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TECHNICAL REGULATION 3.2.7 REQUIREMENTS FOR VOLTAGE QUALITY FOR GENERATION FACILITY CONNECTIONS TO THE TRANSMISSION GRID - REVISION 2

VALID FROM 29 MARCH 2019

REV.	DESCRIPTION	PREPARED BY	CHECKED	REVIEWED	APPROVED
2	PUBLISHED UK EDITION	29-03-2019	29-03-2019	29-03-2019	29-03-2019
		CFJ	FBN	ARY	JBO

Revision view

SECTION	CHANGE:	REV.	DATE
7.2 2	Swapped threshold values for *flicker* corrected and regulatory provisions updated.	2	29-03-2019
All		1	03-08-2018

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Reading instructions

This regulation includes all general and specific requirements for voltage quality for the connection of *generation facilities* to the transmission grid.

The regulation is structured as follows: Section 1 contains terminology and definitions used in the regulation.

Section 2 contains objective, scope and regulatory provisions.

Sections 3-8 contains technical and functional requirements.

This regulation is also published in Danish. If there are inconsistencies, the Danish version applies.

The regulation is published by Energinet, CVR no. 28 98 06 71, and can be downloaded from: www.energinet.dk.

1. Terminology and definitions

1.1 Definitions

This section contains the definitions used in this document.

1.1.1 Facility owner

The *facility owner* is the entity that legally owns the *generation facility*. The facility owner may hand over operational responsibility to a *generation facility operator*.

1.1.2 Plant component

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

1.1.3 Electricity supply undertaking

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

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

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

1.1.4 Power quality

General term for the quality of the voltage that exists in the transmission grid. *Power quality* is defined on the basis of a number of *voltage quality parameters*.

1.1.5 Electricity generation facility

An electricity generation unit or collection of electricity generation units that are not synchronously connected to the grid or are connected using power electronics and also have one single point of connection to a transmission system. The term "power park module" is also used synonymously with *electricity generation facility*.

1.1.6 Emission limits

Threshold values for the applicable *voltage quality parameters*.

1.1.7 Flicker

Flicker is rapid voltage fluctuations which for some types of light sources are identified by flicker being an irritant to the eye. *Flicker* is measured as described in DS/EN 61000-4-15 [1].

1.1.8 Flicker contribution

The *electricity generation facility's* contribution of *flicker* to the transmission grid.

1.1.9 Threshold value for harmonic voltage distortion contribution (LHD)

The limit set for the *harmonic voltage distortion contribution.*

1.1.10 Threshold value for interharmonic voltage distortion contribution

The limit set for the *interharmonic voltage distortion contribution.*

1.1.11 Harmonic background distortion

The *harmonic voltage distortion* present in *the point of connection* before *the electricity generation facility* is connected.

1.1.12 Harmonic emission

The *electricity generation facility* 's emission of harmonics, including the *harmonic voltage distortion* caused by harmonic voltages or currents from the *electricity generation facility* (actively introduced distortion) and the amplification of existing *harmonic background distortion* in *the point of connection* due to interaction between the unit and the transmission grid's *harmonic grid impedance* (passively introduced distortion).

1.1.13 Harmonic grid impedance

The frequency-dependent grid impedance, determined as positive sequence, negative sequence and zero sequence impedances, expressed either as a real and imaginary value or as a magnitude and angle.

1.1.14 Harmonic planning margin

The part of the *available harmonic distortion headroom* that is reserved for future facilities while also used as a safety measure in case of deviations.

1.1.15 Harmonic spectrum

An illustration of the Fourier coefficients (frequency components) resulting from a Fourier analysis of a given signal.

1.1.16 Harmonic voltage distortion

The distortion of grid voltage due to the presence of one or more higher order *harmonic voltage components*. Contribution may cover the full contribution in the form of *total harmonic voltage distortion* or be calculated per *harmonic voltage component*.

1.1.17 Harmonic voltage distortion contribution (HD)

The *electricity generation facility's* contribution of *harmonic voltage distortion* to the transmission grid in *the point of connection*. Contribution may cover the full contribution in the form of *total harmonic voltage distortion* or be calculated per *harmonic voltage component*. The individual *harmonic voltage components* are defined as described in IEC/TR 61000-3-7:2008 [2] .

1.1.18 Harmonic voltage component

Fourier coefficients (frequency components) stemming from a Fourier analysis of a given voltage signal, wherein the frequency applicable to the Fourier coefficient is an integer multiple of the fundamental frequency.

1.1.19 Interharmonics

Fourier coefficients (frequency components) stemming from a Fourier analysis of a given voltage signal, wherein the frequency applicable to the Fourier coefficient is not an integer multiple of the fundamental frequency.

1.1.20 Interharmonic voltage distortion contribution

The *electricity generation facility's* contribution of *interharmonic voltage distortion* to the transmission grid in *the point of connection*. The contribution is determined using *interharmonic subgroups.*

1.1.21 Interharmonic subgroup

Grouping of a series of *interharmonics*, executed as described in DS/EN 61000-4-7 [3].

1.1.22 Public electricity supply network

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

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

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

1.1.23 Grid impedance polygons

Method for describing the transmission grid's frequency-dependent grid impedance in *the point of connection*.

1.1.24 Grid Connection Agreement

Terms and conditions entered into between the *electricity supply undertaking* and the *facility owner*, which includes relevant data and specific requirements and conditions.

1.1.25 Point of connection

The *Point of Connection (POC)* is the physical point in the *public electricity supply grid,* where the *generation facility* is or can be connected.

All requirements specified in this regulation apply to the *Point of Connection*. The *electricity supply undertaking* determines the *Point of Connection*.

1.1.26 Planning level

The level of a specific *voltage quality parameter* according to which the transmission grid is coordinated.

1.1.27 Generation facility

A *synchronous generation facility* or an *electricity generation facility*.

1.1.28 Generation facility operator

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

1.1.29 Voltage quality parameters

The parameters that voltage quality is determined by. More specifically, *harmonic voltage distortion*, *interharmonics*, *flicker*, *voltage unbalances* and DC content are used.

1.1.30 Voltage unbalance

The negative sequence voltage content, calculated as a percentage of the positive sequence voltage.

1.1.31 Voltage unbalance contribution

The *voltage unbalance contribution,* stemming from the connection of the *electricity generation facility* to the transmission grid, is defined as the size of the *voltage unbalance contribution vector*.

The v*oltage unbalance contribution vector* is the difference between the *voltage unbalance vectors,* determined in the *electricity generation facility's Point of Connection* after and before the *electricity generation facility* is connected:

$$\vec{u}_{2,bidrag} = \vec{u}_{2,efter} - \vec{u}_{2,før}$$

where $\vec{u}_{2,før}$ is the *voltage unbalance vector* before the *electricity generation facility* is connected, and $\vec{u}_{2,efter}$ is the *voltage unbalance vector* after *the electricity generation facility* is connected.

The v*oltage unbalance vector* is defined as:

$$\vec{u}_2 = \frac{\vec{U}_2}{\vec{U}_1}$$

where $\vec{U}_2$ is the negative sequence voltage, and $\vec{U}_1$ is the positive sequence voltage, both set as voltage vectors (described by magnitude and angle) and determined in the *electricity generation facility's Point of Connection*.

1.1.32 Synchronous generation facility

An interconnected unit which can produce electrical energy in such a way that the resulting voltage frequency, AC generator speed and grid voltage frequency are in a constant ratio to each other and thus synchronous.

1.1.33 System model defined by impedance polygons

Limited simulation model of the transmission grid around a *Point of Connection*.

1.1.34 Available harmonic distortion headroom

The headroom available after *harmonic background distortion* has been deducted from *planning levels*.

1.1.35 Total harmonic voltage distortion

Total harmonic voltage distortion is calculated as:

$$THD_U = \sqrt{\sum_{h=2}^{50} U_h^2}$$

where U_h is the root-mean-square (RMS) value of the h-th *harmonic voltage component* expressed as a percentage of the root-mean-square value of the fundamental voltage.

2. Purpose, scope of application and administrative provisions

Voltage quality for generation facilities connected to the transmission grid is implemented as a national requirements with this regulation, as voltage quality is not included in Commission Regulation (EU) 2016/631 of 14 April 2016 establishing a network code on requirements for grid connection of generators (RfG).

2.1 Purpose

The purpose of this technical regulation is to establish the general and specific requirements for voltage quality for *generation facilities* connected to the transmission grid*,* which the *generation facility* must comply with in the *Point of Connection*.

The regulation has been issued under the provisions of section 7(1), no. 1, 3 and 4 of the Danish Executive Order no. 891 of 17 August 2011 on transmission system operation and the use of the electricity transmission grid, etc. [4] Under Section 7(1) of the Danish Executive Order on transmission system operation and the use of the electricity transmission grid, etc., this regulation has been prepared following discussions with market participants and been subject to public consultation before being registered with the Danish Utility Regulator.

This regulation is effective within the framework of the promulgation of Act no. 52 of 17 January 2019 on electricity supply Act [5] (hereinafter the Danish Electricity Supply Act).

In addition to this regulation, generation facilities connected to the transmission grid are subject to applicable Danish legislation, including the promulgation of Act no. 26 of January 2019 on the safety of electrical facilities, electrical installations and electrical equipment (the electrical safety act) [6] and executive orders issued pursuant hereto, as well as the grid connection agreement between *facility owner* and the public *electricity supply enterprise*.

2.2 Scope of application

Throughout its service life, a *generation facility* connected to the transmission grid must comply with the provisions of this regulation.

2.2.1 New generation facility

The requirements in the regulation apply to all *generation facilities* connected to the transmission grid*,* which are commissioned as of the effective date of this regulation.

2.2.2 Existing generation facility

A *generation facility* connected to the *transmission grid* before the effective date of this regulation must comply with the regulation in force at the time of its commissioning.

2.2.3 Changes to existing generation facility

An existing *generation facility* to which substantial functional modifications are made must comply with the provisions of this regulation relating to such modifications. In case of doubt, Energinet Elsystemansvar A/S decides whether a specific modification is substantial.

A substantial modification covers the replacement of one or more vital *facility components*, which may alter the properties of the generation facility.

The facility's documentation 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 Energinet.

At present, this document only defines requirements for *electricity generation facilities*. Requirements for *synchronous generation facilities* will be included at a later stage and will go through a separate consultation process.

The technical regulations contain the technical minimum requirements that apply to *facility owners*, *generation facility operators* and *electricity supply undertakings* regarding the connection of facilities to the transmission grid.

Together with the market regulations, the technical regulations (including the grid connection and system operation regulations) constitute the set of rules which the *facility owner* and *generation facility operators* must comply with when operating a facility:

- Technical regulation 5.8.1, Måledata til systemdriftsformål (Metering data for system operation purposes) [7]
- Technical regulation 5.9.1, Ancillary services [8]
- Regulation D1, Settlement metering [9]
- Regulation D2, Technical requirements for electricity metering [10]
- Technical regulation 3.2.5 for wind power plants with a power output above 11 kW [11]
- Technical regulation 3.2.2 for photovoltaic (pv) power plants with a power output above 11 kW [12]
- Technical regulation 3.2.3 for thermal plants above 11 kW [13].

In addition, special contractual conditions may apply.

In case of discrepancies between the requirements of the individual regulations, Energinet Elsystemansvar A/S decides which requirements should apply.

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

Operational matters must be agreed between *facility owner* and *electricity supply undertaking* within the framework laid down in this regulation.

2.4 Statutory authority

This regulation is issued in pursuance of:

- section 26 of the promulgation of Act No. 52 of 17 January 2019 on electricity supply [5].
- section 7(1) no. 1, 3 and 4 of Executive Order no. 891 of 17 August 2011 on transmission system operation and the use of the electricity transmission grid etc. [4]

2.5 Effective date

This revised regulation comes into force on notification of the Danish Utility Regulator on 29 March 2019, replacing

- Technical regulation 3.2.7 Requirements for voltage quality for generation facility connections to the transmission grid, rev. 1

This regulation replaces section 4 applicable to transmission-connected facilities in the following technical regulations:

- Technical regulation 3.2.2 for PV power plants with a power output above 11 kW, Revision 4, effective from 14 July 2016 [12]
- Technical regulation 3.2.5 for PV power plants with a power output above 11 kW, Revision 4, effective from 22 July 2016 [11]
- Technical regulation 3.3.1 for battery plants, Revision 1, effective from 23 June 2017 [14].

Please direct questions and requests for additional information on this technical regulation to Energinet Elsystemansvar A/S.

Please find the relevant contact information at https://en.energinet.dk/Electricity/Rules-and-Regulations/Regulations-for-grid-connection.

The regulation was registered with the Danish Utility Regulator pursuant to the provisions of section 76 of the Danish Electricity Supply Act, cf. section 73(a) of the Danish Electricity Supply Act and section 7 of the Danish Executive Order on transmission system operation and the use of the electricity transmission grid, etc.

As regards *generation facilities*, the construction of which was definitely ordered in a binding written order before the regulation was registered with the Danish Utility Regulator, but which are scheduled to be commissioned after the effective date of this regulation, an exemption can be applied for in accordance with section 2.9, enclosing any relevant documentation.

2.6 Complaints

Complaints about this regulation can be filed with the Danish Utility Regulator, www. forsyningstilsynet.dk, cf. section 7(3) Executive Order on transmission system operation and the use of the electricity transmission grid, etc..

Complaints about decisions made by Energinet cannot be appealed to another administrative authority. Decisions can only be appealed to the courts.

2.7 Breaches

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

Any necessary regular maintenance of the *generation facility* is required to ensure compliance with the provisions of this regulation.

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

2.8 Penalties

If a *generation facility* 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 *generation facility* as a last resort, subject to the decision made by Energinet, until the provisions are complied with.

2.9 Exemptions and unforeseen events

Energinet may grant exemption from specific requirements in this regulation.

A generation facility must meet the following conditions to be granted an exemption:

- Special conditions must exist, for instance of a local nature.
- The deviation must not impair the technical quality and balance of the *public electricity supply grid.*
- The deviation must not be inappropriate from a socioeconomic viewpoint.

Additionally, exemptions may be applied for for *generation facilities* ordered before the regulation came into force, see section 2.5.

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

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

Should circumstances not foreseen in this technical regulation occur, Energinet Elsystemansvar A/S must consult the parties involved to reach an agreement on what to do.

If an agreement cannot be reached, Energinet must decide what to do. The decision must be based on what is reasonable, taking the views of the parties involved into consideration where possible.

Any complaints about Energinet's decision may be filed with the Danish Utility Regulator, see section 2.6.

3. General

When assessing a *generation facility's* impact on power quality in the transmission grid, the various *power quality* parameters in the *Point of Connection* must be documented. These parameters, as well as methods for their verification, are described in this technical regulation.

Energinet Elsystemansvar A/S must state emission limits for the various types of distortions caused by the *generation facility*, to ensure that *planning levels* for *power quality* in the transmission grid overall are not exceeded.

Generally, the *facility owner* must ensure that the *generation facility* is designed, constructed and configured in compliance with specified emission limits. The *facility owner* must verify that the *generation facility* complies with the threshold values defined for the *Point of Connection* using the verification methods stated in this regulation.

Energinet Elsystemansvar A/S must provide relevant background data for the verification of all *power quality* requirements. Data provided by Energinet Elsystemansvar A/S must be stored and transferred in a safe manner, and may not be disclosed or made available to others without Energinet Elsystemansvar A/S' consent.

Energinet Elsystemansvar A/S approves both the *facility owner's* calculation and measurement methods and the final documentation, hereinafter referred to as the products, for verification of all *power quality* parameters.

Energinet Elsystemansvar A/S and the *facility owner* must agree on a timetable for delivery of the products to document compliance with the *power quality* requirements. Please note that the final studies must be submitted at least six months before energisation of the first generation unit.

The *generation facility's* impact on *harmonic voltage distortion*, *interharmonics*, *voltage unbalance*, *flicker* and DC content must be documented.

4. Harmonic voltage distortion

Threshold values are determined for the *electricity generation facility's* maximum contribution for *harmonic voltage distortion* in the *Point of Connection*.

4.1 Planning level and definition of harmonic voltage distortion contribution

The *electricity generation facility* is allocated threshold values in *the Point of Connection,* corresponding to the facility's *harmonic voltage distortion contribution*. Energinet Elsystemansvar A/S uses *planning levels* for high-voltage systems, as specified in IEC/TR 61000-3-6 [15] Table 2, and will coordinate the individual facility's contribution according to these levels.

Threshold values for *the electricity generation facility* are determined as the threshold value *for harmonic voltage distortion contribution (LHD)* and defined as the maximum *harmonic voltage distortion contribution (HD)*, which the *electricity generation facility* is permitted to introduce into the transmission grid.

The *electricity generation facility's harmonic voltage distortion contribution* includes:

1. *harmonic voltage distortion* caused by *harmonic voltages* or currents from the *electricity generation facility* (actively introduced distortion)
2. amplification of existing *harmonic background distortion* in *the Point of Connection* due to interaction between the unit's and the transmission grid's *harmonic grid impedance* (passively introduced distortion).

Contributions are illustrated graphically in Figure 1.

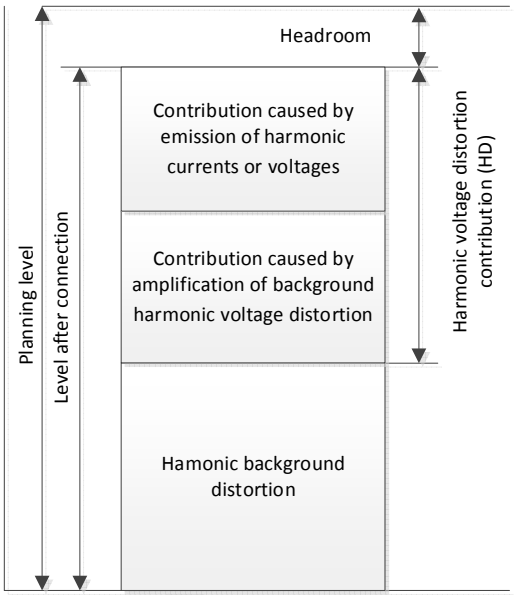


Figure 1 Visual presentation of contributions to harmonic voltage distortion in the Point of Connection after commissioning of the electricity generation facility

Unique limits are defined per *harmonic voltage component* from the 2nd to the 50th order. These limits are determined as the root-mean-square (RMS) value of the individual harmonic voltage overtone, expressed as a percentage of the root-mean-square value of the fundamen-

tal voltage. In addition to the threshold value per *harmonic voltage component*, a limit for the *total harmonic voltage distortion* is determined (THD_U).

All these *harmonic voltage components* are defined as 95% percentile levels, calculated on the basis of 10-minute aggregated values measured over a week. Aggregation is carried out as specified in DS/EN 61000-4-30 [16].

4.2 Establishing requirements for harmonic voltage distortion contribution

The *threshold value of the harmonic voltage distortion contribution* is determined by Energinet Elsystemansvar A/S. The threshold value is determined per *harmonic voltage component* based on the principle shown in Figure 2.

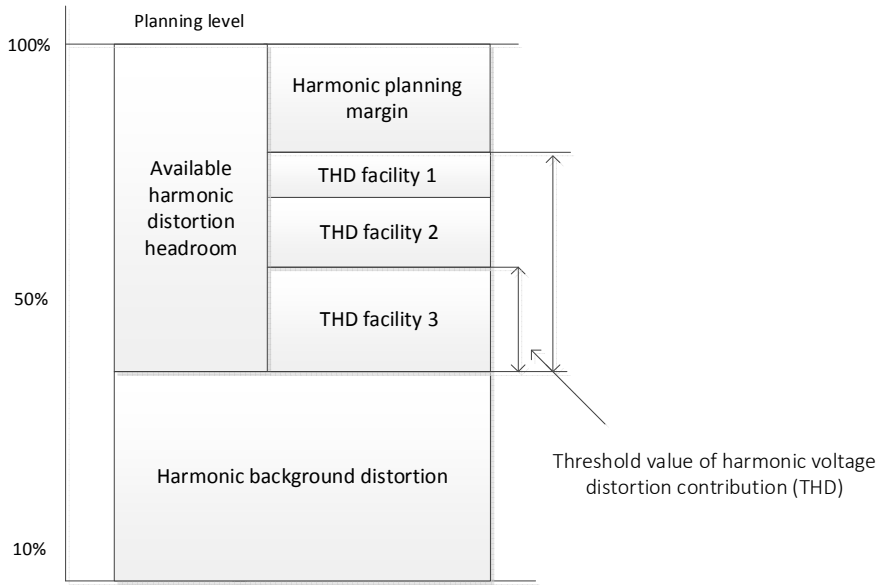


Figure 2 Illustration of method used for determination of the threshold value of harmonic voltage distortion contribution.

The method for determining the limit is based on the fact that the levels of *harmonic background distortion* in the *Point of Connection* are known for all relevant *harmonic voltage components*. Based on this, the *available harmonic distortion headroom is calculated*. This is shared between the planned facilities (generation or demand) connected at or near the *Point of Connection* of the *electricity generation facility*. Part of the *available harmonic distortion headroom* is reserved for future facilities while also functioning as a safety buffer in the event of deviations. This reserved headroom is called the *harmonic planning margin.* The headroom is determined by Energinet Elsystemansvar A/S and may vary from one connection point to another. When connecting several facilities at the same time, the available headroom is split relative to the facility sizes, determined using apparent power.

The *threshold value of the harmonic voltage distortion contribution* for plant number one is calculated by arithmetically subtracting the background level and the *harmonic planning margin* from the *planning level* of the relevant *harmonic voltage component*. In addition, limits allocated to other facilities that are not part of the *harmonic background distortion* at the time of measurement are subtracted (see **Fejl! Henvisningskilde ikke fundet.**):

$$U(h)_{GHF1} = U(h)_{PL} - U(h)_{bag} - U(h)_{PM} - U(h)_{GHF2} - \cdots - U(h)_{GHFn}$$

where $U(h)_{PL}$ is the *planning level*, $U(h)_{bag}$ is the *harmonic background distortion*, $U(h)_{PM}$ is the *harmonic planning margin* and $U(h)_{GHFn}$ is the *value limit of the harmonic voltage distortion contribution* for the nth plant. All variables apply to the nth *harmonic voltage component*.

This means that the *facility owner* shall select an appropriate method for summation of the contributions from active *harmonic emission* and amplification of the existing *harmonic background distortion* (passive *harmonic emission*).

4.3 Verification of requirements

Sections 4.3.2 and 4.3.3 describe the respective calculation and measurement methods for verification of requirements for *harmonic distortion contribution*. Section 4.3.1 describes the data basis which Energinet Elsystemansvar A/S makes available to the *facility owner*.

4.3.1 Data basis for the verification of requirements for harmonic components

Energinet Elsystemansvar A/S makes the following data available for verification of the requirements for the *electricity generation facility's harmonic distortion contribution*:

1. level of *harmonic background distortion*
2. *grid impedance polygons* in the *electricity generation facility*'s Point of Connection or *system model defined by impedance polygons*

4.3.1.1 Harmonic background distortion

Harmonic background distortion is stated as 95% percentile levels of 10-minute values aggregated as described in DS/EN 61000-4-30 [16] and measured over a week. Typically, measurements are recorded for 6-12 months prior to connection, and the highest *harmonic voltage components* for the three phases, of all recorded weeks, are stated.

Please note that the stated *background harmonic distortion* is only to be used for the verification of operational requirements (THD). In respect of component design, design levels are determined by the component manufacturer, under the prerequisite that the individual *harmonic* component must be able to take on *the planning levels* in the *Point of Connection*.

4.3.1.2 Grid impedance polygons in the *electricity generation facility's Point of Connection* or the *system model* delimited by grid impedance polygons

Energinet Elsystemansvar A/S decides whether the transmission grid behind the *Point of Connection* of the *electricity generation facility* is described using *impedance polygons,* or whether a *system model delimited by impendance polygons* is used. This decision is made by Energinet Elsystemansvar A/S prior to the start-up of analyses for verification of requirements.

Grid impedance polygons in the electricity generation facility's Point of Connection

The transmission grid's *grid impedance polygons* are defined in the R-X plane, seen from the *Point of Connection,* with the *electricity generation facility* not connected. *The grid impedance polygons* are calculated using a number of network and system configurations, including unfavourable, but planned, component outages. The *harmonic spectrum* from 50 Hz to 2500 Hz is divided into a number of frequency intervals, each represented by a six-point polygon. The polygon corner points are illustrated in Figure 3.

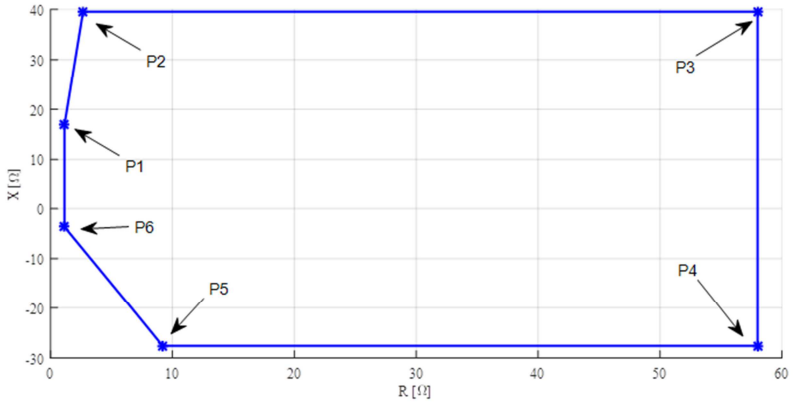


Figure 3 Example of grid impedance polygon descriptive of grid impedance at the electricity generation facility's Point of Connection.

The *facility owner* must verify that the *harmonic distortion contribution* does not exceed the allocated *threshold values for harmonic voltage distortion contribution* throughout the polygon area for each polygon stated. The calculation method using *grid impedance polygons* is determined by Energinet Elsystemansvar A/S in collaboration with the *facility owner*.

System model defined by grid impedance polygons

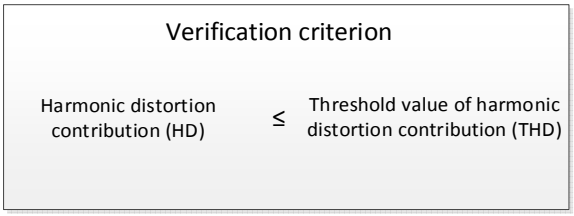
Energinet Elsystemansvar A/S may opt to provide a system model to verify *threshold values for harmonic voltage distortion contribution*. This option is relevant if the complexity of the system makes a system model either more representative due to mutual impact between parts of the system, or if it facilitates the *facility owner's* verification of requirements. If a system model option is selected, details of the process and method is agreed between Energinet Elsystemansvar A/S and the *facility owner* prior to the start-up of relevant studies.

4.3.2 Verification of requirements by calculation

To verify that the *electricity generation facility* complies with the requirements for *harmonic voltage distortion* before energisation, the *facility owner* must complete a theoretical study that documents that the *electricity generation facility*'s *harmonic distortion contribution* does not exceed the limits stated. This must be verified for all operating configurations to be used to operate, making the 95% percentile level of one week's 10-minute values relevant. This includes any temporary configurations used when commissioning the plant.

The *facility owner* must determine and account for the method used to summarise *harmonic emissions* from several *electricity generation facilities*. The *facility owner* must also determine and account for the method used to summarise contributions of actively and passively introduced distortion (points a and b in section 4.1). The method must be approved by Energinet Elsystemansvar A/S.

Compliance with the requirements for the individual voltage components and THD_U is achieved when:



In addition to stating the *electricity generation facility*'s *harmonic voltage distortion contribution*, the theoretical study must include the extent of contributions from active emissions as well as the amplification of existing *harmonic background distortion* (passive emission) before summation (points a and b in section 4.1). The exact scope of the study and the calculation method is agreed on by the *facility owner* and Energinet Elsystemansvar A/S*,* before the study is performed. The *facility owner* must submit descriptions of study scope and method before the study is performed.

4.3.3 Verification of requirements by measurement

The method for verification of requirements by measurement is determined jointly by Energinet Elsystemansvar A/S and the *facility owner*. The method is determined individually for each *electricity generation facility* due to the complexity of measuring *harmonic voltage distortion contributions* at the high voltage level.

5. Interharmonics

5.1 Planning level and definition of interharmonic voltage distortion contribution

The p*lanning level* for *interharmonic voltage distortion contribution* for the transmission grid is determined as described in IEC/TR 61000-3-6 [15] and measured as defined in DS/EN 61000-4-7 [3].

5.2 Specification of requirements for interharmonic voltage distortion contributions

Threshold values for interharmonic voltage distortion contributions are specified as requirements for the *interharmonic subgroups.* Each *interharmonic subgroup* must be evaluated as described in DS/EN 61000-4-30 [17] and DS/EN 61000-4-7 [3]. *The threshold value for interharmonic voltage distortion contributions* is specified as 0.15% for frequencies below 100 Hz and 0.36% in the frequency range 100 Hz-2.5 kHz.

5.3 Verification of requirements

Documentation of compliance with requirements for interharmonics must be submitted to Energinet Elsystemansvar A/S no later than six months before commissioning of the *electricity generation facility*. Verification is done using one of the following two methods:

1. By submitting a written technical report showing that the *interharmonic voltage distortion contribution* of the *electricity generation facility* is negligible in the *point of connection*
2. By running a worst-case operating condition simulation using a simulation model that includes sources of *interharmonics*.

If the option to verify requirements using method 2 is selected, Energinet Elsystemansvar A/S will forward relevant data describing the transmission grid in the *point of connection*. The amount of data will depend on the simulation method selected for verification, and is therefore determined following this selection. The verification method and products must be approved by Energinet Elsystemansvar A/S

Verification of requirements by measurement is done by Energinet Elsystemansvar A/S. This may be both immediately after commissioning before a final *grid connection agreement* is signed, and at any time during the *electricity generation facility*'s service life. Should the facility fail to comply with requirements, the sanctions described in section **Fejl! Henvisningskilde ikke fundet.** will be imposed.

6. Voltage unbalance

A limit for the *voltage unbalance* originating from the *electricity generation facility* is set in the *point of connection*.

6.1 Planning level and definition of voltage unbalance contributions

The *planning level* for *voltage unbalance* for the transmission grid is determined as described in IEC/TR 61000-3-13 [18] Table 2. The *electricity generation facility's voltage unbalance contribution* is defined as described in section 1.1.31.

6.2 Setting requirements for voltage unbalance contributions

The *electricity generation facility's voltage unbalance contribution* must not exceed 0.2% in the *point of connection*.

Connecting an *electricity generation facility* may result in a reduced voltage unbalance in the *point of connection*. If this is the case, the *voltage unbalance contribution* is set equal to zero, and the requirement has been met.

Connecting a balanced *electricity generation facility* may result in an increased unbalance level in *the point of connection* if the transmission grid is asymmetrical with a low short-circuit level. Any consequences of such an increase are not the responsibility of *the facility owner*.

6.3 Verification of requirements

Documentation of compliance with requirements for *voltage unbalance* must be submitted to Energinet Elsystemansvar A/S no later than six months before commissioning of the *electricity generation facility*. Verification is done using one of the following two methods:

1. by submitting a written technical report showing that the *voltage unbalance contribution* of the *electricity generation facility* is negligible in the *point of connection*
2. by running a worst-case operating condition simulation using a simulation model that includes sources of *voltage unbalance*.

If the option to verify requirements using method 2 is selected, Energinet Elsystemansvar A/S will forward relevant data describing the transmission grid in the *point of connection*. The amount of data will depend on the simulation method selected for verification, and is therefore determined following this selection. The verification method and products must be approved by Energinet Elsystemansvar A/S

Verification of requirements by measurement is done by Energinet Elsystemansvar A/S. This may be both immediately after commissioning before a final *grid connection agreement* is signed, and at any time during the *electricity generation facility*'s service life. Should the facility fail to comply with requirements, the sanctions described in section **Fejl! Henvisningskilde ikke fundet.** will be imposed.

7. Flicker

A limit for *flicker* originating from the *electricity generation facility* is set in the *point of connection*.

7.1 Planning level and definition of flicker contribution

The p*lanning level* for *flicker* for the transmission grid is determined as described in IEC/TR 61000-3-7 [2] and measured as defined in DS/EN 61000-4-15 [1].

7.2 Setting requirements for flicker

The requirements for *flicker contribution* for the *electricity generation facility* in *the point of connection* are shown in Table 1. They are defined as the minimum thresholds recommended, see. IEC/TR 61000-3-7 [2].

Parameters	Limit
P_{st}	0.35
P_{lt}	0.25

Table 1 Threshold values for flicker caused by the electricity generation facility.

P_{st} is short-term *flicker* intensity, and P_{lt} is long-term *flicker* intensity, both defined as described in DS/EN 61000-4-15 [1].

7.3 Verification of requirements

Documentation of compliance with requirements for *flicker* must be submitted to Energinet Elsystemansvar A/S no later than six months before commissioning of the *electricity generation facility*. Verification is done using one of the following two methods:

1. by submitting a written technical report showing that the *flicker contribution* of the *electricity generation facility* is negligible in the *point of connection*
2. by running a worst-case operating condition simulation using a simulation model that includes sources of *flicker*.

If the option to verify requirements using method 2 is selected, Energinet Elsystemansvar A/S will forward relevant data describing the transmission grid in the *point of connection*. The amount of data will depend on the simulation method selected for verification, and is therefore determined following this selection. The verification method and products must be approved by Energinet Elsystemansvar A/S.

Verification of requirements by measurement is done by Energinet Elsystemansvar A/S. This may be both immediately after commissioning before a final *grid connection agreement* is signed, and at any time during the *electricity generation facility*'s service life. Should the facility fail to comply with requirements, the sanctions described in section **Fejl! Henvisningskilde ikke fundet.** will be imposed.

8. DC content

A limit for *DC content* in current supplied by the *electricity generation facility* is set in the *point of connection*.

8.1 Establishment of requirements for DC content

DC content, measured in the AC current supplied by the *electricity generation facility*, must not exceed 0.5% of the rated current in *the point of connection*.

8.2 Verification of requirements

Documentation of compliance with requirements for *DC content* must be submitted to Energinet Elsystemansvar A/S no later than six months before commissioning of the *electricity generation facility*. Verification is done using one of the following two methods:

1. by submitting a written technical report showing that the *DC content* originating from the *electricity generation facility* is negligible in the *point of connection*
2. by running a worst-case operating condition simulation using a simulation model that includes sources of DC current or DC voltage.

If the option to verify requirements using method 2 is selected, Energinet Elsystemansvar A/S will forward relevant data describing the transmission grid in the *point of connection*. The amount of data will depend on the simulation method selected for verification, and is therefore determined following this selection. The verification method and products must be approved by Energinet Elsystemansvar A/S.

Verification of requirements by measurement is done by Energinet Elsystemansvar A/S. This may be both immediately after commissioning before a final *grid connection agreement* is signed, and at any time during the *electricity generation facility*'s service life. Should the facility fail to comply with requirements, the sanctions described in section **Fejl! Henvisningskilde ikke fundet.** will be imposed.

9. References

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[3] DS/EN 61000-4-7:2002 Electromagnetic compatibility (EMC) - Part 4-7: Testing and measurement techniques - General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto, Danish Standards, 2002.

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Assessment of emission limits for the connection of distorting installations to MV, HV and EHV power systems, International Electrotechnical Commission, 2008.

[16] DS/EN 61000-4-30:2015 Electromagnetic compatibility (EMC) - Part 4-30: Testing and measurement techniques - Power quality measurement tools, Danish Standards, 2015.

[17] IEC/TR 61000-3-13:2008 Electromagnetic compatibility (EMC) - Part 3-13: Limits - Assessment of emission limits for the connection of unbalanced installations to MV, HV and EHV power systems, International Electrotechnical Commission, 2008.