



Requirements for Offshore Grid Connections in the E.ON Netz Network

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1. Introduction

The following requirements pertain to the grid connections of offshore wind parks in seas, which are referred to here as offshore grid connections.

Except for the deviations and amendments contained herein, the same requirements for the offshore connections basically apply as for all other connections of the Grid for E.ON Netz GmbH (ENE), as defined in "Netzanschlussregeln Hoch- und Höchstspannung" ("Grid Code High and Extra-High Voltage") (NAR, Updated: 01.04.2006).

The fulfilment of the NAR and of the requirements for the offshore grid connections are an essential condition to ensure a securely operating system, not only for the offshore wind parks, but also for the grid onshore.

2. Legal Framework and Scope

The law which came into effect in December 2006 to accelerate the planning process for infrastructure projects, that is, §17 sec. 2a Energiewirtschaftsgesetz (Energy Industry Act), requires transmission system operators (TSO) to lay out and operate grid connection cables up to the substations for generating plants which are erected in the North and Baltic Seas, and which comply with the Erneuerbare-Energien-Gesetz (Renewable Energy Sources Act).

The amended or deviating requirements as set forth herein apply, in combination with the NAR for the grid connection point.

3. Terminology

Generating plant

A generating plant (offshore wind park) can comprise of one or more generation units. It includes all auxiliary operations and units.

Generation unit

A generation unit consists of a single wind energy turbine with the corresponding generator, generator transformer and switching stations in a tower.

Grid connection system

The term grid connection system denotes all connections between the grid coupling point and the connectee. Depending on the connection design, the grid connection system can consist of partial DC transmission (HVDC) or a direct AC connection.

Grid connection point

The grid connection point is the point at which the connectee's station is connected to the grid connection system. For the offshore wind parks this is the offshore cable sealing end of the grid connection system. Concurrently, it represents the ownership boundary between the connectee's facility and that of the TSO.

Grid coupling point

The grid coupling point is where the grid connection system of the offshore-wind park is connected to the transmission grid of the ENE onshore.

Abbreviations for the Voltage Levels

HV – high voltage

MV – medium voltage

LV – low voltage (generator voltage)

4. Requirements at the Grid Connection Point

4.1. Voltage and Frequency Characteristics

Supplementary to the NAR section 3.1.7, the following nominal voltage is specified for the grid connection point:

- 155 kV: continuous operating voltage of 140 - 170 kV

For individual connections, other nominal voltages are acceptable, subject to ENE approval.

The nominal frequency for the offshore grid connection is 50 Hz as in the NAR.

In contrast to the specified frequency range as specified in the NAR section 3.1.7, an extended range is applicable:

- within an uninterrupted continuous operation and within a limited operation of 10 minutes (fig. 3): 47.5 – 51.5 Hz
- limited to up to 10 seconds: 46.5 and 53.5 Hz

4.2. Neutral Point Connection and Layout of the Generating Plant Transformers

Supplementary to the NAR section 3.1.8 the following applies:

The grid connection system, including the metallicly connected parts, operates at a low resistance neutral point (solidly earthed).

To decouple the zero phase sequence components, improve the symmetry of the line-to-earth- voltage during short circuits, and avoid transmitting odd-numbered harmonics, divisible by three, the HV/MV transformers are to be implemented in the vector group YN/d5.

Not all of the neutral points at the high voltage side of the HV/MV transformer need a switchable direct connection to earth.

The HV/MV transformers must be equipped with +/- 6 steps from +/- 13 % by means of a tap changer. This tap changer is to be integrated within the control design of the grid connection. Both the control design and settings are subject to ENE approval.

4.3. Active Power Output

The following deviations to the NAR section 3.2.5 apply:

All generation units must be disconnected from the grid upon reaching a frequency at the grid connection point of less than 46.5 Hz or greater than 53.5 Hz and after a time delay of 300 ms.

If the frequency at the grid connection point reaches a range of 46.5 – 47.5 Hz or 51.5 – 53.5 Hz, a subsequent disconnection is allowed only after 10 seconds.

Consequently, when the operating range deviates from the nominal frequency the requirements in the NAR, in contrast to those depicted in figure 3, are as follows:

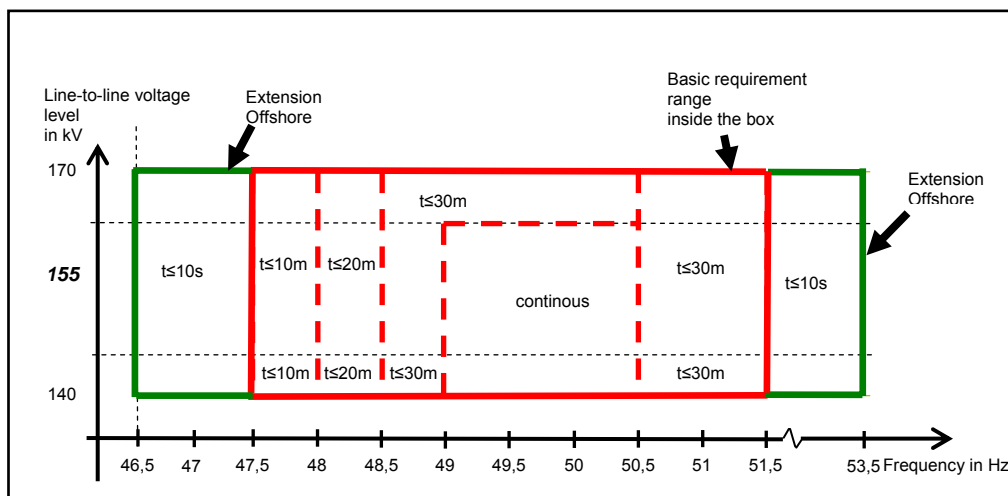


Figure 3 “Offshore” Requirements for a generating plant power output for the grid within a specified time period, relative to grid frequency and voltage.

After a failure involving loss of voltage at the grid connection point, a restart is only permitted at a maximum rate of increase of 10% of the installed active power per minute.

4.4 Reactive Power Exchange and Voltage Stability

At the grid connection point with a nominal voltage of 155 kV the following requirements apply, in contrast to those in figure 4 of the NAR:

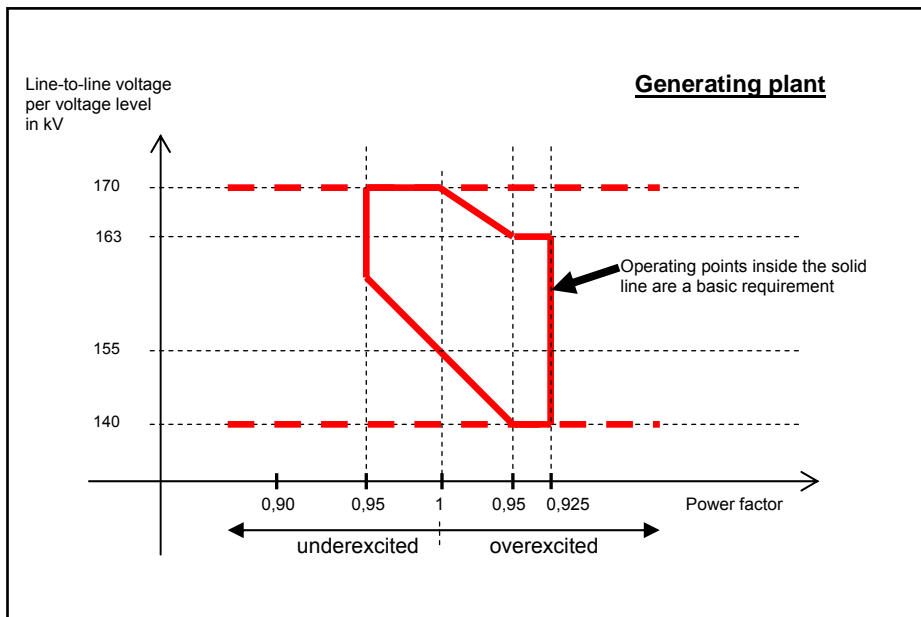


Figure 4a “Offshore” Minimum requirements for the reactive power compensation of a generation plant at frequencies between 47.5 and 51.5 Hz with unrestricted active power output

The following specifications for the reactive power exchange apply for the generation unit:

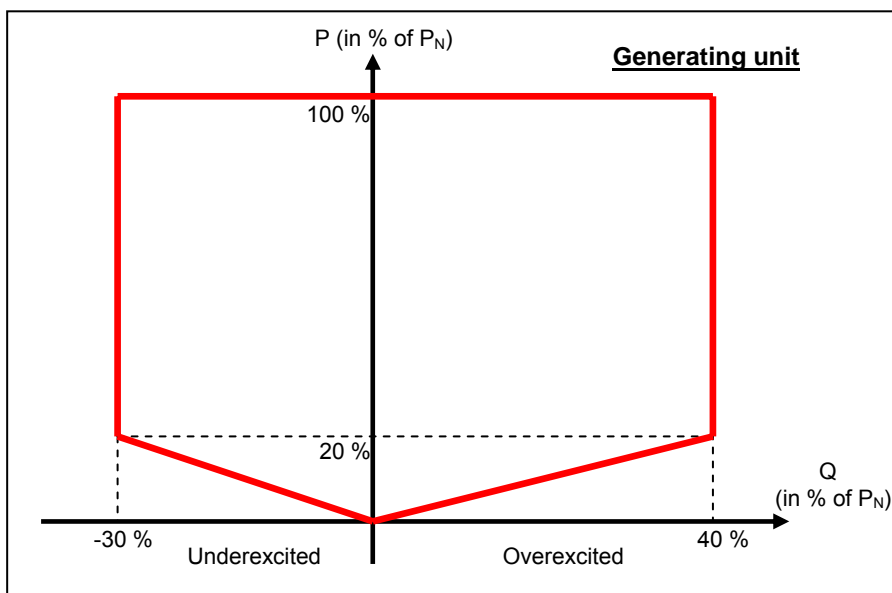


Figure 4b “Offshore” Minimum requirements for the useable P/Q-operation range of a generation unit within the voltage range of $\pm 5\% U_N$ (at the generation unit).

The connectee is responsible for the complete compensation of the MV grid of the generation plant at no load, for example, by means of a switchable reactance coil. The compensation plant is to be integrated within the control design of the grid connection. Both the regulated design and settings are subject to ENE approval.

4.5 Characteristics of Generating Plants during Grid Failures

Supplementary to and/or deviating from the NAR section 3.2.6.2 established requirements, the following characteristics of the generating plants at the grid connection point apply:

The voltage support of the generation unit is to be activated when a voltage dip of over 5 % of the rms value of the generator voltage occurs.

The voltage support must occur within 20 ms of fault detection.

Based on the established requirements as described herein, the following applies for figure 7 of the NAR:

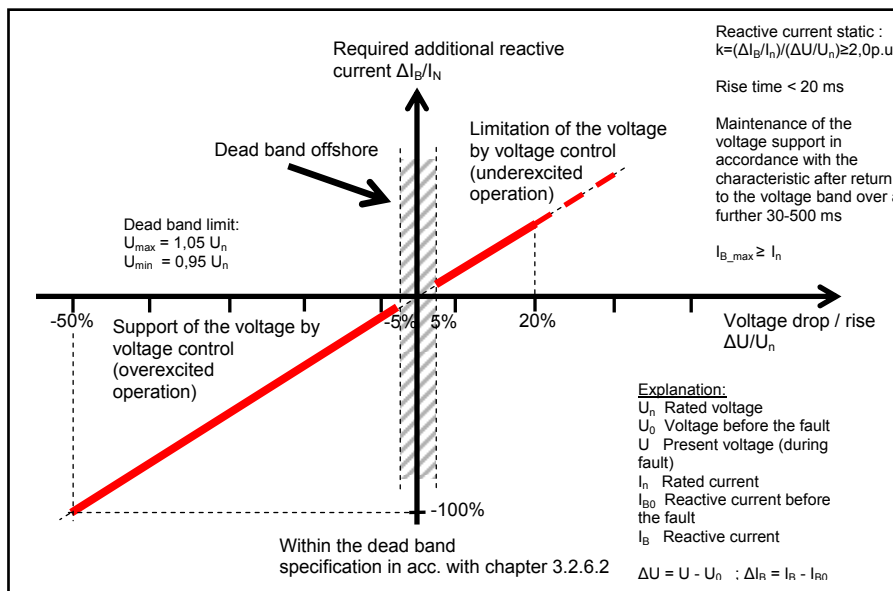


Figure 7 “Offshore” Principle of voltage support at the individual generator during a grid failure. In some cases the incline of the voltage support can be altered.

4.6 Active Power Reduction During Overfrequency

The following deviations to NAR section 3.3.2 apply:

Frequency-dependent reduction of the active power occurs within a range of 50.1 to 51.5 Hz. The active power fed in is to be reduced at a rate of 98 % per Hz and 25 % per second of the active power of the generation unit available at that moment.

Figure 8 of the NAR is replaced by the following for offshore connections:

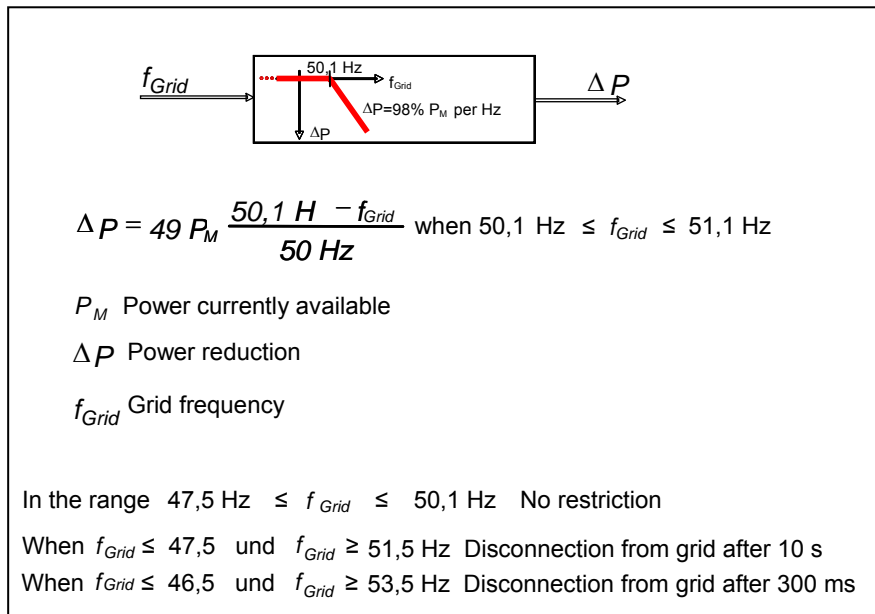


Figure 8 “Offshore” Active power reduction at overfrequency

5. Protection Devices and Automation

Supplementary to NAR sections 3.2.7 and 4.4, these specified requirements for the offshore connections apply:

At least two independent protection systems will be implemented. Both protection systems operate in first-zone time protection and under different protection principles (for example, differential and distance protection). For the two protection systems different hard and software platforms must be implemented. In addition, transformers and reactive coils are equipped with a Buchholz relay.

Busbars in the generating plants are to be protected in first-zone time protection.

Short fault clearance times are to be maintained throughout the whole protection zone. During a circuit breaker failure (also within the generating plant), a disconnecting time limit of 250 ms must be observed.

In the generating plant a direct longitudinal unsymmetrical state of over 20% of the nominal operation average current should automatically be eliminated at a disconnecting time of up to 500 ms.

The design and the settings of this protective function are subject to ENE approval.

6. Data Exchange

6.1 Basic design

To carry out the static and dynamic grid connection tests, the data and documents required in appendix E, table 2 of the NAR, must be made available to ENE in the form of a so-called basic design.

This basic design supplies definitive information on the generating plant in descriptive detail.

6.2 Expanded Data Range for the Grid Connection Test.

To carry out the grid connection test on offshore wind parks, additional data and documents are to be submitted:

- a) design for the voltage and frequency regulation of the generating plant.
- b) for the steady state study:
 - documents in accordance with appendix E, table 2 (basic design)
 - simulation model in Integral (Version 6.8) for the network between the grid connection point and the generation unit including a schematic diagram.
- c) for the dynamic system study:
 - proof of the behaviour of the generating plant and/or of the generation units during failures in the grid connection and/or at the generator terminal
 - detailed dynamic NETOMAC model including:
 - an illustration including all essential features of the wind park, including the dynamic behaviour of the WEA for the grid connection point
 - all limitations and boundary of the equipments, voltage and frequency control within the wind park
 - modelling of transformers
 - modelling of cables
 - modelling of compensation facilities (reactive coils, capacitors, active compensators, etc.)
 - proof of verification that the model correlates with the actual generation unit.