Technical regulation 3.2.5
for wind power plants above 11 kW

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**Revision view**

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**Reading instructions**

This regulation contains the technical and functional minimum requirements which *wind power plants* with a *rated power* above 11 kW 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 up to and including section 7 contain the technical and functional minimum requirements for *wind power plants* in Denmark. Section 8 contains the documentation requirements, and section 9 contains the requirements for the electrical simulation model for the different *wind power plant categories*.

The technical requirements of the regulation are divided into four *plant categories* as described in sections 1.2.21 and 2.2.

The regulation makes extensive use of terminology and definitions. The most important terminology and definitions are found in section 1. In this regulation, terminology and definitions are written in *italics*.

The regulation is also published in English. In case of doubt, the Danish version applies.

The *transmission system operator publishes the* regulation and it is available on the website [www.energinet.dk](http://www.energinet.dk).
1. Terminology, abbreviations and definitions

1.1 Abbreviations
This section contains the abbreviations used in the document.

1.1.1 \( c_f \)
The flicker coefficient must be indicated by \( c_f \).

1.1.2 \( \Psi_k \)
\( \Psi_k \) is used as an abbreviation for the short circuit angle in the Point of Connection. Flicker values are calculated for each electricity-generating unit using the \( \Psi_k \) parameter.

1.1.3 \( d(\%) \)
\( d(\%) \) denotes rapid voltage changes in \% of \( U_n \). See section 1.2.38 for a more detailed description.

1.1.4 \( df/dt \)
\( df/dt \) denotes the frequency change as a function of time. See section 1.2.6 for a more detailed description.

1.1.5 \( f_c \)
\( f_c \) denotes the operational setting for underfrequency in the relay protection. See section 6 for a more detailed description.

1.1.6 \( f_o \)
\( f_o \) denotes the operational setting for overfrequency in the relay protection. See section 6 for a more detailed description.

1.1.7 \( f_R \)
\( f_R \) denotes the frequency at which a wind power plant is to begin downward regulation with the agreed droop. See section 5.2.1 for a more detailed description.

1.1.8 \( f_x \)
\( f_x \), where \( x \) may be 1 to 7 or minimum and maximum, are points used for frequency control and described in more detail in section 5.2.2.

1.1.9 \( G_{lt} \)
\( G_{lt} \) denotes the planning value of the flicker emission from a plant.

1.1.10 \( I_h \)
\( I_h \) denotes the sum of the individual harmonic currents.

1.1.11 \( I_k \)
\( I_k \) denotes the short circuit current. See section 1.2.44 for more detail.

1.1.12 \( I_n \)
The rated current \( I_n \) is the maximum continuous current that a wind power plant or a wind turbine is designed to deliver. See section 1.2.39 for a more detailed description.
1.1.13 \( I_Q \)
The reactive current delivered or absorbed by a plant is referred to as \( I_Q \).

1.1.14 \( k_U \)
The voltage change factor is denoted by \( k_U \). The voltage change factor is calculated as a function of \( \Psi_k \).

1.1.15 \( P_{\text{current}} \)
\( P_{\text{current}} \) denotes the current level of active power.

1.1.16 \( P_{\delta} \)
\( P_{\delta} \) denotes a rolling reserve. See section 5.2.2 for a more detailed description.

1.1.17 \( P_l \)
\( P_l \) denotes the long-term flicker emission from a plant. \( P_l \) stands for 'long-term' and is assessed over a period of two hours. See IEC 61000-3-7 [ref. 32] for a more detailed definition.

1.1.18 \( P_N \)
\( P_N \) indicates the active power which can be generated under the given circumstances.

1.1.19 \( P_{\min} \)
\( P_{\min} \) denotes the lower limit for active power control.

1.1.20 \( P_n \)
\( P_n \) denotes the rated power of a plant. See section 1.2.41 for a more detailed description.

1.1.21 \( P_{st} \)
\( P_{st} \) 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. 32] for a more detailed definition.

1.1.22 \( P_{\text{available}} \)
\( P_{\text{available}} \) denotes the available active power.

1.1.23 \( \text{PCC} \)
This is the Point of Common Coupling (PCC). See section 1.2.26 for a more detailed description.

1.1.24 \( \text{PCI} \)
Point of Connection in Installation (PCI). PCI is the point in the installation where the plant is connected and where consumption is connected. See section 1.2.29 for a more detailed definition.

1.1.25 \( \text{PCOM} \)
Point of Communication (PCOM). See section 1.2.27 for a more detailed definition.

1.1.26 \( \text{PF} \)
Power Factor (PF). See section 1.2.32 for a more detailed description.
1.1.27 PGC
Point of Generator Connection (PGC). PGC is the point which the supplier of a wind turbine or a wind power plant defines as the terminals of a wind turbine or wind power plant. See section 1.2.30 for a more detailed description.

1.1.28 POC
Point of Connection (POC). See section 1.2.28 for a more detailed definition.

1.1.29 PWHD
This is Partial Weighted Harmonic Distortion. See section 1.2.19 for a more detailed description.

1.1.30 $Q_{\text{max}}$
$Q_{\text{max}}$ denotes the maximum level of reactive power at a Power Factor of 0.95 lagging that a plant can deliver.

1.1.31 $Q_{\text{min}}$
$Q_{\text{min}}$ denotes the minimum level of reactive power at a Power Factor of 0.95 leading that a plant can absorb.

1.1.32 $Q_n$
$Q_n$ denotes the reactive rated power of a wind turbine or a wind power plant.

1.1.33 $S_i$
$S_i$ denotes the apparent power of an electricity-generating unit no. i. See section 1.2.42 for a more detailed description.

1.1.34 $S_k$
$S_k$ denotes the short circuit power. See section 1.2.45 for a more detailed description.

1.1.35 $S_{\text{last}}$
$S_{\text{last}}$ denotes the apparent power for the total radial load.

1.1.36 $S_n$
$S_n$ denotes the nominal apparent power of a plant.

1.1.37 $S_{\text{out}}$
$S_{\text{out}}$ denotes the apparent power for the total radial output.

1.1.38 SCR
Short Circuit Ratio (SCR) is the abbreviation used for the short circuit ratio of the Point of Connection.

1.1.39 THD
The abbreviation used for Total Harmonic Distortion. See section 1.2.47 for a more detailed description.

1.1.40 $U_c$
$U_c$ denotes the normal operating voltage. See section 1.2.17 for a more detailed description.
1.1.41 $U_h$
$U_h$ denotes the sum of the harmonic voltages.

1.1.42 $U_{\text{max}}$
$U_{\text{max}}$ denotes the maximum value of the nominal voltage $U_n$ that an electricity-generating unit may be exposed to.

1.1.43 $U_{\text{min}}$
$U_{\text{min}}$ denotes the minimum value of the nominal voltage $U_n$ that an electricity-generating unit may be exposed to.

1.1.44 $U_n$
$U_n$ denotes the nominal voltage. This voltage is measured phase to phase. See section 1.2.16 for a more detailed description.

1.1.45 $U_{\text{PGC}}$
$U_{\text{PGC}}$ denotes the voltage measured on the wind turbine's terminals. See section 1.2.30 for a more detailed description.

1.1.46 $U_{\text{POC}}$
$U_{\text{POC}}$ denotes the normal operating voltage in the POC. See section 1.2.28 for a more detailed description.

1.1.47 $U_x$
$U_x$ 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 a more detailed description.

1.1.48 UTC
UTC is an abbreviation of Coordinated Universal Time (Universal Time, Coordinated).

1.1.49 $v_a$
This is average annual velocity and denoted by $v_a$. 
1.2 Definitions

This section contains the definitions used in the document. Several of the definitions are derived from IEC 60050-415:1999 [ref. 27], but have been modified as needed in this regulation.

1.2.1 Absolute power constraint

Adjustment of active power to a maximum level is indicated by a set point. The set point adjustment's +/- tolerance is referred to as the absolute power constraint. See section 5.2.3.1 for a more detailed description.

1.2.2 Balance-responsible party for production

A balance-responsible party for production is financially accountable to the transmission system operator.

The balance-responsible party for production holds the balance responsibility for a given plant vis-à-vis the transmission system operator.

1.2.3 COMTRADE

COMTRADE (Common Format for Transient Data) is a standardised file format specified in IEEE C37.111-2013 [ref. 43]. The format is designed for exchange of information about transient phenomena 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.

1.2.4 Cut-out wind speed

The cut-out wind speed is the maximum wind speed at hub height at which a wind turbine is designed to generate power, see IEC 60050-415-03-06 [ref. 27].

1.2.5 Delta power constraint

The control of active power with a set point-defined deviation (delta) between potential and actual power is called delta power constraint. See section 5.2.3.2 for a more detailed description.

1.2.6 df/dt

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

Note 1:
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 when the mean value is calculated. Frequency measurements must be carried out continuously, so that a new value is calculated for every 20 ms. $df/dt$ must be calculated as the difference between the frequency calculation just carried out and the frequency calculation carried out 80-100 ms ago.
Note 2: The $df/dt$ function is used in decentralised generation facilities to detect situations of island operation where island operation occurs without any prior voltage dip.

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

1.2.8 Electricity supply undertaking
The electricity supply undertaking is the enterprise to whose grid a plant is electrically connected. Responsibilities in the public electricity supply grid are distributed onto 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.

1.2.9 Electricity-generating unit
An electricity-generating unit is a unit which generates electricity, and which is directly or indirectly connected to the public electricity supply grid. In a wind power context, the term wind turbine is often used for an electricity-generating unit. Wind turbine is defined in more detail in section 1.2.54.

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

Flicker is measured as described in IEC 61000-4-15 [ref. 11].

1.2.11 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.

1.2.12 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.

1.2.13 Generator convention
The sign for active/reactive power indicates the power flow 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.
The voltage level at the interconnected electricity supply system. The internationally standardised voltage levels are shown in Table 1.

1.2.14 Harmonic distortions
Harmonic distortions are defined as electrical disturbances 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.

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

1.2.16 Nominal voltage ($U_n$)
The voltage level at the POC for which a grid is defined and to which operational characteristics refer. Voltage is measured phase to phase. Nominal voltage is denoted by $U_n$.

The internationally standardised voltage levels are shown in Table 1.

1.2.17 Normal operating voltage ($U_r$)
Normal operating voltage indicates the voltage range within which an electricity-generating unit must be able to continuously generate the specified rated power, see sections 3.1 and 3.2. Normal operating voltage is denoted by $U_r$. Normal operating voltage is determined by the electricity supply undertaking and is used to determine the normal production range.

1.2.18 Normal production
Normal production indicates the voltage/frequency range within which a wind power plant must be able to continuously generate the specified rated power, see sections 3.1 and 3.2.
### 1.2.19 Partial Weighted Harmonic Distortion (PWHD)

The partial weighted harmonic distortions 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 ($h$: 14th-40th 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:

$$ PWHD = \sqrt[2]{\sum_{h=14}^{40} h \left( \frac{X_h}{X_1} \right)^2} $$

See IEC 61000-3-12 [ref. 34] 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.

### 1.2.20 Plant

A *plant* is one or more *electricity-generating units*, which are defined in more detail in section 1.2.9. For wind power, the term *wind power plant*, defined in more detail in section 1.2.52, is often used for a *plant*.

### 1.2.21 Plant categories

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

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

### 1.2.22 Plant component

A *plant component* is a component or subsystem which is part of an overall *plant*.

### 1.2.23 Plant infrastructure

*Plant infrastructure* is the electrical infrastructure between the Point of Generator (PGC) of the individual *electricity-generating units* (*wind turbines*) in a *plant* (*wind power plant*) and up to the Point of Connection (POC).

### 1.2.24 Plant operator

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

### 1.2.25 Plant owner

The *plant owner* is the entity that legally owns the *wind power plant*. In certain situations, the term *company* is used instead of *plant owner*. The *plant owner* can hand over the operational responsibility to a *wind turbine operator*. 
1.2.26 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 located the farthest into the public electricity supply grid, i.e. the farthest away from the plant, see Figure 2 and Figure 3.

The electricity supply undertaking determines the point of common coupling.

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

1.2.28 Point of Connection (POC)
The Point of Connection (POC) is the point in the public electricity supply grid where the wind power 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 small wind turbines, 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 example below, the Point of Common Coupling (PCC) and the Point of Connection (POC) coincide.
Figure 2 Example of installation connection of a small wind turbine.

Figure 3 shows a typical grid connection of several wind power plants, indicating where the Point of Generator Connection (PGC), Point of Connection (POC), Point of Common Coupling (PCC) and the voltage reference point can 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.
1.2.29 Point of Connection in Installation (PCI)
The Point of Connection in installation (PCI) is the point in the installation where electricity-generating units in the installation are connected or can be connected, see Figure 2 for the typical location.

1.2.30 Point of Generator Connection (PGC)
The Point of Generator Connection is the point in the plant infrastructure, where the terminals/generator terminals for the electricity-generating unit are located. For the electricity-generating unit, the Point of Generator Connection is the point defined by the wind turbine manufacturer as the wind turbine’s terminals.

1.2.31 Positive list
A so-called positive list has been prepared to facilitate the technical approval process for grid connection of a category A2 plant. The list contains plant components deemed to comply with the specific property and functionality requirements under the relevant technical regulations.

This positive list is available at the Danish Energy Association’s website: www.danskenergi.dk/positivlister.

1.2.32 Power Factor (PF)
The Power Factor, cosine $\varphi$, for AC voltage systems indicates the ratio of active power $P$ to apparent power $S$, where $P = S \times \cos \varphi$. Likewise, reactive power $Q = S \times \sin \varphi$. The angle between current and voltage is denoted by $\varphi$. 

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Figure 3 Example of grid connection of wind power plants.
1.2.33 **Power factor control**

*Power factor control* is the control of reactive power proportionately to active power generated. See section 5.3.2 for a more detailed description.

1.2.34 **Power infrastructure**

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

1.2.35 **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 nominal voltage** of 100 kV.

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

1.2.36 **Q control**

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

1.2.37 **Ramp rate constraint**

A *ramp rate constraint* controls the interval of active power with a set point-defined maximum increase/reduction (ramp rate) of the active power. See section 5.2.3.3 for a more detailed description.

1.2.38 **Rapid voltage changes**

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

1.2.39 **Rated current (Iₙ)**

*Rated current* Iₙ is defined as the maximum continuous current that a *wind power plant* is designed to provide under normal operating conditions, see DSF/CLC/FprTS 50549-1:2014 [ref. 38] and DSF/CLC/FprTS 50549-2:2014 [ref. 39]. *Rated current* is denoted by Iₙ.

1.2.40 **Rated power of a wind power plant (Pₙ)**

The *rated power* (Pₙ) of a *wind power plant* is the highest active power that the *wind power plant* is designed to continuously provide and that appears from the type approval, see IEC 61400-1 [ref. 9] and Danish Executive Order no. 73 of 25 January 2013 [ref. 18]. *Rated power* is denoted by Pₙ.

1.2.41 **Rated power of a wind turbine (Pₙ)**

The *rated power* of a *wind turbine* is the highest active power that the *wind turbine* is designed to continuously provide and that appears from the type approval. *Rated power* is denoted by Pₙ.
1.2.42  Rated value for the 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 a wind turbine or a wind power plant is designed to continuously deliver.

1.2.43  Rated wind speed
The rated wind speed is the wind speed at which a wind turbine achieves its rated power, see IEC 60050-415-03-04 [ref. 27].

1.2.44  Short circuit current ($I_k$)
The short circuit current ($I_k$) is the amount of power [kA] that the wind power plant can deliver to the Point of Connection in the event of a short circuit at the wind power plant's terminals.

1.2.45  Short circuit power ($S_k$)
The short circuit power $S_k$ is the amount of three-phase short circuit power in the Point of Connection.

1.2.46  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 plant's nominal apparent power $S_n$.

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

$$\text{THD}_I = \sqrt{\sum_{h=2}^{40} \left( \frac{X_h}{X_1} \right)^2}$$

See IEC 61000-3-16 [ref. 31] 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.

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

1.2.49  Voltage control
Voltage control is the control of reactive power with the configured droop to achieve the desired voltage in the voltage reference point.

1.2.50  Voltage fluctuation
Voltage fluctuation is a series of rapid voltage changes or a periodic variation of the root-mean-square (RMS) value of the voltage.
1.2.51 Voltage reference point
A 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 electric supply undertaking chooses the location of the voltage reference point, see Figure 3.

1.2.52 Wind power plant
A wind power plant is one or several wind turbines with a total rated power above 11 kW which are connected to the public electricity supply grid, see IEC 61400-1 [ref. 9] and IEC 61400-2 [ref. 10]. The term wind power plant is equivalent to the term plant. Wind turbine is defined in more detail in section 1.2.54.

A wind power plant comprises all necessary power supply and auxiliary equipment, and it is therefore the entire wind power plant that must comply with the technical minimum requirements specified in this regulation.

A wind power plant has only one Point of Connection.

1.2.53 Wind power plant controller
A wind power plant controller is a set of control functions that make it possible to control the services provided by a wind power plant as a single plant in the Point of Connection. The set of control functions must be part of the wind power plant in a communicative context. This means that if the communication to a wind power plant is interrupted, the plant must be able to continue providing services as scheduled or carry out a controlled shutdown. See section 6.2 for more detail.

1.2.54 Wind turbine
A wind turbine is a system which converts the wind’s kinetic energy into electrical power, see IEC 60050-415-01-02 [ref. 27]. In a wind power context, a wind turbine is an electricity-generating unit. Electricity-generating unit is defined in more detail in section 1.2.9.

1.2.55 Wind turbine operator
The wind turbine operator is the enterprise responsible for the operation of the wind power plant, either through ownership or contractual obligations.
2. **Objective, scope of application and regulatory provisions**

2.1 **Objective**

The objective of technical regulation TR 3.2.5 is to specify the minimum technical and functional requirements that a *wind power plant* with a *rated power* above 11 kW must comply with in the *Point of Connection* when the *wind power plant* is connected to 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 parties 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 *wind power plant* must comply with Danish legislation, including the Danish Heavy Current Regulation (Stærkstrømsbekendtgørelsen) [ref. 4], [ref. 5], the Joint Regulation [ref. 3], the Machinery Directive [ref. 6], [ref. 7] and the grid connection and grid use agreement.

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

2.2 **Scope of application**

Throughout its lifetime, any *wind power plant* connected to the *public electricity supply grid* must comply with the provisions of this regulation.

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

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

**) *Plant components* used in this *plant category* may be included in the *positive list of plant components or plants* which may be installed in Denmark.

All requirements in this regulation respect the *plants’* design framework and properties that the current wind power technology offers, including properties at different wind conditions.

For planning and grid expansion reasons, the *electricity supply undertaking* has the right to reject grid connection for non-three phase *plants*.
2.2.1 **New wind power plants**
This regulation applies to all wind power plants with rated power above 11 kW connected to the public electricity supply grid and commissioned as of the effective date of this regulation.

2.2.2 **Existing wind power plants**
A wind power plant with rated power above 11 kW 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 commissioning.

2.2.3 **Modifications to existing wind power plants**
If substantial functional modifications are made to an existing wind power plant, the plant must comply with the provisions of this regulation relating to such modifications. In case of doubt, the transmission system operator decides whether a specific modification is substantial.

A substantial modification is one that changes one or more vital plant components, which may alter the properties of the wind power plant.

The documentation described in section 8 must be updated and submitted in a version showing any modifications made.

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 the plant owner, wind turbine operator and electricity supply undertaking regarding connection to the public electricity supply grid.

Together with the market regulations, the technical regulations, including the system operation regulations, constitute the set of rules to be complied with by plant owners, wind turbine operators and electricity supply undertakings with regard to the operation of wind power plants.

- Technical regulation TR 5.8.1 'Metering data for system operation purposes' [ref. 19]
- Technical regulation TR 5.9.1 'Ancillary services' [ref. 20]
- Regulation D1 'Settlement metering' [ref. 21]
- Regulation D2 'Technical requirements for electricity metering' [ref. 22]
- Technical regulation 3.2.5 'Wind power plants above 11 kW'.

In addition, special contractual conditions may apply to the compensation for downward regulation of an offshore wind farm. In such cases, the following regulation applies:

- Regulation E – appendix 'Compensation for offshore wind farms ordered to perform downward regulation' [ref. 23].

In case of any discrepancy 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 [www.energinet.dk](http://www.energinet.dk).

Operational matters will be agreed between the *plant owner* and the *electricity supply undertaking* within the framework set by the *transmission system operator*.

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, settlement metering or technical settlement metering requirements.

The *plant owner* must safeguard the *wind power 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, among other things safeguard *wind turbines* and other *plant components* against condensation in the event of a lack of electricity supply.

### 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 **22 July 2016** and replaces

- Technical regulation 3.2.5 for wind power plants with a power output above 11 kW, Revision 2, effective from 12 June 2015.


The regulation was registered with the Danish Energy Regulatory Authority pursuant to the provisions of section 26 of the Danish Electricity Supply Act (Elforsyningsloven) and section 7 of the Danish executive order on transmission system operation and the use of the electricity transmission grid, etc. (Systemansvarsbekendtgørelsen).

As regards *wind power plants*, the construction of which was definitively ordered in a binding written order before the regulation was registered with the Danish Energy Regulatory Authority, but which are scheduled to be commissioned after this regulation becomes effective, an exemption can be applied for in accordance with section 2.9, enclosing any relevant documentation.
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 can also be lodged with the Danish Energy Regulatory Authority.

Complaints about how the individual electricity supply undertaking enforces the provisions of the regulation can 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 life of the wind power plant.

The wind power plant must be subjected to regular maintenance checks 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 wind power 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 wind power plant as a last resort subject to the decision made by Energinet.dk, 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 impair the technical quality and balance of the public electricity supply grid
- the deviation is not inappropriate from a socio-economic viewpoint.

To obtain an exemption, a written application must be submitted 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, where possible taking the views of the parties involved into consideration.
Complaints against the decision 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
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.
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.
17. **IEC 61400-25-4:2008**: Communications for monitoring and control of wind power plants – mapping to communication protocol stacks.
18. **Danish Executive Order no. 73 of 25 January 2013**: Executive Order on the technical certification scheme for wind turbines.
19. **Technical regulation TR 5.8.1**: 'Måledata til systemdriftsformål' (Metering data for system operation purposes), dated 28 June 2011, Rev. 3.0, document no. 17792/10 (= new doc. no. 13/89692-218).
24. IEC 61850-7-4 Ed2.0:2012: Basic communication structure for substation and feeder equipment – Compatible logical node classes and data classes
25. IEC 61850-90-7 Ed1.0:2013: Object models for power converters in distributed energy resources (DER) systems.
26. IEEE 1459:2010: Standard definitions for the measurement of electrical power quantities under sinusoidal, non-sinusoidal, balanced or unbalanced conditions.
29. DS/EN TR 61000-3-2:2014: Limit values – Limit values for harmonic current emissions (equipment input current up to and including 16A per phase).
30. DS/EN TR 61000-3-3:2013: Limit values – Limitation of voltage fluctuations and flicker in public low-voltage supply systems, from equipment with a rated current <= 16A per phase which is not subject to conditional connection rules.
31. 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.
32. 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.
33. 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 a rated current up to and including 75A which is subject to conditional connection.
34. DS/EN 61000-3-12:2012: Limits – Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current > 16A and ≤ 75A per phase.
36. 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.
37. 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.
38. DS/CLC/TS 50549-1:2014: Requirements for generating plants to be connected in parallel with a distribution network – Part 1: Generating plants larger than 16A per phase to be connected with a low voltage network.
2.10.2 Informative references


3. **Tolerance of frequency and voltage deviations**

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

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

Normal operating conditions are described in section 3.2, and abnormal operating conditions are described in section 3.3.

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

### 3.1 Determination of voltage level

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

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.

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

If normal operating voltage range $U_c \pm 10\%$ is lower than the minimum voltage indicated in Table 1, the requirements for production in the event of frequency/voltage variations must be adjusted so as not to overload the wind power plant.

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

*Table 1 Definition of voltage levels applied in this regulation.*
Maximum \( (U_{\text{max}}) \) and minimum \( (U_{\text{min}}) \) voltage limits are determined using the standards DS/EN 50160 (10-minute mean values) [ref. 1] and DS/EN 60038 [ref. 2].

The wind power plant must be able to briefly withstand voltages exceeding the maximum voltages within the required protective settings specified in section 6.

### 3.2 Normal operating conditions

Within the normal production range, a wind power plant must be designed start and generate power continuously within the design specifications (for example with proper wind conditions), restricted only by the settings of the protective function as described in section 6 and/or other functions impacting the plant's output.

Within the normal production range, the normal operating voltage is \( U_c \pm 10\% \), see section 3.1, and the frequency range is 49.50 to 50.20 Hz.

Automatic connection of a wind power plant can take place no earlier than three minutes after the voltage and frequency have come within the normal production range.

Frequency limit settings are determined by the transmission system operator.

#### 3.2.1 Category A2 wind power plants

The overall requirements for active power production that a wind power plant must comply with in the event of frequency and voltage deviations are shown in Figure 4.

![Figure 4: Active power requirements in the event of frequency and voltage fluctuations for category A2 wind power plants.](image-url)
There are no requirements for active power production outside the normal production range, but the wind power plant must remain connected to the public electricity supply grid in accordance with the required settings for protective functions as specified in section 6.

### 3.2.2 Category B, C and D wind power plants

The overall requirements for active power production that category B, C and D wind power plants must comply with in the event of frequency and voltage deviations are shown in Figure 5.

![Figure 5: Active power requirements in the event of frequency and voltage fluctuations for category B, C and D wind power plants.](image)

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

### 3.3 Abnormal operating conditions

The following requirements apply to category C and D wind power plants.

The wind power plant must be designed to withstand transitory (80-100 ms) phase jumps of up to 20° in the Point of Connection (POC) without disrupting or reducing its output.

After a transient start-up period, the wind power plant must deliver normal production no later than five seconds after the operating conditions in the Point of Connection have reverted to the normal production range.

The wind power plant must be designed to withstand voltage dips as shown in Figure 6 and during fault sequences supply added reactive current as shown in Figure 7 without disrupting or reducing its output.
After a settling period, the wind power plant must be capable of delivering normal production no later than five seconds after the operating conditions in the Point of Connection have reverted to the normal production range.

Irrespective of the requirements outlined in the following sections, the protective settings must be as specified in section 6.

Documentation proving that the wind power plant complies with the specified requirements must be as stated in section 8.

The wind power plant must be protected against damage caused by out-of-phase reclosing and against disconnections in non-critical situations.

### 3.3.1 Voltage dip tolerance

In the Point of Connection, a wind power plant must be designed to withstand voltage dips down to 20% of the voltage in the Point of Connection over a period of minimum 0.5 seconds, as shown in Figure 6, without disconnecting. In the figure below, the Y-axis indicates the smallest line-to-line voltage for the 50 Hz component.

![Figure 6 Voltage dip tolerance requirements for category C and D wind power plants.](image)

The following requirements must be complied with in the event of symmetrical and asymmetrical faults, i.e. the requirements apply in case of faults in one, two or three phases:

- Area A: The wind power plant must stay connected to the grid and maintain normal production.
- Area B: The wind power plant must stay connected to the grid. The wind power plant must provide maximum voltage support by supplying an added amount of controlled reactive current so as to ensure that the wind power
The terminal voltage measurement for the individual wind turbine may be used to control the reactive current during a voltage dip.

Figure 7 Requirements for the delivery of added reactive current $I_Q$ during voltage dips for category C and D wind power plants.

The reactive current control must follow Figure 7, so that the added reactive current (synchronous component) after 100 ms follows the characteristic with a tolerance of ± 20% within the wind power plant's design limitations. In Figure 7, the Y-axis indicates the applied control voltage for the 50 Hz component.

With regard to the control concept for the delivery of added reactive current during a voltage dip, it is up to the wind turbine supplier to specify which control voltage is used. This may be the minimum or maximum line-to-line voltage or phase voltage. Alternatively, the synchronous voltage component may be used as long as the characteristic shown in Figure 7 can be observed in the event of three-phase faults and after disconnection of all types of asymmetrical faults.
If necessary, total reactive current can be limited to 1 p.u. of the plant’s nominal output.

If necessary, added reactive current can be reduced relative to the maximum recorded phase voltage to avoid overvoltage.

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

If possible, active power must be maintained during voltage dips, but a reduction in active power within the wind power plant’s design limitations is acceptable, however.

### 3.3.2 Recurring faults in the public electricity supply grid

The wind power plant and any compensation equipment must stay connected during and after faults have occurred in the public electricity supply grid as specified in Table 2.

These requirements apply to the Point of Connection, but the fault sequence is at a random point in the public electricity supply grid.

To further ensure compliance with the voltage dip requirements as stated in section 3.3.1, the requirements in Table 2 must be verified by documenting that the wind power plant is designed to withstand the specified recurring faults.

<table>
<thead>
<tr>
<th>Type</th>
<th>Duration of fault</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three-phase short circuit</td>
<td>Short circuit for 150 ms</td>
</tr>
<tr>
<td>Phase-to-phase-to-earth short circuit/phase-to-phase short circuit</td>
<td>Short circuit for 150 ms followed by a new short circuit 0.5 to 3 seconds later, also with a duration of 150 ms½</td>
</tr>
<tr>
<td>Phase-to-earth short circuit</td>
<td>Phase-to-earth fault for 150 ms followed by a new phase-to-earth fault 0.5 to 3 seconds later, also with a duration of 150 ms</td>
</tr>
</tbody>
</table>

*Table 2  Fault types and duration in the public electricity supply grid.*

The energy reserves provided by auxiliary equipment such as emergency supply equipment, and the hydraulic and pneumatic systems should be sufficient for the wind power plant to meet the requirements in Table 2 in the event of at least two independent faults of the specified types occurring within two minutes.

The energy reserves provided by auxiliary equipment such as emergency supply equipment, and the hydraulic and pneumatic systems should be sufficient for the wind power plant to meet the specified requirements in the event of at least six independent faults of the types specified in Table 2 occurring at five-minute intervals.
4. Power quality

4.1 General

When assessing a wind power plant’s impact on power quality in the public electricity supply grid, the various power quality parameters in the Point of Connection must be documented.

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

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Category</th>
<th>A2</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC content (4.2)</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Asymmetry (4.3)</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Rapid voltage changes (4.4)</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Flicker (4.5)</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Harmonic distortions (4.6)</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Interharmonic distortions (4.7)</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Distortions 2-9 kHz (4.8)</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Bracketed numbers indicate the sections that specify the respective requirements.

Table 3 Overview of power quality requirements for plant categories.

For each of these distortion types, the following is specified:
- Data used 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 TR 61000-3-2:2014 [ref. 29], DS/EN 61000-3-3:2013 [ref. 30], IEC/TR 61000-3-6:2008 DS/EN 61000-3-12 [ref. 34], [ref. 31], IEC/TR 61000-3-7:2008 [ref. 32], DS/EN 61000-3-11 [ref. 33], DS/EN 61000-3-12 [ref. 34], DS/EN 61000-3-13 [ref. 35], DS/EN 61000-3-14 [ref. 36] and DS/EN 61000-3-15 [ref. 37] and national recommendations in the Research Association of the Danish Electric Utilities recommendation no. 16 [ref. 41] and the Research Association of the Danish Electric Utilities recommendation no. 21 [ref. 42].

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 wind power plant is designed, constructed and configured in compliance with the specified emission limits.
The plant owner may purchase supplementary services from the electricity supply undertaking as agreed 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 wind power plant as well as the public electricity supply grid will be used to assess a wind power plant’s impact on power quality.

The plant owner must provide data as specified in IEC 61400-21 [ref. 12] to determine emission of flicker and high-frequency distortions for the wind power plant.

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

1. The plant owner uses the results of the type test for each of the electricity-generating units that make up the wind power plant. The type test must be performed in accordance with the relevant parts of IEC 61400-21 [ref. 12].

   The plant owner calculates the total emissions as the sum of the contributions from each of the electricity-generating units that make up the plant.

2. The plant owner develops an emission model for the wind power 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 electricity-generating units and 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, see 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, minimum and typical $S_k$ for the Point of Connection.

4.1.2 Limit values
The electricity supply undertaking is responsible for supplying limit values for the emission of various types of distortions coming from the wind power plant in the Point of Connection 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 the Research Association of the Danish Electric Utilities recommendation no. 21 [ref. 42], IEC/TR 61000-3-6 [ref. 31], IEC/TR 61000-3-7 [ref. 32], DS/EN 61000-3-12 [ref. 34] and DS/EN 61000-3-11 [ref. 33].

4.1.3 Verification
The plant owner must use calculations, simulations or measurements to verify that the wind power 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 plant’s Point of Connection (POC) may not exceed 0.5% of the nominal current, see IEC/TS 61000-3-15, section 7.5 [ref. 37].

4.3 Asymmetry
For all plant categories, asymmetry between phases at normal operation or in the event of faults in the electricity-generating unit may not exceed 16A.

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

4.4 Rapid voltage changes

4.4.1 Data basis
The plant owner must use data for the voltage change factor $k_{U,I} (\psi_k)$ for each wind turbine, $I$, during connections, as specified by the type test, see IEC 61400-21 [ref. 12].

The type test specifies $k_{U,I} (\psi_k)$ for the short circuit angle $\psi_k = 30, 50, 70$ and $85$ degrees for different types of connections. The type test also specifies the location of the metering point.

4.4.2 Limit values

4.4.2.1 Requirements for category A2 wind power plants
The connection of a wind turbine in the wind power plant must not give rise to rapid voltage changes $d$ (%) exceeding the limit values indicated in the table below, see DS/EN 61000-3-11, section 5 [ref.33].

<table>
<thead>
<tr>
<th>Voltage level</th>
<th>d (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$U_n \leq 35$ kV</td>
<td>4%</td>
</tr>
</tbody>
</table>

Table 4 Limit values for rapid voltage changes $d$ (%) – category A2

4.4.2.2 Requirements for category B, C and D wind power plants
The connection of a wind turbine in the wind power plant must not give rise to rapid voltage changes $d$ (%) exceeding the limit values indicated in the table below.
<table>
<thead>
<tr>
<th>Voltage level</th>
<th>d (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$U_n \leq 35$ kV</td>
<td>4%</td>
</tr>
<tr>
<td>$U_n &gt; 35$ kV</td>
<td>3%</td>
</tr>
</tbody>
</table>

Table 5  Limit values for rapid voltage changes $d$ (%) – category B, C and D.

Excepted are rare voltage changes such as voltage dips resulting from the energising of the plant infrastructure with connected wind turbine transformers.

4.4.3 Verification

The voltage change factor $k_U$ is determined for the public electricity supply grid in the Point of Connection for each type of wind turbine and for each of the different types of connections by simple interpolation between the values for $\psi_k$ indicated in the type approval. Subsequently, $k_U(\psi_k)$ is determined as the largest voltage change factor among the different types of connections for each wind turbine indicated by $i$.

The voltage change $d_i(\%)$ is then determined for each wind turbine:

$$d_i(\%) = 100\% \cdot k_{u,i}(\psi_k) \cdot \frac{S_{n,i}}{S_k}$$

Subsequently, $d(\%)$ is determined as the highest value of $d_i(\%)$. Finally, it must be verified that the calculated voltage change, i.e. $d(\%)$, is below the limit values stated in Table 5.

4.4.3.1 Category A2 wind power plants

It must be verified that the calculated rapid voltage change for the entire wind power plant is below the limit values stated in Table 4.

4.4.3.2 Category B, C and D wind power plants

It must be verified that the calculated rapid voltage change for the entire wind power plant is below the limit values stated in Table 5.

4.5 Flicker

4.5.1 Data basis

The flicker emission must be documented for continuous operation and for connections. The flicker level is documented using data from type tests or emission models.

When calculating the flicker contribution at continuous operation, use the flicker coefficient $c_{fi}(\psi_k, \nu_a,i)$ data that appear from the type test.

The type test specifies $c_{fi}(\psi_k)$ for $\psi_k = 30, 50, 70$ and 85 degrees and $\nu_a = 6.0$ m/s, 7.5 m/s, 8.5 m/s and 10.0 m/s for the average velocities.

Use the annual average velocity $\nu_a$ for the wind power plant for the calculation.

Use data for the flicker step factor $k_{fi}(\psi_k)$ as specified in the type test for connections.
The type test specifies $k_f(\psi_k)$ for $\psi_k = 30, 50, 70$ and 85 degrees for different types of connections. In addition, use the maximum number of each type of connection within 10 min. $P_{st}$ (short-term flicker) and 120 min. $P_{lt}$ (long-term flicker).

### 4.5.2 Limit values

The *wind power plant*’s total *flicker* contribution must meet the requirements in the following sections in the *Point of Connection*.

#### 4.5.2.1 Requirements for category A2 wind power plants

The limit values for *plants* in this category are stated in the table below for emissions from the individual *wind power plant*, see DS/EN 61000-3-11, section 5 [ref. 33].

<table>
<thead>
<tr>
<th>Voltage level</th>
<th>$P_{st}$</th>
<th>$P_{lt}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$U_n \leq 1 \text{kV}$</td>
<td>1.0</td>
<td>0.65</td>
</tr>
</tbody>
</table>

*Table 6  Limit values for short-term flicker $P_{st}$ and long-term flicker $P_{lt}$.*

#### 4.5.2.2 Requirements for category B wind power plants

If the connected rated power is lower than 0.4% of $S_k$, the *wind power plant* can be connected without further checks.

Otherwise, the limit values in the table below apply to emissions from the individual *wind power plant*, see DS/EN 61000-3-11, section 5 [ref. 33].

<table>
<thead>
<tr>
<th>Voltage level</th>
<th>$P_{st}$</th>
<th>$P_{lt}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$U_n \leq 1 \text{kV}$</td>
<td>0.35/0.45/0.55*</td>
<td>0.25/0.30/0.40*</td>
</tr>
<tr>
<td>$U_n &gt; 1 \text{kV}$</td>
<td>0.30</td>
<td>0.20</td>
</tr>
</tbody>
</table>

*) The limit values apply if any 4/2/1 generation facility is already connected under the same substation.

*Table 7  Limit values for short-term flicker $P_{st}$ and long-term flicker $P_{lt}$.*

#### 4.5.2.3 Requirements for category C and D wind power 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.

### 4.5.3 Verification

Verify that the *flicker* emission from continuous operation of the *wind power plant* and from connections is lower than the limit value for the *Point of Connection*.

Determine the *flicker* coefficient on the basis of the current $\psi_k$ for the *electricity-generating unit* by simple interpolation between the values for $\psi_k$ specified in the type test.

#### 4.5.3.1 Continuous operation

Determine the *flicker* coefficient for the *public electricity supply grid* in the *Point of Connection* and the current location of the *wind power plant* by simple interpolation between the values for $\psi_k$ and $\nu_k$ specified in the type approval.
The *flicker* emission for each *electricity-generating unit* \( i \) that make up the *wind power plant* is calculated as:

\[
P_{st,i} = c_i \left( \psi_k, v_{a,i} \right) \cdot \frac{S_{a,i}}{S_k}
\]

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

\[
P_{st} = P_{st} = \sqrt[3]{\sum_i \left( P_{st,i} \right)^3}
\]

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

### 4.5.3.2 Connections

The *flicker* step factor is determined for each of the different types of connection for the *public electricity supply grid* in the *Point of Connection* by simple interpolation between the values for \( \psi_k \) specified in the type approval. Subsequently, \( k_{f,i}(\psi_k) \) is determined as the largest *flicker* step factor among the different types of connection.

The *flicker* emission is then determined for each of the *wind turbines* \( i \) that make up the *wind power plant* by using the *flicker* step factor \( k_{f,i}(\psi_k) \), see IEC 61400-21, Ed2, section 8 [ref. 12]:

\[
P_{st,i} = 18 \cdot N_{10_{\text{min}},i}^{0.31} \cdot k_{f,i}(\psi_k) \cdot \frac{S_{a,i}}{S_k}
\]

\[
P_{st,i} = 8 \cdot N_{120_{\text{min}},i}^{0.31} \cdot k_{f,i}(\psi_k) \cdot \frac{S_{a,i}}{S_k}
\]

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

\[
P_{st} = \sqrt[3]{\sum_i \left( P_{st,i} \right)^3}
\]

\[
P_{st} = \sqrt[3]{\sum_i \left( P_{st,i} \right)^3}
\]

It must be checked that the calculated values are below the limit values.

### 4.5.3.3 Category A2, B, C and D wind power plants

It must be verified that the *flicker* emission from continuous operation and connections is below the limit value in the *Point of Connection*.

### 4.6 Harmonic distortions

Emission of *harmonic distortions* must be documented for the entire *wind power plant*.
4.6.1 Data basis
Data from type tests or emission models are used to document the emission level.

The type test specifies measured mean values for 2-50 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 percentages of the rated current.

4.6.2 Limit values
The wind power plant is not allowed to emit harmonic distortions exceeding the limit values specified in this section.

For wind power plants which are electrically connected far from other consumers, the emission limits may, however, be changed to values higher than the standard emission limits following approval from the electricity supply undertaking.

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

4.6.2.1 Requirements for category A2 wind power plants
The limit values for harmonic current emissions for different orders \( h \) are listed in the table below, see DS/EN 61000-3-12, table 3 [ref. 34]. The requirements below presuppose that SCR is less than 33. If the short circuit ratio is different, reference is made to table 3 of the above standard.

<table>
<thead>
<tr>
<th>Harmonic</th>
<th>Odd harmonic order ( h ) (not a multiple of 3)</th>
<th>Even harmonic order ( h )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Limit value [%]</td>
<td>10.7</td>
<td>7.2</td>
</tr>
</tbody>
</table>

Table 8 Limit values for harmonic current \( I_h/I_n \) (% of \( I_n \)) – A2.

Limit values for emission of total harmonic current distortion are listed in the table below.

<table>
<thead>
<tr>
<th>Voltage level</th>
<th>SCR</th>
<th>THD</th>
<th>PWHD</th>
</tr>
</thead>
<tbody>
<tr>
<td>( U_c \leq 1 \text{kV} )</td>
<td>&lt;33</td>
<td>13</td>
<td>22</td>
</tr>
<tr>
<td>( U_c &gt; 1 \text{kV} )</td>
<td>-</td>
<td>No requirements</td>
<td>No requirements</td>
</tr>
</tbody>
</table>

Table 9 Limit values for total harmonic current distortion (% of \( I_n \)) – A2.

4.6.2.2 Requirements for category B wind power plants
Limit values for harmonic current emissions for different orders \( h \) are listed in the table below, see DS/EN 61000-3-12, table 3 [ref. 34].
Limit values for total harmonic current distortion emissions are listed in the table below.

<table>
<thead>
<tr>
<th>Voltage level</th>
<th>SCR</th>
<th>THD₁</th>
<th>PWHD₁</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uₑ ≤ 1 kV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;25</td>
<td>4.5</td>
<td>7.9</td>
<td></td>
</tr>
<tr>
<td>≥33</td>
<td>4.9</td>
<td>8.1</td>
<td></td>
</tr>
<tr>
<td>≥66</td>
<td>6.0</td>
<td>9.0</td>
<td></td>
</tr>
<tr>
<td>≥120</td>
<td>8.3</td>
<td>10.5</td>
<td></td>
</tr>
<tr>
<td>≥250</td>
<td>13.9</td>
<td>14.3</td>
<td></td>
</tr>
<tr>
<td>≥350</td>
<td>18.0</td>
<td>17.3</td>
<td></td>
</tr>
<tr>
<td>Uₑ &gt; 1 kV</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

*) Minimum 0.1%.

Table 11 Limit values for total harmonic current distortion (% of Iₑ) – B.

4.6.2.3 Requirements for category C and D wind power plants

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

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

The emission limits must ensure that the total permissible noise levels of the individual harmonic distortions and THDₑ are not exceeded in the Point of Connection.

4.6.3 Verification

It must be verified that plant emissions are below the limit value in the Point of Connection.

Therefore, the value from the level of generated active power at which the individual harmonic current is the greatest is used to verify observance of the harmonic current limit values for the individual harmonic currents \( h \). The current
values are used to calculate $THD_I$ and $PWHD_I$ for the respective levels of generated active power to verify compliance with the limit values for $THD_I$ and $PWHD_I$.

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

$$THD_I = \left(\sum_{h=2}^{h=40}(I_h^2 / I_1^2)\right)^{1/2} \quad \text{[ref. 31]} \quad \text{and} \quad PWHD_I = \left(\sum_{h=14}^{h=40}h(I_h^2 / I_1^2)\right)^{1/2} \quad \text{[ref. 34]}$$

For voltage harmonic $U_h$, $THD_U$ is defined as follows:

$$THD_U = \left(\sum_{h=2}^{h=40}(U_h^2 / U_1^2)\right)^{1/2}$$

For wind power plants consisting of multiple electricity-generating units, contributions from individual units may be summarised in accordance with the general summation law, see IEC/TR 61000-3-6 [ref. 31] and DS/EN 61000-3-11 [ref. 29].

$$I_h = a^{\alpha} \sum I_{h,i}^{\alpha}$$

Values for the exponent $\alpha$ are listed in the table below.

<table>
<thead>
<tr>
<th>Harmonic order</th>
<th>$\alpha$ (alpha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$h &lt; 5$</td>
<td>1</td>
</tr>
<tr>
<td>$5 \leq h \leq 10$</td>
<td>1.4</td>
</tr>
<tr>
<td>$h &gt; 10$</td>
<td>2</td>
</tr>
<tr>
<td>$h &gt; 40$</td>
<td>3</td>
</tr>
</tbody>
</table>

*Table 12 Values for the exponent $\alpha$.

Calculation examples are found in 'Guidelines on the calculation of power quality parameters – TR 3.2.5' [ref. 44].

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

**4.6.3.1 Category A2 and B wind power plants**

It must be verified that limit values are observed for all levels of generated active power.

**4.6.3.2 Category C and D wind power plants**

It must be verified that limit values are observed for all levels of generated active power.
The sum of the individual harmonic currents $I_h$ is translated into harmonic voltages by multiplying individual harmonic currents by the numerical value of grid impedance at the individual frequencies as stated by the *electricity supply undertaking*.

$THD_U$ is determined by using the formulas in section 4.6.3.

Unless otherwise stated by the *electricity supply undertaking*, use the model found in 'Guidelines on the calculation of power quality parameters – TR 3.2.5' [ref. 44] – section: Approximate model for the frequency dependence of the grid impedance.

Calculations of emission limits are described with examples in 'Guidelines on the calculation of power quality parameters – TR 3.2.5' [ref. 44].

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

### 4.7 Interharmonic distortions

Emission of interharmonic distortions must be documented for the entire *wind power plant*.

#### 4.7.1 Data basis

The type test specifies measured mean values for interharmonic distortions in the 75 Hz to 1975 Hz frequency range for 11 levels of generated active power from 0% to 100% of the *rated power* $P_{n,i}$ with a *Power Factor* of 1.

Measured mean values are stated as percentages of the *rated current* $I_n$.

#### 4.7.2 Limit values

The *wind power plant* is not allowed to emit interharmonic distortions that exceed the limit values specified in this section.

#### 4.7.2.1 Requirements for category A2 wind power plants

There are no requirements for interharmonic distortions for this category.
4.7.2.2 Requirements for category B wind power plants
Limit values for interharmonic distortion emissions are listed in the table below which is based on RA557 [ref. 40] and scaling according to the specifications in DS/EN 61000-3-12 [ref. 34].

<table>
<thead>
<tr>
<th>Voltage level</th>
<th>SCR</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>75 Hz</td>
</tr>
<tr>
<td>U_C ≤ 1kV</td>
<td>&lt;33</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>≥33</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>≥66</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>≥120</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>≥250</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>≥350</td>
<td>1.5</td>
</tr>
<tr>
<td>U_C &gt; 1kV</td>
<td>-</td>
<td>0.44</td>
</tr>
</tbody>
</table>

*) Minimum 0.1%.

Table 13 Limit values for interharmonic distortion emissions – B.

4.7.2.3 Requirements for category C and D wind power plants
The electricity supply undertaking determines emission limits for interharmonic distortions from the wind power plant in the Point of Connection.

The emission limits are to ensure that the electricity supply undertaking’s planning limits for the individual interharmonic distortions are not exceeded in the Point of Connection.

4.7.3 Verification

4.7.3.1 Category A2 wind power plants
There are verification requirements for this category.

4.7.3.2 Category B, C and D wind power plants
It must be verified that the wind power plant complies with the limit values for interharmonic distortion emissions in the same way as for harmonic distortion emissions, see section 4.6.3.1. The exponent α=3 must, however, be used if summation rules are used.

Alternatively, the approved emission model is used to verify that limit values are met.
4.8 Distortions in the 2-9 kHz frequency range
Distortion emission in the 2-9 kHz frequency range must be documented for the entire wind power plant.

4.8.1 Data basis
The type test specifies measured mean values for frequency components of the current in groups of 200 Hz width from 2.1 kHz to 8.9 kHz for 11 levels of generated active power from 0% to 100% of the rated power $P_{n,i}$ and a Power Factor of 1.

Measured mean values are stated as percentages of the rated current $I_n$.

4.8.2 Limit values

4.8.2.1 Requirements for category A2 wind power plants
There are no requirements for distortions above 2 kHz.

4.8.2.2 Requirements for category B wind power plants
The emission of currents with frequencies higher than 2 kHz must not exceed 0.2% of rated current in any frequency group measured.

4.8.2.3 Requirements for category C and D wind power plants
The electricity supply undertaking determines emission limits for voltages from the wind power plant in the Point of Connection.

The emission limits are to ensure that the electricity supply undertaking's planning limits for the individual frequency groups are not exceeded in the Point of Connection.

4.8.3 Verification

4.8.3.1 Category A2 wind power plants
There are no verification requirements for this category.

4.8.3.2 Category B, C and D wind power plants
It must be verified that the wind power plant complies with limit values for the emission of distortion above 2 kHz in the same way as for harmonic distortion emissions. The exponent $\alpha=3$ must, however, be used if summation rules are used.

Alternatively, the approved emission model is used to verify that limit values are complied with.
5. Control and regulation

5.1 General requirements
All control functions mentioned in the following sections refer to the Point of Connection.

It must be possible to activate/deactivate all control functions and set them using external signals as described in section 7.

The currently activated functions and parameter settings must be agreed with the electricity supply undertaking within the framework laid down by the transmission system operator before the wind power plant can be connected to the public electricity supply grid.

In order to ensure the security of supply, the transmission system operator must be able to activate or deactivate the specified control functions and, by further agreement with the plant owner, be able to change current function settings via for example set points and activation commands.

All setting values for frequency parameters are determined by the transmission system operator.

For all active power and reactive power control functions, the accuracy of a completed control operation over a period of 1 minute may not deviate by more than 2\% of $P_n$ and $Q_n$, respectively.

The signs used in all figures follow the generator convention.

Required MW and MVar power will be reduced on a pro-rata basis relative to the number of wind turbines in operation in the wind power plant.

Table 14 below specifies the minimum control functionality requirements for a wind power plant in the four plant categories, see section 1.2.21.

Section 7.2 lists required activation signals and related parameters.
### Control function

<table>
<thead>
<tr>
<th>Control function</th>
<th>Category</th>
<th>A2</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency response (5.2.1)</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Frequency control (5.2.2)*</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>Absolute power constraint (5.2.3.1)</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Delta power constraint (5.2.3.2)</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>Ramp rate constraint (5.2.3.3)</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Q control (5.3.1)*</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Power factor control (5.3.2)*</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Voltage control (5.3.3)*</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>System protection (5.4)</td>
<td></td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Bracketed numbers indicate the sections that describe the respective functions.

*) A plant must not perform frequency control, Q control, Power Factor control or voltage control without prior specific agreement with the transmission system operator.

**Table 14 Overview of control functions required for wind power plants.**

After a wind power plant has been disconnected due to a fault in the public electricity supply grid, the wind power plant must automatically reconnect no earlier than three minutes after the voltage and frequency are once again within the limits stated in sections 3.1 and 3.2.

A wind power plant which was disconnected by an external signal prior to a fault 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 limits stated in sections 3.1 and 3.2.

Wind power plants must be equipped with the control functions specified in Table 14.

The purpose of the various control functions is to ensure overall control and monitoring of the wind power plant’s output.

The various control functions may be implemented in an individual wind turbine, combined into a single wind turbine plant controller or be a combination thereof, provided there is only one communication interface as shown in Figure 8.
All set point changes must be registered with an identification of the party requesting the change.

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

### 5.2 Active power control functions

A wind power plant must be equipped with active power control functions capable of controlling the active power supplied by a wind power plant in the Point of Connection using activation orders with set points.

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 fulfilling 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

In the event of frequency deviations in the public electricity supply grid, the wind power plant must contribute to grid stability by automatically reducing active power at grid frequencies above \( f_R \). This is referred to as frequency response.

Frequency measurements must be carried out with an accuracy of ± 10 mHz or higher and with a standard deviation (\( \sigma \)) of ±5 mHz or better.

It must be possible to set the frequency response function for the frequency points in Figure 9.

It must be possible to set the frequency \( f_R \) to any value in the 50.00-52.00 Hz range with an accuracy of 10 mHz or higher. The standard \( f_R \) value is 50.20 Hz. The \( f_R \) setting 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 2-12% of \( P_n \) and this must be effected 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 the plant's nominal output.

The frequency response control must start no later than two seconds after a frequency change is detected and must be completed within 15 seconds.

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

![Figure 9 Frequency response for a wind power plant.](image)

1 The function is deactivated if \( f_R \) is set to 52 Hz.
5.2.2 Frequency control
In case of frequency deviations in the public electricity supply grid, the wind power plant must be able to provide frequency control to stabilise the grid frequency (50.00 Hz).

Frequency measurements must be carried out with an accuracy of ± 10 mHz or higher and with a standard deviation (1 σ) of ±5 mHz or better.

It must be possible to set the frequency control function for all frequency points shown in Figure 10, just as it must be possible to set the frequencies $f_{\text{min}}$, $f_{\text{max}}$ and $f_1$ to $f_7$ to any value in the 47.00 Hz to 52.00 Hz range with an accuracy of 10 mHz.

The purpose of frequency points $f_1$ to $f_6$ is to be able to produce different frequency response curves in line with the delivery requirements for the 'critical power frequency' ancillary service, see TR 5.9.1 [ref. 20].

The droop required to perform control between the various frequency points is illustrated in Figure 10 and specified in the signal list in section 7.

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 plant’s nominal output.

$P_{\text{delta}}$ is the set point that current active power has been reduced to in order to possibly provide frequency stabilisation (upward regulation) in the event of falling grid frequency.

Figure 10 and Figure 11 show two different $P_{\text{delta}}$ values with the same droop (droops 1, 2, 3 and 4).

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

When regulating the wind power plant’s active power downward below $P_{\text{min}}$, the shutdown of individual wind turbines is allowed.

When regulating the wind power plant’s active power upward, it is accepted that design limitations may increase the regulation time if the upward regulation exceeds 10% of $P_n$.

In case of grid frequencies above $f_5$, upward regulation of the wind power plant cannot be commenced until the grid frequency is lower than $f_7$.

The purpose of the frequency control function is to reduce active power at grid frequencies above $f_1$ as shown in Figure 10 and Figure 11.
Figure 10  Frequency control for wind power plants shown with a small downward regulation $P_{\Delta}$. 

Figure 11  Frequency control for wind power plants shown with a large downward regulation $P_{\Delta}$. 

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

*Frequency control* using a new parameter set must be possible no later than 10 seconds from receipt of the order to change this parameter.
5.2.3 Constraint functions

A wind power plant must be equipped with constraint functions, i.e. supplementary active power control functions. Constraint functions are used to avoid instability or overloading of the public electricity supply grid in connection with switching in the public electricity supply grid, in fault situations or the like.

The required constraint functions are specified in the sections below.

5.2.3.1 Absolute power constraint

An absolute power constraint is used to limit active power from a wind power plant to a set point-defined maximum power limit in the Point of Connection.

An absolute power constraint is mainly used to protect the public electricity supply grid against overload in critical situations.

Control using a new parameter for the absolute power constraint must be commenced within two seconds and completed no later than 10 seconds after receipt of the order to change the parameter.

5.2.3.2 Delta power constraint (spinning reserve)

A delta power constraint is used to constrain the active power from a wind power plant to a required constant value in proportion to the possible active power.

A delta power constraint is typically used to establish a regulating reserve for upward regulation purposes in connection with frequency control.

Control using a new parameter for the delta power constraint must be commenced within two seconds and completed no later than 10 seconds after receipt of an order to change the parameter.

5.2.3.3 Ramp rate constraint

A ramp rate constraint is used to limit the maximum speed by which the active power can be changed in the event of changes in wind speed or active power set points.

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

Control using a new parameter for the active power ramp rate constraint must be commenced within two seconds and completed no later than 10 seconds after receipt of an order to change the parameter.

The maximum standard value for the ramp rate constraint is 100 kW/s.

Figure 12 shows an overview of active power constraint functions.
5.3 Reactive power and voltage control functions

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

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

It must be possible to set the ramp rate for reactive power control via set points. By default, the control ramp rate must be 10 MVAr/s.

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.

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

5.3.1 Q control

The Q control function controls reactive power independently of the active power in the Point of Connection.

This control function is shown as a horizontal line in the figure below.
Any change to the Q control set point must be commenced within two seconds and completed no later than 30 seconds after receipt of an order to change the set point.

The wind power plant must be able to receive a Q set point with an accuracy of 1 kVAr.

**5.3.2 Power factor control**

The Power Factor control controls the reactive power proportionately to the active power in the Point of Connection, which is shown by a line with a constant gradient in Figure 14.

The wind power plant must be able to receive a Power Factor set point with a resolution of 0.01.
Figure 14 Reactive power control functions for a wind power plant, Power Factor control.

Any change to the Power Factor set point must be commenced within two seconds and completed no later than 30 seconds after receipt of an order to change the set point.

For the control function, the accuracy of a completed control operation over a period of 1 minute may not deviate by more than 2% of $Q_n$.

5.3.3 Voltage control
The voltage control function stabilises the voltage in the voltage reference point. Voltage control must have a setting range for minimum to maximum voltage as stated in Table 1 with an accuracy of 0.5% or higher of the nominal voltage.

Any change to the voltage set point must be commenced within two 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 control operation over a period of 1 minute may not deviate by more than 2% of $Q_n$.

The individual wind power plant must be capable of performing the control within its dynamic range and voltage limits with the droop configured.

A drawing of such a control is shown in Figure 15.

The voltage control reference point is the voltage reference point.

When the voltage control has reached the wind power plant's dynamic design limits, the control function must await a possible overall control from the tap changer or other voltage control functions.

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

Figure 15 Voltage control for a wind power plant.
5.4 System protection

A wind power plant must be equipped with system protection – a control function which must be capable of very quickly regulating the active power supplied by a wind power plant to one or more predefined set points based on a downward regulation order. Set points are determined by the electricity supply undertaking upon commissioning within the framework laid down by the transmission system operator.

The wind power plant must have at least five different configurable regulation step options.

The following regulation steps 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 25% of rated power
5. Up to 0% of rated power, i.e. the plant is shut down, but not disconnected from the grid.

When performing downward regulation, the shut-down of individual wind turbines is allowed.

Regulation must be commenced within one second and completed no later than 10 seconds after receipt of a downward regulation order.

If upward regulation is ordered for the system protection, e.g. from step 4 (25%) to 3 (40%), an increased order completion time is acceptable if caused by the design limitations of the plant’s wind turbines or other plant components.

5.5 Order of priority for control functions

The individual control functions of a wind power 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 recommended prioritisation between the functions of a wind power plant is as follows:

1. Protective functions, see section 6.
2. System protection, see section 5.4
3. Frequency control, see section 5.2.2
4. Constraint functions, see section 5.2.3.
5.6 Active power control requirements

Table 15 specifies the minimum requirements for control functionality for active power in the four plant categories, see section 1.2.21.

<table>
<thead>
<tr>
<th>Control function</th>
<th>Category</th>
<th>A2</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency response (5.2.1)*</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Frequency control (5.2.2)*</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>Absolute power constraint (5.2.3.1)</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Delta power constraint (5.2.3.2)</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>Ramp rate constraint (5.2.3.3)</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>System protection (5.4)</td>
<td></td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Bracketed numbers indicate the sections that describe the respective functions.

*) By default, a wind power plant must be configured with the frequency response function activated. Other methods of frequency control must be agreed with the transmission system operator.

Table 15 Active power control functions.

5.6.1 Category A2 wind power plants

In addition to fulfilling the general requirements in section 5.1 and the normal production requirements in section 3.2, category A2 wind power plants must as a minimum be equipped with the control functions specified in Table 15.

A wind power plant in this category must be prepared for the possible exchange of the information specified in sections 7.1.1 and 7.2.1.

5.6.2 Category B wind power plants

In addition to fulfilling the general requirements in section 5.1 and the normal production requirements in section 3.2, category B wind power plants must as a minimum be equipped with the control functions specified in Table 15.

A wind power plant in this category must be prepared for the possible exchange of the information specified in sections 7.1.2 and 7.2.2.

5.6.3 Category C wind power plants

In addition to fulfilling the general requirements in section 5.1 and the normal production requirements in section 3.2, category C wind power plants must as a minimum be equipped with the control functions specified in Table 15.

A wind power plant in this category must be prepared for the possible exchange of the information specified in sections 7.1.3 and 7.2.3.

Wind power plants in this category must as a minimum be able to reduce active power from the wind power plant continuously to a random value in the interval from 100% to a maximum of 40% of rated power.

A wind power plant in this category must be able to reduce active power generated in the event of high wind speeds, before the wind turbines' built-in protective function is activated (cut-out wind speed).
This is because the stability of the public electricity supply grid must be maintained during extreme weather conditions, including high wind speeds. As a minimum, the wind power plant must be equipped with an automatic downward regulation function that makes it possible to avoid a transitory interruption of the active power production at wind speeds exceeding the cut-out wind speed of the wind turbines.

It must be possible to activate/deactivate the control function using orders.

Downward regulation can be performed as continuous or discrete regulation. Discrete regulation must have a step size of maximum 25% of rated power within the hatched area shown in Figure 16. When performing downward regulation, the shutdown of individual wind turbines is allowed.

The downward regulation band must be agreed with the transmission system operator upon commissioning of the wind power plant. The width of the downward regulation band may depend on local wind conditions.

![Figure 16](image)

Figure 16  Downward regulation of active power at high wind speeds.

### 5.6.4 Category D wind power plants

In addition to fulfilling the requirements in section 5.6.3, category D wind power plants must as a minimum be equipped with the control functions specified in Table 15.

A wind power plant in this category must be capable of continuously regulating active power to a random value in the interval from 100% to a maximum of 20% of rated power.

A wind power plant in this category must be prepared for the possible exchange of the information specified in sections 7.1.3 and 7.2.4.
5.7 Calculation of non-provided active power

For wind power plants subject to compensation legislation in connection with downward regulation orders – see market regulation E – appendix: 'Compensation for offshore wind farms ordered to perform downward regulation' [ref. 23], the wind power plant operator must as a minimum provide the required information specified in the above-mentioned market regulation.

5.8 Reactive power control requirements

As a minimum, wind power plants in the four plant categories, see section 1.2.21, must be equipped with the reactive power control functions specified in Table 16.

<table>
<thead>
<tr>
<th>Control function</th>
<th>Category</th>
<th>A2</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q control (5.3.1)*)</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Power factor control (5.3.2)*</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Voltage control (5.3.3)*</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

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. Other methods of reactive power control must be agreed with the electricity supply undertaking.

Table 16 Reactive power control functions

5.8.1 Category A2 wind power plants

In addition to fulfilling the general requirements in section 5.1 and the normal production requirements in section 3.2, wind power plants in this category must as a minimum be equipped with the control functions specified in Table 16.

The wind power plant must be designed in such a way that the Power Factor interval $0.95 < \text{Power Factor} < 1.0$ is observed at output of more than 20% of rated power.

5.8.2 Category B wind power plants

In addition to fulfilling the general requirements in section 5.1 and the normal production requirements in section 3.2, wind power plants in this category must as a minimum be equipped with the control functions specified in Table 16.

The wind power plant must be designed in such a way that the operating point is always within the hatched area shown in Figure 17.

When the wind power plant is disconnected or not producing any active power, no compensation is required for the reactive power from the plant infrastructure.
In addition to fulfilling the general requirements in section 5.1 and the normal production requirements in section 3.2, wind power plants in this category must as a minimum be equipped with the control functions specified in Table 16.

**Figure 17** Requirements for the delivery of reactive power in relation to the active power level at $U_C$ for category B wind power plants.

### 5.8.3 Category C wind power plants

In addition to fulfilling the general requirements in section 5.1 and the normal production requirements in section 3.2, wind power plants in this category must as a minimum be equipped with the control functions specified in Table 16.
The wind power plant must be designed in such a way that the operating point for delivery of reactive power can lie anywhere within the hatched area in Figure 18.

Control method and settings must be agreed with the electricity supply undertaking within the framework laid down by the transmission system operator.

The plant owner must compensate for the plant infrastructure’s reactive power in situations where the wind power plant is disconnected or not generating active power. Compensation may take place in the electricity system by agreement with the electricity supply undertaking.

Figure 18 Requirements for the delivery of reactive power in relation to the active power level at $U_c$ for category C wind power plants.
Figure 19 shows in which $U_C$ area the delivery of reactive power is required for category C wind power plants.

![Figure 19 Requirements for the delivery of reactive power in relation to $U_C$ for category C wind power plants.](image)

5.8.4 Category D wind power plants

In addition to fulfilling the general requirements in section 5.1 and the normal production requirements in section 3.2, wind power plants in this category must as a minimum be equipped with the control functions specified in Table 16.

The wind power plant must be designed in such a way that the operating point for the delivery of reactive power can lie anywhere within the hatched area in Figure 20.

Control method and settings must be agreed with the electricity supply undertaking within the framework laid down by the transmission system operator.

The plant owner must compensate for the plant infrastructure’s reactive power in situations where the wind power plant is disconnected or not generating active power.
Compensation may take place in the electricity system by agreement with the electricity supply undertaking.

Figure 20 Requirements for the delivery of reactive power in relation to the active power level at $U_c$ for category D wind power plants.
Figure 21 shows in which $U_c$ area the delivery of reactive power is required for category D wind power plants.

*Figure 21 Requirements for the delivery of reactive power in relation to $U_c$ for category D wind power plants.*
6. Protection

6.1 General
The purpose of the wind power plant’s protective functions is to protect the wind power plant and to ensure a stable public electricity supply grid.

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

- is protected against damage due to faults and incidents in the public electricity supply grid
- is protected against damage due to out-of-phase reclosing
- is protected against disconnections in non-critical situations for the wind power 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 wind power plant being exposed to impacts outside of the design requirements, as specified in section 3, from the public electricity supply grid.

After a wind power plant has been disconnected due to a fault in the public electricity supply grid, the wind power 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 wind power plant which was 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 that are necessary to determine the wind power plant’s protective functions.

6.2 Protective setting requirements
The wind power plant’s protective functions and associated settings must be as specified in the following subsections. Settings that deviate from the stated setting values, in the event of, for example, problems with local overvoltages, may only be used with the electricity supply undertaking’s permission.

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

The wind power plant must be disconnected or shut down if a measuring signal deviates more from its nominal value than the setting.

The trip time stated is the measuring period during which the trip condition must constantly be fulfilled 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.

Recording of frequency must take place simultaneously on the phases used.

The wind power plant must not disconnect at a transitory phase jump of up to 20° in the Point of Connection.

### 6.2.1 Category A2 wind power plants

Protective functions with associated operating settings and trip times must be as shown in the table below.

<table>
<thead>
<tr>
<th>Protective function</th>
<th>Symbol</th>
<th>Setting</th>
<th>Trip time</th>
<th>Standard value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overvoltage (step 2)</td>
<td>U&gt;&gt;</td>
<td>1.15 \cdot U_n</td>
<td>200 ms</td>
<td>200 ms</td>
</tr>
<tr>
<td>Overvoltage (step 1)</td>
<td>U&gt;</td>
<td>1.10 \cdot U_n</td>
<td>60 s</td>
<td>60 s</td>
</tr>
<tr>
<td>Undervoltage (step 1)</td>
<td>U&lt;</td>
<td>0.85 \cdot U_n</td>
<td>10...60 s</td>
<td>50 s</td>
</tr>
<tr>
<td>Undervoltage (step 2) ***</td>
<td>U&lt;&lt;</td>
<td>0.80 \cdot U_n</td>
<td>100...200 ms</td>
<td>100 ms</td>
</tr>
<tr>
<td>Overfrequency</td>
<td>f&gt;</td>
<td>52.0 Hz</td>
<td>200 ms</td>
<td>200 ms</td>
</tr>
<tr>
<td>Underfrequency</td>
<td>f&lt;</td>
<td>47.0 Hz</td>
<td>200 ms</td>
<td>200 ms</td>
</tr>
<tr>
<td>Change of frequency ***</td>
<td>df/dt</td>
<td>\pm 2.5 Hz/s</td>
<td>50...100 ms</td>
<td>80 ms</td>
</tr>
</tbody>
</table>

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

*Table 17 Requirements for category A2 wind power plants.*

### 6.2.2 Category B wind power plants

Protective functions with associated operating settings and trip times must be as shown in the table below.

<table>
<thead>
<tr>
<th>Protective function</th>
<th>Symbol</th>
<th>Setting</th>
<th>Trip time</th>
<th>Standard value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overvoltage (step 2)</td>
<td>U&gt;&gt;</td>
<td>1.15 \cdot U_n</td>
<td>200 ms</td>
<td>200 ms</td>
</tr>
<tr>
<td>Overvoltage (step 1)</td>
<td>U&gt;</td>
<td>1.10 \cdot U_n</td>
<td>60 s</td>
<td>60 s</td>
</tr>
<tr>
<td>Undervoltage (step 1)</td>
<td>U&lt;</td>
<td>0.90 \cdot U_n</td>
<td>10...60 s</td>
<td>10 s</td>
</tr>
<tr>
<td>Overfrequency</td>
<td>f&gt;</td>
<td>52 Hz</td>
<td>200 ms</td>
<td>200 ms</td>
</tr>
<tr>
<td>Underfrequency</td>
<td>f&lt;</td>
<td>47 Hz</td>
<td>200 ms</td>
<td>200 ms</td>
</tr>
<tr>
<td>Change of frequency</td>
<td>df/dt</td>
<td>\pm 2.5 Hz/s</td>
<td>50...100 ms</td>
<td>80 ms</td>
</tr>
</tbody>
</table>

*Table 18 Requirements for category B wind power plants.*
6.2.3 Category C wind power plants
Protective functions with associated operating settings and trip times must be as shown in the table below.

<table>
<thead>
<tr>
<th>Protective function</th>
<th>Symbol</th>
<th>Setting</th>
<th>Trip time</th>
<th>Standard value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overvoltage (step 3)</td>
<td>( U_{\gg} )</td>
<td>1.20 ( \cdot U_n ) V</td>
<td>0...100 ms</td>
<td>100 ms</td>
</tr>
<tr>
<td>Overvoltage (step 2)</td>
<td>( U_{\gg} )</td>
<td>1.15 ( \cdot U_n ) V</td>
<td>100...200 ms</td>
<td>200 ms</td>
</tr>
<tr>
<td>Overvoltage (step 1)</td>
<td>( U_{&gt;^\circ} )</td>
<td>1.10 ( \cdot U_n ) V</td>
<td>60 s</td>
<td>60 s</td>
</tr>
<tr>
<td>Undervoltage (step 1)</td>
<td>( U_{&lt;} )</td>
<td>0.90 ( \cdot U_n ) V</td>
<td>10...60 s</td>
<td>10 s</td>
</tr>
<tr>
<td>Overfrequency</td>
<td>( f_{&gt;^\circ} )</td>
<td>52 Hz</td>
<td>200 ms</td>
<td>200 ms</td>
</tr>
<tr>
<td>Underfrequency</td>
<td>( f_{&lt;} )</td>
<td>47 Hz</td>
<td>200 ms</td>
<td>200 ms</td>
</tr>
<tr>
<td>Change of frequency</td>
<td>( df/dt )</td>
<td>±2.5 Hz/s</td>
<td>50...100 ms</td>
<td>80 ms</td>
</tr>
</tbody>
</table>

Table 19 Requirements for category C wind power plants.

6.2.4 Category D wind power plants
Protective functions with associated operating settings and trip time must be as shown in the table below.

<table>
<thead>
<tr>
<th>Protective function</th>
<th>Symbol</th>
<th>Setting</th>
<th>Trip time</th>
<th>Standard value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overvoltage (step 3)</td>
<td>( U_{\gg} )</td>
<td>1.20 ( \cdot U_n ) V</td>
<td>0...100 ms</td>
<td>100 ms</td>
</tr>
<tr>
<td>Overvoltage (step 2)</td>
<td>( U_{\gg} )</td>
<td>1.15 ( \cdot U_n ) V</td>
<td>100...200 ms</td>
<td>200 ms</td>
</tr>
<tr>
<td>Overvoltage (step 1)</td>
<td>( U_{&gt;^\circ} )</td>
<td>1.10 ( \cdot U_n ) V</td>
<td>60 s</td>
<td>60 s</td>
</tr>
<tr>
<td>Undervoltage (step 1)</td>
<td>( U_{&lt;} )</td>
<td>0.90 ( \cdot U_n ) V</td>
<td>10...60 s</td>
<td>10 s</td>
</tr>
<tr>
<td>Overfrequency</td>
<td>( f_{&gt;^\circ} )</td>
<td>52 Hz</td>
<td>200 ms</td>
<td>200 ms</td>
</tr>
<tr>
<td>Underfrequency</td>
<td>( f_{&lt;} )</td>
<td>47 Hz</td>
<td>200 ms</td>
<td>200 ms</td>
</tr>
<tr>
<td>Change of frequency</td>
<td>( df/dt )</td>
<td>±2.5 Hz/s</td>
<td>50...100 ms</td>
<td>80 ms</td>
</tr>
</tbody>
</table>

Table 20 Requirements for category D wind power plants.
7. Exchange of signals and data communication

7.1 Data communication requirements
To ensure the operation of the public electricity supply grid, the plant must be prepared for data communication between the wind turbine operator and the transmission system operator as well as the electricity supply undertaking in the plant's communication interface in line with this regulation.

7.1.1 Category A2 wind power plants
Category A2 wind power plants must be prepared to receive an external start signal ('released for start') and an external stop signal. The external signals are expected to be pulse signals.

This requirement is regarded as having been met if the normal stop circuit can be controlled by the external stop signal and the 'released for start' signal via a terminal strip.

7.1.2 Category B wind power plants
Category B wind power plants must be prepared to receive an external start signal ('released for start') and an external stop signal.

These signals must be accessible via a terminal strip or in the PCOM interface via commands as specified in section 7.2.

7.1.3 Category C and D wind power plants
Category C and D wind power plants must be capable of exchanging the information in the PCOM interface specified in sections 7.2.3 and 7.2.4.

Signals must be accessible in the PCOM interface via commands as specified in section 7.2.

It must be possible to obtain correct measurements and maintain data communication in all situations, including when wind power plants are 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 wind power 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 10 ms accuracy and 1 ms precision or higher.

7.2 Data communication
Information for a wind power plant must be referred to, modelled and grouped as specified in the IEC 61400-25 standard series, IEC 61400-25-1 [ref. 14], IEC 61400-25-2 [ref. 15] and IEC 61400-25-3 [ref. 16].
For a wind power plant, information exchange must be implemented with a protocol stack as specified in IEC 61400-25-4 [ref. 17] and IEC 60870-5-104 [ref. 8].

The protocol stack must be configured so that the wind power plant as a minimum can communicate with two master units.

The final solution must be agreed with the transmission system operator.

Data communication with the plant must be available to the transmission system operator and the electricity supply undertaking in the plant’s communication interface referred to as PCOM as shown in Figure 3.

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

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. 19].

The specific requirements for the amount of information and signals are specified in the following sections for the individual plant categories.

### 7.2.1 Category A2 wind power plants

No online communication is required for category A2 wind power plants.

Wind power plants in this category must as a minimum be able to exchange the following signals:

<table>
<thead>
<tr>
<th>Signal #</th>
<th>Signal description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1.1</td>
<td>Stop signal</td>
</tr>
<tr>
<td>A1.2</td>
<td>Holding signal – 'Released for start'</td>
</tr>
</tbody>
</table>

*Table 21 Requirements for information exchange with a category A2 wind power plant.*

The requirements are regarded as having been complied with if the normal stop circuit can be controlled by the external signals (A1.1 and A1.2) via a terminal strip.

As a minimum, it must be possible to activate/deactivate and configure parameters for the frequency response function as well as the active and reactive power control functions via a control panel, relay switches or external signals. Parameters are listed in table below.

<table>
<thead>
<tr>
<th>Signal #</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1.3</td>
<td>Active power control – ramp rate constraint</td>
</tr>
<tr>
<td>A1.4</td>
<td>Active power control – ramp rate for upward regulation of active power</td>
</tr>
<tr>
<td>A1.5</td>
<td>Active power control – ramp rate for downward regulation of active power</td>
</tr>
<tr>
<td>A1.6</td>
<td>Active power control – absolute power constraint</td>
</tr>
</tbody>
</table>

*Table 22 Requirements for activation and configuration of frequency response function and power control functions.*
TR 3.2.5 for wind power plants above 11 kW  Exchange of signals and data communication

A1.7  Active power control – desired maximum active power
A1.8  Reactive power control – Q control
A1.9  Reactive power control – Power Factor control
A1.10 Reactive power control – automatic Power Factor control
A1.11 Frequency response – droop for downward regulation from \( f_R \)
A1.12 Frequency response – initial frequency for frequency response – \( f_R \)

Table 22 Requirements for control function parameters – A2.

7.2.2 Category B wind power plants
Online communication is required for category B wind power plants.

Wind power plants in this category must as a minimum be able to exchange the following signals in accordance with the specifications in section 7.2:

<table>
<thead>
<tr>
<th>Signal #</th>
<th>Signal description</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1.1</td>
<td>Switch gear status in the plant’s Point of Connection</td>
</tr>
<tr>
<td>B1.2</td>
<td>Active power kW – measured in the Point of Connection</td>
</tr>
<tr>
<td>B1.3</td>
<td>Active power kW – set point for active power</td>
</tr>
<tr>
<td>B1.4</td>
<td>Reactive power MVar – measured in the Point of Connection</td>
</tr>
<tr>
<td>B1.5</td>
<td>Stop signal</td>
</tr>
<tr>
<td>B1.6</td>
<td>Holding signal – 'Released for start'</td>
</tr>
</tbody>
</table>

Table 23 Requirements for information exchange with a category B wind power plant.

As a minimum, it must be possible to activate/deactivate and configure parameters for the frequency response function as well as the active and reactive power control functions via a control panel or external signals. Parameters are listed in table below.

<table>
<thead>
<tr>
<th>Signal #</th>
<th>Signal description</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1.7</td>
<td>Active power control – ramp rate constraint</td>
</tr>
<tr>
<td>B1.8</td>
<td>Active power control – ramp rate for upward regulation of active power</td>
</tr>
<tr>
<td>B1.9</td>
<td>Active power control – ramp rate for downward regulation of active power</td>
</tr>
<tr>
<td>B1.10</td>
<td>Active power control – absolute power constraint</td>
</tr>
<tr>
<td>B1.11</td>
<td>Active power control – desired maximum active power</td>
</tr>
<tr>
<td>B1.12</td>
<td>Reactive power control – Q control</td>
</tr>
<tr>
<td>B1.13</td>
<td>Reactive power control – Power Factor control</td>
</tr>
<tr>
<td>B1.14</td>
<td>Frequency response – droop for downward regulation from ( f_R )</td>
</tr>
<tr>
<td>B1.15</td>
<td>Frequency response – initial frequency for frequency response – ( f_R )</td>
</tr>
</tbody>
</table>

Table 24 Requirements for control function parameters – B.

7.2.3 Category C wind power plants
Online communication is required for category C wind power plants.
wind power plants in this category must as a minimum be able to exchange the following signals in accordance with the specifications in section 7.2:

<table>
<thead>
<tr>
<th>Signal #</th>
<th>Signal description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1.1</td>
<td>Switch gear status in the Point of Connection</td>
</tr>
<tr>
<td>C1.2</td>
<td>Active power kW – measured in the Point of Connection</td>
</tr>
<tr>
<td>C1.3</td>
<td>Active power control – ramp rate constraint</td>
</tr>
<tr>
<td>C1.4</td>
<td>Active power control – ramp rate for upward regulation of active power</td>
</tr>
<tr>
<td>C1.5</td>
<td>Active power control – ramp rate for downward regulation of active power</td>
</tr>
<tr>
<td>C1.6</td>
<td>Active power control – absolute power constraint</td>
</tr>
<tr>
<td>C1.7</td>
<td>Active power control – desired maximum active power</td>
</tr>
<tr>
<td>C1.8</td>
<td>Active power control – delta power constraint</td>
</tr>
<tr>
<td>C1.9</td>
<td>Active power control – desired regulating reserve – ( P_{\delta} )</td>
</tr>
<tr>
<td>C1.10</td>
<td>Reactive power MVAr – measured in the Point of Connection</td>
</tr>
<tr>
<td>C1.11</td>
<td>Power factor – calculated on the basis of measurements in the Point of Connection</td>
</tr>
<tr>
<td>C1.12</td>
<td>Power factor set point – desired Power Factor in the Point of Connection</td>
</tr>
<tr>
<td>C1.13</td>
<td>Reactive power control – activated/deactivated</td>
</tr>
<tr>
<td>C1.14</td>
<td>Reactive power control – desired reactive power in the Point of Connection</td>
</tr>
<tr>
<td>C1.15</td>
<td>Voltage – voltage measured in the voltage reference point</td>
</tr>
<tr>
<td>C1.16</td>
<td>System protection</td>
</tr>
<tr>
<td>C1.17</td>
<td>Stop signal</td>
</tr>
<tr>
<td>C1.18</td>
<td>Holding signal – 'Released for start'</td>
</tr>
<tr>
<td>C1.19</td>
<td>Overspeed protection – activated/deactivated</td>
</tr>
</tbody>
</table>

Table 25 Requirements for information exchange with a category C wind power plant.

A more detailed description of the signals can be found in 'Guidelines on signal list – TR 3.2.5' [ref. 45] which is available electronically at [www.energinet.dk](http://www.energinet.dk).

To ensure the security of supply, the transmission system operator must at all times be able to activate or deactivate the required control functions, also by using set points and activation commands to change current function settings.

7.2.4 Category D wind power plants

Online communication is required for category D wind power plants.

wind power plants in this category must as a minimum be able to exchange the following signals in accordance with the specifications in section 7.2:

<table>
<thead>
<tr>
<th>Signal #</th>
<th>Signal description</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1.1</td>
<td>Switch gear status in the Point of Connection</td>
</tr>
<tr>
<td>D1.2</td>
<td>Active power kW – measured in the Point of Connection</td>
</tr>
<tr>
<td>D1.3</td>
<td>Active power control – ramp rate constraint</td>
</tr>
<tr>
<td>D1.4</td>
<td>Active power control – ramp rate for upward regulation of active power</td>
</tr>
<tr>
<td>D1.5</td>
<td>Active power control – ramp rate for downward regulation of active power</td>
</tr>
<tr>
<td>D1.6</td>
<td>Active power control – absolute power constraint</td>
</tr>
<tr>
<td>D1.7</td>
<td>Active power control – desired maximum active power</td>
</tr>
</tbody>
</table>
### Table 26 Requirements for information exchange with a category D wind power plant.

A more detailed description of the signals can be found in 'Guidelines on signal list – TR 3.2.5' [ref. 45] which is available electronically at [www.energinet.dk](http://www.energinet.dk).

In order to ensure the security of supply, the transmission system operator must at all times be able to activate or deactivate the required control functions, also by using set points and activation commands to change the current function settings.
7.3 Fault incident recording

The requirements for recording fault incidents in the public electricity supply grid apply to category D wind power plants.

Logging must be performed using electronic equipment that as a minimum can be configured 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 capable of recording as a minimum:

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

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 wind power plant.

All measurements and data to be collected in accordance with Technical regulation 5.8.1 [ref. 19] 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 of incidents and data must refer to UTC with a 10 ms accuracy 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 and the transmission system operator must be granted access to logged and relevant recorded information in COMTRADE format [ref. 43].

7.4 Requesting metered data and documentation

The requirements in this section apply to category D wind power plants.

The electricity supply undertaking and the transmission system operator are entitled to request relevant information about a wind power plant at any time. Expenses relating to such requests must be paid by the plant owner.

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

At any time, the electricity supply undertaking and the transmission system operator are entitled to request that a wind power plant verify and document its
compliance with the provisions of this regulation. Such request 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 wind power 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 wind power plant complies with the provisions of this regulation.

The standard procedure regarding the approval and issue of a final grid connection permit for a wind power plant is as follows:

1. Appendix 1 must be completed and submitted electronically to the electricity supply undertaking.

2. The electricity supply undertaking reviews and approves the documentation and determines whether any information is missing.

3. Once the documentation has been approved, a final grid connection permit can be issued.

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

<table>
<thead>
<tr>
<th>Category</th>
<th>A2**</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protective functions</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Single-line representation</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Power quality</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Voltage dip</td>
<td>-</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>PQ diagram</td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Signal list</td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Dynamic simulation model</td>
<td>-</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Verification report</td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

X: Documentation must be submitted.
**) May be included on the positive list.

Table 27 Documentation requirements for all plant categories.
8.1.1 Protective functions
Documentation of protective functions is a list of the relay configurations applicable at the time of commissioning. These values must be stated in the documentation.

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

8.1.3 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. The document 'Guidelines on the calculation of power quality parameters – TR 3.2.5' [ref. 44] contains examples and guidance on how the individual power quality parameters can be calculated.

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

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

8.1.6 Signal list
The signal list is a list of the signals/information that needs to be exchanged between the parties that control and monitor a plant. Documentation proving that the signals specified in section 7.1 are present in the PCOM interface must be supplied as part of the verification report. The document 'Guidelines on signal list – TR 3.3.2' [ref. 45] contains a detailed description of the individual signals.

8.1.7 Dynamic simulation model
A 'dynamic simulation model' is a model of a plant's electrical properties and constraints. The electrical simulation model must comply with the requirements specified in section 9.1.

8.1.8 Verification report
A 'verification report' is a report on/documentation of completed tests, demonstrating that the required functions, see section 5, have been implemented and work as intended with the configured parameters. The document 'Guidelines on verification reports – TR 3.2.5' [ref. 46] may be used for inspiration.
8.2 Documentation requirements – category A2 wind power plants

The documentation requirements for plant category A2 are divided into the following two sections.

8.2.1 Documentation for plants not included on the positive list

If the 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 that answers given in Appendix 1 (B1.1.) are correct.

8.2.2 Documentation for plants included on the positive list

The supplier of a plant will often have had the plant components used added to the positive list, making the technical processing easier.

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

Appendix 1 (B1.2.), duly completed.

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

To request that a plant or plant components be included on the positive list, the following documentation must be submitted to positivlister@danskenergi.dk:

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

1. CE declaration of conformity
2. Technical documentation proving that answers given in Appendix 1 (B1.1.) are correct.

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

8.4 Documentation requirements – category B wind power plants

The following documentation is required for the plant:

   a. Protective functions
   b. Single-line representation
   c. Power quality
   d. Voltage dip
   e. Dynamic simulation model.

Appendix for the documentation can be found in section B1.3.
8.5 Documentation requirements – category C wind power plants

The documentation to be provided must be in the form of preliminary data for the wind power plant which must be sent to the electricity supply undertaking no later than three months before the date of commissioning.

The documentation must be filled in with specific data for the entire wind power plant and sent to the electricity supply undertaking no later than three months after the date of commissioning. The required documentation comprises the following:

a. Protective functions
b. Single-line representation
c. Power quality
d. Voltage dip
e. PQ diagram
f. Signal list
g. Dynamic simulation model
h. Verification report.

Appendix for the documentation can be found in section B1.4.

8.6 Documentation requirements – category D wind power plants

The documentation to be provided must be in the form of preliminary data for the wind power plant which must be sent to the electricity supply undertaking no later than three months before the date of commissioning.

The documentation must be filled in with specific data for the entire wind power plant and sent to the electricity supply undertaking no later than three months after the date of commissioning. The required documentation comprises the following:

a. Protective functions
b. Single-line representation
c. Power quality
d. Voltage dip
e. PQ diagram
f. Signal list
g. Dynamic simulation model
h. Verification report.

Appendix for the documentation can be found in section B1.5.
9. Electrical simulation model

The requirements in this section apply to all category B, C and D wind power plants.

For the purposes of analysing the public electricity supply grid, the transmission system operator regularly maintains and expands the simulation models as new wind power plants are connected to the grid.

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

From the design phase to the verification phase, the plant owner must keep the transmission system operator informed if the preliminary data can no longer be regarded as being indicative of the finally commissioned wind power plant.

The plant owner must provide the transmission system operator with the simulation models specified.

In pursuance of Section 84a 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 wind turbine manufacturer to the transmission system operator.

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

9.1 Simulation model requirements

The simulation model for the entire wind power plant must dynamically describe the electrical properties seen from the public electricity supply grid.

The simulation model must be supplied in the form of block diagrams which by means of mainly logical and mathematical functions, primarily transfer functions in the Laplace/z domain, describe the properties of the wind power plant.

The simulation model must be accompanied by model descriptions which as a minimum comprise function descriptions of the main elements of the model and detailed descriptions of the individual model components and associated model parameters.

A simulation model consisting of compiled code is acceptable provided the source code is included.

A simulation model with encrypted parts will not be accepted, as the transmission system operator needs to be able to include the plant model in the modelling of the public electricity supply grid.

The simulation model must comprise all control functions as required in section 5.
The simulation model must 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.

It must be possible to use the simulation model to simulate RMS values in the synchronous system (positive sequence).

It must be possible to use the simulation model to simulate RSM values in the individual phases during asymmetrical incidents and faults in the public electricity supply grid.

As a minimum, it must be possible to use the simulation model in the 47-53 Hz frequency range and in the 0.0 to 1.4 pu voltage range.

The simulation model must be able to describe the dynamic reply from a wind power plant for at least 30 seconds after any incident and fault in the public electricity supply grid.

It must be possible to initialise the simulation model directly on the basis of a load-flow solution without subsequent iterations.

The simulation model must be numerically stable and capable of utilising numerical equation solvers with variable sample lengths.

9.2 Verification of simulation model

If the model is not verified by an accredited institute, the plant owner must no later than three months after final commissioning of the wind power plant submit measurements that the transmission system operator can use to verify the simulation model for the entire plant.

The simulation model for the entire wind power plant must be verified for all control types as required in section 5.

The practical performance of verification tests must be determined no later than three months before the final commissioning of the wind power plant on the basis of the plant owner's proposal and in collaboration with the transmission system operator.

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

Measurements used to verify the simulation model for the entire wind power plant must be documented by the plant owner in a report containing detailed descriptions of each individual test.

The time-series measurements used to verify the simulation model must be enclosed with the verification report in COMTRADE format [ref. 43].

9.3 Simulation model requirements – category A2 wind power plants

No simulation model is required for category A2 wind turbines or wind power plants.
9.4 Simulation model requirements – category B wind power plants
The transmission system operator needs to be able to develop a dynamic simulation model for the public electricity supply grid, and to this end, the transmission system operator needs to know the simulation model for the wind turbines used.

The plant owner must submit a simulation model for the wind turbines used no later than three months after commissioning.

9.5 Simulation model requirements – category C wind power plants
The transmission system operator requires a dynamic simulation model for the entire wind power plant.

The plant owner must submit a simulation model for the entire wind power plant, including the wind power plant controller, if any, no later than three months after commissioning.

The content and level of detail of the simulation models for the wind power plant controller and the individual wind turbines 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 plant infrastructure data upon request.

9.6 Simulation model requirements – category D wind power plants
The transmission system operator requires a dynamic simulation model for the entire wind power plant.

The plant owner must submit a simulation model for the entire wind power plant, including the wind power plant controller and plant infrastructure no later than three months after commissioning.

The content and level of detail of the simulation models for the wind power plant controller and the individual wind turbines 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 scope and level of detail of data for components and parts that form part of the plant infrastructure must also enable the construction of a single fully operational simulation model as required in section 9.1.

The simulation model must be verified as specified in section 9.2.
Appendix 1 Documentation

Appendix 1 specifies the documentation requirements for the four plant categories, see section 1.2.21.

The documentation (see the specifications in section 8) must be sent electronically to the electricity supply undertaking.

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

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

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

A template for Appendix 1 for the different plant categories is available on the website www.energinet.dk.
B1.1. Appendix 1 for plant category A2 not included on the positive list

Please fill in the documentation form with data for the wind power plant at the time of commissioning and send it to the electricity supply undertaking.

### B1.1.1. Identification

<table>
<thead>
<tr>
<th>Plant</th>
<th>Description of the plant:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GSRN number</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plant owner name and address</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plant owner tel. no.</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plant owner e-mail</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type/model</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Voltage (nominal)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rated power (data sheet)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### B1.1.2. Power quality

Please state how each power quality parameter result was achieved.

### B1.1.2.1. Voltage changes

Are the voltage changes for the entire wind power plant below the limit value?

Yes [ ]
No [ ]

Where to find documentation that this requirement has been met?
### B1.1.2.2. DC content

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the DC content at normal operation exceed 0.5% of the rated current?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Where to find documentation that this requirement has been met?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### B1.1.2.3. Asymmetry

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the asymmetry at normal operation and during faults exceed 16A?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Where to find documentation that this requirement has been met?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In case of a wind power plant made up of single-phase electricity-generating units, have you taken measures to ensure that the above limit is not exceeded?

Where to find documentation that this requirement has been met?

### B1.1.2.4. Flicker

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the flicker contribution for the entire wind power plant below the limit value?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Where to find documentation that this requirement has been met?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### B1.1.2.5. Harmonic distortions

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are all the harmonic distortions for the entire wind power plant below the limit values?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Where to find documentation that this requirement has been met?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### B1.1.3. Connection and synchronisation

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can the wind power plant be started and generate power continuously within the normal production range limited only by the protective settings?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Where to find documentation that this requirement has been met?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do connection and synchronisation occur three minutes, at the earliest, after voltage and frequency have come within the normal production range?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Where to find documentation that these requirements have been met?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### B1.1.4. Active power control at overfrequency

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the wind power plant equipped with a frequency response function?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the function activated?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Where to find documentation that these requirements have been met?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### B1.1.5. Absolute power constraint function

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the wind power plant equipped with an absolute power constraint function?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the function activated?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Where to find documentation that these requirements have been met?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
B1.1.6. **Ramp rate constraint function**

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the wind power plant equipped with a ramp rate constraint function?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the function activated?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Where to find documentation that these requirements have been met?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

B1.1.7. **Reactive power control**

<table>
<thead>
<tr>
<th>Reactive power can be controlled by means of</th>
<th>Q control</th>
<th>Power factor control</th>
<th>Voltage control</th>
</tr>
</thead>
</table>

B1.1.8. **Q control**

<table>
<thead>
<tr>
<th>Is the control function activated with a set point of _____ VAr?</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Value may not differ from 0 VAr unless agreed with the electricity supply undertaking).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Where to find documentation that this requirement has been met?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

B1.1.9. **Power factor control**

<table>
<thead>
<tr>
<th>Is the control function deactivated?</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where to find documentation that this requirement has been met?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

B1.1.10. **Voltage control**

<table>
<thead>
<tr>
<th>Is the control function deactivated?</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where to find documentation that this requirement has been met?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
B1.1.11. Protection against electricity system faults

B1.1.11.1. Relay settings
Please state current values at the time of commissioning in the table below.

<table>
<thead>
<tr>
<th>Protective function</th>
<th>Symbol</th>
<th>Setting</th>
<th>Trip time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overvoltage (step 2)</td>
<td>$U_{&gt;&gt;}$</td>
<td>V</td>
<td>ms</td>
</tr>
<tr>
<td>Overvoltage (step 1)</td>
<td>$U_&gt;$</td>
<td>V</td>
<td>s</td>
</tr>
<tr>
<td>Undervoltage (step 1)</td>
<td>$U_&lt;$</td>
<td>V</td>
<td>s</td>
</tr>
<tr>
<td>Undervoltage (step 2)</td>
<td>$U_{&lt;&lt;}$</td>
<td>V</td>
<td>ms</td>
</tr>
<tr>
<td>Overfrequency</td>
<td>$f_&gt;$</td>
<td>Hz</td>
<td>ms</td>
</tr>
<tr>
<td>Underfrequency</td>
<td>$f_&lt;$</td>
<td>Hz</td>
<td>ms</td>
</tr>
<tr>
<td>Change of frequency</td>
<td>$df/dt$</td>
<td>Hz/s</td>
<td>ms</td>
</tr>
</tbody>
</table>

B1.1.12. Signature

<table>
<thead>
<tr>
<th>Date of commissioning</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Company</td>
<td></td>
</tr>
<tr>
<td>Person responsible for</td>
<td></td>
</tr>
<tr>
<td>commissioning</td>
<td></td>
</tr>
<tr>
<td>Signature</td>
<td></td>
</tr>
</tbody>
</table>
B1.2. **Appendix 1 for plant category A2 included on the positive list**

Please fill in the documentation form with data for the wind power plant at the time of commissioning and send it to the electricity supply undertaking.

### B1.2.1. Identification

<table>
<thead>
<tr>
<th>Plant</th>
<th>Description of the plant:</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSRN number</td>
<td></td>
</tr>
<tr>
<td>Plant owner name and address</td>
<td></td>
</tr>
<tr>
<td>Plant owner tel. no.</td>
<td></td>
</tr>
<tr>
<td>Plant owner e-mail</td>
<td></td>
</tr>
<tr>
<td>Type/model</td>
<td></td>
</tr>
<tr>
<td>Voltage (nominal)</td>
<td></td>
</tr>
<tr>
<td>Rated power (data sheet)</td>
<td></td>
</tr>
</tbody>
</table>

### B1.2.2. Active power control at overfrequency

| Is the wind power plant equipped with a frequency response function? | Yes □ No □ |
| Is the function activated? | Yes □ No □ |

### B1.2.3. Absolute power constraint function

| Is the wind power plant equipped with an absolute power constraint function? | Yes □ No □ |
| Is the function activated? | Yes □ No □ |
B1.2.4. Reactive power control

Reactive power can be controlled by means of

- Q control □
- Power factor control □
- Voltage control □

B1.2.5. Q control

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 □

B1.2.6. Power factor control

Is the control function deactivated?

Yes □
No □

B1.2.7. Voltage control

Is the control function deactivated?

Yes □
No □

B1.2.8. Protection against electricity system faults

B1.2.8.1. Relay settings

Please state current values at the time of commissioning in the table below.

<table>
<thead>
<tr>
<th>Protective function</th>
<th>Symbol</th>
<th>Setting</th>
<th>Trip time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overvoltage (step 2)</td>
<td>U_{&gt;&gt;}</td>
<td>V</td>
<td>ms</td>
</tr>
<tr>
<td>Overvoltage (step 1)</td>
<td>U_{&gt;}</td>
<td>V</td>
<td>s</td>
</tr>
<tr>
<td>Undervoltage (step 1)</td>
<td>U_{&lt;}</td>
<td>V</td>
<td>s</td>
</tr>
<tr>
<td>Undervoltage (step 2)</td>
<td>U_{&lt;&lt;}</td>
<td>V</td>
<td>ms</td>
</tr>
<tr>
<td>Overfrequency</td>
<td>f_{o}</td>
<td>Hz</td>
<td>ms</td>
</tr>
<tr>
<td>Underfrequency</td>
<td>f_{&lt;}</td>
<td>Hz</td>
<td>ms</td>
</tr>
<tr>
<td>Change of frequency</td>
<td>df/dt</td>
<td>Hz/s</td>
<td>ms</td>
</tr>
</tbody>
</table>
### B1.2.9. Signature

<table>
<thead>
<tr>
<th>Date of commissioning</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Company</td>
<td></td>
</tr>
<tr>
<td>Person responsible for commissioning</td>
<td></td>
</tr>
<tr>
<td>Signature</td>
<td></td>
</tr>
</tbody>
</table>
B1.3. **Appendix 1 for plant category B**

Please fill in the documentation form with data for the *wind power plant* at the time of commissioning and send it to the electricity *supply undertaking*.

### B1.3.1. Identification

<table>
<thead>
<tr>
<th>Plant</th>
<th>Description of the plant:</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSRN number</td>
<td></td>
</tr>
<tr>
<td><em>Plant owner</em> name and address</td>
<td></td>
</tr>
<tr>
<td><em>Plant owner</em> tel. no.</td>
<td></td>
</tr>
<tr>
<td><em>Plant owner</em> e-mail</td>
<td></td>
</tr>
<tr>
<td>Type/model</td>
<td></td>
</tr>
<tr>
<td>Voltage (nominal)</td>
<td></td>
</tr>
<tr>
<td>Rated power (data sheet)</td>
<td></td>
</tr>
</tbody>
</table>

### B1.3.2. Voltage dip tolerances

<table>
<thead>
<tr>
<th>Will the <em>wind power plant</em> remain connected to the <em>public electricity supply grid</em> during voltage dips as specified in section 3.3.1 of TR 3.2.5?</th>
<th>Yes ☐ No ☐</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is a simulation enclosed, documenting that the Low Voltage Fault Ride Through (LVFRT) requirements have been met?</td>
<td>Yes ☐ No ☐</td>
</tr>
<tr>
<td>If No, how is compliance then documented?</td>
<td></td>
</tr>
</tbody>
</table>
### B1.3.3. Voltage quality

Please state how each power quality parameter result was achieved.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Calculation</th>
<th>Measurement</th>
<th>Reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Were the values calculated?</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Were the values measured?</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Is a report enclosed, documenting that the calculations or measurements meet emission requirements?</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>If No, how are calculations or measurements documented?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### B1.3.3.1. DC content

Does the DC content at normal operation exceed 0.5% of the rated current?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

#### B1.3.3.2. Asymmetry

Does asymmetry at normal operation and during faults exceed 16A?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

In case of a wind power plant made up of single-phase electricity-generating units, have you taken measures to ensure that the above limit is not exceeded?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

#### B1.3.3.3. Flicker

Is the flicker contribution for the entire wind power plant below the limit value?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

#### B1.3.3.4. Harmonic distortions

Are all harmonic distortions for the entire wind power plant below the limit values?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>
### B1.3.3.5. Interharmonic distortions

Are all the interharmonic distortions for the entire wind power plant below the limit values?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

### B1.3.3.6. Distortions from 2-9 kHz

Is the emission of distortions with frequencies in the 2-9 kHz range lower than 0.2% of the rated current $I_n$?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

### B1.3.4. Connection and synchronisation

Can the wind power plant be started and generate power continuously within the normal production range limited only by the protective settings?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

Do connection and synchronisation occur three minutes, at the earliest, after voltage and frequency have come within the normal production range?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

### B1.3.5. Active power control at overfrequency

Is the wind power plant equipped with a frequency response function?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

### B1.3.6. Absolute power constraint function

Is the wind power plant equipped with an absolute power constraint function?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

Is the function activated?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>
**B1.3.7. Ramp rate constraint function**

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the wind power plant equipped with a ramp rate constraint function?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Is the function activated?</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

**B1.3.8. Reactive power control**

<table>
<thead>
<tr>
<th>Reactive power can be controlled by means of</th>
<th>Q control</th>
<th>Power factor control</th>
<th>Voltage control</th>
</tr>
</thead>
</table>

**B1.3.9. Q control**

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the control function activated with a set point of _____ VAr?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>(Value may not differ from 0 VAr unless agreed with the electricity supply undertaking).</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**B1.3.10. Power factor control**

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the control function deactivated?</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

**B1.3.11. Voltage control**

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the control function deactivated?</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
B1.3.12. Protection against electricity system faults

B1.3.12.1. Relay settings
Please state current values at the time of commissioning in the table below.

<table>
<thead>
<tr>
<th>Protective function</th>
<th>Symbol</th>
<th>Setting</th>
<th>Trip time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overvoltage (step 2)</td>
<td>U_{&gt;&gt;}</td>
<td>V</td>
<td>ms</td>
</tr>
<tr>
<td>Overvoltage (step 1)</td>
<td>U_&lt;&gt;</td>
<td>V</td>
<td>s</td>
</tr>
<tr>
<td>Undervoltage (step 1)</td>
<td>U_&lt;</td>
<td>V</td>
<td>s</td>
</tr>
<tr>
<td>Overfrequency</td>
<td>f_&gt;</td>
<td>Hz</td>
<td>ms</td>
</tr>
<tr>
<td>Underfrequency</td>
<td>f_&lt;</td>
<td>Hz</td>
<td>ms</td>
</tr>
<tr>
<td>Change of frequency</td>
<td>df/dt</td>
<td>Hz/s</td>
<td>ms</td>
</tr>
</tbody>
</table>

B1.3.13. Single-line representation

Is a single-line representation for the wind power plant enclosed with the documentation?

Yes ☐ No ☐

If No, when will the final single-line representation be provided?

B1.3.14. Signature

<table>
<thead>
<tr>
<th>Date of commissioning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company</td>
</tr>
<tr>
<td>Person responsible for commissioning</td>
</tr>
<tr>
<td>Signature</td>
</tr>
</tbody>
</table>
B1.4. Appendix 1 for plant category C

Please fill in the documentation form with preliminary data for the wind power plant and send it to the electricity supply undertaking no later than three months before the date of commissioning.

Please fill in the documentation form with specific data for the entire wind power plant and send it to the electricity supply undertaking no later than three months after the date of commissioning.

The required documentation comprises the following:

<table>
<thead>
<tr>
<th>B1.4.1. Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plant</strong></td>
</tr>
<tr>
<td>GSRN number</td>
</tr>
<tr>
<td><strong>Plant owner</strong> name and address</td>
</tr>
<tr>
<td><strong>Plant owner</strong> tel. no.</td>
</tr>
<tr>
<td><strong>Plant owner</strong> e-mail</td>
</tr>
<tr>
<td>Type/model</td>
</tr>
<tr>
<td>Voltage (nominal)</td>
</tr>
<tr>
<td>Rated power (data sheet)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B1.4.2. Voltage dip tolerances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Will the wind power plant remain connected to the public electricity supply grid during voltage dips as specified in section 3.3.1? Yes ☐ No ☐</td>
</tr>
</tbody>
</table>

| Is a simulation enclosed, documenting that the Low Voltage Fault Ride Through (LVFRT) requirements have been met? Yes ☐ No ☐ |

<table>
<thead>
<tr>
<th>If No, how is compliance then documented?</th>
</tr>
</thead>
</table>
**B1.4.3. Voltage quality**

Please state how each power quality parameter result was achieved.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Calculated?</th>
<th>Measured?</th>
<th>Documentation?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

**B1.4.3.1. DC content**

Does the DC content at normal operation exceed 0.5% of rated current?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

**B1.4.3.2. Asymmetry**

Does the asymmetry at normal operation and during faults exceed 16A?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

In case of a wind power plant made up of single-phase electricity-generating units, have you taken measures to ensure that the above limit is not exceeded?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

**B1.4.3.3. Flicker**

Is the flicker contribution for the wind power plant below the limit value?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

**B1.4.3.4. Harmonic distortions**

Are all harmonic distortions for the wind power plant below the limit values?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>
### B1.4.3.5. Interharmonic distortions

Are all interharmonic distortions for the wind power plant below the limit values?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

### B1.4.3.6. Distortions from 2-9 kHz

Emission of distortions with frequencies in the 2-9 kHz range is determined by the electricity supply undertaking. Is the requirement met?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

### B1.4.4. Connection and synchronisation

Can the wind power plant be started and generate power continuously within the normal production range, limited only by the protective settings?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

Do connection and synchronisation occur three minutes, at the earliest, after voltage and frequency have come within the normal production range?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

### B1.4.5. Active power control at overfrequency

Is the wind power plant equipped with a frequency response function?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

### B1.4.6. Frequency control

Is the wind power plant equipped with a frequency control function as specified in section 5.2.2?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>
### B1.4.7. Absolute power constraint function

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the <em>wind power plant</em> equipped with an <em>absolute power constraint</em> function?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the function activated?</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

### B1.4.8. Delta power constraint function

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the <em>wind power plant</em> equipped with a <em>delta power constraint</em> function?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the function activated?</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

### B1.4.9. Ramp rate constraint function

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the <em>wind power plant</em> equipped with a <em>ramp rate constraint</em> function?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the function activated?</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

### B1.4.10. System protection

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the <em>wind power plant</em> equipped with a system protection function?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the function activated?</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

### B1.4.11. Reactive power control

<table>
<thead>
<tr>
<th>Question</th>
<th>Q control</th>
<th>Power factor control</th>
<th>Voltage control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactive power can be controlled by means of</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### B1.4.12. Q control

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the control function activated with a set point of _____ VAr? (Value may not differ from 0 VAr unless agreed with the <em>electricity supply undertaking</em>).</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
B1.4.13. Power factor control

Is the control function deactivated?

Yes ☐
No ☐

B1.4.14. Voltage control

Is the wind power plant equipped with a voltage control function as specified in section 5.3.3?

Yes ☐
No ☐

B1.4.15. Protection against electricity system faults

B1.4.15.1. Relay settings

Please state current values at the time of commissioning in the table below.

<table>
<thead>
<tr>
<th>Protective function</th>
<th>Symbol</th>
<th>Setting</th>
<th>Trip time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overvoltage (step 3)</td>
<td>U_{&gt;&gt;}</td>
<td>V</td>
<td>ms</td>
</tr>
<tr>
<td>Overvoltage (step 2)</td>
<td>U_{&gt;}</td>
<td>V</td>
<td>ms</td>
</tr>
<tr>
<td>Overvoltage (step 1)</td>
<td>U_{&gt;0}</td>
<td>V</td>
<td>s</td>
</tr>
<tr>
<td>Undervoltage (step 1)</td>
<td>U_{&lt;}</td>
<td>V</td>
<td>s</td>
</tr>
<tr>
<td>Overfrequency</td>
<td>f_{&gt;0}</td>
<td>Hz</td>
<td>ms</td>
</tr>
<tr>
<td>Underfrequency</td>
<td>f_{&lt;}</td>
<td>Hz</td>
<td>ms</td>
</tr>
<tr>
<td>Change of frequency</td>
<td>df/dt</td>
<td>Hz/s</td>
<td>ms</td>
</tr>
</tbody>
</table>

B1.4.16. Single-line representation

Is a single-line representation for the wind power plant enclosed with the documentation?

Yes ☐
No ☐

If No, when will the final single-line representation be provided?

B1.4.17. PQ diagram

Has the final PQ diagram been submitted to the electricity supply undertaking?

Yes ☐
No ☐

If No, when will the final PQ diagram be provided?
### B1.4.18. Signal list

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Has the final signal list been submitted to the <em>electricity supply undertaking</em>?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If No, when will the final signal list be provided?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### B1.4.19. Simulation model

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Has the electrical simulation model for the <em>wind power plant</em> been submitted to the <em>electricity supply undertaking</em>?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If No, when will the final simulation model be provided?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### B1.4.20. Verification report

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Has the verification report been submitted to the <em>electricity supply undertaking</em>?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If No, when will the verification report be provided?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### B1.4.21. Signature

<table>
<thead>
<tr>
<th>Date of commissioning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company</td>
</tr>
<tr>
<td>Person responsible for commissioning</td>
</tr>
<tr>
<td>Signature</td>
</tr>
</tbody>
</table>
B1.5. Appendix 1 for plant category D

Please fill in the documentation form with preliminary data for the wind power plant and send it to the electricity supply undertaking no later than three months before the date of commissioning.

Please fill in the documentation form with specific data for the entire wind power plant and send it to the electricity supply undertaking no later than three months after the date of commissioning.

The required documentation comprises the following:

B1.5.1. Identification

<table>
<thead>
<tr>
<th>Plant</th>
<th>Description of the plant:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

GSRN number

Plant owner name and address

Plant owner tel. no.

Plant owner e-mail

Type/model

Voltage (nominal)

Rated power (data sheet)

B1.5.2. Voltage dip tolerances

Will the wind power plant remain connected to the public electricity supply grid during voltage dips as specified in section 3.3.1?  
Yes ☐ No ☐

Is a simulation enclosed, documenting that the Low Voltage Fault Ride Through (LVFRT) requirements have been met?  
Yes ☐ No ☐

If No, how is compliance then documented?
### B1.5.3. Voltage quality

Please state how each power quality parameter result was achieved.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Were the values calculated?</td>
<td>☐</td>
<td>☑</td>
</tr>
<tr>
<td>Were the values measured?</td>
<td>☐</td>
<td>☑</td>
</tr>
<tr>
<td>Is a report enclosed, documenting that the calculations or measurements meet the emission requirements?</td>
<td>☐</td>
<td>☑</td>
</tr>
<tr>
<td>If No, how are the calculations or measurements documented?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### B1.5.3.1. DC content

Does the DC content at normal operation exceed 0.5% of the rated current?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>☐</td>
<td>☑</td>
</tr>
</tbody>
</table>

#### B1.5.3.2. Asymmetry

Does the asymmetry at normal operation and during faults exceed 16A?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>☐</td>
<td>☑</td>
</tr>
</tbody>
</table>

In case of a wind power plant made up of single-phase electricity-generating units, have you taken measures to ensure that the above limit is not exceeded?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>☐</td>
<td>☑</td>
</tr>
</tbody>
</table>

#### B1.5.3.3. Flicker

Is the flicker contribution for the wind power plant below the limit value?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>☐</td>
<td>☑</td>
</tr>
</tbody>
</table>

#### B1.5.3.4. Harmonic distortions

Are all harmonic distortions for the wind power plant below the limit values?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>☐</td>
<td>☑</td>
</tr>
</tbody>
</table>
### B1.5.3.5. Interharmonic distortions

Are all interharmonic distortions for the wind power plant below the limit values?  

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

### B1.5.3.6. Distortions from 2-9 kHz

Emission of distortions with frequencies in the 2-9 kHz range is determined by the electricity supply undertaking. Is the requirement met?  

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

### B1.5.4. Connection and synchronisation

Can the wind power plant be started and generate power continuously within the normal production range limited only by the protective settings?  

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

Do connection and synchronisation occur three minutes, at the earliest, after voltage and frequency have come within the normal production range?  

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

### B1.5.5. Active power control at overfrequency

Is the wind power plant equipped with a frequency response function?  

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

### B1.5.6. Frequency control

Is the wind power plant equipped with a frequency control function as specified in section 5.2.2?  

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>
### B1.5.7. Absolute power constraint function

<table>
<thead>
<tr>
<th>Is the wind power plant equipped with an absolute power constraint function?</th>
<th>Yes ☐  No ☐</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the function activated?</td>
<td>Yes ☐  No ☐</td>
</tr>
</tbody>
</table>

### B1.5.8. Delta power constraint function

<table>
<thead>
<tr>
<th>Is the wind power plant equipped with a delta power constraint function?</th>
<th>Yes ☐  No ☐</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the function activated?</td>
<td>Yes ☐  No ☐</td>
</tr>
</tbody>
</table>

### B1.5.9. Ramp rate constraint function

<table>
<thead>
<tr>
<th>Is the wind power plant equipped with a ramp rate constraint function?</th>
<th>Yes ☐  No ☐</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the function activated?</td>
<td>Yes ☐  No ☐</td>
</tr>
</tbody>
</table>

### B1.5.10. System protection

<table>
<thead>
<tr>
<th>Is the wind power plant equipped with a system protection function?</th>
<th>Yes ☐  No ☐</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the function activated?</td>
<td>Yes ☐  No ☐</td>
</tr>
</tbody>
</table>

### B1.5.11. Reactive power control

<table>
<thead>
<tr>
<th>Reactive power can be controlled by means of</th>
<th>Q control ☐</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Power factor control ☐</td>
</tr>
<tr>
<td></td>
<td>Voltage control ☐</td>
</tr>
</tbody>
</table>

### B1.5.12. Q control

<table>
<thead>
<tr>
<th>Is the control function activated with a set point of _____ VAr?</th>
<th>Yes ☐  No ☐</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Value may not differ from 0 VAr, unless agreed with the electricity supply undertaking).</td>
<td></td>
</tr>
</tbody>
</table>
B1.5.13. Power factor control

Is the control function deactivated?  
Yes ☐  No ☐

B1.5.14. Voltage control

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

B1.5.15. Protection against electricity system faults

B1.5.15.1. Relay settings

Please state current values at the time of commissioning in the table below.

<table>
<thead>
<tr>
<th>Protective function</th>
<th>Symbol</th>
<th>Setting</th>
<th>Trip time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overvoltage (step 3)</td>
<td>U₃₃₃</td>
<td>V</td>
<td>ms</td>
</tr>
<tr>
<td>Overvoltage (step 2)</td>
<td>U₃₃</td>
<td>V</td>
<td>ms</td>
</tr>
<tr>
<td>Overvoltage (step 1)</td>
<td>U₃</td>
<td>V</td>
<td>s</td>
</tr>
<tr>
<td>Undervoltage (step 1)</td>
<td>U₃₃₃</td>
<td>V</td>
<td>s</td>
</tr>
<tr>
<td>Overfrequency</td>
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<td>Hz</td>
<td>ms</td>
</tr>
<tr>
<td>Underfrequency</td>
<td>f₃₃₃</td>
<td>Hz</td>
<td>ms</td>
</tr>
<tr>
<td>Change of frequency</td>
<td>df/dt</td>
<td>Hz/s</td>
<td>ms</td>
</tr>
</tbody>
</table>

B1.5.16. Single-line representation

Is a single-line representation for the wind power plant enclosed with the documentation?  
Yes ☐  No ☐

If No, when will the final single-line representation be provided?

B1.5.17. PQ diagram

Has the final PQ diagram been submitted to the electricity supply undertaking?  
Yes ☐  No ☐

If No, when will the final PQ diagram be provided?
### B1.5.18. Signal list

Has the final signal list been submitted to the *electricity supply undertaking*?

| Yes ☐ | No ☐ |

If No, when will the final signal list be provided?

### B1.5.19. Simulation model

Has the electrical simulation model for the *wind power plant* been submitted to the *electricity supply undertaking*?

| Yes ☐ | No ☐ |

If No, when will the final simulation model be provided?

### B1.5.20. Verification report

Has the verification report been submitted to the *electricity supply undertaking*?

| Yes ☐ | No ☐ |

If No, when will the verification report be provided?

### B1.5.21. Signature

<table>
<thead>
<tr>
<th>Date of commissioning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company</td>
</tr>
<tr>
<td>Person responsible for commissioning</td>
</tr>
<tr>
<td>Signature</td>
</tr>
</tbody>
</table>