Ordinance on System Services by Wind Energy Plants
(System Service Ordinance – SDLWindV)

A. Problem and objective

The development of wind energy generation onshore is progressing forward in line with the political objectives in respect to the development of renewable energies. It is to be expected that up to 36,000 megawatts of facility power will be installed by 2020. This development represents a challenge for the network operators. These must ensure the security of the networks – in tandem with significantly rising shares of wind energy electricity. System services therefore have to be increasingly provided by wind energy plants, which have so far only been required from conventional power stations.

This involves solutions to the following problems in particular:

- In contrast to conventional power stations, wind energy plants are only involved in the frequency control in the network to a limited extent, with the result that power fluctuations can only be compensated to an insufficient degree.
- The voltage control in the network is rendered more difficult if conventional power stations which are involved in the voltage control with synchronous generators are replaced by wind energy plants, and no new devices are provided for reactive power supply.
- The retention of the network security is rendered more difficult if wind energy plants switch off over a large area during a network, thereby resulting in a power deficit after clarification of the network fault.

The aim of the ordinance is to boost the security and stability of electricity networks even with high shares of wind energy in the network as well as the technical development in this field, and hence lay the groundwork for the further development of wind energy.

Operators of wind energy plants shall be ensured an incentive through this ordinance, so that the above problems at the network junction of the wind energy plant with the network are solved. At the same time, the ordinance does not stipulate any specific technology for the wind energy plant, but instead promotes technological openness and is oriented towards the characteristics of the current feed-in at the network junction.

Operators of existing systems shall receive a bonus in order to cover the costs for the investments necessary due to the additional requirements. The above requirements become remuneration prerequisites for wind energy plants newly entering service; however, they too shall receive an increased initial remuneration for a limited time in order to cover the additional costs.

B. Solution

Enactment of a legal ordinance pursuant to section 64 paragraph 1 clause 1 number 1 of the Renewable Energy Sources Act.

C. Alternatives

None.

D. Financial consequences on public budgets

None.

E. Other costs

Business and, in particular, medium-sized companies are faced with additional costs due to this law. Additional costs for compliance with the requirements of this ordinance, which are incurred by the operators of wind energy plants, shall be compensated by higher remunerations or bonuses.

The effect of the price level through higher remunerations in the area of wind energy has already been evaluated within the framework of the cost estimations for the Renewable Energy Sources Act.

F. Bureaucracy costs

The following bureaucracy costs for business, citizens and administration result from the present draft according to the ex-ante estimation:

a) Bureaucracy costs for business

The ordinance draft contains two new information obligations for business. As part of the ex-ante estimation, a total net burden of 189,810 Euros is to be expected, which shall only result in the first two years after the ordinance comes into force.

b) Bureaucracy costs for citizens

The ordinance draft does not contain any new information obligations for citizens.

c) Bureaucracy costs for administration

The ordinance draft does not contain any new information obligations for administration.

Draft of an

Ordinance on System Services by Wind Energy plants

(System Service Ordinance – SDLWindV)

Of …

On the basis of section 64 paragraph 1 clause 1 number 1 of the Renewable Energy Sources Act of 25th October 2008 (Federal law Gazette I p. 2074) the German Federal Government decrees:

Part 1

General Regulations

§ 1

Scope of application

This ordinance regulates

1. the technical and operational specifications pursuant to section 6 number 2 of the Renewable Energy Sources Act,

2. the requirements for the system service bonus pursuant to section 29 paragraph 2 clause 4 of the Renewable Energy Sources Act and how the validation is to be realised, as well as

3. the requirements for the system service bonus pursuant to section 66 paragraph 1 number 6 of the Renewable Energy Sources Act and how the validation is to be realised.

Part 2

New Wind Energy Plants

§ 2

Connection to the medium-voltage network

(1) Operators of wind energy plants pursuant to section 29 paragraph 2 clause 4 and section 30 clause 2 of the Renewable Energy Sources Act, which are connected to the medium-voltage network after the 30th June 2010 must, at the network junction individually or jointly with other systems or by additional technical or operational equipment, meet the requirements of the technical directive "*Erzeugungsanlagen am Mittelspannungsnetz*", edition June 2008 issued by the Federal Association for Energy and Water Management (Medium-voltage Directive 2008 BAnz [add: number and publication date of the supplement in which the Medium-voltage Directive 2008 is

published in the Federal Gazette, as well as the number of pages]), unless otherwise regulated in this ordinance.

(2) Section 2.5.1.2 of the Medium-voltage Directive 2008 applies with the provision that during a network fault the system voltage must be ensured by feeding in a reactive current to the grid in accordance with number II.12.d and number II.12.e of Annex 1.

§ 3

Connection to the high- and maximum-voltage network

Operators of wind energy plants pursuant to section 29 paragraph 2 clause 4 and section 30 clause 2 of the Renewable Energy Sources Act, which are connected to the high- and maximum-voltage network after the 30th June 2010 must, at the network junction individually or jointly with other systems or by additional technical or operational equipment, meet the requirements of the "*TransmissionCode 2007 – Netz- und Systemregeln der deutschen Übertragungsnetzbetreiber*", edition Version 1.1 August 2007 (TransmissionCode 2007 BAnz [add number and publication date of the supplement in which the TransmissionCode 2007 is published in the Federal Gazette, as well as the number of pages]) according to the provision of Annex 1.

§ 4

Connection of various systems to a network junction

The claim for the system service bonus pursuant to section 29 paragraph 2 clause 4 and section 30 clause 2 of the Renewable Energy Sources Act also results if several wind energy plants are connected to a network junction, of which at least one has been put into service by the 30th June 2010, and the requirements pursuant to section 2 or section 3 with provision of the following requirements are fulfilled:

1. the requirements for the available reactive power provision also according to Appendix 2 and
2. the requirements for reactive current provision for the dynamic network support according to the TransmissionCode 2007 also on the undervoltage side of the machine transformer or a reference point comparable in effect.

Part 3

Old Wind Energy Plants

§ 5

Prerequisites for the system service bonus

Operators of those wind energy plants which have been put into service after the 31st December 2001 and before the 1st January 2009, have a claim to the system service bonus pursuant to section 66 paragraph 1 number 6 of the Renewable Energy Sources

Act, if they meet the requirements according to the [add: date at which this ordinance comes into effect] and first specified in Annex 3 before the 1st January 2011 at the network junction or at another point located between the network junction and wind energy plant.

Part 4

Validation and Concluding Provisions

§ 6

Certificates, expert surveys and prototypes

(1) The validation that the prerequisites of sections 2 to 4 in conjunction with Annexes 1 and 2 are complied with at the network junction, must be provided by submission of unit certificates according to the method of chapter 6.1 of the Medium-voltage Directive 2008 and by the expert survey of a qualified expert. The compilation of the certificates and the expert appraisal must be carried out in accordance with the state of the art. Certifying bodies must be accredited in accordance with DIN EN 45011:1998[1] .

(2) The validation that the prerequisites of section 5 in conjunction with Annex 3 are complied with at the network junction can be provided by unit certificates and by the expert survey of a qualified expert. Paragraph 1 clause 2 and 3 apply correspondingly.

(3) If a wind energy plant is a prototype, the requirements of sections 2 to 4 in conjunction with Annexes 1 and 2 shall be deemed to be fulfilled in a period of two years from the commissioning of the system for the remuneration claim pursuant to section 16 paragraph 6 in conjunction with section 6 number 2 of the Renewable Energy Sources Act. Divergent from paragraph 1, the validation that the prerequisites of sections 2 to 4 in conjunction with Annexes 1 and 2 are complied with at the network junction for the prototype, must be provided within two years after commissioning. If the validation according to clause 2 is provided, the requirements of this ordinance shall be deemed to be fulfilled since commissioning of the system. Prototypes are the first wind energy plant of a type exhibiting essential technical further developments or new innovations, and all further wind energy plants of this type which are put into operation within two years after commissioning the first wind energy plant of this type. The existence of an essential technical further development or new innovation must be confirmed by the certifying body.

§ 7

Multiple wind energy plants

---

1 Available from Beuth Verlag GmbH, Berlin, and archived at the Deutscher Patent- und Markenamt in Munich.

When connecting several wind energy plants to a network junction, section 19 paragraph 3 of the Renewable Energy Sources Act applies correspondingly for allocation of the system service bonus.

§ 8

Transitional provisions

(1) Operators of those wind energy plants which are put into service after the 31st December 2008 and until the 30th June 2010, only have a claim to the system service provision bonus pursuant to section 29 paragraph 2 clause 4 and section 30 clause 2 of the Renewable Energy Sources Act, if the requirements pursuant to sections 2 to 4 in conjunction with Annex 1 and 2 are met. Instead of the requirements in Annex 1 number II.12.d and number II.12.e, they can fulfil the requirements of section 3.3.13.5 paragraph 17 and 18 of the TransmissionCode 2007. No requirements pursuant to section 6 number 2 of the Renewable Energy Sources Act are placed on these operators. If operators of wind energy plants according to clause 1 provide evidence pursuant to section 6 paragraph 1 by the 31st December 2010, the requirements are deemed to be fulfilled with the commissioning of the system.

(2) Operators of those wind energy plants which are put into service after the 30th June 2010 and until the 30th June 2011 can, instead of the requirements in Annex 1 number II.12.d and number II.12.e, fulfil the requirements of section 3.3.13.5 paragraph 17 and 18 of the TransmissionCode 2007.

§ 9

Entry into effect

This ordinance comes into effect on the day after its promulgation.

Annex 1

I. The TransmissionCode 2007 must be complied with at the network junction with the following provisions:

1. The words "generating unit" and "generating unit with regenerative energy sources" are to be replaced by the word "*wind energy plant*".

2. The words "energy generating units" and "generating units using renewable energy sources" are to be replaced by the word "*wind energy plants*".

3. The words "of the generator" are to be replaced by the words "of the *wind energy generating unit*".

4. The words "generating units of type 1" are to be replaced by the words "*wind energy plants* which contain *wind energy generating units* of type 1".

5. The words "generating units of type 2" are to be replaced by the words "*wind energy plants* which contain *wind energy generating units* of type 2".

6. The words "grid connection point" are to be replaced by the words "*network junction*".

II. Chapter 3 of the TransmissionCode 2007 applies with the following provisions:

1. In figure 3.2 of section 3.3.6 the words "above the curve requirements $P = P_n$" are replaced by the words "above the curve requirements $P = P_{vb}$".

2. Section 3.3.7.1 is not applicable.

3. The following paragraphs are added before section 3.3.8.1:

"(1) The reactive power refers to the positive phase-sequence system component of the current/voltage oscillation as per IEC 61400-21 Ed. 2[2] Annex C.

(2) The requirement for the reactive power supply on the grid side corresponds to a slow reactive power control in the minute range."

4. Section 3.3.8.1 is formulated as follows:

"3.3.8.1. Reactive power supply at rated active power

(1) Each new *wind energy plant* to be connected to the network must meet within the *rated operating point* ($P_{mom} = P_{bb\ inst}$) the requirements at the *grid connection point* according to a variant of Figure 3.3 (3.3a, 3.3b or 3.3c).

(2) The transmission grid operator selects one of the potential variants on the basis of the relevant network requirements. The agreed reactive power range must be able

[2] Official note: Available form the IEC International Electrotechnical Commission, ISBN 2-8318-9938-9, www.iec.ch.

to be completely cycled through within maximum four minutes and is to be provided at the operating point $P_{mom} = P_{bb\ inst}$. Changes to the reactive power specifications within the agreed reactive power range must be possible at all times.

(3) The network operator must specify one of the three variants according to Figures 3.3a to 3.3c by the time of the grid connection of the *wind energy converter* on the basis of the relevant network requirements. If the network operator later requires a variant other than the one agreed, the claim for the system service bonus will remain unaffected by this.

Figure 3.3a: Minimum requirement for the network-side reactive power supply from *wind energy plants* for the network (Variant 1)

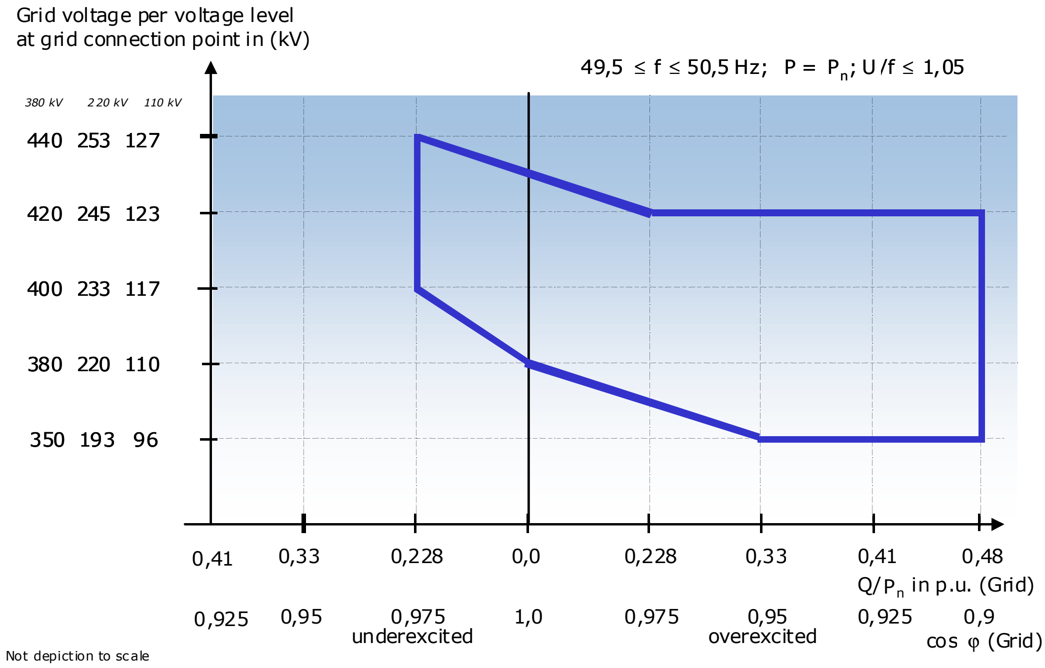


Figure 3.3b: Minimum requirement for the network-side reactive power supply from *wind energy plants* for the network (Variant 2)

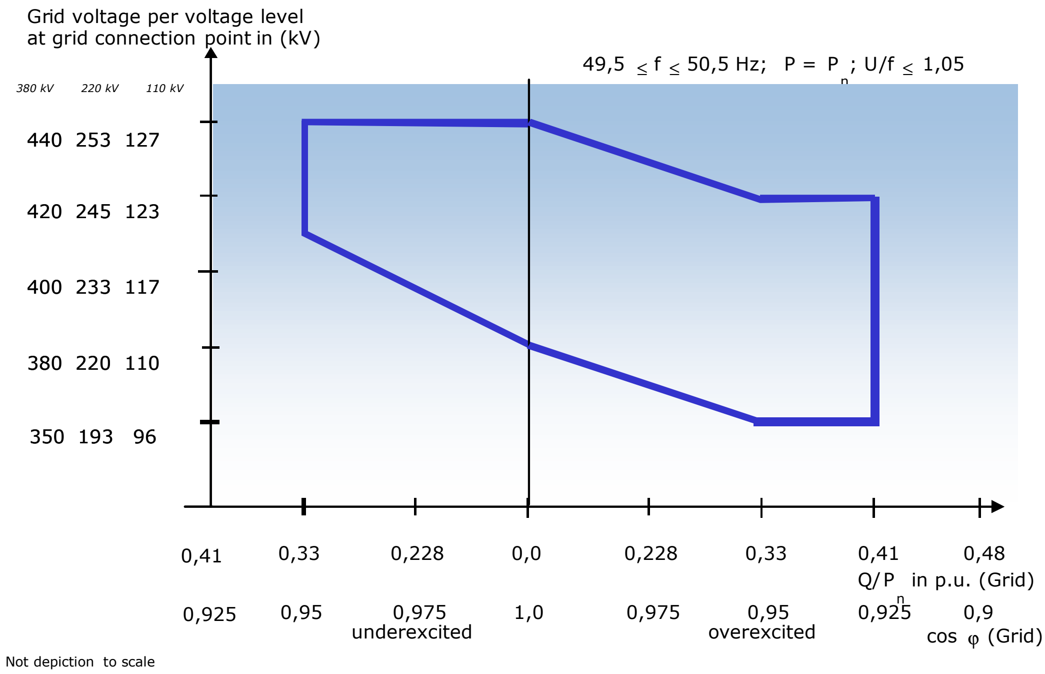
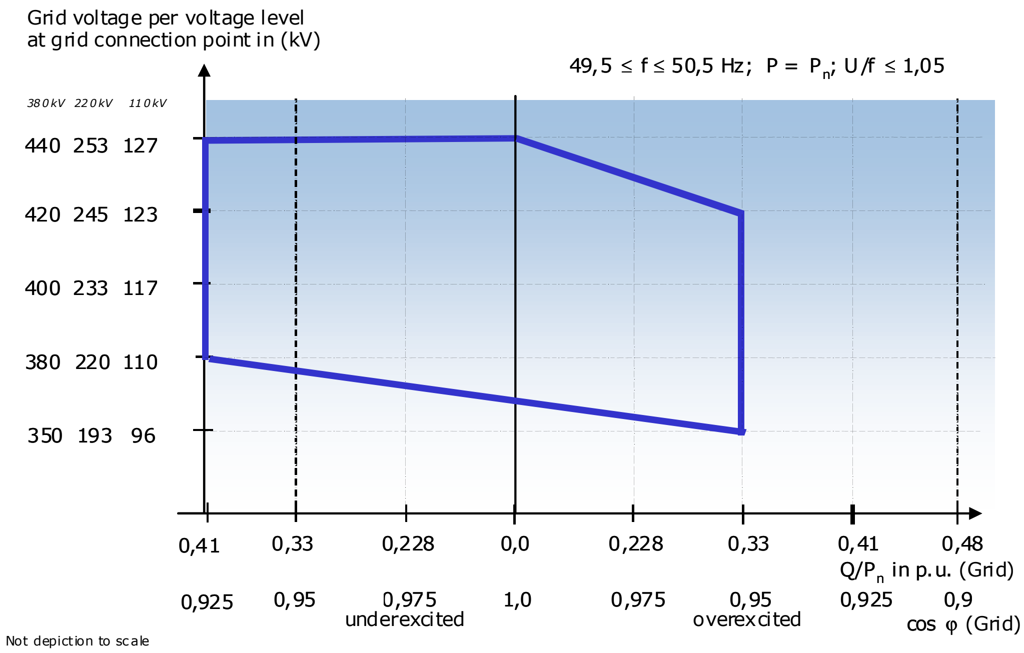


Figure 3.3c: Minimum requirement for the network-side reactive power supply from *wind energy plants* for the network (Variant 3)



5. Section 3.3.8.2 is formulated as follows:

"Section 3.3.8.2. Reactive power supply from generating units operating at less than full output

(1) Apart from the requirements as to the reactive power supply at the *rated operating point of the wind energy plant* ($P_{mom} = P_{bb\ inst}$) there are also requirements concerning operation with an *instantaneous active power* P_{mom}, which is less than the *operational installed active power* $P_{bb\ inst}$ ($P_{vb} < P_{bb\ inst}$).

(2) In this case, it must be possible to operate the *wind energy plant* at every possible working point in accordance with the *generator output diagram*. Figures 3.3d to 3.3f show the minimum requirement for the reactive power supply from generating units operating at less than full output ($0\ \% < P_{mom}/|P_{bb\ inst}| \leq 100\ \%$) at the *grid connection point*. The PQ diagrams are assigned to figures 3.3a to 3.3c. The highest reactive power range to be covered and the associated voltage band are indicated in these figures. The abscissa indicates the *reactive power* Q_{vb} to be provided in relation to the amount of *operational installed active power* $P_{bb\ inst}$ in percent. The ordinate indicates the *instantaneous active power* P_{mom} (in the *consumer meter arrow system* negative) in relation to the amount of *operational installed active power* $P_{bb\ inst}$ in percent.

(3) Every point within the bordered areas in figures 3.3d, 3.3e or 3.3f must be able to be started up within four minutes. The requirement for this can result, depending on the situation, in the network and denote a supply of reactive power taking priority over the active power output. The operating mode is coordinated between the operators of the *wind energy plant* and the operator of the transmission grid.

Figure 3.3d: PQ diagram of the *wind energy plant* at the *grid connection point* in the *consumer meter arrow system (VZS)* for Figure 3.3a (Variant 1)

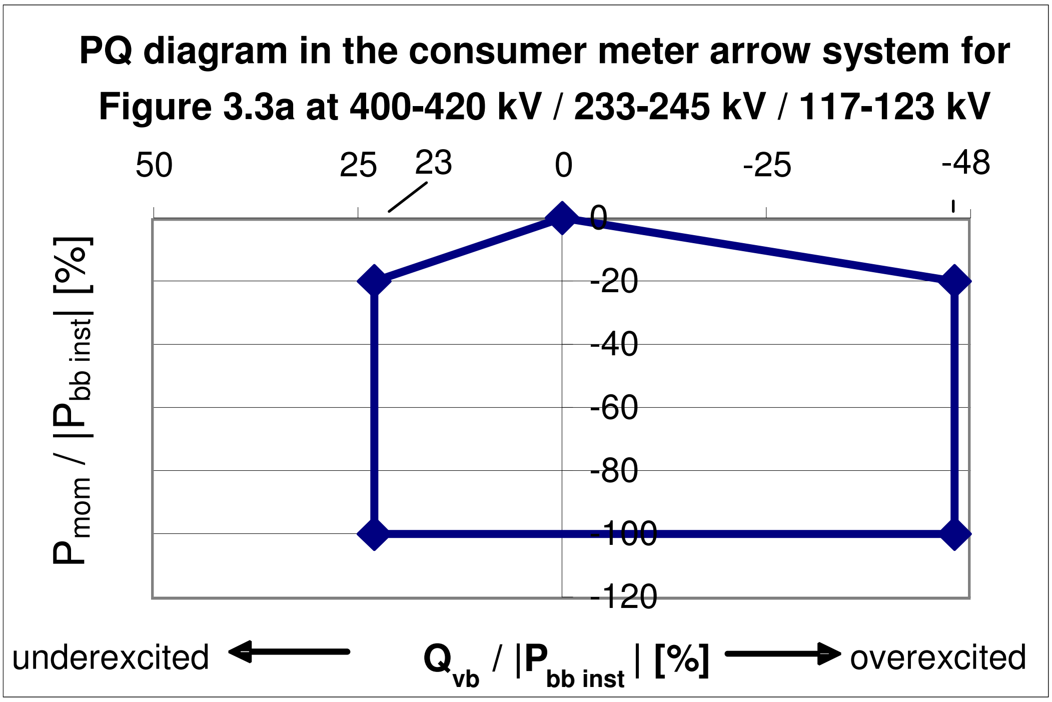


Figure 3.3e: PQ diagram of the *wind energy plant* at the *grid connection point* in the *consumer meter arrow system (VZS)* for Figure 3.3b (Variant 2)

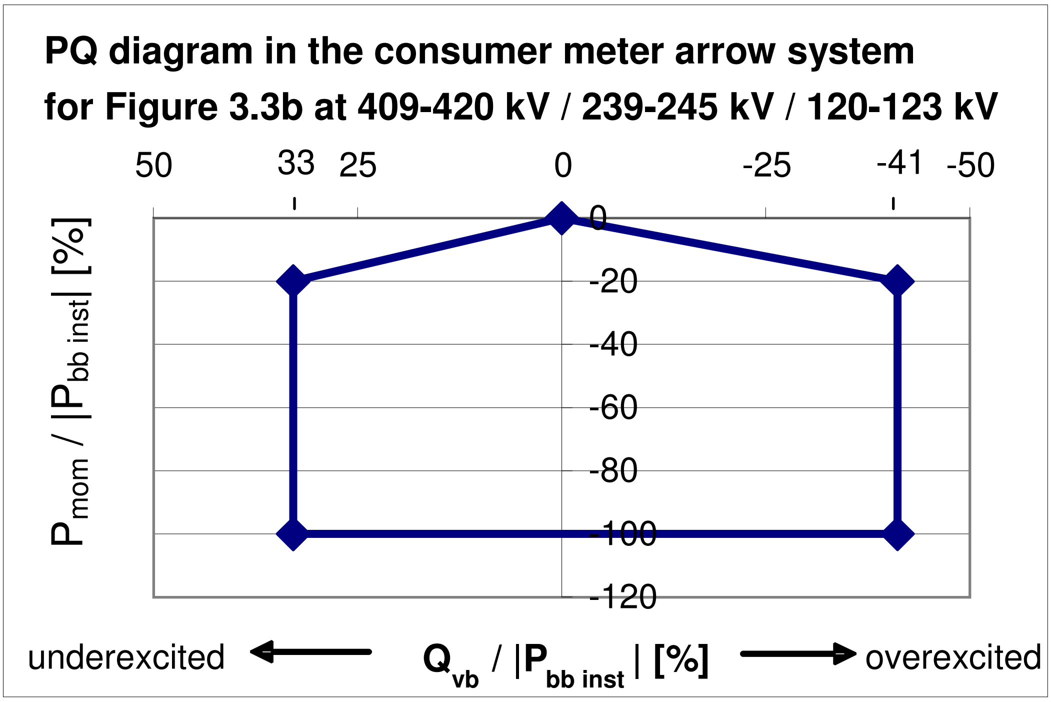
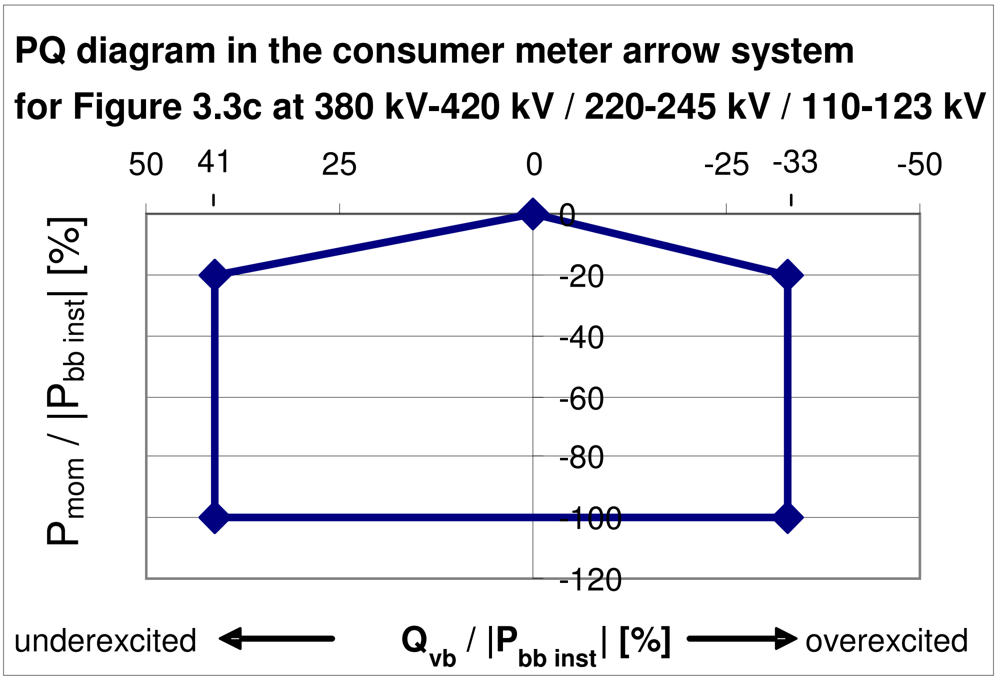


Figure 3.3f: PQ diagram of the *wind energy plant* at the *grid connection point* in the *consumer meter arrow system (VZS)* for Figure 3.3c (Variant 3)



6. Section 3.3.9 is formulated as follows:

"3.3.9 Surge protection concept of the generator transformers

(1) The surge protection concept of the generator transformer is to be coordinated with the transmission grid operator."

7. Section 3.3.10 is not applicable to *wind energy plants*.

8. Section 3.3.12 applies with the following provisions:

a. Paragraph 1 is not applicable to *wind energy plants*.

b. Section 3.3.12.1 applies with the provision that the regulation for symmetrical and asymmetrical (1.2 and 3-pole) network short-circuits is applicable and that the active current feed-in has to be reduced during the fault for the benefit of the reactive current feed-in as well as for securing the stability of the *wind energy generating units*.

c. Section 3.3.12.2 only applies for *wind energy plants* which contain *wind energy generating units* of type 1.

9. Section 3.3.13.1 is not applicable to *wind energy plants*.

10. Section 3.3.13.3 applies with the following provisions:

a. In Figure 3.4 the words "P_m instantaneous available power" correspond to the words "*instantaneous active power* P_{mom} without active power reduction at over-frequency".

b. In paragraph 3 the clause "This regulation is executed decentralised (at each individual generator)" is omitted.

c. Paragraph 4 is replaced by the following paragraphs 4 and 5:

"(4) The regulation according to Figure 3.4 and the regulation for restoration of active power after the return of the frequency to a value of $f \leq 50.05$ Hz can optionally be executed decentralised or centrally in *undisrupted operation*. In the case of faults within the superordinate control of the *wind energy plant* suitable measures for the active power reduction of *wind energy plant units* must be kept ready decentralised in the event of over-frequency.

(5) Upon the request of the network operator (for example via radio ripple control etc.), the function for the automatic recoupling to the network must be blocked."

11. Section 3.3.13.4 applies with the following provisions:

a. The specifications apply for all *wind energy plants.*

b. The reactive power output must correspond within four minutes to the setpoint value specified by the network operator.

c. In the case of an online setpoint value specification, the new specifications for the working point of the reactive power exchange must be realised at the *grid connection point* no later than after four minutes.

12. Section 3.3.13.5 applies with the following provisions:

a. The following paragraphs are added before paragraph 1:

"(i) The reactive power refers to the positive phase-sequence system component of the current/voltage oscillation as per IEC 61400-21 Ed. 2[3] Annex C.

(ii) The minimum requirement corresponds to compliance with the requirements specified according to paragraphs 2, 7, 8, 11 and 17 at the undervoltage side of the generator transformer.

(iii) It is permissible to meet this requirement using another reference point (for example the high-voltage side of the generator transformer), if the same operating performance is demonstrated at the *grid connection point*."

b. Paragraph 8 becomes paragraph 8a. After paragraph 8a the following paragraph 8b is added:

"(8b) The caption for Figure 3.1, according to which voltage gradients less than/equal to 5 % per minute within the voltage bands indicated in Figure 3.1 are permissible and may not lead to disconnection of the *wind energy plants*, applies here also."

c. Paragraph 13 is formulated as follows:

"(13) Single-pole, dual-pole and triple-pole short-circuits (with and without earth contact) or fault-induced symmetrical and asymmetrical voltage dips must not lead to instability of the *wind energy plant* or to disconnection from the grid above the borderline 1 in Figure 3.5. The voltage value refers to the highest value of the three concatenated network voltages, as shown in Figure 3.5."

d. Paragraph 17 is formulated as follows:

"(17) Voltage back-up at network faults through reactive current feed-in

a) Scope of validity

i. In the case of a progression of the highest value of the three concatenated network voltages above the borderline 1 in Figure 3.5, the requirements for the voltage back-up upon network faults through reactive current feed-in must be provided by all *wind energy generating units* according to the following letters b and c.

ii. In the case of a progression of the highest value of the three concatenated network voltages below the borderline 1 and above the borderline 2 in Figure 3.5, it is permissible to diverge from the requirements for the voltage back-up upon network faults according to the following letters b and c:

- The following requirements for the voltage back-up upon network faults through reactive current feed-in only have to be met to the extent that the

[3] Official note: Available form the IEC International Electrotechnical Commission, ISBN 2-8318-9938-9, www.iec.ch.

grid connection concept of the *wind energy generating unit* makes this possible.

- If when cycling through the fault the individual *wind energy generating unit* becomes unstable or the generator protection responds, a short-term disconnection of the *wind energy plant* (KTE) from the grid is allowed in coordination with the relevant network operator.

iii. In the case of a progression of the highest value of the three concatenated network voltages below the borderline 2 in Figure 3.5, a KTE from the network is always allowed. The requirements according to the following letters b and c for the voltage back-up upon network faults through reactive current feed-in only have to be met to the extent that the grid connection concept of the *wind energy generating unit* makes this possible.

b) Basic performance:

i. In the case of a *significant voltage deviation* the *wind energy generating units* must back up the voltage by adjusting (increasing or reducing) the *reactive current* I_B.

ii. The *reactive current deviation* (ΔI_B) of the *wind energy generating unit* must be proportional to the *relevant voltage deviation* ΔU_r ($\Delta I_B / I_N = K * \Delta U_r / U_N$) for this and be in the range (defined by $0 \leq K \leq 10$), as shown in Figure 3.6.

iii. The constant K must be adjustable between 0 and 10.

iv. The fluctuation width of the fed-in reactive current resulting from the set reactive current voltage characteristic must be between –10 % and +20 % of the rated current.

v. The following requirements are set for the level of the *reactive current* I_B:

a. 3-pole faults: *Wind energy generating units* must be technically able to feed in a *reactive current* I_B of minimum 100 % of the rated current.

b. 1.2-pole faults: *Wind energy generating units* must be technically able to feed in a *reactive current* I_B of minimum 40 % of the rated current. The feed-in of the reactive current must not put the requirements for cycling through network faults at risk.

vi. During *significant voltage deviations* U_s the *active current* I_W can be reduced sufficiently for the benefit of the reactive current feed-in and for ensuring the system stability.

c) Time progression:

i. The dynamic performance of the reactive current back-up is characterised by the *step response of the reactive current*, as can approximately occur as a result of network short-circuits.

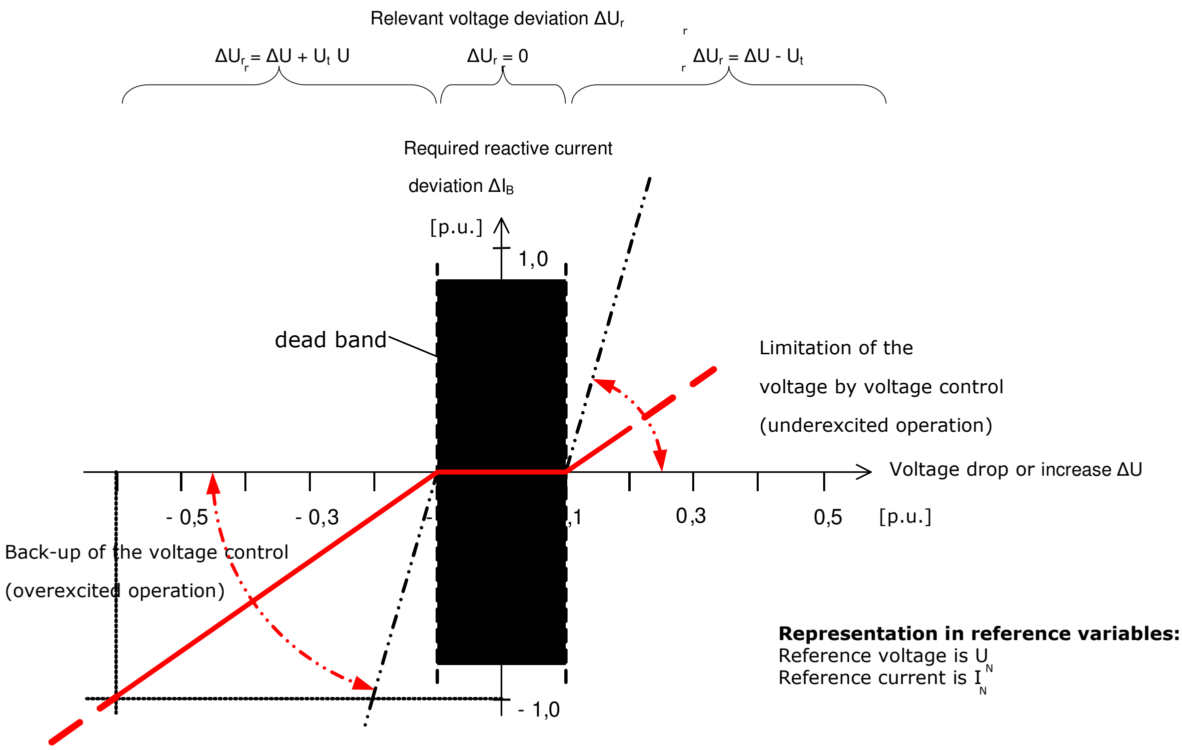
ii. In the case of a *significant voltage deviation*, *step response of the reactive current* must comply with the following values:

a. *Response time*: 30 ms

b. *Transient time*: 60 ms

iii. In the case of continuous voltage progression, the reactive current must not exhibit any discontinuities which are not intended by the reactive current voltage characteristic according to Figure 3.6 and which can affect the network quality in a negative way. This also applies in particular for the transition between the operation at *voltage deviations* ΔU within the *voltage dead band* U_t and operation at *significant voltage deviation* U_s.

Figure 3.6: Principle of voltage back-up in the case of network faults in *wind energy generating units*



“

e. Paragraph 18 is not applicable.

f. Paragraph 19 is not applicable.

g. Paragraph 20 is formulated as follows:

"In the case of distances between the *wind energy generating units* of the *wind energy plant* and the *grid connection point* causing the voltage control to become ineffective, the network operator can require the operators of the *wind energy plant* to measure the voltage dip at the *grid connection point* and control the voltage at the same point depending on this measuring value. The *wind energy generating units* must therefore be able to use a reference voltage which is outside the *wind energy generating unit* instead of the voltage at the undervoltage side of the generator transformer. This can be calculated using a measuring system or suitable method in coordination with the network operator."

h. Section 3.3.13.6 is not applicable.

i. Section 3.3.13.7 is not applicable.

III. The following definitions are added at chapter 9.2:

"1. "*Response time*" is the characteristic variable of the step response. This involves the time between the abrupt entry of a *significant voltage deviation* U_s and first reaching the tolerance band around the *stationary end value* of the *reactive current* I_B. The *response time* comprises the time of detecting a *significant voltage deviation* as well as the settling time of the reactive current control.

2. "*Operational installed active power* $P_{bb\,inst}$", also designated as "nominal active power", is the sum of the nominal active powers of the *wind energy generating units* within a *wind energy plant*. *Wind energy generating units* which are in revision or defective are excluded.

3. "*Reactive current* I_B" is the total reactive current which is ascertained from the positive phase-sequence system components (indexing with "1") of the basic oscillation component of current and voltage on the low-voltage side of the generating transformer: $I_B = \frac{Q1}{\sqrt{3} \cdot U1}$ with $Q1 = \mathrm{Im}\{\underline{U}1 \cdot \underline{I}1^*\}$; underlined: complex variable; "*": conjugated complex variable.

4. "*Reactive current deviation* ΔI_B" is the deviation of the *reactive current* I_B from the 1-minute mean value.

5. "*Transient time*" is the characteristic variable of the step response. This involves the time between the step-like occurrence of a *significant voltage deviation* U_s until the time at which the transient processes have abated to the extent that the *reactive current* I_B is in the tolerance band around the *stationary end value* and remains there.

6. "*Disrupted operation*" is an operating state of the *wind energy plant* in which one or more of its systems do not work in line with the concept.

7. "*Installed active power* P_{inst}" is the sum of nominal active powers of the *wind energy generating units* within a *wind energy plant*.

8. "*Output diagram"* is the active power reactive current diagram (PQ diagram) of the *wind energy plant* at the *grid connection point*.

9. "*Instantaneous reactive power Q_{mom}*" is the instantaneous value of the reactive power of a *wind energy plant* at the *grid connection point* in the *consumer meter arrow system*.

10. "*Instantaneous active power P_{mom}*" is the instantaneous value of the active power fed in at the grid connection point.

11. The "*rated operating point* of a *wind energy plant"* is the operation of a *wind energy plant* with output of *operational installed active power $P_{bb\,inst}$* at nominal voltage and nominal frequency in *undisrupted operation*.

12. "*Network junction*" is the network point at which the *wind energy connection facility* is connected to the grid of the network operator.

13. "*Relevant voltage deviation ΔU_r*" is the component of the *voltage deviation ΔU*, with which the *voltage U1* deviates beyond the limits of the *voltage dead band U_t*. Within the *voltage dead band U_t* the *relevant voltage deviation (ΔU_r)* is equal to zero:

- If: $\Delta U > U_t$: $\Delta U_r = \Delta U - U_t$
- If: $\Delta U < -U_t$: $\Delta U_r = \Delta U + U_t$
- Otherwise: $\Delta U_r = 0$

14. "*Significant voltage deviation ΔU_s*" is a *voltage deviation ΔU* with an amount which is greater than the *voltage dead band U_t*.

15. "*Voltage U1*" is the voltage which is determined from the positive phase-sequence system components of the basic oscillation share of current and voltage on the low-voltage side of the generator transformer.

16. "*Voltage deviation ΔU*" is the deviation of the *voltage U1* from the 1-minute mean value. A voltage deviation with negative sign corresponds to a voltage dip. A voltage deviation with positive sign corresponds to a voltage rise.

17. "*Voltage dead band U_t*" corresponds to 10 % of the nominal voltage, but can also be reduced or set equal to, with the agreement of the network operator, for example when using a continuous voltage control.

18. "*Step response of the reactive current I_B*" is the time progression of the *reactive current I_B* as a result of the abrupt change to the *voltage U1*.

19. "*Stationary end value*" of the *reactive current I_B* is the value of the *reactive current I_B* in relation to the *voltage U1* in the transient state.

20. "*Static reactive current compensation*" is a non-rotating facility which can be used as a controlled reactive current source or reactive current sink.

21. "*Current I1*" is a positive phase-sequence system component of the phase current on the low-voltage side of the generator transformer.

22. "*Undisrupted operation*" is an operating state of the *wind energy plant* in which all systems of the *wind energy plant* work in line with the concept.

23. "*Consumer meter arrow system (VZS)*" is a uniform meter arrow system for consumers and producers.

24. "*Available reactive current Q_{vb}*" is the maximum possible value of reactive current which a *wind energy plant* can provide at the *grid connection point* both overexcited and underexcited; it depends on the operating point (*instantaneous active power P_{mom}* and voltage at the *grid connection point*).

25. "*Available active power P_{vb}*" is the maximum possible value of the active power feed-in of the *wind energy plant* at the *grid connection point*.

26. "*Wind energy connection facility*" is the totality of all operating equipment which is necessary in order to connect one or more units for generating electrical energy from wind energy to the grid of a network operator.

27. "*Wind energy plant*" is a facility in which one or more units for generating electrical energy from wind energy (*wind energy generating unit*) are located. This also comprises the connection facility and all electrical equipment necessary for operation. *Wind energy plants* are units for generating electrical energy from wind energy. These can be connected to a grid either individually or linked via an internal wind farm cabling. A *wind energy plant* can consist of different types of *wind energy generating units*.

28. "*Wind energy generating unit*" is an individual system for generating electrical energy from wind energy. A *wind energy generating unit* of type 1 is present if a synchronous generator is coupled directly to the grid. A *wind energy generating unit* of type 2 is present if this condition is not fulfilled.

29. "*Active current I_W*" is the total active current which is determined from the positive phase-sequence system component (indexing with "1") of the basic oscillation share of current and voltage: $I_W = \frac{P1}{\sqrt{3} \cdot U1}$ with $P1 = \mathrm{Re}\{\underline{U}1 \cdot \underline{I}1^*\}$; underlined: complex variable; "*": conjugated complex variable."

Annex 2

$\sum_{i}^{N_{neu}} \boldsymbol{P}_{bb\,inst,i}$ with N_{new} = Number of all newly erected or re-powered *wind energy generating units* and the total *operational installed active power. $P_{bb\,inst}$* $\sum_{j}^{N_{WEA}} \boldsymbol{P}_{bb\,inst,j}$ with N_{WEP} = Number of all old and new *wind energy generating units* in the extended *wind energy plant.*

$Q_{vb,\,required}$ is the *available reactive power Q_{vb}* required according to sections 2 and 3, if a *wind energy plant* would only consist of newly erected or re-powered *wind energy generating units*.

$Q_{vb,\,proportionally,\,NAP}$ is the *available reactive power Q_{vb}*, required proportionally at the *grid connection point*, if an extended *wind energy plant* comprises both newly erected and old *wind energy generating units*:

$$Q_{vb,\,anteilig,\,NAP} = Q_{vb,\,gefordert} \frac{\sum_{i}^{N_{neu}} P_{bb\,inst,i}}{\sum_{j}^{N_{WEA}} P_{bb\,inst,j}}$$

Annex 3

1. The definitions of Annex 1 number III are also applicable within the framework of Annex 3.

2. Symmetrical and asymmetrical faults with a voltage dip above boundary line 1, which are described according to Figure 3.5 in section 3.3.13.5 of the TransmissionCode 2007 (for systems of type 2), must be cycled through without disconnection from the grid.
   The reactive power reference must not lead to activation of the reactive power undervoltage protection.
   The requirement in section 3.3.13.5 paragraph 2 of the TransmissionCode 2007, must not be observed according to which a shutdown or switch-off command from the off auxiliary contacts of the power switch on the upper voltage or undervoltage side of the network transformer is given to all individual generators of the system, so that the isolated operation is terminated after no later than three seconds.

3. A reactive power undervoltage protection (Q→& U<) must be present. Its setting values are specified in accordance with the Medium-voltage Directive 2008.

4. A disconnection from the network at frequencies between 47.5 Hz and 51.0 Hz is not allowed.

5. At an *available active power* P_{vb} of greater than or equal to half the *available installed active power* ($P_{vb} \geq 50\ \%\ P_{bb\ inst}$), and a frequency higher than 50.2 Hz and lower than 51.0 Hz, the *instantaneous active power* P_{mom} of every individual *wind energy generating unit* must be able to be reduced with a gradient of 40 % of the *available active power* P_{vb} of the *wind energy generating units* per Hz.
   Between 51.0 Hz and 51.5 Hz, the over-frequency protection devices of the individual *units* of a *wind energy plant* must be set staggered using the entire area in such way that all *wind energy generating units* are disconnected from the network at a frequency of 51.5 Hz.

6. Upon the request of the network operator (for example via radio ripple control or similar), the function for the automatic recoupling to the network must be blocked.

7. The settings to be modified for the decoupling protection are specified by the network operator.

Substantiation

A. General

I. Objectives and necessity of the ordinance

The present ordinance is necessary in order to be able to attain the improvement in the network integration of wind energy plants aimed for in the Renewable Energy Sources Act of 31st October 2008 (Federal Gazette I p. 2074). The ordinance regulates the requirements which operators of wind energy plants have to meet for improvement of the network integration at the network junction.

The Renewable Energy Sources Act entered into effect on 1st January 2009 contains in section 64 paragraph 1 number 1 the authorisation to regulate requirements in respect to wind energy plants for improvement of the network integration and for hazard beacons and navigation lights (system service bonus). Requirements which generally have to be complied with by the system operators at the network junction are regulated in this ordinance, and not requirements for individual systems. The ordinance is to specify, in particular, the performance in relation to voltage control and reactive power supply, the frequency control, validation process as well as the supply restoration in the event of a fault, also in the case of extension and upgrading of existing wind farms. The hazard beacons and navigation lights are not regulated in this ordinance; to this extent the ordinance authorisation is not fully utilised.

The remuneration of the electricity from wind energy plants newly connected to the network onshore is linked for the first time to the requirement with the enactment of this ordinance that definite technical requirements for the network integration of the systems are fulfilled. A minimum standard for the improved network integration and for the performance in the event of a fault is to be ensured. The legal anchoring of technical requirements means that special significance is ascribed to the aspect of the network integration of wind energy plants.

For a certain transitional period, an increased initial remuneration (system service bonus) is guaranteed for wind energy plants onshore, which meet the connection prerequisites; this economic incentive is meant to accelerate the technological further development of the technology in and relating to wind energy plants short-term as well.

Moreover, the new Renewable Energy Sources Act also creates incentives for voluntarily upgrading of wind energy plants already in service with a view to improving the network security. This is based on insights concerning a potential hazard to the network operation due to an extensive shutdown of wind energy plants over a large area in the event of a fault and the absence of an option for controlling this by the network operator. These problems are to be surmounted with the upgrading, so as to be able to ensure system security long-term.

II. Background

At the end of 2008 around 20,000 wind energy plants with a power of over 23,000 MW were in service. With over 40 billion kWh (Bundesverband Erneuerbare Energien e. V.,

7. January 2009), the share in the entire gross electricity consumption in Germany was around 6 %. The generation of electricity from wind energy onshore has therefore attained a significant share in the generation of electricity; it is increasingly influencing the planning and operation of electricity networks as well as power station applications.

It is to be expected that up to 36,000 MW will have been installed by 2020 (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, pilot study 2009, September 2008, p. 135). This development represents a challenge for the network operators. These must ensure the security of the grids in the case of significantly rising shares of wind energy electricity. This is confronted with the following problems in particular:

- In contrast to conventional power stations, wind energy plants are not involved with the frequency control in the grid, with the result that the power fluctuations can only be compensated to an insufficient degree.
- The voltage control in the grid is rendered more difficult if conventional power stations which are involved in the voltage control with synchronous generators are replaced by wind energy plants, and no new devices are provided for reactive power supply;
- The retention of the network security after network faults is rendered more difficult if wind energy plants switch off over a large area during a network fault, thereby resulting in a power deficit after clarification of the network fault.

III. Essential content of the ordinance

The ordinance envisages definite technical requirements for remedying the problems in the network, which the wind energy plants have to fulfil at the network junction.

1. New wind energy plants

For operators of wind energy plants who put their systems into service after the 30th June 2010 and have connected to the medium voltage network, compliance with the requirements of the "*Erzeugungsanlagen am Mittelspannungsnetz* (Generation Facilities in the Medium-voltage Network)", edition June 2008 (hereinafter Medium-voltage Directive 2008) is rendered binding with the ordinance. If the systems are connected directly to the high- or maximum-voltage network, the TransmissionCode 2007 – *Netz- und Systemregeln der deutschen Übertragungsnetzbetreiber* (Network and System Regulations of the German Transmission grid Operators)", edition Version 1.1 August 2007 (hereinafter Transmission Code 2007) with the provisions planned in Annex 1 applies for the system operators. System operators whose systems are put into service before the 1st January 2014, shall receive a bonus of 0.5 cents per kilowatt hour for compliance with these requirements in accordance with sections 29 paragraph 2 clause 4 and section 30 clause 2 of the Renewable Energy Sources Act for the period of the initial remuneration.

2. Old wind energy plants

Wind energy plants which have been put into service after the 31st December 2001 and before the 1st January 2009, shall receive, pursuant to section 66 paragraph 1 number 6 of the Renewable Energy Sources Act, the so-called system service bonus for five years to the amount of 0.7 cents per kilowatt hour, if they fulfil certain technical requirements. This essentially includes the obligation for cycling through faults, and the obligation for contributing to frequency control.

IV. Alternatives

None.

V. Notification obligations

No new notification obligations, administrative duties or approval procedures are introduced or extended with the ordinance draft.

VI. Ordinance consequences

1. Desired and undesired consequences

This ordinance has positive effects on the development of electricity generation from renewable energies, as the security of the grid is significantly improved by this and hence wind energy plants increasingly assume the properties of a power station. As a result, the grid stability can also be maintained at a very high level with an increasing share of wind energy in the generation of electricity.

Although the ordinance regulates new requirements in conjunction with the remuneration of wind energy plants, a bonus shall nevertheless be paid for this for a transitional period, so that the incentive to erect wind energy plants may not be diminished by the new requirements. It is assumed that the costs for compliance with the requirements will fall due to the spread of technology to such an extent that no further additional remuneration will be necessary after expiry of the transitional period.

2. Costs for the public budgets, business and consumers

No additional costs arise for the public budgets, business and consumers as a result of the ordinance.

Although additional costs can arise through the new requirements for business in the form of operators of wind energy plants, these are nevertheless compensated by the higher remuneration payments or bonuses which are ensured according to this ordinance win conjunction with the Renewable Energy Sources Act.

The situation is represented as follows for operators of new wind energy plants.

Ecofys has, in a research project for the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, conducted its own estimation regarding the level of the system service bonus for new wind energy plants (Ecofys, *Abschlussbericht Verbesserte Netzintegration* *für Windenergieanlagen* (Concluding Report on Improved Network Integration for Wind Energy Plants) 2009, p. 43ff.). In this estimation, the additional costs for an entire example wind farm were ascertained and apportioned to a in-feed remuneration, which result from the requirements of the Medium-voltage Directive 2008 and the TransmissionCode 2007 as well as the specifications in comparison to the previous connection practice as defined by the EEC amendment.

The extra costs for new wind farms in the medium voltage level are in the range from 0.30 to 0.40 cents per kilowatt hour according to these calculations for all economically feasible projects. For wind farms in the high- and maximum-voltage level with a power of between around 35 and 70 MW, the additional costs are between about 0.37 and 0.47 cents per kilowatt hour; however, these extra costs are reduced for wind farms in the high and maximum voltage level with a power of more than 100 MW to values of 0.30 to 0.40 cents per kilowatt hour. The costs relate to an amortisation period of 16 years.

These results are marred by a certain degree of uncertainty, which result above all from the price development of the requisite components that is difficult to ascertain. One the one hand, the regulations of the EEC amendment will lead to an increased demand and hence rising prices; on the other hand, however, effects of scale are also to be expected.

Pursuant to section 29 paragraph 2 clause 4 of the Renewable Energy Sources Act, the initial remuneration rises by 0.5 cents per kilowatt hour. The initial remuneration shall be paid at the reference location for 16 years, so that the additional costs for the higher technical requirements can be covered by this.

As it is not compulsory for existing facilities to meet the requirements, but only receive a bonus if they comply with the requirements, only facilities shale be upgraded where the upgrading does not involve any extra costs. The amount of the remuneration has also been estimated here on the basis of the research project carried out by Ecofys.

The level of the system service bonus has already been specified within the framework of the Renewable Energy Sources Act and the rising costs resulting from this in the area of electricity prices have already been taken into account there.

3. Bureaucracy costs

Two new information obligations have been introduced with section 7 of the ordinance.

a. Bureaucracy costs for business

aa. Validation of the requirements pursuant to section 5 in conjunction with Annex 3

In order to receive the system service bonus pursuant to section 66 paragraph 1 number 6 of the Renewable Energy Sources Act, wind energy plants which have been put into service after the 31st December 2001 and before the 1st January 2009 according to section 5, must submit a unit certificate and an expert survey for the wind energy plant pursuant to section 6 paragraph 2, as validation for compliance with the requirements of this ordinance.

Overall, around 8000 wind energy plants have been connected to the network in the period from 31st December 2001 until 1st January 2009. The upgrading for certain system types is expensive and therefore not viable. As a result, only around 5000 facilities will be upgraded. The upgrading cannot be implemented until the ordinance comes into effect presumably by the beginning of July 2009 and only until the 31st December 2010. According to this, a total of 1.5 years remain for the upgrading. Around 3330 cases a year therefore result. Consequently, the number of cases is significantly below 10,000 cases here as well.

Nevertheless, an individual cost estimation is carried out because, according to chapter 5.3 of the guideline for the ex-ante estimation of the bureaucracy costs following the standard cost model (SKM) for certifications, costs of 70.31 Euros are incurred for each case and hence the total costs according to the estimation in the simplified method are over 100,000 Euros.

The unit certificate will already be available for some of the systems to be upgraded, as some manufacturers have already had their system types certified in the past few years. In the case of other systems, the unit certificate will easily be possible, as the relevant data is already available. In order to submit the unit certificate and expert survey, the system operator must carry out the following standard activities. He must become involved in the information obligation, in particular by finding a certification body and expert evaluator. The later must be commissioned and given the opportunity to inspect the wind energy plant, at least one session with the certification body having to be arranged for this. Finally, the certificate issued by the expert or certification body must be sent to the network operator. The obligations are estimated as moderately complex, with the result that 15 minutes are anticipated for the integration, 60 minutes for the meeting with the certification body and a further 15 minutes or so for communication of the information. The time required therefore amounts to 1.5 hours in total.

This involves coordinating activities, which can be assigned to a medium level of qualification, for which an average hourly rate of 38 Euros is to be expected in the energy sector.

This therefore results in costs of approximately 57 Euros per case. At 3330 case per year, this would result in administrative costs of 189,810 Euros a year.

bb. Validation of the requirements in sections 2 ff. in conjunction with Annexes 1 and 2

Pursuant to section 6 paragraph 1 or section 8 clause 2, validation must also be provided for new wind energy plants which are connected to the medium-, high- and maximum-voltage network, that the requirements according to sections 2 to 4 in conjunction with Annexes 2 and 3 are complied with. Operators of wind energy plants which are put into service after the 31st December 2008 and before the 1st July 2010, shall receive a bonus pursuant to section 8 clause 1, if they provide the validation that they meet the requirements according to sections 2 to 4 at the network junction. Operators of wind energy plants which are connected to the grid after the 30th June 2010 shall also receive, pursuant to sections 2 to 4 in conjunction with sections 6 number 2 and section 16 paragraph 6 of the Renewable Energy Sources Act, the remuneration according to sections 29 and 30 of the Renewable Energy Sources Act only if they fulfil these requirements.

As a rule, the relevant operators of wind energy plants are anyhow obliged to submit this validation on the basis of the grid connection conditions of the respective network operators. To this extent, no additional bureaucracy costs arise here for the system operator. Here too, only around 800 – 1000 wind energy plants entering service are involved.

b. Bureaucracy costs for citizens

The ordinance draft does not contain any information obligations affecting citizens.

c. Bureaucracy costs for administration

Administration is not encumbered with any information obligations whatsoever through this ordinance.

VIII. Period of validity

A time limit to the ordinance is out of the question. The requirements which are set out in this ordinance are important prerequisites for the stability and security of the German electricity supply grids. The requirements must continue to be complied with even after expiry of the bonus payments. An unlimited period of validity guarantees the security. A periodic evaluation of the ordinance within the framework of the empirical report for the Renewable Energy Sources Act is envisaged.

IX. Consequences for the equality of women and men

The ordinance does not have any effect on the equality of women and men in the proposed version. It is directly concerned with the operators of systems for the generation of electricity from renewable energies and of electricity supply grids and does not have any direct consequences for persons who consume electricity. The effects result irrespective of the gender of the persons in question. Consequences in respect to the different life situations of women and men are not to be expected.

B. Regarding the individual regulations

Part 1 General Regulations

Regarding section 1 Scope of validity

Section 1 specifies the objective scope of application of the ordinance.

It does not definitively regulate the requirements for operators of wind energy plants. Apart from this ordinance, further requirements can be stipulated for operators of wind energy plants or for wind energy plants. However, these requirements do not have to be complied with either pursuant to section 6 number 2 of the Renewable Energy Sources Act or for the payment of the system service bonus pursuant to section 29 paragraph 2 clause 4, section 30 clause 2 and section 66 paragraph 1 number 6 of the Renewable Energy Sources Act.

On the other hand, further requirements can result both from the Renewable Energy Sources Act as well as from the Energy Economy Act. In particular, section 7 paragraph 2 of the Renewable Energy Sources Act also remains unaffected. Such regulations apply irrespective of the guarantee of the system service bonus.

Part 2 New Wind Energy Plants

Regarding § 2 Connection to the medium voltage network

Regarding paragraph 1

Section 2 regulates which technical requirements operators of wind energy plants who connect their systems to the medium-voltage network after the 30th June 2010 have to meet at the network junction, and refers to the technical directive "*Erzeugungsanlagen am Mittelspannungsnetz* (Generating Systems in the Medium-voltage Network)", edition June 2008 (Medium-voltage Directive 2008) for this. A medium-voltage network is distinguished by a nominal voltage of > 1 kV to < 60 kV.

The term "network junction" is defined in section 5 paragraph 1 clause 1 of the Renewable Energy Sources Act as the point in the network of the operator at which the systems for the generation of electricity from renewable energy sources and mine gas are connected to the grid. An identical definition is also contained in Annex 1 number III.12 of this ordinance for the term network junction. On the basis of the reference to the junction point, the operator of a wind energy plant is free to decide whether he fulfils the requirements through a central installation, for example connected capacitor banks or FACTS (Flexible Alternating Current Transmission System – device), for example static var compensator for the "static reactive power compensation" and other FACTS, for example STATCOM for the reactive current deviation in the event of a fault, or through the corresponding design of the individual *wind energy generating units,* for example by over-dimensioning the inverters and generators for the "static reactive power compensation". The regulation therefore enables the use of innovative solutions in the area of a wind farm.

Regarding paragraph 2

Paragraph 2 regulates the applicability of the specification in Annex 1 at a point in which the Medium-voltage Directive 2008 refers to the TransmissionCode 2007.

Regarding § 3 Connection to the maximum voltage network

Section 3 specifies the requirements which are stipulated for wind energy plants at the network junction, which are connected to the high- and maximum-voltage network after the 30th June 2010. A high voltage network is distinguished by a nominal voltage of 110 kV and a maximum voltage network by a nominal voltage of 380 kV or 220 kV. For compliance with section 3, the requirements modified by Annex 1 regarding the "TransmissionCode 2007 – *Netz- und Systemregeln der deutschen Übertragungsnetzbetreiber* (Network and System Regulations of the German Transmission Network Operators)", edition Version 1.1 August 2007 (hereinafter TransmissionCode 2007) have to be fulfilled.

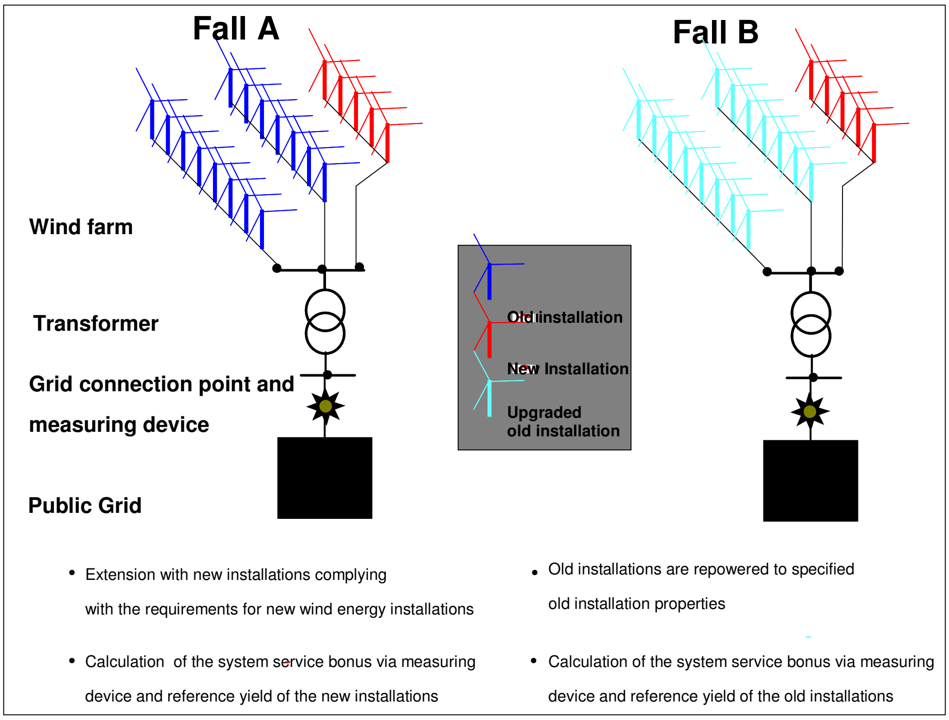
See also section 2 above for definition of the network junction.

Regarding section 4 Connection of different systems to a network junction

Section 4 states, in particular, for the extension of existing wind farms with new wind energy plants, that definite requirements only have to be provided pro rata at the network junction in order to receive the system service. The requirements for the available reactive power supply and for the reactive current supply for the dynamic network back-up cannot be provided by old wind energy plants in some cases.

Figure 1 illustrates the various cases for extending and upgrading existing wind farms:

Figure 1: Various cases for the upgrading of existing wind farms



Part 3 Old Wind Energy Plants

Regarding section 5 Prerequisites for the system service bonus

Section 5 regulates which requirements operators of wind energy plants have to comply with at the network junction, in order to receive the system service bonus pursuant to section 66 paragraph 1 number 6 of the Renewable Energy Sources Act. Only operators of wind energy plants which have been put into service after the 31st December 2001 and before the 1st January 2009, can benefit from the system service bonus for old wind energy plants. Apart from an upgrading of the generators or *wind energy generating units*, measures comparable in their effect are also permitted. In particular, measures which do not affect each individual system, but instead change the situation for the entire wind farm are considered here.

The claim for the system service bonus pursuant to section 66 paragraph 1 number 6 of the Renewable Energy Sources Act only results if the operator ensures that the prerequisites are met at the network junction or at a point between the network junction and the system. Compliance between the network junction and system is then taken into consideration in particular, if only some systems are upgraded out of several systems which are connected to a network junction. In this way, it is to be ensured that an upgrade in the context of network security is also carried out in wind farms at which individual systems are difficult or impossible to upgrade.

Section 66 paragraph 1 number 6 of the Renewable Energy Sources Act regulates the beginning and duration of remuneration. According to this, the remuneration period begins on the date at which compliance with the prerequisites pursuant to section 5 is first validated.

Part 4 Validation

Regarding section 6 Certificates and expert surveys

Section 6 regulates the form in which it is possible to validate that the requirements of this ordinance are complied with.

Regarding paragraph 1

Paragraph 1 regulates the validation pursuant to sections 2 to 4 in conjunction with Annexes 2 and 3. This must basically be realised by unit certificates and an expert survey. Unit certificates identify the electrical properties of the individual wind energy plants or other devices in order to demonstrate the conformity of the wind energy plant (also jointly with other devices) with the requirements of this ordinance. A unit certificate can also be issued for a wind energy plant or another device, which does not fulfil the requirements of this ordinance in all points, if the electrical properties diverging from the requirements are indicated in the unit certificate.

The unit certificates are to be issued according to the procedure defined in the Medium-voltage Directive 2008. Insofar as the unit certificates are issued for systems which are connected to the high- and maximum-voltage network, the content requirements of the TransmissionCode 2007 in conjunction with Annex 1 must be observed.

The appraisal survey of the expert and certification body must be conducted in accordance with the state of the art. It is assumed that the methodology, as it describes the directives coordinated between the Fördergesellschaft Windenergie e. V. (FGW e. V.) and the Bundesverband der Energie- und Wasserwirtschaft e. V. (BDEW) corresponds to the state of the art. The state of the art is continually developing further. This includes, in particular:

- The regulations for the testing and measuring regulation for the compilation of unit certificates for wind energy generating units are specified by the Technical Directive Part 3: "*Bestimmung der elektrischen Eigenschaften von Erzeugungseinheiten am Mittel- Hoch- und Höchstspannungsnetz* (Determination of the Electrical Properties of Generating Units in the Medium-, High- and Maximum-voltage Network)" (from Revision 19) of the FGW e.V.

- The regulations for the compilation and validation of models for wind energy generating units are specified by the Technical Directive Part 4: "Modellbildung und -validierung von Erzeugungseinheiten (*Model Creation and Validation of Generating Units*)" (in preparation) of the FGW e. V.

- The regulations for the procedure for the compilation of unit certificates for wind energy generating units and wind energy plants are specified by the Technical Directive Part 8: "*Zertifizierung der elektrischen Eigenschaften von*

Erzeugungseinheiten und Erzeugungsanlagen am Mittel- Hoch- und Höchstspannungsnetz (Certification of the Electrical Properties of Generating Units and Generators in the Medium-, High and Maximum Voltage Network)" (in preparation) of the FGW e.V.

Insofar as a methodology for implementation of the appraisal survey of the expert and certification body is described in regulations of other member states of the European Union, which contains equivalent requirements to the above directives, it is also assumed for these regulations that they correspond to the state of the art.

At present, there are not yet any definitive regulations concerning the certification system. As soon as a certification system, providing sufficient security for compliance with the requirements of this ordinance is established, the Federal Government plans to revise this ordinance to the effect that this certification procedure is rendered binding. This concerns, in particular, certification procedures in the above mentioned technical directives. Until then, attention is drawn to the fact that the requirement for compliance with the state of the art for the compilation of expert surveys and certificates guarantees a certain minimum standard.

Insofar as a certification body is already accredited in another member state of the European Union in accordance with DIN EN 45011:1998, there is no need for a renewed accreditation according to the standard in Germany.

Regarding paragraph 2

The submission of a unit certificate for the validation is necessary, in particular in order to ensure that the requisite measurements have been carried out corresponding to the state of the art, thereby establishing a plausible basis for the expert survey. The unit certificate does not necessarily have to have been compiled in accordance with the Medium-voltage Directive 2008 for the upgrading of the existing system. It is sufficient if the unit certificate has been compiled by an accredited certification body corresponding to the respective state of the art. In this way, unit certificates already issued in the past can be used as a basis for compilation of the expert survey. If a unit certificate according to the Medium-voltage Directive 2008 is available, it can, of course, also be used in all cases. In addition to this, an expert survey is necessary in order to record the upgrading, in particular the adjustments to be changed for the decoupling protection.

Regarding paragraph 3

Paragraph 3 enables a later validation for prototypes, as the necessary measurements for validation still cannot be available, as a rule, at time of the commissioning.

Regarding section 7 Multiple wind energy plants

Section 7 stipulates that the allocation of the system service bonus when connecting several wind energy plants to a network junction whose in-feed remuneration is calculated via a joint measuring instrument, can be realised via the ratio of the relevant reference yields.

Part 5 Concluding Provisions

Regarding section 8 Transitional provisions

Regarding paragraph 1

Section 8 regulates the claim to the system service bonus for operators of wind energy plants whose wind energy plants are put into operation after the entry into effect of the Renewable Energy Sources Act on the 1st January 2009 and before the 1st July 2010. This is necessary in order to make it possible for these systems, insofar as they demonstrably fulfil the requirements pursuant to sections 2 to 4, to receive the bonus pursuant to section 29 paragraph 2 clause 4 and section 30 clause 2 of the Renewable Energy Sources Act. This therefore provides an incentive, so that the operators of these systems will also ensure network security at the network junction of their systems.

Moreover, clause 2 makes it possible for systems which demonstrably fulfil the requirements of the TransmissionCode 2007 for reactive current feed-in in the event of a fault to also receive the system service bonus.

Regarding paragraph 2

Paragraph 2 enables systems put into service after the 30th June 2010 and before the 30th June 2011 and which demonstrably fulfil the requirements of the TransmissionCode 2007 for reactive current feed-in in the event of a fault to receive the initial remuneration and the system service bonus. This also corresponds to the systematics of the Medium-voltage Directive 2008, according to which the requirements for the dynamic grid back-up only have to be complied with after an transition period.

Regarding section 9 Entry into effect

Section 9 regulates the entry into effect of the ordinance.

Regarding Annex 1

Regarding part I

The TransmissionCode 2007 regulates the economic and process engineering principles for use of the transmission grids. It represents in itself a closed document. However, the structure of the TransmissionCode 2007 exhibits some unclear points. At several points in the TransmissionCode 2007 there are also inconsistent usages of terms or requirements. Finally, certain requirements of the TransmissionCode 2007 are not necessary within the framework of the area regulated by this ordinance.

As a result, the TransmissionCode 2007 in its present form is not suitable for specifying the technical requirements of this ordinance by simple reference. Various measures are therefore defined in Annex 1, among which the requirements corresponding to the TransmissionCode 2007 apply in the context of this ordinance.

All sections for which no provisions are made remain unaffected.

Regarding numbers 1 to 5

This ordinance only stipulates requirements for wind energy plants. As a result, references to other generating systems must be adapted correspondingly at all points in the TransmissionCode 2007.

Regarding number 6

In number 6, the word "grid connection point" is replaced by the word "network junction" throughout, in order to ensure a uniform terminology for the entire ordinance. This is not associated with a change in respect to content, as the terms "network junction" and "grid connection point" are equivalent in terms of content.

Part II

Regarding number 1

Number 1 stipulates that *wind energy plants* at frequency dips corresponding to Figure 3.2 of the TransmissionCode 2007 still have to be able to feed in the *available active power* P_{vb}.

At the same time, it is assumed that the active power specified by the network operator never exceeds the *available active power* P_{vb}. The *available active power* P_{vb} can be equal to the *installed active power* P_{inst} in individual cases. Attention is drawn to the fact that Figure 3.1 of the TransmissionCode 2007 applies again in the subsequent stationary state.

Regarding number 2

Number 2 stipulates that the requirement in 3.3.7.1 is not applicable for wind energy plants.

Attention is drawn to the fact that according to section 3.3.13.6 of the TransmissionCode 2007 *wind energy plants* can be exempted from the primary control capability, also if their *installed active power* P_{inst} exceeds 100 MW. Assurance of the connection prerequisites by the operator of a system according to section 6 number 2 of the Renewable Energy Sources Act and payment of the system service bonus pursuant to section 29 paragraph 2 clause 4 and section 30 clause 2 of the Renewable Energy Sources Act are not therefore coupled to the requirement for the primary control capability. Only section 3.3.13.3 applies for requirements for the active power output of *wind energy plants*.

Regarding number 3

It is stipulated that the reactive power control in normal operation or in stationary mode involves a slow regulation in the minute range. Within the framework of the permissible impairment of the network quality, this control can also be executed as a discrete control for example using capacitor switching banks. The reactive power of the positive phase-sequence system component of the current/voltage oscillation as per IEC 61400-21 Ed. 2[4] Annex C is to be controlled at the network junction.

Regarding number 4

Number 4 defines the maximum permissible time, within which the agreed reactive power range has to be able to be cycled through, at four minutes. Furthermore, it is stipulated that the reactive power to be supplied at the *grid connection point* refers to the *operational installed active power* $P_{bb\ inst}$; in this way, it is ensured that only so much reactive power has to be provided at the *network junction*, as is possible with the operational *wind energy generating units* within a *wind energy plant* (in other words apart from *wind energy generating units* which are in revision or defective) without additional equipment.

In addition, the network operator must specify one of the three variants according to Figures 3.3a to 3.3c of the TransmissionCode 2007 by the time of the grid connection of the *wind energy plant* on the basis of the relevant network requirements. If a variant other than the one agreed is required by the network operator at a later date, the claim for receipt of the system service bonus will remain unaffected by this.

However, wind energy plants do not have to meet the requirements pursuant to 3.3.7.1 paragraph 3 of the TransmissionCode 2007 for receipt of the system service bonus. The system service bonus also has to be counted according to this, if the claim of the network operator in respect to the operators of the *wind energy plant* to keep additional devices ready in order to be able to carry out a voltage / reactive power control in the area of the relevant network operator, cannot be fulfilled.

Regarding number 5

The requirements for the reactive power supply at the *grid connection point* if a *wind energy plant* is not operating at full load are specified in number 5. Here too, the reactive power to be supplied at the *network junction* refers to the *operational installed active power* $P_{bb\ inst}$ and it is thereby ensured that only so much reactive power has to be provided at the *network junction*, as is possible with the operational *wind energy generating units* within a *wind energy plant* without additional equipment.

The formulation in the TransmissionCode 2007, according to which the reactive power supply at the *network junction* also has to correspond to the full scope of the generator *output diagram* also at reduced active power output with consideration of the auxiliary service power and the losses due to the generator transformer and at machine power,

---

4 Official note: Available form the IEC International Electrotechnical Commission, ISBN 2-8318-9938-9, www.iec.ch.

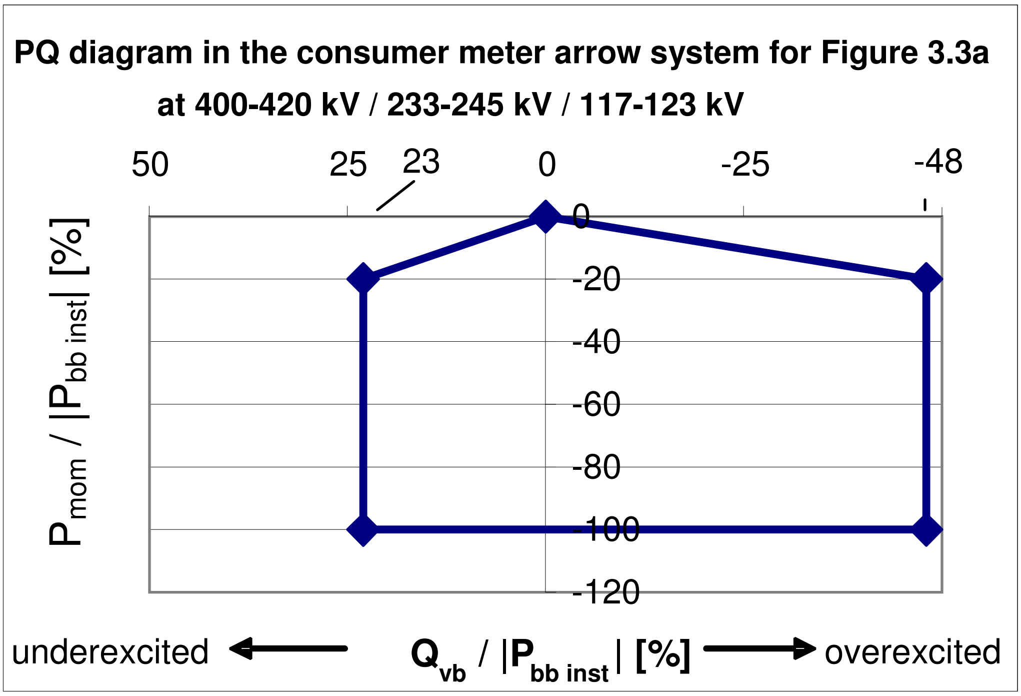
remains ambiguous and allows a broad margin of interpretation. It is therefore clearly specified with the PQ diagrams in Figures 3.3d, 3.3e and 3.3f of this ordinance, which reactive power range of *wind energy plants* has to be able to be covered at the *network junction* when not operating at full load.

Figures 3.3d, 3.3e and 3.3f of this ordinance show the largest reactive power range to be covered and the associated voltage band. The abscissa (x axis) indicates the *reactive power* Q_{vb} to be provided in relation to the amount of *operational installed active power* $P_{bb\ inst}$ in percent. The ordinate (y axis) indicates the *instantaneous active power* P_{mom} (in the *consumer meter arrow system* negative) in relation to the amount of *operational installed active power* $P_{bb\ inst}$ in percent.

The voltage dependency of the reactive power range to be supplied is shown in Figures 3.3a to 3.3c below.

Figure 3.3d: PQ diagram of the *wind turbine generator* at the *network junction* in the *consumer meter arrow system (VZS)* for Figure 3.3a (Variant 1) and illustration of the voltage dependency

Note: Negative reactive powers are shown on the right half of the axis on the basis of the representation in the *consumer meter arrow system* and the better comparability of the reactive power ranges with Figure 3.3a of the TransmissionCode 2007.



For illustration of the voltage dependency:

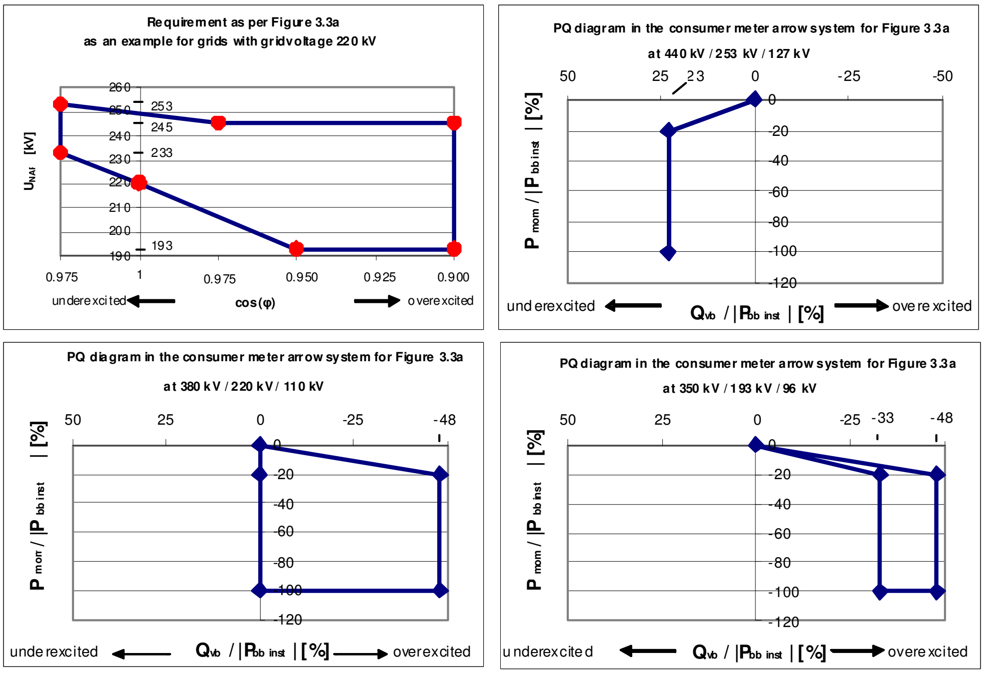
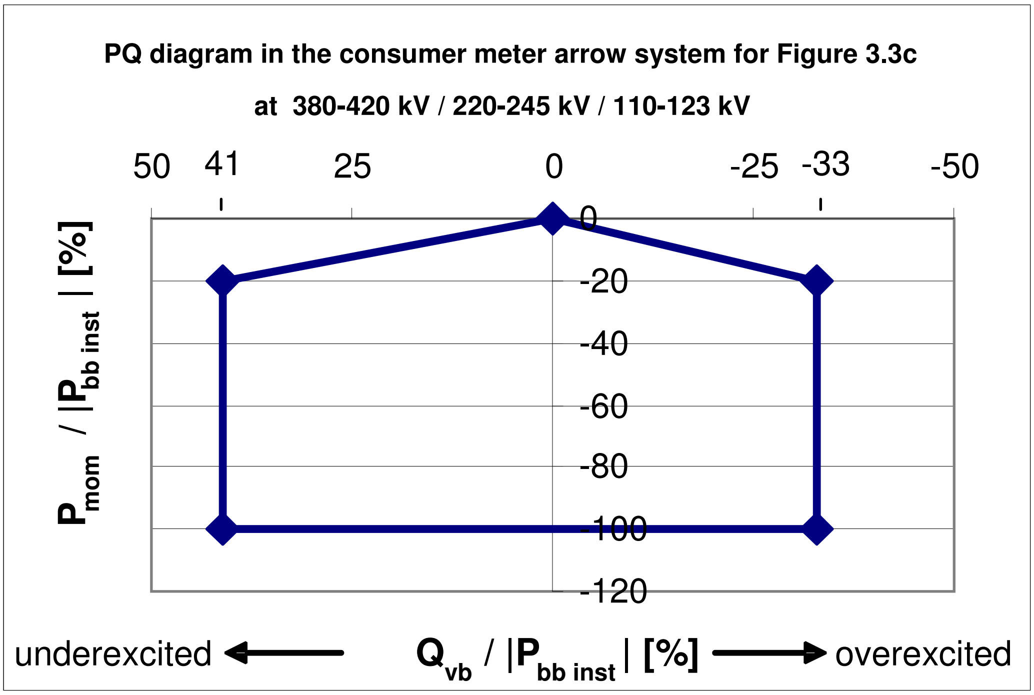


Figure 3.3e: PQ diagram of the *wind turbine generator* at the *network junction* in the *consumer meter arrow system (VZS)* for Figure 3.3b (Variant 2) and illustration of the voltage dependency

Note: Negative reactive powers are shown on the right half of the axis on the basis of the representation in the *consumer meter arrow system* and the better comparability of the reactive power ranges with Figure 3.3b of the TransmissionCode 2007.



For illustration of the voltage dependency:

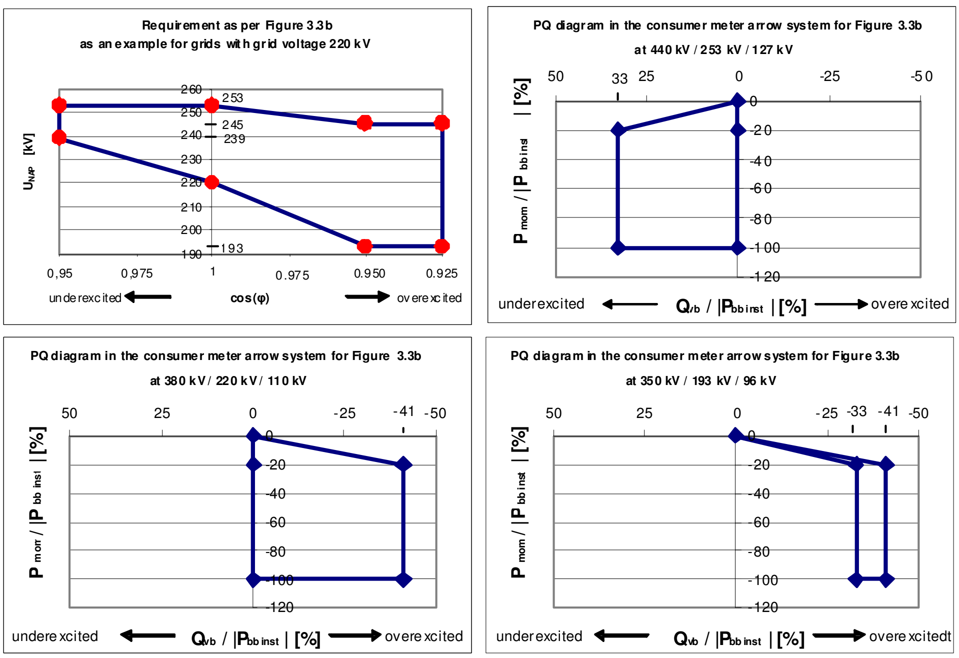
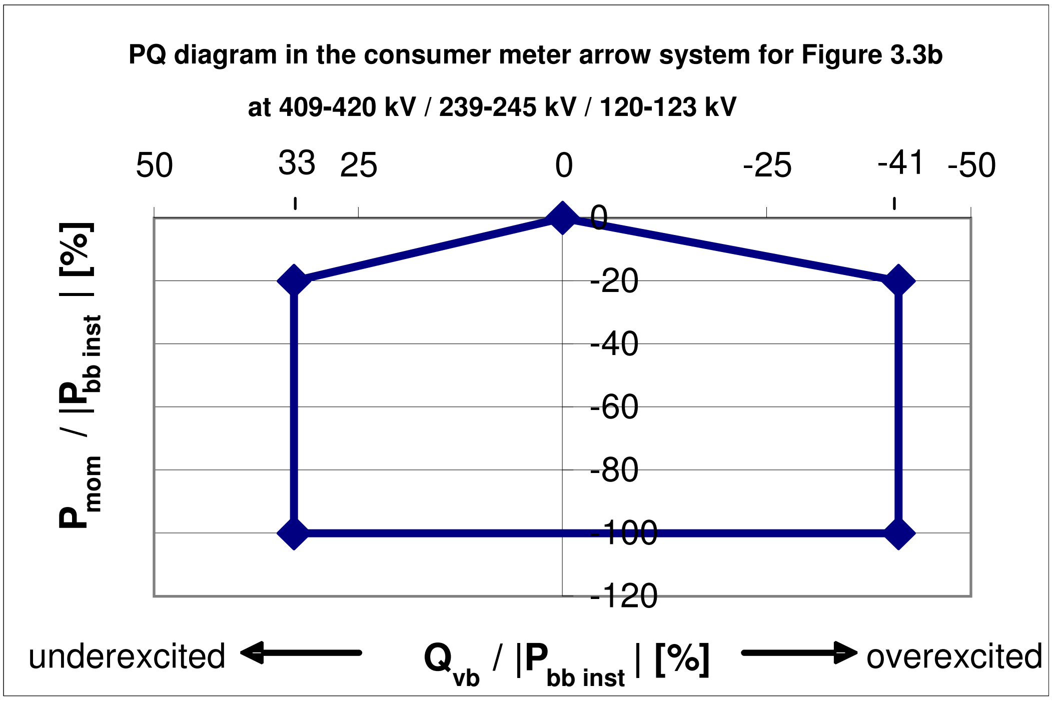
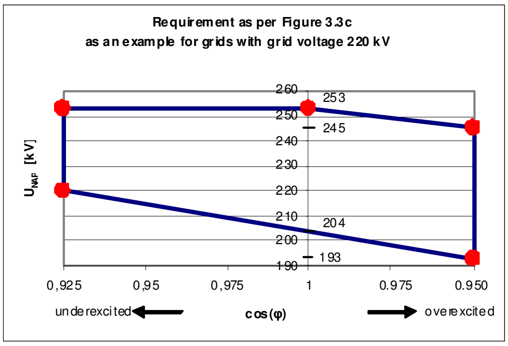
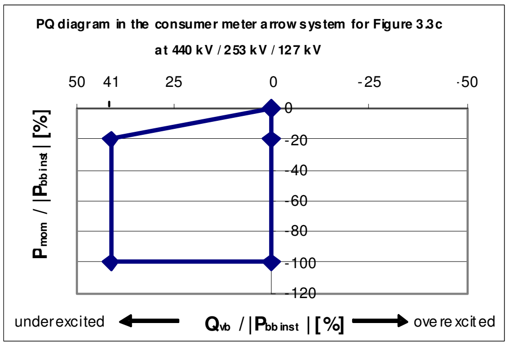


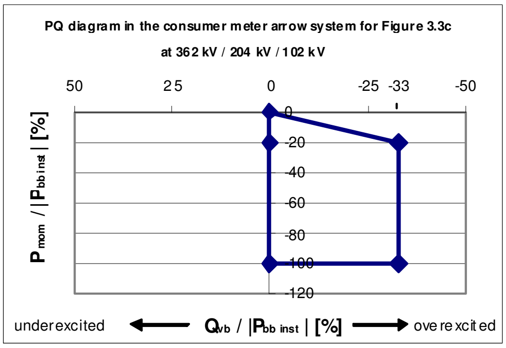
Figure 3.3f: PQ diagram of the *wind turbine generator* at the *network junction* in the *consumer meter arrow system (VZS)* for Figure 3.3c (Variant 3) and illustration of the voltage dependency
Note: Negative reactive powers are shown on the right half of the axis on the basis of the representation in the *consumer meter arrow system* and the better comparability of the reactive power ranges with Figure 3.3c of the TransmissionCode 2007.

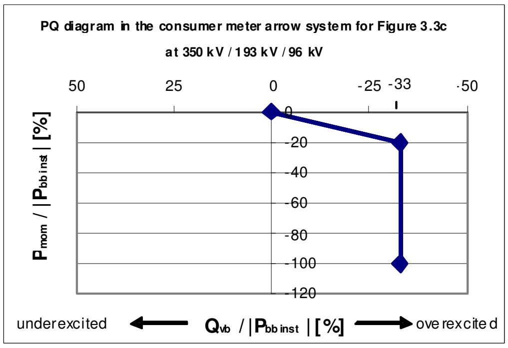


For illustration of the voltage dependency:









The lower part of Figures 3.3d to 3.3f shows the following, taking variant 1 and networks with a nominal voltage of 220 kV as an example:

- A *wind energy plant* must be dimensioned and able to be operated in such way that, at a network voltage at the *network junction* of 253 kV (upper value of the voltage band) in the operating range of the *instantaneous active power output* P_{mom} from 20 to 100 percent of the *operational installed active power* $P_{bb\ inst}$, it provides an *available reactive power* Q_{vb} of 23 percent of the *operational installed active power* $P_{bb\ inst}$ underexcited (voltage reducing) at the *network junction*.

- A *wind energy plant* must be dimensioned and operated in such way that, at a network voltage at the *network junction* of 220 kV (nominal voltage of the network) in the operating range of the *instantaneous active power output* P_{mom} from 20 to 100 percent of the *operational installed active power* $P_{bb\ inst}$, it provides an *available reactive power* Q_{vb} of 0 to 48 percent of the *operational installed active power* $P_{bb\ inst}$ overexcited (voltage supporting) at the *network junction*;

- A *wind energy plant* must be dimensioned and be able to be operated in such way that, at a network voltage at the *network junction* of 193 kV (lower value of the voltage band) in the operating range of the *instantaneous active power output* P_{mom} from 20 to 100 percent of the *operational installed active power* $P_{bb\ inst}$, it provides an *available reactive power* Q_{vb} of 33 to 48 percent of the *operational installed active power* $P_{bb\ inst}$ overexcited (voltage supporting) at the *network junction*;

- A wind energy plant only has to provide an *available reactive power* Q_{vb} in the operating range of the *instantaneous active power output* P_{mom} from 0 to 20 percent of the operational installed *active power* $P_{bb\ inst}$ in the above three cases, this being limited by the linear cluster between the area required for a *instantaneous active power output* P_{mom} of 20 percent and the origin of the PQ diagram.

The PQ diagrams reveal that a supply of reactive power taking priority over the active power output must be possible, depending on the situation in the grid and the *instantaneous active power output* P_{mom}.

It is also the case for Figures 3.3d, 3.3e and 3.3f that each point within the bordered areas must be able to be approached within four minutes. As specified according to section 3, the exact mode of operation must be coordinated between the operator of the *wind energy plant* and the transmission grid operator.

Regarding number 6

As the requirements for the reactive power supply consistently refer to the *network junction*, no specifications for the design of the generator transformers are necessary. Only the surge voltage concept is to be coordinated with the transmission grid operator, as a concept relevant to the grid security.

Regarding number 7

No rapid reactive power control at the *network junction* is required for *wind energy plants* in the context of this ordinance. As a result, no specifications are made for the generator voltage control corresponding to section 3.3.10. The operator of a *wind energy plant* only has to ensure that the *wind energy generating units* are operated in such way that the safety-relevant limit values for voltages and currents within the entire *wind energy plant* are complied with.

Regarding number 8

Regarding letter a

Paragraph 1 of section 3.3.12 is not applicable to *wind energy plants*, because it can only reasonably be applied to directly coupled synchronous generators of conventional power stations with turbo-generating set.

Regarding letter b

Section 3.3.12.1 stipulates the provision that the specifications also apply for asymmetrical (1.2-pole) network short-circuits. This means that symmetrical and asymmetrical (1.2-pole and 3-pole) network short-circuits in the vicinity of the *wind energy plant* do not lead to instability during fault clarification times of up to 150 ms in the entire operating range of the *wind energy generating unit*, if the initial short-circuit AC power (S''_{kN}) present at the interface "network – *wind energy plant*" on the network side after fault clarification is greater than 6 times the numerical value of the total of the nominal active powers of all *wind energy plants* galvanically connected at the *network junction* of this *wind energy plant*.

It is also stipulated that the active current feed-in has to be reduced to the benefit of the reactive current feed-in and for ensuring the stability of the *wind energy generating units* during the fault.

Regarding letter c

The regulations for the static stability (network oscillations) in section 3.3.12.2 only apply for synchronous generators directly coupled to the grid and hence only for *wind energy plants* which contain *wind energy generating units* of type 1.

Regarding number 9

Number 9 stipulates that section 3.3.13.1 is not applicable to *wind energy plants*. Section 3.3.13.1 states the more extensive explanations are described in more detail in the VDN guidelines "*EEG-Erzeugungsanlagen am Hoch- und Höchstspannungsnetz* (EEC

Generating Facilities in the High and Maximum Voltage Network)"[5] . However, there are contradictions between these guidelines and the TransmissionCode 2007. This section is not therefore applicable.

Regarding number 10

Regarding letter a

The term "*instantaneous available power* P_m" is not defined in the TransmissionCode 2007. This term is therefore understood as *instantaneous active power* P_{mom} in the context of this ordinance.

In this way, it is ensured that the active power reduction occurs relative to the active power actually currently being fed in with consideration of already extant specification values by the network operator as well as the potentially fluctuating wind situation. The previous practice, according to which the active power is reduced relatively to the value of the *instantaneous active power* P_{mom}, which resulted when exceeding a frequency of 50.2 Hz ("time point of the requirement; freezing of the value"), has the following disadvantages:

- If the *available active power* P_{vb} rises after exceeding a frequency of 50.2 Hz on account of more wind on offer, the active power feed-in from *wind energy plants* can also not be reduced sufficiently at greater frequency deviations.

- If the *available active power* P_{vb} drops after exceeding a frequency of 50.2 Hz on account of less available wind, the active power feed-in from *wind energy plants* can be reduced to zero even at small frequency deviations.

Regarding letter b

As all requirements consistently refer to the *network junction*, the specification in paragraph 3 that this regulation is executed decentralised (at each individual generator) is omitted.

Regarding letter c

A new paragraph 4 is added in letter c, according to which the regulation for the restoration of active power after return of the frequency to a value $f \leq 50.05$ Hz in *undisrupted operation* can optionally be executed decentralised or centrally. Nevertheless, it must always be ensured for reasons of superordinate system security that, in the case of faults within the superordinate control of the *wind energy plant*, suitable measures must be provided decentralised for the active power reduction of *wind energy generating units* at over-frequency. The speed of the active power reduction at over-frequency should be in the range of the control speed of the pitch control of the *wind*

---

[5] Available from the Bundesverband der Energie- und Wasserwirtschaft e. V. (BDEW), Robert-Koch-Platz 4, 10115 Berlin.

energy generating units, i.e. the power gradient must not be greater than 100 % of the *instantaneous active power* P_{mom} every 5 seconds.

The previous paragraph 4 points out in a purely explanatory manner that a concept for the re-synchronisation with the grid is to be formulated for *wind energy plants* which have been disconnected from the network at an over-frequency. This paragraph is replaced by a new paragraph 5, according to which the function for automatic recoupling to the grid is to be blocked on the request of the network operator (for example via radio ripple control or similar). The necessity of such a function has arisen for example during supply restoration after a power failure. Further requirements remain unaffected by this.

Regarding number 11

These provisions make clear again that the reactive power control in normal operation or in stationary mode involves a slow regulation in the minute range. The reactive power specification must correspond within four minutes to the setpoint value specified by the network operator. This also applies within the context of this ordinance in the case of an online setpoint value specification.

Regarding number 12.

Regarding letter a

The regulation in section i stipulates that the requirements for the performance of the wind energy generating units at network disturbances refer to the positive phase-sequence system components of the basic oscillation of current and voltage as per IEC 61400-21 Ed. 2[6] Annex C. As a grid code should dispense with detailed specifications for implementation of the relevant requirements, no further explanations are necessary here.

The specifications according to section ii and iii make clear that the requirements for the undervoltage side of the generator transformer defined in paragraphs 2, 7, 8, 11 and 17 must be met as a minimum requirement. Divergent from this, however, it is permissible to choose another reference point (for example, the upper voltage side of the generator transformer), as long as it can be verified that the same operational performance results from this at the *network junction*. These specifications pursue the objective for defining all requirements consistently for the *network junction* and making as few requirements as possible for the design of the *wind energy generating units*. The application of innovative solutions on a wind farm level is allowed by this.

Regarding letter b

In section 3.3.13.5, paragraph 8 stipulates the requirements for the surge voltage protection of the *wind energy generating units*, which has to disconnect the relevant *wind energy generating unit* from the grid with a time delay of 100 ms if the voltage rises and remains at and over a value of 120 % of the upper value of the voltage band (for example,

6 Official note: Available form the IEC International Electrotechnical Commission, ISBN 2-8318-9938-9, www.iec.ch.

690 V x 1.05 x 1.2 = 870 V) on the undervoltage side of each individual generator transformer. The voltage value refers to the lowest value of the three concatenated network voltages; this means that the two other concatenated network voltages may occasionally be over a value of 120 % of the upper value of the voltage band, without the surge voltage protection of the *wind energy generating units* having to trigger.

Attention is drawn to the fact that the requirements for the active power output in section 3.3.6 of the TransmissionCode 2007 have to be observed: According to Figure 3.1 of the TransmissionCode 2007, an output of active power is only required up to a maximum network voltage 440 / 253 / 127 kV. No requirements are made beyond this.

In addition, the new paragraph 8b refers to the caption for Figure 3.1 in the TransmissionCode 2007, according to which voltage gradients less than or equal to 5 % per minute are permissible within the voltage bands indicated in Figure 3.1 and may not lead to disconnection of the *wind energy plants*. Insofar as greater voltage gradients occur, there are also no requirements for the output of active power.

Finally, it is pointed out at this point that the provision according to letter d also has to be observed, according to which the *wind energy generating units* are to support the voltage by adjusting (increasing or reducing) the *reactive current*. This requirement sometimes leads to a situation where an overvoltage at the *wind energy generating unit* is counteracted in the time range of the required *reactive current deviation* upon occurrence of a *significant voltage deviation*.

Regarding letter c

Letter c stipulates, as regulated by the provisions for section 3.3.12.1, that not only three-pole, but also one-pole and two-pole short-circuits with and without earth contact and not only fault-induced symmetrical voltage dips, but also asymmetrical voltage dips above boundary line 1 in Figure 3.5 may not lead to instability or to disconnection of the *wind energy plant* from the grid. It is also made clear that this requirement may only come into effect if the voltage value in Figure 3.5 refers to the highest value of the three concatenated network voltages.

The requirements for the performance during network disturbances with asymmetrical faults can mean that *wind energy plants* may also not be disconnected from the grid, if one or two of the three concatenated network voltages are far below a value of 45 % of the nominal voltage U_N of the network (for example at 15 % U/U_N).

Paragraphs 14 and 15 in section 3.3.13.5 of the TransmissionCode 2007 specify the permissible deviations from the basic requirement that all symmetrical and asymmetrical voltage dips may not lead to instability or to disconnection of the *wind energy plant* from the grid.

Regarding letter d

The formulation according to paragraph 17 and the representation shown in Figure 3.6 of the TransmissionCode 2007 in section 3.3.13.5 of the TransmissionCode 2007, according to which *wind energy generating units* are to back up the voltage by adjusting (increasing or decreasing) the *reactive current*, has frequently lead to misunderstandings in practice. Paragraph 17 letter a therefore describes the scope of validity, while paragraph 17 letter b describes the basic performance and paragraph 17 letter c describes the time progression of the specified requirement for the voltage back-up in the case of network faults through reactive current feed-in.

The newly formulated paragraph 17 letter a restricts the scope of validity for the mandatory compliance with the requirements for the voltage back-up in the case of network faults through reactive current feed-in to network faults with a progression of the highest value of the three concatenated network voltages above boundary line 1 in Figure 3.5 of the TransmissionCode 2007. Although, in the case of a progression below boundary line 1 and above boundary line 2 in Figure 3.5 of the TransmissionCode 2007, the same performance of the *wind energy generating unit* should basically be ensured, it is permissible under certain conditions to deviate from the requirements for the voltage back-up during network faults and – if also necessary – execute a short-term disconnection of the *wind energy plant* (KTE) from the grid in coordination with the network operator. A short-term disconnection from the grid is always allowed below boundary line 2 in Figure 3.5 of the TransmissionCode 2007. In the case of a short-term disconnection, the requirements for the voltage back-up during network faults through reactive power feed-in only have to be met to the extent that the grid connection concept of the *wind turbine generating unit* makes this possible.

The newly formulated paragraph 17 letter b describes the basic performance as represented below:

In the case of *voltage deviations* ΔU within the *voltage dead band* U_t, the requirements for "*normal operation*" according to section 3.3.13.4 of the TransmissionCode 2007 apply.

The *reactive current deviation* (ΔI_B), i.e. an adjustment (increase or decrease) of the *reactive current* I_B,, must occur relative to the reactive current, which results through the relevant requirements for the reactive power supply in normal operation of the grid and the operating mode coordinated between the operator of the *wind energy plant* and the transmission grid operator according to section 3.3.13.4 of the TransmissionCode 2007.

The *reactive current deviation* (ΔI_B) of the *wind energy generating units* must occur in the transient state proportional to the *relevant voltage deviation* (ΔU_r). K indicates the stationary reactive current voltage characteristic: $\Delta I_B / I_{BN} = K * \Delta U_r / U_N$. The permissible range in which the stationary reactive current voltage characteristic K has to be, is designated by the yellow hatched area in the reformulated Figure 3.6. This area is defined by $2 \leq K \leq 10$; it therefore comprises the minimum requirement of the TransmissionCode 2007, but also permits a desirable more significant reactive current voltage characteristic K beyond this, for example for modern *wind energy generating units*. Nevertheless, it should be observed that, depending on the network situation, no significant reactive current voltage characteristic is selected whereby the *wind energy generating unit* becomes unstable or the generator protection responds.

The constant K of the reactive current voltage characteristics must be adjustable. Nevertheless, it is sufficient if the constant K can be set, upon written request by the network operator. An online setpoint value specification for the constant K is not necessary. The setting value for the constant K should be coordinated with the network operator, depending on the network situation; in individual cases, the network operator can require deactivation of the voltage back-up in the case of network faults through reactive current feed-in (K = 0).

The fluctuation width of the measured reactive current resulting from the set reactive current voltage characteristic must be between -10 % and +20 % of the rated current. Further requirements for the accuracy of the reactive current control will be defined later in a corresponding certification procedure.

In reference to the maximum possible total *reactive current* I_B to be fed in, a distinction is made between the fault types as follows:

- For 3-pole faults, *wind energy generating units* must be technically able to reach a *reactive current* I_B of at least 100 % of the rated current in the case of these fault types. An upper limit for the *reactive current deviation* ΔI_B should result solely from the manufacturer-specific system concept and the dimensioning of the *wind energy generating units*.

- For 1.2-pole faults, *wind energy generating units* must be technically able to feed in a *reactive current* I_B of at least 40 % of the rated current in the case of these fault types. The feed-in of the reactive current must not put the requirements for cycling through network faults at risk.
  It is desirable for the *wind energy generating unit* to feed in the maximum possible *reactive current* I_B, permitted by the dimensioning of the *wind energy generating unit* in consideration of a simultaneously flowing current in the negative sequence system.

During *significant voltage deviations* U_s the *active current* I_W must be reduced sufficiently for the benefit of the reactive current feed-in and for ensuring the system stability.

The newly formulated paragraph 17 letter c describes the requirements for the time progression of the voltage back-up in the case of network faults through reactive current feed-in as outlined below.

The dynamic performance of the reactive current back-up is characterised by the *step response of the reactive current* I_B, as can approximately occur for example as a result of network short-circuits.

In the case of a *significant step deviation* U_s, the *step response of the reactive current* I_B must meet the following requirements:

- Response time: 30 ms
- Transient time: 60 ms

During the voltage recovery process, the progression of the *reactive current* must not exhibit any discontinuities which can affect the network quality in a negative way. This applies, in particular, also for the transition between a *significant voltage deviation* U_s and the normal operating range of the voltage.

The requirements for the voltage back-up in the event of network faults through reactive current feed-in are to be understood as "observational", not as instructions for the design of a controller. It is essential to be able to validate that the control is designed in such way that the following requirements are met:

- The *reactive current deviation* ΔI_B is proportional to the *relevant voltage deviation* (ΔU_r). A switchover between two or more discrete values of the *reactive current* I_B is not allowed.

- During the course of the *reactive current* I_B no irregularities may occur which are not envisaged by the reactive current-voltage characteristics according to Figure 3.6 and which could lead to negative network disturbances. This applies, in particular, for the transition between the operation at *voltage deviations* ΔU within the *voltage dead band* U_t and operation at *significant voltage deviations* U_s.

- The relevant requirements only consider the voltage and reactive current changes ascertained from the positive phase-sequence system components of the basic harmonic component, and are to be understood (like all requirements) as minimum requirements.

- A voltage back-up in the event of network faults through reactive current feed-in using a global device is permissible in the case of operating performance demonstrably the same at the *network junction*.

Regarding letter e

Letter e stipulates that section 3.3.13.5 paragraph 18 is not applicable, because the changed regulation in paragraph 17 renders this regulation dispensable.

Regarding letter f

Letter f stipulates that section 3.3.13.5 paragraph 19 is not applicable, i.e. it does not involve requirements pursuant to section 6 number 2 of the Renewable Energy Sources Act and the claim to the system service bonus pursuant to section 29 paragraph 2 clause 4 and section 30 paragraph 2 of the Renewable Energy Sources Act remains unaffected by this additional requirement.

Regarding letter g

Letter g concerns excessive distances between the *wind energy generating units* of the *wind energy plant* and the *network junction*, which cause the voltage control to become ineffective. In this case, the network operator shall ask the operator of the *wind energy plant* for measurement of the voltage dip at the *network junction* and the voltage control there depending on this measuring value.

A distance resulting in ineffectiveness of the voltage control is typically present, if the impedance between the *wind energy generating units* and the *network junction* is so great that a network fault at the *network junction* only leads to a voltage back-up through reactive current feed-in that is insufficient for the network operator. The decision as to which voltage is used as a reference voltage for the voltage back-up through reactive current feed-in is the responsibility of the network operator, depending on the network situation. In order to comply with the requirements of the network operator on an individual basis, the *wind energy generating units* therefore have to be able to use a reference voltage outside the *wind energy generating unit* instead of the voltage at the undervoltage side of the generator transformers. This can be determined using measuring technology or in a suitable way in coordination with the network operator, in order to reduce the expense for the operator of a *wind energy plant* regulating from this.

Regarding letter h

Letter h stipulates that section 3.3.13.6 of the TransmissionCode 2007 is not applicable. Section 3.3.13.6 of the TransmissionCode 2007 envisages that *wind energy plants* can be exempted from the primary control capability, also if their *installed active power* P_{inst} exceeds 100 MW.

Regarding letter i

According to letter i, section 3.3.13.7 is not applicable. It only specifies special requirements when connecting offshore wind energy plants. However, this ordinance only refers to wind energy plants onshore; section 3.3.13.7 is therefore not applicable for *wind energy plants* as defined by this ordinance.

Regarding Part IV

An analysis of the existing technical directives has revealed that no uniform definitions of terms have so far been used. Although the VDN Guidelines 2004 and the Medium-voltage Directive 2008 introduce a comprehensive section with definitions of terms for the first time, several terms are, however, not used uniformly or a definition is absent. The most important are:

- Different power terms, including nominal active power, instantaneous active power, available active power, instantaneous available active power
- Generator, generating unit, generating system
- Output diagram
- Settling time

Against this background, section 9.2 of the TransmissionCode 2007 is supplemented by more precise definitions of a large number of terms. These definitions are explained further below and illustrated in the figures.

Regarding number 1

The term "response time" is illustrated by Figure 2.

Regarding number 2

The term "*operational installed active power* $P_{bb\ inst}$" is illustrated by Figure 3.

Regarding number 3

The term "*reactive current* I_B" is the "inductive reactive current". This is provided with a positive sign corresponding to the specification for the consumer meter arrow system and has the effect of lowering the voltage. A "capacitive reactive current" is provided with a negative sign corresponding to the specification for the consumer meter arrow system and has the effect of supporting the voltage.

Regarding number 4

Defines the "reactive current deviation ΔI_B".

Regarding number 5

The term "*transient time*" is illustrated by Figure 4.

Regarding number 6

Number 6 defines the term "*disrupted operation*". A *disrupted operation* is typically present in the case of superordinate control of the *wind energy plant.*

Regarding number 7

The term "*installed active power* P_{inst}" is explained by Figure 3.

Regarding number 8

Number 8 defines the term for the "*output diagram*".

Regarding number 9

The term "*instantaneous reactive power* Q_{mom}" is explained in Figure 5.

Regarding number 10

The term "*instantaneous active power* P_{mom}" is explained in Figure 3.

Regarding number 11

Number 11 defines the "rated operating point of a wind energy plant".

Regarding number 12

The "*grid connection point*" is above all significant in conjunction with the network planning. A distinction between grid connection point and junction is not necessary in all cases (see Figure 4) and is not relevant here.

Regarding number 13

Number 13 defines the term "*relevant voltage deviation* ΔU_r".

Regarding number 14

Number 14 defines the term "*significant voltage deviation* ΔU_s".

Regarding number 15

Number 15 defines the term "*voltage U1*".

Regarding number 16

Number 16 defines the term "*voltage deviation* ΔU".

Regarding number 17

Number 17 defines the term "*voltage dead band* U_t ".

Regarding number 18

Number 18 defines the term "*step response of the reactive current* I_B".

Regarding number 19

Number 19 defines the term "*stationary end value*".

Regarding number 20

"*Static reactive power compensation*" includes switched capacitor banks or also FACTS such as Static Var Compensator (SVC) and STATCOM.

Regarding number 21

Number 21 defines the term "*current I1*".

Regarding number 22

Number 22 defines the term "*undisrupted operation*".

Regarding number 23

"*Consumer meter arrow system (VZS)*" is a uniform meter arrow system and has advantages for network operators – in particular for the operation of metering facilities at connection points with continuously changing direction of the active power. In this ordinance, the consumer meter arrow system applies to consumers who are connected to the network as well as to producers. Currents and voltages in the direction of the arrow are metered positively. The operating states are assigned in accordance with Figure B.4-3 of the Medium-voltage Directive 2008 (see also Figure 5). At the same time, the reactive power exchange with the network for wind energy plants is positive in underexcited operation and negative in overexcited operation. It must be noted that the active power has a negative sign when feeding into the network.

Regarding number 24

Number 24 defines the "*available reactive power* Q_{vb}".

Regarding number 25

The "*available active power* P_{vb}" of *wind energy plants* is time dependent; it basically depends on the current level of the wind as well as the state (in operation, in revision, defective etc.). Further factors determined by external factors, for example a speed restriction during the night can also limit the *available active power*. A possible limitation by the network operators remains out of consideration for this.

The term is designated as "instantaneous available active power" in the VDN Guideline 2004, in the TransmissionCode 2007 and the Medium-Voltage Directive 2008.

Regarding number 26

The term "*wind energy connection system*" is explained in more detail in Figure 4.

Regarding number 27

In Annex 1 of the Ordinance, a basic distinction is made between "*wind energy plant*" and "*wind energy generating unit*":

A "*wind energy plant*" can also be referred to as "wind farm" or "wind power station" and is a facility comprising one or more units for generating electrical energy from wind energy (*wind energy generating unit*) (including the connection system) and all electrical equipment necessary for operation. *Wind energy plants* are both individual units connected to a network as well as multiple units jointly connected to a network via an internal wind farm cabling for generating electrical energy from wind energy. A *wind energy plant* can consist of different types of *wind energy generating units*.
The corresponding terms are "*installation*" in the Renewable Energy Sources Act and "*generating unit*" in the TransmissionCode 2007.

Regarding number 28

"*Wind energy generating unit*" is an individual system for generating electrical energy from wind energy. The corresponding term is "*generator*" in the Renewable Energy Sources Act and in the TransmissionCode 2007. The designations "*wind power installation*" or "*wind turbine*" are also common.

A wind energy generating unit of type 1 is present if a synchronous generator is coupled directly to the grid. A wind energy generating unit of type 2 is present if this condition is not fulfilled.

Regarding number 29

Number 29 defines the term "*active current* I_W".

Figure 2: Characteristic variables for the step response of the *reactive current I_B* upon occurrence of a *significant voltage deviation U_s*

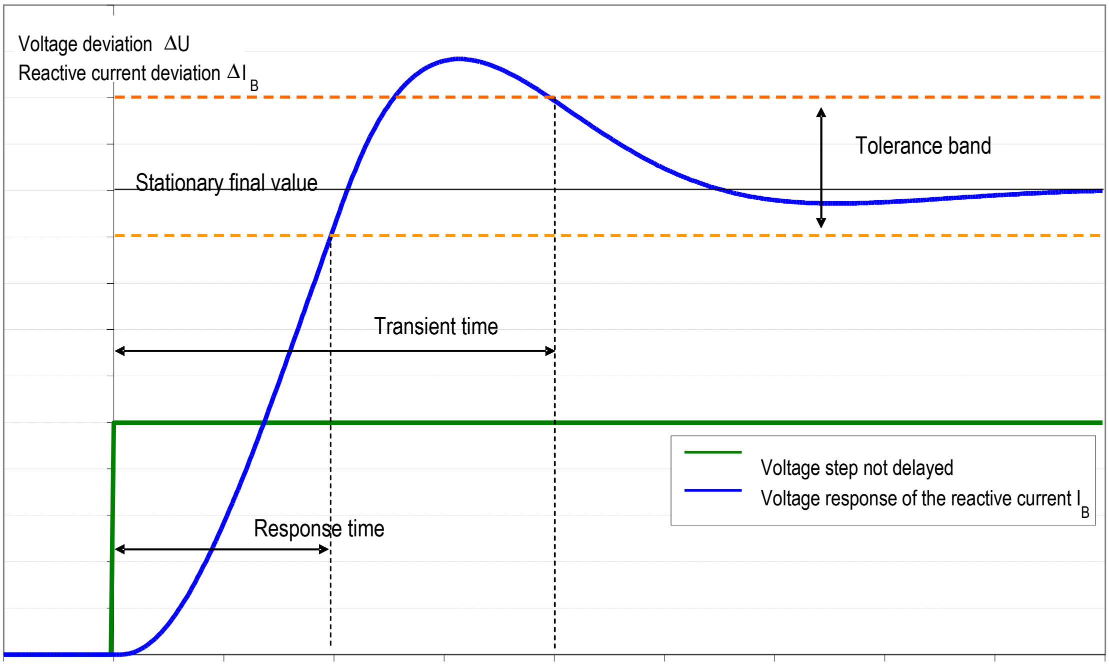


Figure 3: Illustration of the various power terms

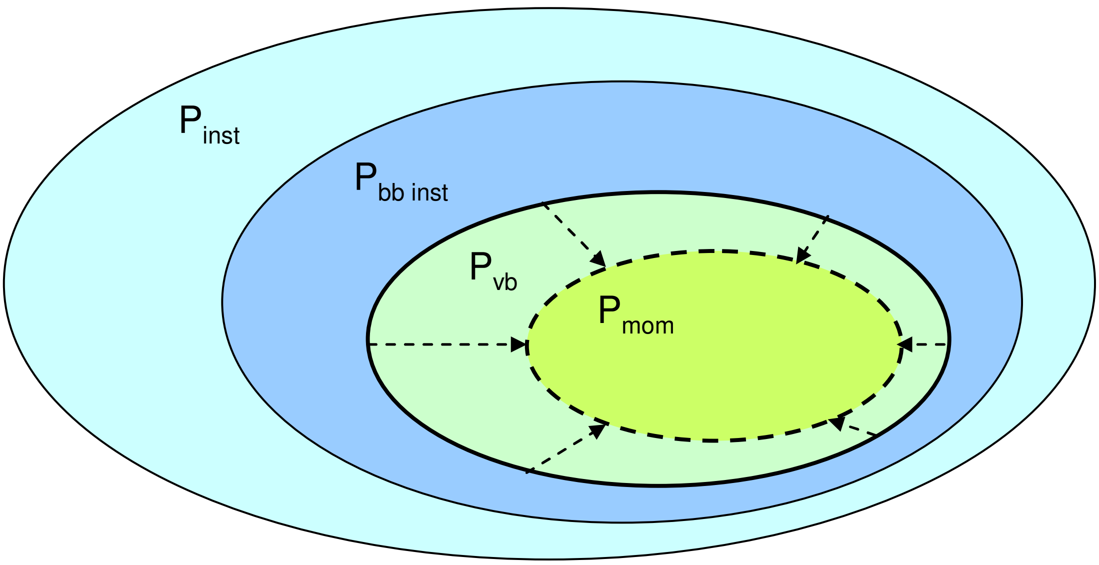


Figure 4: Explanation of terms (corresponds to Figure "Terms" of the Medium-voltage Directive 2008)

① Grid connection point
② Wind energy plant
③ Wind energy connection system*
④ Wind energy generating unit

* The wind energy connection system generally consists of medium-voltage lines and a transfer station.

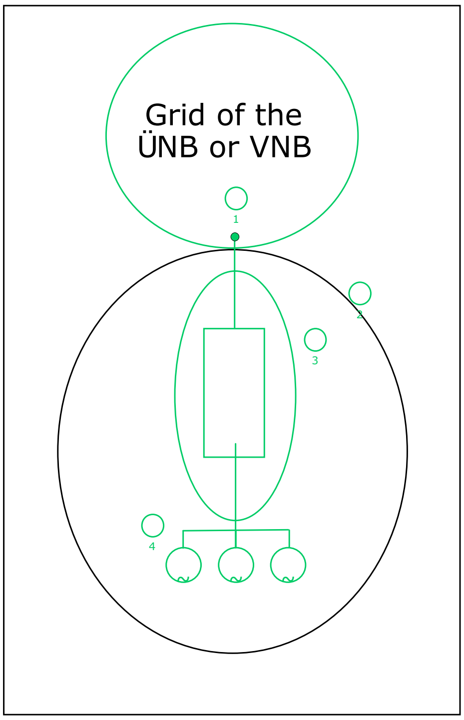
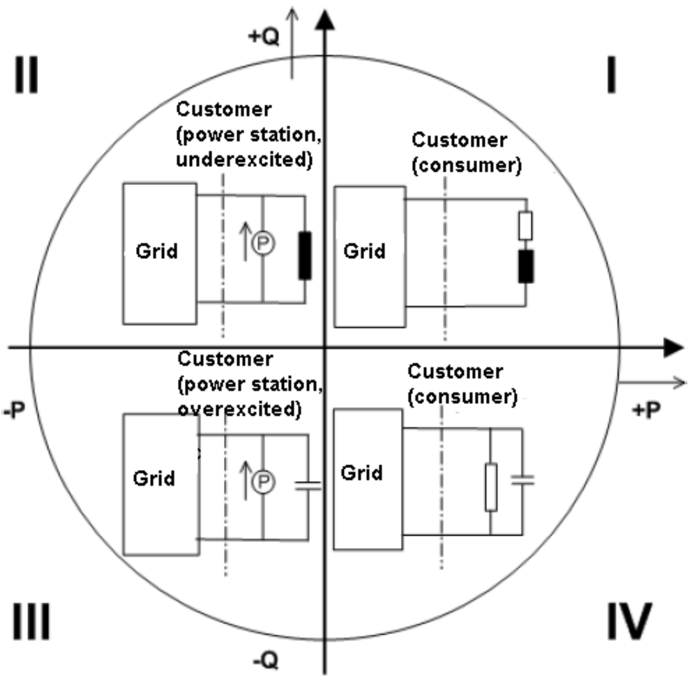


Figure 5: Representation of the consumer meter arrow system (corresponds to Figure B.4-3 of the Medium-voltage Directive 2008)



Regarding Annex 2

Annex 2 specifies the calculation regulation, according to which the pro rata compliance with the requirements for the available reactive power supply by *wind energy plants*, which are connected to a *junction* or *network junction* together with other *wind energy plants*, of which at least one has been put into service before the 1st January 2009. The component to be provided is derived from the ratio of the sum concerning the *operational installed active power* $P_{bb\text{-}inst}$ of all newly erected or repowered *wind energy generating units* and the total sum concerning the *operational installed active power* $P_{bb\ inst}$ of all old and new *wind energy generating units* in the extended *wind energy plant*.

Regarding Annex 3

Annex 3 specifies the requirements which *wind energy generating units* that have been put into service after the 31st December 2001 and before the 1st January 2009 have to meet, if they are upgraded as a result of a conversion or a measure comparable in its effect within the associated *wind energy plant* before the 1st January 2011 and aim to receive the system service bonus pursuant to section 66 paragraph 1 number 6 of the Renewable Energy Sources Act.

The requirements for old wind energy plants definitively stipulate: the cycling through of faults in the grid; the active power reduction at over-frequency; and the option for a requirement by the network operator to block the function for automatic recoupling to the grid. A reactive current feed-in in the event of a fault is not required.