

Technical Regulation 3.2.1 for electricity generation facilities with a rated current of 16 A per phase or lower

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To the reader

This Technical Regulation 3.2.1 (TR 3.2.1) includes the technical and functional minimum requirements which *electricity generation facilities* with a *rated current* of 16 A per phase or lower must comply with if they are to be connected to the Danish network. The minimum requirements lie within the framework of the Danish Electricity Supply Act (lov om elforsyning), see Consolidated Act no. 1115 of 8 November 2006, as amended.

The regulation is structured so that **section 1** outlines the terminology and definitions used; **section 2** describes the regulatory provisions and relevant references, while the technical and functional requirements are described in **section 3 onwards**.

The regulation makes extensive use of terminology and definitions, the most important of which are described in **section 1**. In the regulation, terminology and definitions are written in *italics*. Where relevant in relation to the applied European norm EN50438, the corresponding English terminology and definitions have been added.

The regulation is published by Energinet.dk and can be downloaded from www.energinet.dk.

Previous provisions

Below follows an overview of the previous provisions and recommendations applying to *thermal power station units*. Existing plants commissioned before this regulation came into force are subject to the previous provisions and recommendations.

For power station units in the West Danish area (Jutland and Funen):

- 1995-2006: 'Kraftværksspecifikationer for produktionsanlæg mindre end 2 MW', (*Power station specifications for generating facilities under 2 MW*), memorandum NP91/SP-515h, Elsam, 1995.

For power station units in the East Danish area (Zealand and islands):

- 1990-1995: 'Driftstekniske specifikationer for mindre varmekraft anlæg, Tillæg nr. 1', (*Operational performance specifications for small-scale CHP plants, amendment no. 1*), Nordel, 1995.
- 1995-2004: 'Operational Performance Specifications for Small Thermal Power Units, Amendment no. 1', Nordel, 1995.
- 1999-2006: 'Standardvilkår for nettilslutning af lokale kraftvarmeanlæg mindre end 25 MW' (*Standard terms for grid connection of local CHP plants smaller than 25 MW*), Sjællandssamarbejdet, 1999.

Harmonised document for the entire Danish area:

- 2003-2007: 'Lavspændingsinstallationer med egenproduktion – Retningslinjer for nettilslutning af produktionsanlæg', (*Low-voltage installations with autogeneration – Guidelines for grid connection of production plants*), prepared for ELFOR, Eltra and Elkraft, DEFU report RA498, November 2003.

1. Terminology and definitions

1.1 Plant owner

The legal owner of the *electricity generation facility*.

1.2 Electricity generation facility

Facility producing single-phase, two-phase or three-phase alternating current.

1.3 Public electricity supply network

Transmission grids and distribution networks the purpose of which is to transmit electricity for an indefinite group of electricity suppliers and consumers on the terms laid down by public authorities.

The transmission grid is defined as the *public electricity supply network* with a *nominal voltage* greater than 100 kV, while the distribution network is defined as the *public electricity supply network* with a *nominal voltage* lower than 100 kV.

1.4 Point of common coupling (PCC)

The point in the *public electricity supply network* to which consumers are or can be connected. Electrically, the *point of common coupling* and the *point of connection* may coincide. The *point of common coupling* is always placed closest to the *public electricity supply network*, see **Figure 1**. The *distribution network operator* determines the *point of common coupling*.

1.5 Rated power

The highest nominal electrical output of an *electricity generation facility* under nominal operating conditions. Stated in kW or kVA.

1.6 Rated current

The highest nominal current supplied by an *electricity generation facility* under nominal operating conditions.

1.7 Loss of main (LoM)

Failure in the connection to the *public electricity supply network*.

1.8 Distribution network operator

Enterprise licensed to operate the distribution network. The *distribution network operator* is the enterprise to whose network an *electricity generation facility* is connected electrically.

1.9 Nominal voltage

Voltage in a *point of connection* for which the power system is designated, eg 230 V single-phase or 230/400 V polyphase.

1.10 Interconnected electricity supply system

The *interconnected electricity supply system* is defined as the *public electricity supply network* and associated facilities in a large geographical area which are interconnected with a view to joint operation.

1.11 Transmission system operator (TSO)

Enterprise entrusted with the overall responsibility for maintaining security of supply and ensuring the efficient utilisation of an *interconnected electricity supply system*. Energinet.dk is the *transmission system operator*.

1.12 Point of connection (POC)

The point in the *public electricity supply network* to which the *electricity generation facility* is or can be connected. The typical location is shown in **Figure 1**. The *distribution network operator* determines the *point of connection*.

1.12.1 Installation connection

Installation connection of an *electricity generation facility* is established via an electrical installation to the *public electricity supply network*.

Figure 1 shows a typical installation connection for a small wind turbine, but the same connection could also be used for solar plants or other types of *electricity generation facilities*. In the situation shown, the *point of common coupling* (PCC) and the *point of connection* (POC) coincide.

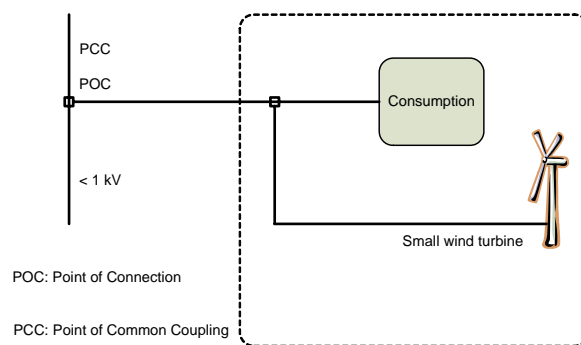


Figure 1 Example of installation connection

1.13 Regional transmission company

Company licensed to operate the transmission grid.

2. Objective, scope and regulatory provisions

2.1 Objective

The objective of TR 3.2.1 is to specify the minimum technical and functional requirements, which *electricity generation facilities* with a *rated current* of 16 A per phase or lower must comply with in the *point of connection* when they are connected to the *public electricity supply network*.

In pursuance of section 7(1) of the Danish Executive Order no. 891 of 17 August 2011 on transmission system operation and the use of the electricity transmission grid etc. (*systemansvarsbekendtgørelsen*), this regulation has been prepared following discussions with the *distribution network operators* and the *regional transmission companies*. The regulation has also been in public consultation before being notified to the Danish Energy Regulatory Authority.

The regulation applies within the framework of the Danish Electricity Supply Act (lov om elforsyning), see Consolidated Act no. 516 of 20 May 2010, as amended.

The regulation substantiates and confirms the European norm EN50438 [1] and thus contributes to harmonising the rules on network connection of *electricity generation facilities* with a *rated current* of 16 A per phase or lower in Europe. The regulation clarifies and supplements the provisions of EN50438. Where this is indicated in the regulation, the rules of the standard VDE-AR-N 4105 [6] can be applied to *electricity generation facilities* connected to the network through inverters. If the rules of VDE-AR-N 4105 are applied, they must be applied consistently to all parts of the regulation where this alternative is possible.

Electricity generation facilities must comply with Danish legislation, including the Danish Heavy Current Regulation (*stærkstrømsbekendtgørelsen*) [3] and the 'Joint Regulation' (*Fællesregulativet*) [2]. In areas not subject to Danish legislation, the CENELEC standards apply, and in areas where there are no CENELEC standards, the ISO and IEC standards apply.

2.2 Scope

Electricity generation facilities connected to the *public electricity supply network* must throughout their lifetime comply with the provisions of this regulation.

New electricity generation facilities

The regulation applies to all *electricity generation facilities* with a *rated current* of 16 A per phase or lower which are connected to the *public electricity supply network* and commissioned on or after 1 January 2012.

Existing electricity generation facilities

Electricity generation facilities with a *rated current* of 16 A per phase or lower which were connected to the *public electricity supply network* before 1 January 2012 must comply with the version of the regulation in force at the time of commissioning.

Modifications to existing electricity generation facilities

Existing *electricity generation facilities* to which substantial functional modifications are made must comply with the provisions of this regulation relating to such modifications. In case of doubt, the *transmission system operator* decides whether or not a specific modification is substantial.

2.3 Delimitation

The regulation does not apply to *electricity generation facilities* where several small *electricity generation facilities* connected to the same installation collectively exceed a *rated current* of 16 A per phase in the *point of connection*.

The regulation does not apply to *electricity generation facilities* used solely for emergency and reserve supply to an installation when the *electricity generation facility* is not connected to the *public electricity supply network*.

The regulation does not deal with the financial aspects of settlement metering or the technical requirements in this connection.

2.4 Statutory authority

The regulation has been issued under the provisions of section 26(1) of the Danish Electricity Supply Act (lov om elforsyning), see Consolidated Act no. 516 of 20 May 2010, and in pursuance of section 7(1), paras 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. (systemansvarsbekendtgørelsen).

2.5 Commencement

This regulation comes into force on 1 January 2012.

Questions regarding this regulation and requests for additional information can be directed to Energinet.dk, Front Office Electricity, fo@energinet.dk.

The regulation was notified to the Danish Energy Regulatory Authority on 16 December 2011 in accordance with the provisions of section 76 of the Danish Electricity Supply Act (lov om elforsyning) and section 7 of the Danish Executive Order on transmission system operation and the use of the electricity transmission grid etc. (systemansvarsbekendtgørelsen).

2.6 Complaints

Complaints about this regulation can be lodged with the Danish Energy Regulatory Authority, Carl Jacobsens Vej 35, DK-2500 Valby.

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

Complaints about the individual *distribution network operator's* administration of the provisions of the regulation can be lodged with the *transmission system operator*. Complaints about the *distribution network operator's* enforcement of the provisions of the regulation can be lodged with the *transmission system operator*. If complaints are lodged about a *distribution network operator*, the

transmission system operator must always ask the *distribution network operator* to comment on the complaint.

2.7 Non-compliance

The *plant owner* must ensure that the provisions of this regulation as well as the manufacturer's requirements and recommendations are complied with throughout the life of the *electricity generation facility*.

Unless otherwise expressly stated, the *plant owner* must pay any expenses incurred in order to comply with the provisions of this regulation.

2.8 Sanctions

If an *electricity generation facility* fails to comply with the provisions of this regulation, the *distribution network operator* is entitled to cut off the electrical connection to the *electricity generation facility*.

2.9 Exemptions and unforeseen events

The *transmission system operator* may grant exemption from specific provisions of this regulation.

Exemption can only be granted if:

- the deviation is not contrary to the intention of EN50438 regarding the harmonisation of the conditions for network connection applying to small *electricity generation facilities*
- special conditions prevail, for instance of local character
- the deviation does not appreciably impair the technical quality and balance of the *public electricity supply network*
- the deviation is not inappropriate from a socioeconomic perspective.

In order to obtain exemption, a written application must be submitted to the *distribution network operator*, indicating which provisions the exemption concerns and the reason for applying for the exemption. The *distribution network operator* has the right to comment on the application before it is submitted to the *transmission system operator*.

If events unforeseen in this regulation occur, the *transmission system operator* must consult with the parties affected in order to agree on what is to be done. If an agreement cannot be reached, the *transmission system operator* decides what is to be done. The decision must be based on what is fair and equitable and, where possible, taking account of the views of the parties affected. Complaints about the decisions of the *transmission system operator* can be lodged with the Danish Energy Regulatory Authority, see **2.6**.

2.10 References

Reference is made to the following documents in the regulation:

1. DS/EN50438:2008 (EN50438:2007) 'Requirements for connection of micro-generators in parallel with public low-voltage distribution networks', December 2007.
2. 'Fællesregulativet 2011' (*Joint Regulation*), Danish Energy Association, October 2011.
3. 'Stærkstrømsbekendtgørelsen' (*Danish Heavy Current Regulation*), section 6, Danish executive order no. 12502 of 01/07/2001.
4. DEFU report RA498, 'Lavspændingsinstallationer med egenproduktion' (*Low-voltage installations with autogeneration*), report 498, November 2003.
5. EMC directive 2004/108/EC of 15 December 2004 on electromagnetic compatibility.
6. VDE-AR-N 4105 'Erzeugungsanlagen am Niederspannungsnetz - Technische Mindestanforderungen für Anschluss und Parallelbetrieb von Erzeugungsanlagen am Niederspannungsnetz', August 2011.

Danish titles of references in EN 50438:

1. DS/EN50110 series, "Drift af elektriske anlæg", stærkstrømsbekendtgørelsen, afsnit 5.
2. DS/EN50160 "Karakteristika for spændingen i offentlige elektricitetsforsyningsnet".
3. DS/EN60664-1 "Isolationskoordinering for udstyr til lavspændingsystemer – Del 1: Principper, krav og prøvninger" (IEC60664-1).
4. DS/EN61000-3-2 "Elektromagnetisk kompatibilitet (EMC) – Del 3-2: Grænseværdier - Grænseværdier for udsendelse af harmoniske strømme (udstyrets strømforbrug op til og inklusive 16 A pr. fase)".
5. DS/EN61000-3-3 "Elektromagnetisk kompatibilitet (EMC) – Del 3-3: Grænseværdier – Begrænsning af spændingsændringer, spændingsfluktuationer og flimmer i offentlige lavspændingsforsyninger, fra udstyr med mærkestrøm op til og med 16 A pr. fase og ikke beregnet til betinget tilslutning" (IEC61000-3-3).
6. DS/EN61000-6-1 "Elektromagnetisk kompatibilitet (EMC) – Del 6-1: Generiske standarder – Immunitet for bolig-, erhvervs- og letindustrimiljøer" (IEC61000-6-1, mod.).
7. DS/EN61000-6-3:2001 "Elektromagnetisk kompatibilitet (EMC) – Del 6-3: Generiske standarder – Emissionsstandard for bolig-, erhvervs- og letindustrimiljøer" (IEC61000-6-3 Ed. 2.0).
8. EN61000-6-3 + A11 2004 "Elektromagnetisk kompatibilitet (EMC) – Del 6-3: Generiske standarder – Emissionsstandard for bolig, erhverv og letindustrimiljøer" (IEC61000-6-3:1996, mod.).
9. HD 384 / EN60364 serie "Elektriske installationer i bygninger" (IEC 60364 series, mod.), stærkstrømsbekendtgørelsen, afsnit 6.

3. Installation requirements

3.1 General

An *electricity generation facility* and its installation must comply with the requirements of the Danish Heavy Current Regulation [3] and clause 4.1 of EN50438.

3.2 Overcurrent protection

An *electricity generation facility* must be fitted with overcurrent protection in compliance with the Danish Heavy Current Regulation [3] and clause 4.1.2 of EN50438.

3.3 Earthing

An *electricity generation facility* must be earthed in compliance with section 6 of the Danish Heavy Current Regulation [3] and clause 4.1.3 of EN50438.

3.4 Protection against indirect contact

An *electricity generation facility* must be protected against indirect contact in accordance with section 6 of the Danish Heavy Current Regulation [3].

3.5 Energy metering

Metering and settlement of electricity generation must be performed in accordance with Energinet.dk's regulations. Note that correct electricity metering cannot be expected until the *distribution network operator* has verified the metered data.

3.6 Rating

An *electricity generation facility* must comply with the rating rules specified in clauses 6.3 and 6.4 of EN50438.

4. Network protection in the point of connection

4.1 General

The protective equipment must ensure that the *electricity generation facility* impairs neither the *public electricity supply network* nor the safety of personnel and equipment.

Protective functions for *electricity generation facilities* connected to the *public electricity supply network* must be established in accordance with clause 4.2.2 of and Annex A to EN50438, as stated in **Table 1**.

Protective function	Symbol	Setting ^{a)}	Function time
Overvoltage (two-stage) ^{b)}	$U_{>>}$	230 V+13%	0.2 s
Overvoltage (one-stage)	$U_{>}$	230 V+10%	40 s
Undervoltage (one-stage)	$U_{<}$	230 V-10%	10 s
Overfrequency	$f_{>}$	52.0 Hz	0.2 s
Underfrequency	$f_{<}$	47.5 Hz	0.2 s
"ROCOF" ^{c)}	df/dt	2.5 Hz/s	0.2 s

Table 1 Protective function, operational settings and function times

- ^{a)} All values are RMS values. The *electricity generation facility* must be disconnected^d or stop supplying power to the *public electricity supply network* if a metered value deviates from its nominal value by more than the setting. A metered value must not initiate disconnection if the value is between the nominal value and the setting.
- ^{b)} Two-stage overvoltage protection is required if the *electricity generation facility* is capable of generating voltages exceeding 230 V + 13%.
- ^{c)} The use of vector jump relays as protection against *loss of main* is not allowed.
- ^{d)} Disconnection of an *electricity generation facility* must be performed using mechanical relay switches or solid-state switching devices whose control signal is galvanically separated from the poles (eg optically insulated or electrically insulated). If solid-state switching devices are used, the leakage current must not exceed 0.1 mA, see clause 4.2.1.2 of EN50438.

Alternatively, protective functions and settings specified in VDE-AR-N 4105 may be used for *electricity generation facilities* connected to the network through inverters.

4.2 Frequency and voltage deviations

If the frequency or the voltage exceeds the limit values in **4.1**, the *electricity generation facility* is automatically disconnected from the *public electricity supply network*.

4.3 Detection of *loss of main*

Loss of main must result in the automatic disconnection of the main circuit for the *electricity generation facility*. Detection of *loss of main* is to be performed as described in **4.1**.

4.4 Reconnection after *loss of main*

After *loss of main*, the *electricity generation facility* must not be able to reconnect until the voltage and the frequency have been within the stationary limit values shown in **4.1** for three minutes (for mechanical AC installations) and 20 seconds (for inverter-based installations), as specified in clause 4.2.4 of EN50438.

Alternatively, settings specified in VDE-AR-N 4105 may be used for *electricity generation facilities* connected to the network through inverters.

4.5 Synchronisation

Synchronisation of the *electricity generation facility* with the *public electricity supply network* must take place automatically in accordance with clause 4.2.5 of EN50438.

Alternatively, settings specified in VDE-AR-N 4105 may be used for *electricity generation facilities* connected to the network through inverters.

5. Voltage quality

5.1 General

An *electricity generation facility* must comply with the European EMC directive [5].

If the EMC directive does not include specific product requirements, the general requirements of clause 5.1 of EN50438 must be observed.

Alternatively, requirements specified in VDE-AR-N 4105 may be used for *electricity generation facilities* connected to the network through inverters.

5.2 Voltage dips, flicker and overcurrents

An *electricity generation facility* must comply with the requirements of clause 5.1 of EN50438.

Furthermore, the inrush current must not lead to voltage dips in the installation greater than 4% [4], and this requirement is considered to have been complied with if the current is lower than the current values given in **Table 2**.

Connection	Inrush current
Phase and zero	25 A
Three phases	40 A

Table 2 Maximum inrush currents

5.3 DC injection from the facility

The *electricity generation facility* must be designed not to inject DC current during normal operation in accordance with clause 5.2 of EN50438.

This requirement is considered to have been complied with when the *electricity generation facility* meets the specifications for DC current injected by appliances, as specified in IEC 61000-3-2.

Alternatively, requirements specified in VDE-AR-N 4105 may be used for *electricity generation facilities* connected to the network through inverters.

5.4 Power factor

Unless a special agreement is made with the *distribution network operator*, the power factor ($\cos \varphi$) for the *electricity generation facility* must be between 0.95 leading and 0.95 lagging when generation constitutes more than 20% of the *rated power* and the voltage and the frequency lie within the stationary limit values indicated in **4.1**, see clause 5.3 of EN50438.

Alternatively, requirements and settings specified in VDE-AR-N 4105 may be used for *electricity generation facilities* connected to the network through inverters.

6. Notification and documentation

6.1 Notification

According to the 'Joint Regulation' (Fællesregulativet) [2], notification must be performed when an *electricity generation facility* is connected to the network. Notification must be performed by a certified electrician before installation is commenced.

6.2 Documentation

The documentation for the *electricity generation facility* must be as described in this section.

The supplier is responsible for preparing the documentation described for the *electricity generation facility* and sending it electronically to the *distribution network operator*.

Supplier statement

In the supplier statement, the supplier states that the requirements of TR 3.2.1 have been complied with. The requirements for the content of the supplier statement are described in Appendix 1 to TR 3.2.1 which can be downloaded from www.energinet.dk.

Test report

The test report must document that the requirements of TR 3.2.1 have been complied with. The requirements for the content of the test report are described in Appendix 2 to TR 3.2.1 which can be downloaded from www.energinet.dk.

Instead of the test report included in Appendix 2 to TR 3.2.1, documentation specified in VDE-AR-N 4105, appendices F3, F4, G2 and G3, may be used for *electricity generation facilities* connected to the network through inverters.

6.3 Denotification, modification or replacement

If an *electricity generation facility* is denotified, modified or replaced, the *distribution network operator's* standard procedure must be observed.