery plant.

The *battery plant* must be able to receive a *Power Factor* set point with an accuracy of 0.01.

Any change to a new *Power Factor* set point must be commenced within 2 seconds and completed no later than 10 seconds after receipt of the order to change the set point.

For the control function, the accuracy of a completed or continuous control operation, including the accuracy at the set point, must not deviate by more than 1% of the Power Factor set point over a period of 0.01 minute. *The battery plant* must be able to receive a *Power Factor* set point with a resolution of 0.01.

5.3.2.1 Category A1, A2, B, C and D battery plants

Battery plants in *category* A1, A2, B, C and D must have the function power *factor control*.

5.3.3 Voltage control

Automatic *voltage control* (AVR) is a control function that automatically controls the voltage in the *voltage reference point*. The setting range of the *voltage control* must lie within the minimum to maximum voltage stated in Table 1, with an accuracy of 0.5% or higher of the *rated voltage*.

Any change to the voltage set point must be commenced within 2 seconds and completed no later than 10 seconds after receipt of an order to change the set point.

For the control function, the accuracy of the completed control operation, including the accuracy at the set point, must not deviate by more than 0.5% of U_C over a period of 1 minute.

It must be possible to set the *droop* for the *voltage control* to a value in the range 2-12%. The specific *droop* setting must be agreed between the *plant owner* and the *electricity supply undertaking* in cooperation with the *transmission system operator*.

The standard value for settings is 4%.

A drawing of the concept in a *voltage control* is shown in Figure 14.

Overall voltage coordination is managed by the *electricity supply undertaking* in collaboration with the *transmission system operator*.

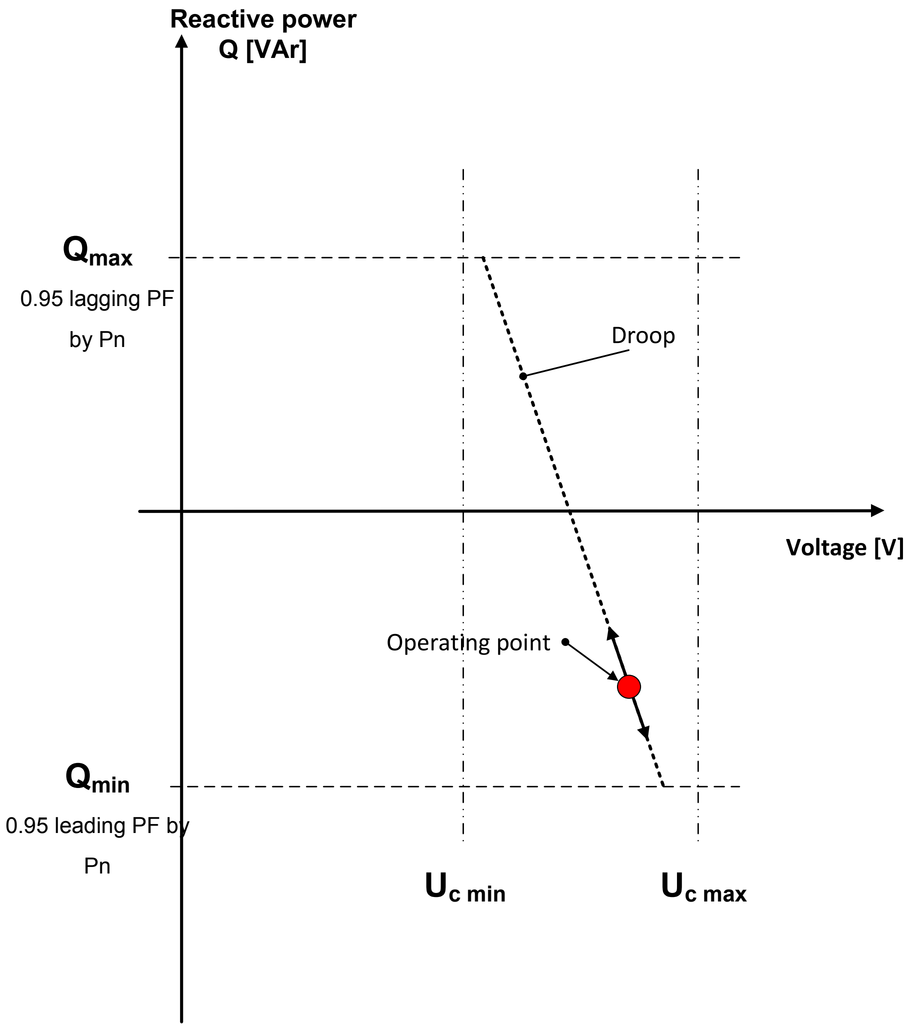

Figure 14 Voltage control for a battery plant.

5.3.3.1 Category A1, A2 and B battery plants

For *battery plants* in *category* A1, A2 and B, the function *voltage control* is not *required.*

5.3.3.2 Category C and D battery plants

Battery plants in *category* C and D must have the function *voltage control*.

5.3.4 Automatic Power Factor control

The *Automatic Power Factor control* function automatically activates/deactivates the *Power Factor control* at defined voltage levels in the *voltage reference point*. The principle of the automatic *Power Factor control* is illustrated in Figure 15.

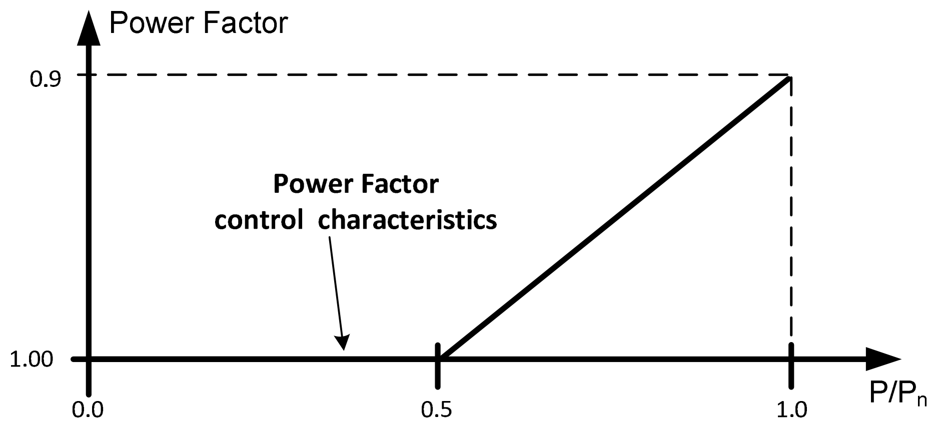

Figure 15 Automatic Power Factor control for a battery plant.

The default setting for *automatic Power Factor control (PF)* is given by the following three support points with linear interpolation between them:

1: P/P_n = 0.0, *PF* = 1.00
2: P/P_n = 0.5, *PF* = 1.00
3: P/P_n = 1.0, *PF* = 0.90

The activation level for the function is normally 105% of *rated voltage*, and the deactivation level is normally 100% of *rated voltage*. The activation/deactivation level must be adjustable via set points.

Initially, the function must be deactivated and it must be activated only by agreement with the *electricity supply undertaking*.

5.3.4.1 Category A1 and A2 battery plants

Battery plants in *category* A1 and A2 must have the function automatic *power factor control*.

5.3.4.2 Category B, C and D battery plants

For *battery plants* in *category* B, C and D, the function automatic *power factor control* is not required.

5.3.5 Requirements for reactive power properties of the plant

As a minimum, *battery plants* must be equipped with the reactive power control functions specified in Table 16.

The *battery plant* must be designed in such a way that the operating point always can be ordered to lie within the hatched area shown in the relevant figures for the different *plant categories*.

5.3.5.1 Category A1, A2 and B battery plants

In addition to complying with the general requirements in section 5.1 and the requirements for normal operating conditions in section 3.2, the *battery plant* must, by default, follow a *Power Factor* of 1.00, unless otherwise agreed.

The *battery plant* must be designed in such a way that its operating point can at any time be ordered to lie within the hatched area shown in Figure 16. There are no precision and accuracy requirements for the *Power Factor* when apparent power is less than 20% of *rated power*.

When the *battery plant* is disconnected or is not delivering or absorbing any active power, no compensation is required for the reactive power from the *plant infrastructure*.

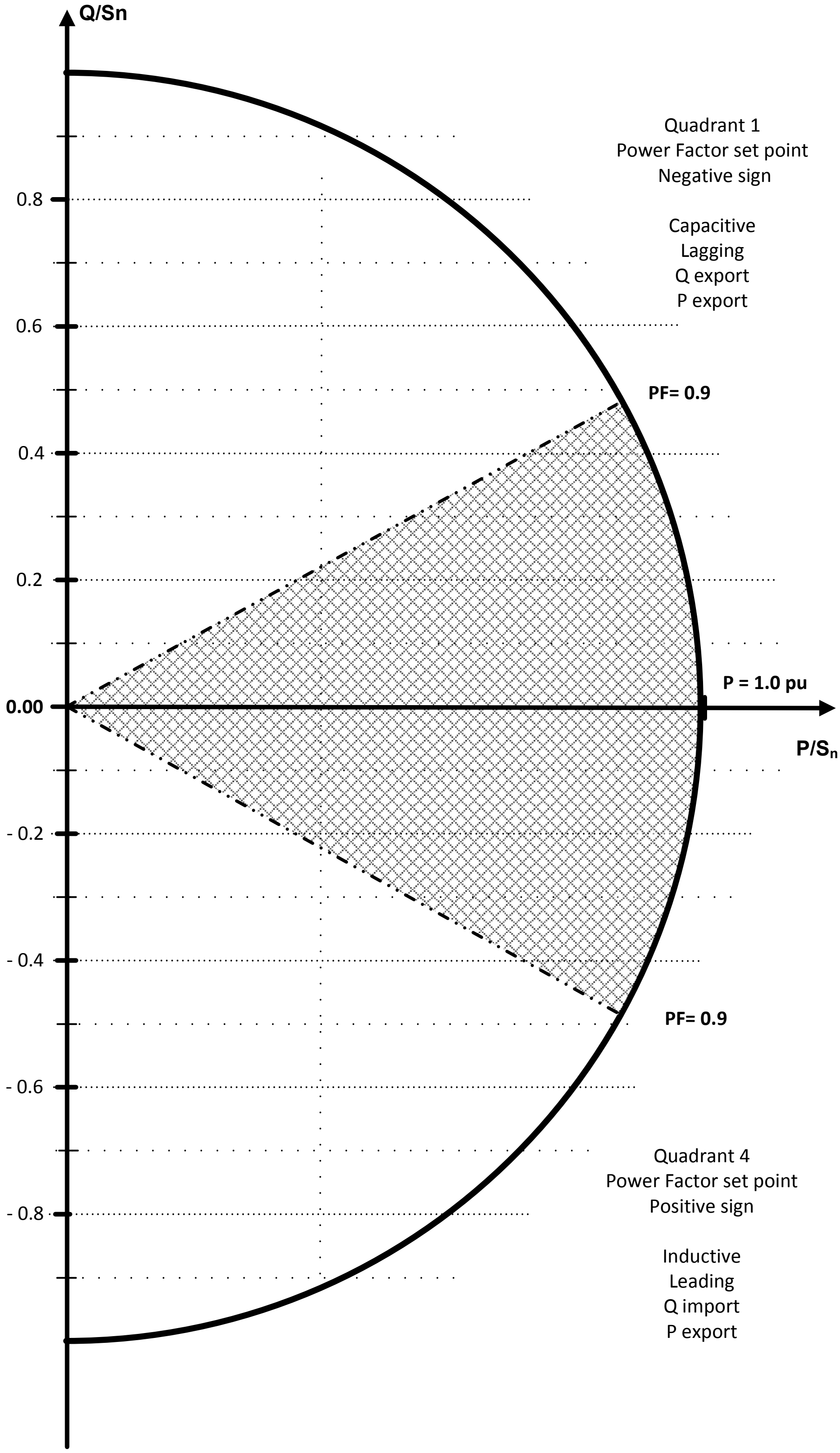

Figure 16 Requirements for the delivery of reactive power by working points less than P_n ($P_{deliver}$) for battery plants in category A1, A2 and B.

5.3.5.2 Category C battery plants

In addition to complying with the general requirements in section 5.1 and the requirements for normal operating conditions in section 3.3, the *battery plant* must be equipped with the control functions specified in Table 16.

The *battery plant* must be designed in such a way that its operating point can at any time be ordered to lie within the hatched area shown in Figure 17. There are no precision and accuracy requirements for the *Power Factor* when apparent power is less than 20% of *rated power*.

Control method and settings must be agreed with the *electricity supply undertaking*.

The *plant owner* must compensate for the reactive power of the *power infrastructure* in situations where the *battery plant* is disconnected or is not absorbing or delivering active power.

Compensation may take place in the electricity system by agreement with the *electricity supply undertaking*.

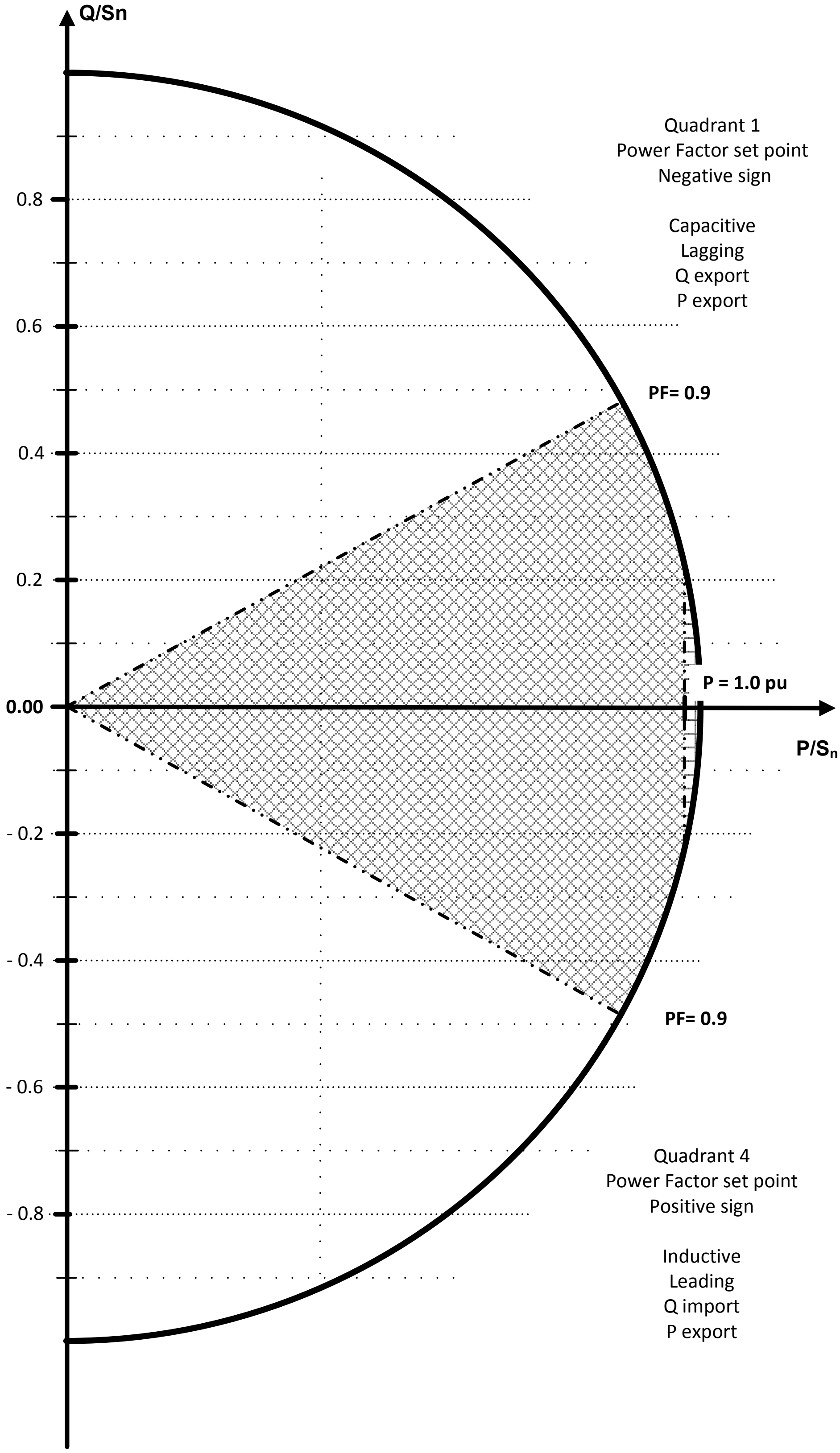

Figure 17 Requirement for the delivery of reactive power by working points less than P_n ($P_{deliver}$) for battery plants in category C.

When the *battery plant* absorbs active power from the *public electricity supply grid*, the *battery plant* must follow a *power factor* of 1.

At rated active power ($P_{deliver}$), it must be possible to deliver reactive power in the voltage range indicated in the figure shown below.

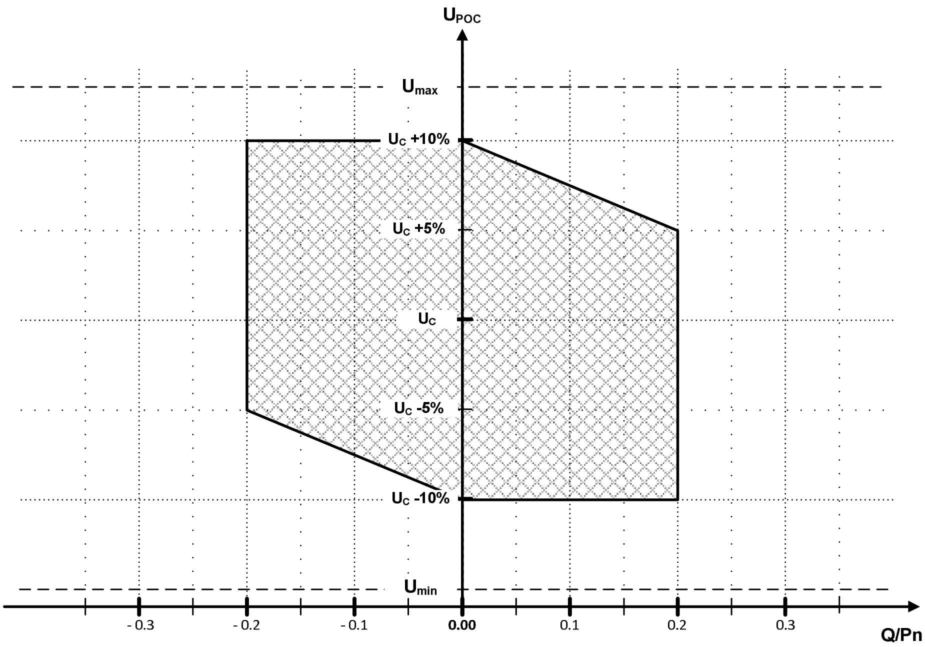

Figure 18 Requirements for the delivery of reactive power as a function of the voltage in the POC for category C battery plants.

5.3.5.3 Category D battery plants

In addition to complying with the general requirements in section 5.1 and the requirements for normal operating conditions in section 3.2, a *battery plant* must be equipped with the control functions specified in Table 16.

The *battery plant* must be designed in such a way that its operating point can at any time be ordered to lie within the hatched area shown in Figure 19.

Control method and settings must be agreed with the *electricity supply undertaking*.

The *plant owner* must compensate for the reactive power of the *power infrastructure* in situations where the *battery plant* is disconnected or is not absorbing or delivering active power.

Compensation may take place in the electricity system by agreement with the *electricity supply undertaking*.

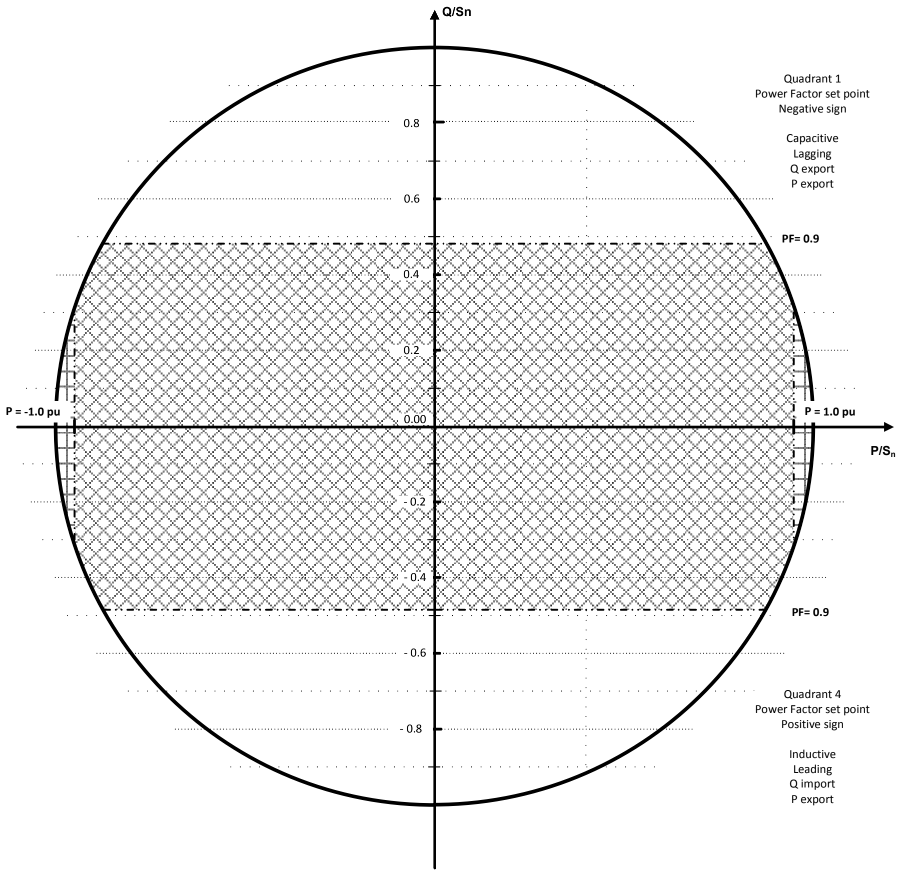

Figure 19 Requirements for the delivery of reactive power by working points less than P_n (P_{absorb} and $P_{deliver}$) for battery plants in category D.

It must be possible to deliver the reactive power in the voltage range indicated in the figure below.

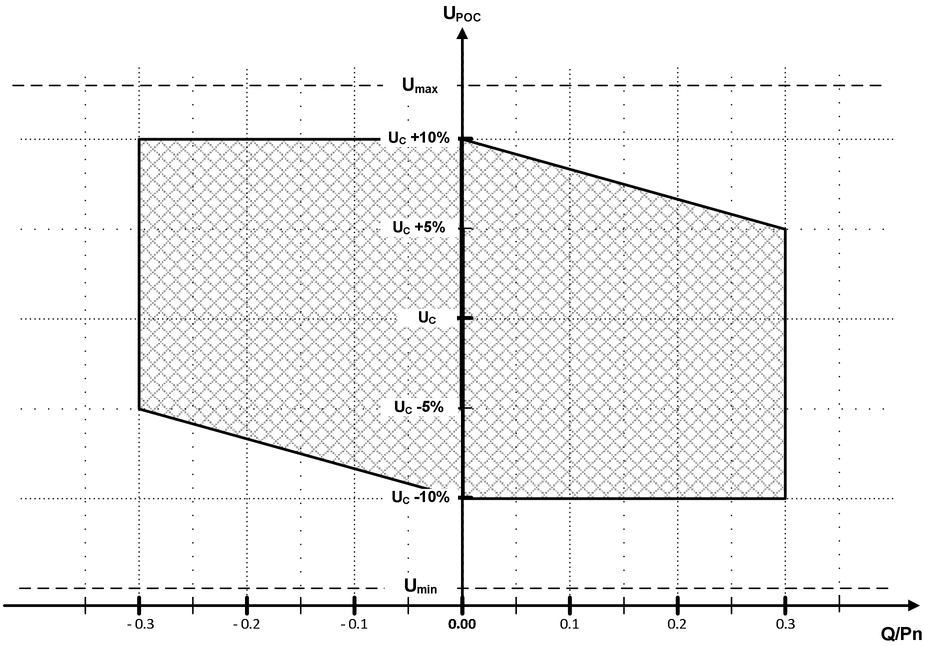

Figure 20 Requirements for the delivery of reactive power P_n (P_{absorb} and $P_{deliver}$) as a function of the voltage in the POC for category D battery plants.

5.4 System protection

System protection is not a minimum requirement for grid connection to the *public electricity supply grid,* but a requirement which may be imposed on a *battery plant* by the *transmission system operator*, depending on the location of the *Point of Connection* in the *public electricity supply grid* and/or the size of the *battery plant*.

System protection is an auxiliary function in maintaining system security and security of supply and is therefore not a normal operation control function.

System protection is a plant functionality, which, based on an order received from the *transmission system operator* or an autonomous signal from one or more relays installed in the *public electricity supply grid*, must very quickly be able to initiate adjustment of the active power delivered by a *battery plant* to one or more predefined set points. Active power is both $P_{deliver}$ and P_{absorb}.

5.4.1 Category A1, A2 and B plants:

There are no *system protection* requirements for *category* A1, A2 and B *battery plants*.

5.4.2 Category C and D plants:

Category C and D *battery plants* must be equipped with system protection which can adjust the active power delivered from the *battery plant* to one or more predefined set points. The set points are determined by the *electricity supply undertaking* upon commissioning.

The *battery plant* must have at least five different configurable adjustment range options.

The following adjustment ranges are recommended as default values:

1. Up to 70% of *rated power*
2. Up to 50% of *rated power*
3. Up to 40% of *rated power*
4. Up to 10% of *rated power*
5. Up to 0% of *rated power*, i.e. the *battery plant* is shut down, but not disconnected from the grid.

For the control function applies that the accuracy of a completed or continuous control operation, including the accuracy at the set point, must not deviate by more than 1% of the Power Factor set point over a period of 1 minute.

5.5 Order of priority for control functions

The individual control functions of a *battery plant* must be ranked in order of priority.

A priority 1 control function takes precedence over a priority 2 control function and so forth.

The order of priority is as follows:

1. Protective functions, see section 6
2. *Frequency response*, see section 5.2.1
3. *Frequency control,* see section 5.2.2
4. Limiter functions, see section 5.2.3.

6. Protection

6.1 General

The purpose of a *battery plant's* protective functions is to protect the *battery plant* and to ensure a stable *public electricity supply grid*.

The *plant owner* is responsible for ensuring that the *battery plant* is dimensioned and equipped with the necessary protective functions so that the *battery plant*:

- is protected against damage due to faults and incidents in the *public electricity supply grid*
- is protected against disconnections in non-critical situations for the *battery plant*
- protects the *public electricity supply grid* to the widest possible extent against unwanted impacts from *battery plant*

The *electricity supply undertaking* or the *transmission system operator* is entitled to demand that the setting values for protective functions be changed following commissioning if this is found to be of importance to the operation of the *public electricity supply grid*.

However, such change must not result in the *battery plant* being exposed to impacts from the *public electricity supply grid* lying outside of the design requirements specified in section 3.

After a *battery plant* has been disconnected due to a fault in the *public electricity supply grid*, the *battery plant* must be automatically reconnected no earlier than three minutes after the voltage and frequency are once again within the normal operating conditions stated in section 3.2.

A *battery plant* which has been disconnected by an external signal prior to a fault occurring in the *public electricity supply grid* must not be reconnected until the external signal has been eliminated, and the voltage and frequency are once again within the normal operating conditions stated in section 3.2.

At the *plant owner's* request, the *electricity supply undertaking* 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 *public electricity supply grid* as may be necessary to determine the *battery plant's* protective functions.

In addition to the relay protection, protection must be established specifically aimed at internal faults in *the battery plant* or installation, including short-circuits, etc. Such protection must not trip *the battery plant* in case of short-circuits or grid rerouting.

In case of internal faults in the *battery plant*, the protection must be selective with the grid protection, meaning that for example short circuits in the *battery plant* must be disconnected within 100 ms.

6.2 Central protection

For *category* B, C and D *battery plants*, a joint central protection unit may be required in the *Point of Connection in Installation (PCI)* for the battery unit if the inverter's settings cannot be documented or do not meet the requirements in section 6.

The grid company decides whether there must be a central protection unit in front of the battery unit and its configured settings.

6.3 Protective setting requirements

The *battery plant's* protective functions and associated settings must be as specified in the following subsections. Settings deviating from the required setting values in the event of, for example, problems with local overvoltages may be used only with the permission of the *electricity supply undertaking*.

All settings are stated as root-mean-square (RMS) values.

The *battery plant* must be disconnected if a measuring signal deviates more from its rated value than the setting.

The trip time stated is the measuring period during which the trip condition must constantly be met in order for the protective function to release a trip signal.

The use of vector jump relays as protection against island operation/loss of mains is not allowed.

It is assumed that the rated voltage of the battery plant is determined on the low-voltage side of the plant transformer. For three-winding transformers, it is the *rated voltage* for the low-voltage winding to which the *battery plant* is connected.

If voltage is measured on the high-voltage side, the setting value must be determined by converting *rated voltage* on the low-voltage side to the high-voltage side of the *plant* transformer.

Voltage and frequency must be measured for all three phases as line-to-line voltage.

Alternatively, if the measuring point is located on the low-voltage side of the *plant* transformer, voltage can be measured between the three phases and ground.

Frequency must be measured simultaneously on all three phases.

6.3.1 Category A1 and A2 battery plants

Protective functions with associated operating settings and trip time must match the values in the table below.

Protective function	Symbol	Setting		Trip time		Recommend-ed value
Overvoltage (step 2)	$U_{>>}$	$1.15 \cdot U_n$	V	200	ms	200 ms
Overvoltage (step 1)	$U_{>}$	$1.10 \cdot U_n$	V	60	s	60 s
Undervoltage (step 1)	$U_{<}$	$0.85 \cdot U_n$	V	10…60	s	50 s
Undervoltage (step 2)***)	$U_{<<}$	$0.80 \cdot U_n$	V	50...1500	ms	200 ms
Overfrequency	$f_{>}$	52.0	Hz	200	ms	200 ms
Underfrequency	$f_{<}$	47.0	Hz	200	ms	200 ms
Change of frequency***)	df/dt	±2.5	Hz/s	200	ms	80 ms

***) One of the specified functions must be implemented.

Table 17 Requirements for category A1 and A2 battery plants.

6.3.2 Category B battery plants

Protective functions with associated operating settings and trip time must match the values in the table below.

Protective function	Symbol	Setting		Trip time		Recommend-ed value
Overvoltage (step 2)	$U_{>>}$	$1.15 \cdot U_n$	V	200	ms	200 ms
Overvoltage (step 1)	$U_{>}$	$1.10 \cdot U_n$	V	60	s	60 s
Undervoltage (step 1)	$U_{<}$	$0.90 \cdot U_n$	V	10…60	s	10 s
Undervoltage (step 2)***)	$U_{<<}$	$0.80 \cdot U_n$	V	50...1500	ms	200 ms
Overfrequency	$f_{>}$	52	Hz	200	ms	200 ms
Underfrequency	$f_{<}$	47	Hz	200	ms	200 ms
Change of frequency***)	df/dt	±2.5	Hz/s	200	ms	80 ms

***) One of the specified functions must be implemented.

Table 18 Requirements for category B battery plants.

6.3.3 Category C battery plants

Protective functions with associated operating settings and trip time must match the values in the table below.

Protective function	Symbol	Setting		Trip time		Recommend-ed value
Overvoltage (step 3)	$U_{>>>}$	$1.20 \cdot U_n$	V	0…100	ms	50 ms
Overvoltage (step 2)	$U_{>>}$	$1.15\ U_n$	V	100…200	ms	200 ms
Overvoltage (step 1)	$U_{>}$	$1.10 \cdot U_n$	V	60	s	60 s
Undervoltage (step 1)	$U_{<}$	$0.90 \cdot U_n$	V	10…60	s	10 s
Undervoltage (step 2)	$U_{<<}$	$0.80 \cdot U_n$	V	1500	ms	1500 ms
Overfrequency	$f_{>}$	52	Hz	200	ms	200 ms
Underfrequency	$f_{<}$	47	Hz	200	ms	200 ms
Change of frequency	df/dt	±2.5	Hz/s	200	ms	80 ms

Table 19 Requirements for category C battery plants.

It must be ensured that the *battery plant* fulfils the requirements specified in section 6, and that the protection does not prevent the *battery plant* from fulfilling the additional requirements of this regulation.

The set relay settings that are important to the operation of the *public electricity supply grid* must be approved by the *transmission system operator* and the *electricity supply undertaking* in whose grid the *battery plant* is connected.

6.3.4 Category D battery plants

For plants in *category* D, the *plant owner* is responsible for ensuring that stability and selectivity studies are carried out with the aim of determining the *battery plant*'s protective functions.

The studies must ensure that the *battery plant* fulfils the requirements specified in section 6, and that the protection does not prevent the *battery plant* from fulfilling the additional requirements of this regulation.

The set relay settings that are important to the operation of the *public electricity supply grid* must be approved by the *transmission system operator* and the *electricity supply undertaking* in whose grid the *battery plant* is connected.

7. Exchange of signals and data communication

To ensure the operation of the *public electricity supply grid*, the *battery plant* must be prepared for signal exchange between the *plant operator* and the *electricity supply undertaking* in the *battery plant's* communication interface in line with this regulation.

7.1 Measurement requirements

Specific requirements for installed measuring equipment and measuring accuracy that must be available in order for a *battery plant* to be connected to the *public electricity supply grid* are specified in the following regulations:

1. Regulation D1 'Settlement metering' [ref. 12]
2. Regulation D2 'Technical requirements for electricity metering' [ref. 13]
3. Technical regulation TR 5.8.1 'Måledata til systemdriftsformål' (Metering data for system operation purposes) [ref. 10].

Compliance with the above regulations must be verified by the meter operator as part of the checks and tests that form the basis for a final approval of the grid connection.

The latest versions of the applicable regulations are available on the *transmission system operator's* website www.energinet.dk.

7.2 Data communication

For a *battery plant*, the information exchange must as a minimum be implemented using a protocol stack as specified in IEC 61850 [ref. 14]. The protocol stack must be configured so that the *battery plant* as a minimum can communicate with two master units (masters) in a master/slave configuration.

Data communication with the *battery plant* must be available to the *electricity supply undertaking* in the *battery plant's* communication interface referred to as *PCOM,* as illustrated in Figure 2 or Figure 3.

Information, measuring signals and activation options specified in this section must be established and must be available to the respective market players as indicated for the individual plant sizes in the following sections.

Activation of individual functions in the battery plants and configuration of specific parameters must fulfil the requirements stated in Technical regulation 5.8.1 [ref. 10].

Specific requirements for the extent of information and signals are specified in the following sections for each *battery plant* category.

7.2.1 Category A1 and A2 battery plants

Capability to establish online communication is not required for *category* A1 and A2 *battery plants.*
A *category* A *battery plant* must be prepared to receive external signals for production 'Stop' and 'Released for start'.

The *battery plant* may start production again when the normal operating conditions specified in section 3.2 have been met, and the 'Released for start' signal has been received.

Signal exchange must be accessible via a terminal strip or in the *PCOM*-interface and must as a minimum include the following signals:

Signal #	**Signal description**
Signal #	Stop signal
Signal #	Holding signal – 'Released for start'

Table 20 Requirements for information exchange with a category A battery plant.

7.2.2 Category B battery plants

Capability to establish online communication is not required for *category* B *battery plants.*

A *category* B *battery plant* must be prepared to receive external signals for production 'Stop' and 'Released for start'.

The *battery plant* may start production again when the normal operating conditions specified in section 3.2.1 have been met, and the 'Released for start' signal has been received.

Signal exchange must be accessible via a terminal strip or in the *PCOM*-interface and must as a minimum include the following signals:

Signal #	**Signal description**
Status	Switch gear status in the *POC*
Measurement	Active power kW – delivered in the POC
Set point	Active power kW – set point for active power
Measurement	Reactive power – import/export in the POC
Status	*Frequency response* – initial frequency for *frequency response* – f_2
Signal #	Stop signal
Signal #	Holding signal – 'Released for start'

Table 21 Requirements for information exchange with a category B battery plant.

7.2.3 Category C and D battery plants

Online communication is required for *category* C and D *battery plants.*

It must be possible to obtain correct measurements and maintain data communication in all situations, including when the plant is shut down and the grid is dead. Local back-up supply must as a minimum ensure the logging of relevant measurements and data and ensure the controlled shutdown of the plant's control and monitoring system. Logging in connection with a shutdown must be performed at minute level.

All measurements and data relevant to recording and analysis must be logged with time stamps and an accuracy that ensures that such measurements and data can be correlated with each other and with similar recordings in the *public electricity supply grid*. Time stamping must refer to *UTC* with a 10 ms resolution and ±1 ms accuracy or better.

Signal exchange must be accessible in the *PCOM*-interface and must as a minimum include the following signals:

Signal type	**Signal description**
Status	Switch gear status in the *POC*
Measurement	Active power delivered in the *POC*
Measurement	Reactive power – import/export in the *POC*
Measurement (calculation)	*Power Factor* – calculated in the *POC*
Measurement	Voltage in the *voltage reference point*
Set point	Active power control – *Frequency response* – LFSM-O – activate/deactivate
Status	Active power control – *Frequency response* – LFSM-O – activated/not activated
Set point	Active power control – *Frequency response* – LFSM-O – setting value – f_2
Status	Active power control – *Frequency response* – LFSM-O – value – f_2
Set point	Active power control – *Frequency response* – LFSM-O – setting value – *droop* f_2 - f_3
Status	Active power control – *Frequency response* – LFSM-O – value – *droop* f_2 – f_3
Set point	Active power control – *Frequency response* – LFSM-U – activate/deactivate
Status	Active power control – *Frequency response* – LFSM-U – activated/not activated
Set point	Active power control – *Frequency response* – LFSM-U – setting value – f_1
Status	Active power control – *Frequency response* – LFSM-U – value – f_1
Set point	Active power control – *Frequency response* – LFSM-U – setting value – *droop* f_1 - f_6
Status	Active power control – *Frequency response* – LFSM-U – value – droop f_1 – f_6
Set point	Active power control – *Frequency control* – activate/deactivate
Status	Active power control – *Frequency control* – activated/not activated
Set point	Active power control – *Frequency control* – setting value – f_0
Status	Active power control – *Frequency control* – value – f_0
Set point	Active power control – *Frequency control* – setting value – f_1
Status	Active power control – *Frequency control* – value – f_1
Set point	Active power control – *Frequency control* – setting value – f_3
Status	Active power control – *Frequency control* – value – f_3
Set point	Active power control – *Frequency control* – setting value – f_4
Status	Active power control – *Frequency control* – value – f_4
Set point	Active power control – *Frequency control* – setting value – f_5
Status	Active power control – *Frequency control* – value – f_5
Set point	Active power control – *Frequency control* – setting value – f_6
Status	Active power control – *Frequency control* – value – f_6
Set point	Active power control – *Power regulator (Absolute power limit)* – activate/deactivate

Status	Active power control – *Power regulator (Absolute power limit)* – activated/not activated
Set point	Active power control – *Power regulator (Absolute power limit)* – desired active power in the *POC*
Status	Active power control – *Power regulator (Absolute power limit)* – desired active power in the *POC*
Set point	Active power control – *Ramp rate limit* – activate/deactivate
Status	Active power control – *Ramp rate limit* – activated/not activated
Set point	Active power control – *Ramp rate limit* – ramp rate for upward/downward adjustment
Status	Active power control – *Ramp rate limit* – ramp rate for upward/downward adjustment
Set point	Active power control – System protection – activate/deactivate
Status	Active power control – System protection – activated/not activated
Set point	Active power control – System protection – set point
Set point	Reactive power control – *Q control* – activate/deactivate
Status	Reactive power control – *Q control* – activated/not activated
Set point	Reactive power control – *Q control* – setting value – desired reactive power in the *POC*
Status	Reactive power control – *Q control* – value – desired reactive power in the *POC*
Set point	Reactive power control – *Power Factor control* – activate/deactivate
Status	Reactive power control – *Power Factor control* – activated/not activated
Set point	Reactive power control – *Power Factor control* – setting value – desired *Power Factor* in the *POC*
Status	Reactive power control – *Power Factor control* – value – desired *Power Factor* in the *POC*
Set point	Reactive power control – *Voltage control* – activate/deactivate
Status	Reactive power control – *Voltage control* – activated/not activated
Status	Reactive power control – *Voltage control* – value – *droop* for *voltage control*
Set point	Reactive power control – *Voltage control* – setting value – desired voltage in the *voltage reference point*
Status	Reactive power control – *Voltage control* – value – desired voltage in the *voltage reference point*
Signal #	Stop signal
Signal #	Released for start

Table 22 Requirements for information exchange with a category C and D battery plant.

7.3 Fault incident recording

The requirements for recording fault incidents in the *public electricity supply grid* for *category* A1, A2, B, C and D *battery plants* are specified below.

The recording 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 case of faults in the *public electricity supply grid*.

In the *Point of Connection*, the *plant owner* must install logging equipment which records, as a minimum:

- Voltage for each phase for the *battery plant*
- Current for each phase for the *battery plant*
- Active power for the *battery plant* (can be computed values)
- Reactive power for the *battery plant* (can be computed values)
- Frequency for the *battery plant* (can be computed values).

Logging must be performed as correlated time series of measuring values from 10 seconds before the incident until 60 seconds after the incident.

Minimum sample frequency for all fault logs must be 1 kHz.

The specific settings for incident-based logging must be agreed with the *transmission system operator* upon commissioning of the *battery plant*.

All measurements and data (metering data) to be collected in accordance with Technical regulation 5.8.1 must be logged with time stamps and a precision and accuracy that ensure that such measurements and data can be correlated with each other and with similar recordings in the *public electricity supply grid*. Time stamping of incidents and data must refer to *UTC* with an accuracy of 10 ms or higher.

Logs must be filed for at least three months from the time of the fault situation. However, the maximum number of incidents to be recorded is 100.

Upon request, the *electricity supply undertaking* must be granted access to logged and relevant recorded information in *COMTRADE* format [ref. 31].

7.3.1 Category A1, A2 and B battery plants

The are no requirements for recording fault incidents in the *public electricity supply grid* for *category* A1, A2 and B *battery plants*.

7.3.2 Category C and D battery plants

The requirements for recording fault incidents in the *public electricity supply grid* apply to *category* C and D *battery plants*.

7.4 Requesting metered data and documentation

The requirements apply to *category* D *battery plants*.

The *electricity supply undertaking* and the *transmission system operator* are entitled to request relevant information about a *battery plant* at any time.

The *transmission system operator* can request metered data and fault recorder data collected for the *battery plant* for a period of up to three months back in time.

Such requests must be based on metered data and/or calculations specified by the *electricity supply undertaking* or the *transmission system operator*.

8. Verification and documentation

The *plant owner* is responsible for ensuring that the *battery plant* complies with this technical regulation and for documenting that the requirements are met.

The *electricity supply undertaking* and the *transmission system operator* are entitled to request, at any time, verification and documentation that a *battery plant* complies with the provisions of this regulation.

The *battery plant* documentation to be provided is specified in the following sections, which have been divided based on the total *rated power* in the *Point of Connection*.

A documentation package must be submitted to the *electricity supply undertaking*.

The standard procedure regarding grid connection, approval and the issue of a final operating permit for a *battery plant* is as follows:

Category A1, A2 and B *battery plants*:

1. The *electricity supply undertaking* assigns the *plant owner* a *POC* and permit for installation as well as issuing a temporary operating permit.

2. Documentation must be submitted electronically to the *electricity supply undertaking*.

3. The *electricity supply undertaking* reviews and approves the documentation and determines whether any plant functionality or documentation is missing. A temporary operating permit is assigned when the preliminary documentation is approved.

4. Once the documentation has been approved, a final operating permit can be issued.

Category C and D *battery plants*:

1. The *electricity supply undertaking* assigns the *plant owner* a *POC* and permit for installation as well as issuing a temporary operating permit. In connection with assigning the POC, the *electricity supply undertaking* informs the *transmission system operator* about the expected grid connection.

2. Documentation must be submitted electronically to the *electricity supply undertaking*.

3. The *electricity supply undertaking* reviews the documentation and determines whether any plant functionality or documentation is missing.

4. The *electricity supply undertaking* sends the documentation electronically to the *transmission system operator*.

5. The *transmission system operator* reviews and approves the documentation for the *battery plant*.

6. *The transmission system operator* issues a written approval of the documentation package for the *battery plant*.

7. Once the documentation has been approved, a final operating permit can be issued.

8.1 Documentation requirements

Required documentation to be submitted for the different *plant categories* is stated in the table below.

Category / Documentation	A1	A2	B	C	D
Supplier statement	X	X	X	X	X
Protective functions	X	X	X	X	X
Single-line representation	X	X	X	X	X
Power quality	X	X	X	X	X
Voltage dip			-	X	X
PQ diagram			-	X	X
Signal list			-	X	X
Dynamic simulation model			-	X	X
Verification report			-	X	X

X: Documentation must be provided as described in this section.

Table 23 Documentation requirements for plant categories.

8.1.1 Supplier statement

By signing a supplier statement, the supplier guarantees that the specific plant complies with all requirements specified in Technical Regulation 3.3.1.

8.1.2 Protective functions

Documentation of protective functions is a list of the relay configurations applicable at the time of verification. These values must be stated in the documentation.

8.1.3 Single-line representation

A single-line representation is a drawing showing the main components of the *battery plant* and their electrical interconnections. As a minimum, the location of protective functions and metering points must be indicated in the diagram.

8.1.4 Power quality

Power quality is a collection of parameters characterising the quality of the power delivered. The verification report must document how the requirements in section 4 have been met.

8.1.5 Voltage dip

Voltage dip is the *battery plant's* ability to stay connected to the electricity system during a voltage dip. The *battery plant's* ability to stay connected to the grid must be documented using the electrical simulation model provided. Alternatively, type test data must be supplied to demonstrate that the requirements have been met. Model simulations must show that the requirements in section 3.3.1 have been met.

8.1.6 PQ diagram

A PQ diagram is a figure illustrating the *battery plant's* properties and ability to deliver reactive power as a function of the *battery plant's* ability to deliver active power. Measurements must show that the requirements in section 5.3 have been met. Alternatively, type test data must be supplied to demonstrate that the requirements have been met.

8.1.7 Signal list

The signal list is a list of the signals/information that needs to be exchanged between the market players that control and monitor a *plant*. Documentation proving that the signals specified in section 7.2 are present in the *PCOM* interface must be supplied as part of the verification report.

8.1.8 Dynamic simulation model

A dynamic simulation model is a model of a *battery plant's* electrical properties and limits. The electrical simulation model must comply with the requirements specified in section 9.

8.1.9 Verification report

A verification report is a report on completed tests, demonstrating that the required functions have been implemented and work as intended with the configured parameters.

8.1.10 Category A1 and A2 battery plants

The *battery plant* may be included on the *positive list*.

The documentation requirements for *category* A1 and A2 *battery plants* are divided into the following subsections.

8.1.10.1 Documentation for battery plants included on the positive list

If the *battery plant* or plant components are included on the *positive list*, the following documentation must be submitted to *the electricity supply undertaking* for approval:

- From Appendix B1.1, appendices duly completed: B1.1.1. , B1.1.2. , B1.1.5.1. B1.1.5.2. B1.1.5.4. B1.1.5.5. B1.1.5.7. B1.1.5.8. B1.1.5.10. B1.1.5.13. B1.1.6.1. B1.1.7.1.

8.1.10.2 Documentation for battery plants not included on the positive list

If the *battery plant* or plant components are not included on the *positive list*, the following documentation must be submitted to the *electricity supply undertaking* for approval no later than three months before the date of commissioning:

- Appendix 1 (B1.1), duly completed and supplemented with the following documents:

    1. CE declaration of conformity
    2. Technical documentation proving the answers given in Appendix 1

8.1.10.3 Procedure for inclusion of plants and plant components on the positive list

To request that a *battery plant* or plant components be included on the *positive list*, the documentation required under section 8.1.10.2 must be submitted to positivlister@danskenergi.dk.

The process for inclusion on the *positive list* is explained on the Danish Energy Association's website: www.danskenergi.dk/positivlister.

8.1.11 Category B battery plants

The documentation form must be filled in with preliminary data for the *battery plant* and sent to the *electricity supply undertaking* no later than three months before the date of commissioning. The required documentation appears from Table 23.

8.1.12 Category C battery plants

The documentation form must be filled in with preliminary data for the *battery plant* and sent to the *electricity supply undertaking* no later than:

- twelve months **before** the date of commissioning for *rated power* ≥ 10 MW
- three months **before** the date of commissioning for *rated power* < 10 MW

From the design phase to the verification phase, the *plant owner* must inform the *transmission system operator* if the preliminary plant data can no longer be regarded as representative of the final commissioned *battery plant*.

No later than three months **after** the date of commissioning, documentation must be provided in the form of specific data for the entire *battery plant,* which must be sent to the *electricity supply undertaking*. The required documentation appears from Table 23.

8.1.13 Category D battery plants

The documentation form must be filled in with preliminary data for the *battery plant* and sent to the *electricity supply undertaking* no later than twelve months **before** the date of commissioning.

From the design phase to the verification phase, the *plant owner* must inform the *transmission system operator* if the preliminary plant data can no longer be regarded as representative of the final commissioned *battery plant*.

No later than three months **after** the date of commissioning, documentation must be provided in the form of specific data for the entire *battery plant,* which must be sent to the *electricity supply undertaking*. The required documentation appears from Table 23.

9. Simulation model

For the purpose of analysing the *public electricity supply grid*, the *transmission system operator* must maintain and expand the simulation models continuously as new *battery plants* are connected to the grid.

The simulation models are used to analyse the static and dynamic properties of the transmission and distribution grids, including stability.

From the design phase to the verification phase, the *plant owner* must inform the *transmission system operator* if the preliminary data can no longer be regarded as representative of the final commissioned plant.

The *plant owner* must provide the *transmission system operator* with the simulation models specified. In pursuance of Section 84 a of the Danish Electricity Supply Act, the *transmission system operator* is bound by a duty of confidentiality where commercially sensitive information is concerned.

Simulation models may be sent directly from the manufacturer of the *battery plant* to the *transmission system operator*.

The *plant owner* is responsible for ensuring that the correct set of data is submitted at the right time.

9.1 Simulation model requirements

The simulation model for the entire *battery plant* must describe the plant's fixed and dynamic electrical properties, as seen from the *public electricity supply grid*.

The simulation model must:

- Be supported by model descriptions which contain, as a minimum, Laplace domain transfer functions, function descriptions of the model's main modules and detailed descriptions of the various model components and associated model parameters, including set-up and initialisation of the simulation model and any limitations on its application.

- Contain all control functions required in section 5, models for voltage regulators etc.

- Include all protective functions that can be activated during all relevant incidents and faults in the *public electricity supply grid* as required in section 6.

- Allow simulation of root-mean-square (RMS) values in the synchronous system (positive sequence).

- Allow simulation of root-mean-square (RMS) values in the individual phases during asymmetrical incidents and faults in the *public electricity supply grid*.

- As a minimum, cover the 47.00-52.00 Hz frequency range and the 0.0-1.4 pu voltage range.

- Be able to describe the dynamic response from *a* plant for at least 30 seconds after incidents or faults in the *public electricity supply grid*.

- Be numerically stable and capable of utilising numerical equation solvers with variable sample lengths.

- Not use sample lengths less than 1 ms.

9.2 Verification of simulation model

The simulation model for the entire *battery plant,* including all control methods, must be verified by the *plant owner*, as required in section 5.

The *plant owner* is responsible for performing all verification tests and is also responsible for measuring equipment, data loggers and staff.

No later than three months before the final commissioning of the *battery plant*, the practical performance of verification tests must be determined on the basis of the *plant owner's* proposal and in collaboration with the *transmission system operator*.

Measurements used to verify the simulation model for the entire *battery plant* must be documented by the *plant owner* in a report containing detailed descriptions of each test. Measurement results must be compared with the corresponding simulated results and documented in a verification report.

The time series measurements used to verify the simulation model must be enclosed with the verification report in IEEE *COMTRADE* format.

The time resolution for the measuring signals used must be 1 ms or higher.

9.2.1.1 Category A1, A2 and B plants:

No simulation model is required for *category* A1, A2 and B *battery plants*.

9.2.1.2 Category C and D plants:

A dynamic simulation model for the entire *category* C and D *battery plant* must be submitted to the *transmission system operator*. Category C *battery plants* with a rated power of less than 10 MW are excluded.

The *plant owner* must submit a simulation model for the *battery plants* used, including the *plant controller*, if any, no later than three months after commissioning.

The content and level of detail of the simulation models for the *plant controller* and the individual *battery plant* must be such that they can be readily integrated and subsequently appear as a single fully functional simulation model as required in section 9.1.

The simulation model must be verified as specified in section 9.2.

The *plant owner* must supply data for the *plant infrastructure* upon request.

Appendix 1 Documentation

Appendix 1 specifies the documentation requirements for the five *plant categories*, see section 1.2.4:

A1. *Battery plants* up to and including 11 kW
A2. *Battery plants* above 11 kW up to and including 50 kW
B. *Battery plants* above 50 kW up to and including 1.5 MW
C. *Battery plants* above 1.5 MW up to and including 25 MW
D. *Battery plants* above 25 MW or connected to over 100 kV.

The documentation, as specified in section 8, must be submitted electronically to the *electricity supply undertaking*.

The technical documentation must include the configuration parameters and configuration data applicable to the *battery plant* at the time of commissioning.

All subsections in the appendix must be filled in for the *battery plant* in question.

If information changes after the time of commissioning, updated documentation must be submitted as required in section 2.2.

A template for Appendix 1 for the various *plant categories* is available on Energinet.dk's website www.energinet.dk.

B1.1. Appendix 1 for battery plants

The documentation form must be filled in with data for the *battery plant*, valid at the time of commissioning, and submitted to the *electricity supply undertaking.*

B1.1.1. Identification

(Applicable to category A1, A2, B, C and D battery plants)

Plant	Description of the plant:
GSRN number	
Plant owner name and address:	
Plant owner tel. no.:	
Plant owner email:	
Inverter – make:	
Inverter – model:	
Inverter – rated power:	
Storage medium – make:	
Storage medium – model no.:	
Storage medium - energy storage capacity at rated inverter power in *POC*: [kW/h]	
Energy storage – runtime at rated inverter power in the *POC*: [kW/h]	

B1.1.2. Tolerance of frequency and voltage deviations
(Applicable to category A1, A2, B, C and D battery plants)

The *battery plant* is designed for single-phase connection when neither P_{no} nor P_{nl} exceeds 3.6 kW.	Yes ☐ No ☐
The *battery plant* is designed for three-phase connection if neither P_{no} nor P_{nl} exceeds 3.6 kW.	Yes ☐ No ☐
The *electricity supply undertaking* has determined the voltage level in the *Point of Connection* within the required limits as specified in table 3.1, section 3.1.	Yes ☐ No ☐
Within the *normal operating* range, the *typical operating voltage* is U_c±10%, see section 47,00, and the frequency range is 52.00 to 52.00 Hz. The *battery plant* can be started and operated continuously within this area, restricted by the protective settings.	Yes ☐ No ☐
The plant can withstand transitory (80-100 ms) phase jumps of up to 20° in the *Point of Connection*.	Yes ☐ No ☐
The plant can withstand transient frequency gradients of up to ±2.5 Hz/s in the *Point of Connection*.	Yes ☐ No ☐
After a voltage dip, the plant is able to return to normal operation no later than 5 seconds after the operating conditions have returned to the *normal operating range*.	Yes ☐ No ☐

B1.1.3. Voltage dip tolerances
(Applicable to category C and D battery plants)

Will the *battery plant* remain connected to the public electricity supply grid during voltage dips as specified in section 3.3.1, Figure 5?	Yes ☐ No ☐
Does the *battery plant* deliver additional reactive current during voltage dips as specified in section 3.3.1, Figure 6?	Yes ☐ No ☐
Will the *battery plant* remain connected to the public electricity supply grid during recurring faults as specified in section 3.3.2?	Yes ☐ No ☐
Is a simulation enclosed, documenting that the Low Voltage Fault Ride Through (LVFRT) requirements have been met? If No, how is compliance then documented?	Yes ☐ No ☐

B1.1.4. Power quality

Category / Requirements	**A1**	**A2**	**B**	**C**	**D**
DC content (4.2)	X	X	X	X	X
Asymmetry (4.3)	X	X	X	X	X
Flicker (4.4)	X	X	X	X	X
Harmonic distortions (4.5)	X	X	X	X	X
Interharmonic distortions (4.6)			X	X	X
Distortions 2-9 kHz (4.7)			X	X	X

Overview of power quality requirements for plant categories

B1.1.4.1. Voltage quality

For each power quality parameter must be indicated how the result was achieved, either by means of the type test for each of the units of which the *battery plant* is composed, or by means of an emission model developed for the system.

Have the values been calculated/simulated?	Yes ☐ No ☐
Have the values been measured?	Yes ☐ No ☐
Is a report enclosed, documenting that the calculations or measurements comply with emission requirements? If No, how are calculations or measurements then documented?	Yes ☐ No ☐
Has the *electricity supply undertaking* set emission limits in the *Point of Connection*? **(Applicable to category C and D *battery plants* for all power quality parameters)** The requirements for category A1 and A2 *battery plants* are specified in the criteria for inclusion on the *positive list* – for all power quality parameters. The requirements for category B *battery plants* can be found in the regulation.	Yes ☐ No ☐

B1.1.4.2. DC content

Does the DC content at normal operation exceed 0.5% of the *rated current*?	Yes ☐ No ☐

B1.1.4.3. Asymmetry

Does asymmetry at normal operation and during faults exceed 16 A?	Yes ☐ No ☐
If the *battery plant* consists of single-phase electricity-generating units, is it ensured that the above limit is not exceeded?	Yes ☐ No ☐

B1.1.4.4. Flicker

Is the *flicker* contribution for the *battery* plant below the limit value? (See requirements for *category* B *battery plants* in Table 5 in the regulation.)	Yes ☐ No ☐

B1.1.4.5. Harmonic distortions

Are all *harmonic distortions* for the *battery* plant below the limit values? (See requirements for *category* B *battery plants* in Table 6 and Table 7 in the regulation.) (See requirements for *category* C and D *battery plants* in Table 8 in the regulation.)	Yes ☐ No ☐

B1.1.4.6. Interharmonic distortions

Are all *interharmonic distortions* for the *battery plant* below the limit values? (See requirements for *category* B *battery plants* in Table 10 in the regulation.)	Yes ☐ No ☐

B1.1.4.7. Distortions in the 2-9 kHz frequency range

Has the requirement for emission of distortions with frequencies in the 2-9 kHz range been met? (Requirements for *category* B *battery plants*: The emission of currents with frequencies higher than 2 kHz must not exceed 0.2% of the *rated current* in any of the frequency groups measured.)	Yes ☐ No ☐

B1.1.5. Control

Control function	A1	A2	B	C	D
Frequency response – LFSM-O (5.2.1.3)	X	X	X	X	X
Frequency response – LFSM-U (5.2.1.5)	-	-	-	X	X
Frequency control	-	-	-	X	X
Absolute power limit (5.2.3.1)	X	X	X	X	X
Ramp rate limit (5.2.3.2)	X	X	X	X	X
Q control (5.3.1) *)	X	X	X	X	X
Power Factor control (5.3.2) *)	X	X	X	X	X
Automatic Power Factor control (5.3.4) *)	X	X	-	-	-
Voltage control (5.3.3) *)	-	-	-	X	X
System protection (5.4)	-	-	-	(X)	(X)

Control functions for a battery.

All control functions mentioned in the following sections refer to the *Point of Connection.*

In order to ensure security of supply, the *transmission system operator* must be able to activate or deactivate the specified control functions by agreement with the *plant owner.*

Control functions must be for single units or for a plant controller.

Before commissioning, current parameter settings for reactive power and voltage control functions must be determined by the *electricity supply undertaking* in collaboration with the *transmission system operator*.

B1.1.5.1. Connection and synchronisation

(Applicable to category A1, A2, B, C and D battery plants)

Can the *battery plant* be started and operate continuously within the normal range restricted only by the protective settings?	Yes ☐ No ☐
Do connection and synchronisation occur more than 3 minutes after voltage and frequency have come within the normal production range?	Yes ☐ No ☐

B1.1.5.2. Control of active power and frequency
(Applicable to category A1, A2, B, C and D battery plants)

Is the *battery plant* equipped with a *frequency response* function? Regulation must be commenced no later than 2 seconds after a frequency change is detected and must be completed within 15 seconds. It must be possible to set the *frequency response* function's frequency points (response frequencies are indicated in Table 11 and Table 12 in the regulation), indicated in Figure 9 and Figure 10 in the regulation, to any value in the 10.00-52.00 Hz range with a resolution of maximum 10 mHz. For *category* C and D *plants*, *frequency response* functionality is required for underfrequency, LFSM-U. This is required for all *battery plants* in case of overfrequency, LFSM-O.	Yes ☐ No ☐

B1.1.5.3. Frequency control
(Applicable to category C and D battery plants)

Is the *battery plant* equipped with a *frequency control* function as specified in section 5.2.2?	Yes ☐ No ☐

B1.1.5.4. Absolute power limit
(Applicable to category A1, A2, B, C and D battery plants)

Is the *battery plant* equipped with an *absolute power limit* function?	Yes ☐ No ☐
Is the function activated?	Yes ☐ No ☐

B1.1.5.5. Ramp rate limiter function
(Applicable to category A1, A2, B, C and D battery plants)

Is the *battery plant* equipped with a *ramp rate limiter* function?	Yes ☐ No ☐
Is the function activated?	Yes ☐ No ☐

B1.1.5.6. Reactive power control

Reactive power can be controlled by means of:	*Q control* ☐ *Power Factor control* ☐ *Voltage control* ☐

B1.1.5.7. Q control
(Applicable to category A1, A2, B, C and D battery plants)

Is the *battery plant* equipped with a *Q control function* as specified in section 5.3.1?	Yes ☐ No ☐
Is the control function activated with a set point of ______ VAr? (Value may not differ from 0 VAr unless agreed with the *electricity supply undertaking*).	Yes ☐ No ☐

B1.1.5.8. Power Factor control
(Applicable to category A1, A2, B, C and D battery plants)

Is the *battery plant* equipped with a *Power Factor control* function as specified in section 5.3.2?	Yes ☐ No ☐

B1.1.5.9. Voltage control
(Applicable to category C and D battery plants)

Is the *battery plant* equipped with a *voltage control* function as specified in section 5.3.3?	Yes ☐ No ☐

B1.1.5.10. Automatic Power Factor control
(Applicable to category A1 and A2 battery plants)

Is the *battery plant* equipped with an automatic *Power Factor control* function as specified in section 5.3.4?	Yes ☐ No ☐
As a starting point, the function must be deactivated and must be activated only by agreement with the *electricity supply undertaking*. Is the function deactivated?	Yes ☐ No ☐

B1.1.5.11. Order of priority for control functions

Has the order of priority for the *battery plant*'s control functions been set as specified in section 5.5?	Yes ☐ No ☐

B1.1.5.12. System protection
(Applicable to category C and D battery plants)

Is the *battery plant* equipped with a *system protection function* as specified in section 5.4?	Yes ☐ No ☐
Is the function activated?	Yes ☐ No ☐

B1.1.5.13. Power Factor interval

Control method and settings must be agreed with the *electricity supply undertaking* for *category* C and D *battery plants*.

Applicable to *category* A1 and A2 *battery plants* Does the *battery plant* lie within the *Power Factor* interval specified in section 5.3.5.1?	Yes ☐ No ☐
Applicable to *category* C battery plants Does the *battery plant* lie within the *Power Factor* interval specified in section 5.3.5.2, Figure 17? Can the *battery plant* deliver reactive power in the voltage range as specified in section 5.3.5.2, Figure 18?	Yes ☐ No ☐ Yes ☐ No ☐
Applicable to *category* D *battery plants* Does the *battery plant* lie within the *Power Factor* interval specified in section 5.3.5.3, Figure 19? Can the *battery plant* deliver reactive power in the voltage range as specified in section 5.3.5.3, Figure 20?	Yes ☐ No ☐ Yes ☐ No ☐

B1.1.6. Protection against electricity system faults

All settings are stated as root-mean-square (RMS) values, and settings deviating from these may be used only with the permission of the *electricity supply undertaking*.

Voltage and frequency must be measured for all three phases as line-to-line voltage.

Alternatively, if the measuring point is located on the low-voltage side of the plant transformer, voltage can be measured between the three phases and ground.

Frequency must be measured simultaneously on all three phases.

B1.1.6.1. Protective functions

Applicable to *category* A1 and A2 *battery plants* Are the protective functions with associated operating settings and trip time for the *battery plant* in accordance with the specifications in section 6.3.1, Figure 17?	Yes ☐ No ☐
Applicable to *category* B *battery plants* Are the protective functions with associated operating settings and trip time for the *battery plant* in accordance with the specifications in section 6.3.2, Figure 18?	Yes ☐ No ☐
Applicable to *category* C *battery plants* Are the protective functions with associated operating settings and trip time for the *battery plant* in accordance with the specifications in section 6.3.3, Figure 19?	Yes ☐ No ☐
Applicable to *category* D *battery plants* Are the protective functions with associated operating settings and trip time for the *battery plant* in accordance with the specifications in section 6.3.4?	Yes ☐ No ☐

B1.1.7. Exchange of signals and data communication

Activation of the individual functions in the plants and configuration of the specific parameters must fulfil the requirements stated in Technical Regulation 5.8.1 [ref. 10].

B1.1.7.1. Signal description

Applicable to *category* A1 and A2 *battery plants* Has the requirement for information exchange with the *battery plant* been met as specified in section 7.2.1, Table 20?	Yes ☐ No ☐
Applicable to *category* B *battery plants* Has the requirement for information exchange with the *battery plant* been met as specified in section 7.2.2, Table 21?	Yes ☐ No ☐
Applicable to *category* C *battery plants* Has the requirement for information exchange with the *battery plant* been met as specified in section 7.2.3, Table 22?	Yes ☐ No ☐
Applicable to *category* D *battery plants* Has the requirement for information exchange with the *battery plant* been met as specified in section 7.2.3, Table 22?	Yes ☐ No ☐

B1.1.7.2. Fault incident recording and requesting of metered data and documentation

(Applicable to category D battery plants)

The specific settings for incident-based logging must be agreed with the *transmission system operator* upon commissioning of the *battery plant*.

Has logging equipment which records voltage for each phase for the *battery plant* been installed in the *Point of Connection*?	Yes ☐ No ☐
Has logging equipment which records current for each phase for the *battery plant* been installed in the *Point of Connection*?	Yes ☐ No ☐
Has logging equipment which records active power for the *battery plant* (can be computed values) been installed in the *Point of Connection*?	Yes ☐ No ☐
Has logging equipment which records reactive power for the *battery plant* (can be computed values) been installed in the *Point of Connection*?	Yes ☐ No ☐
Has logging equipment which records frequency for the *battery plant* (can be computed values) been installed in the *Point of Connection*?	Yes ☐ No ☐
The *transmission system operator* can request metered data and fault recorder data collected for the *battery plant* for a period of up to three months back in time.	Yes ☐ No ☐

B1.1.8. Verification and documentation

The *plant owner* is responsible for ensuring that the *battery plant* complies with this technical regulation and for documenting that requirements are met. A documentation package must be submitted to the *electricity supply undertaking*.

Documentation	**A1**	**A2**	**B**	**C**	**D**
Supplier statement	X	X	X	X	X
Protective functions	X	X	X	X	X
Single-line representation	X	X	X	X	X
Power quality	X	X	X	X	X
Voltage dip	-		-	X	X
PQ diagram	-		-	X	X
Signal list	-		-	X	X
Dynamic simulation model	-		-	X	X
Verification report	-		-	X	X

Documentation requirements for plant categories

B1.1.8.1. Supplier statement

(Applicable to category A1, A2, B, C and D battery plants)

Is a supplier statement regarding the *battery plant* enclosed with the documentation?	Yes ☐ No ☐

B1.1.8.2. Protective functions

(Applicable to category A1, A2, B, C and D battery plants)

Is documentation of protective functions for the *battery plant* enclosed? This means a list of values for the relay configurations applicable at the time of verification.	Yes ☐ No ☐

B1.1.8.3. Single-line representation

(Applicable to category A1, A2, B, C and D battery plants)

Is a single-line representation for the *battery plant* enclosed with the documentation? If No, when will the final single-line representation be provided?	Yes ☐ No ☐

B1.1.8.4. PQ diagram

(Applicable to category C and D battery plants)

Has the final PQ diagram been submitted to the *electricity supply undertaking*? If No, when will the final PQ diagram be provided?	Yes ☐ No ☐

B1.1.8.5. Signal list

(Applicable to category C and D battery plants)

Has the final signal list been submitted to the *electricity supply undertaking*? If No, when will the final signal list be provided?	Yes ☐ No ☐

B1.1.8.6. Simulation model

(Applicable to category C and D battery plants)

Has the electrical simulation model for the *battery plant* been submitted to the *electricity supply undertaking*? If No, when will the final simulation model be provided?	Yes ☐ No ☐

B1.1.8.7. Verification report

(Applicable to category C and D battery plants)

Has the verification report been submitted to the *electricity supply undertaking*? If No, when will the verification report be provided?	Yes ☐ No ☐

B1.1.9. Signature

Date of commissioning	
Company	
Person responsible for commissioning	
Signature	