TransmissionCode 2007

Network and System Rules of the German Transmission System Operators

August 2007

Verband der Netzbetreiber VDN e.V. beim VDEW

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1 Introduction

1.1 General

(1) In Germany, the use of electricity networks is based on the regime of regulated *grid access*. The present Transmission Code 2007 taking account of the new conditions in terms of energy policy resulted from the refinement of the 2003 Transmission Code [Q13] that was formulated on the basis of negotiated *grid access*.

(2) The Network and System Rules of the German *transmission system operators (TSOs)* comprise the rules which form the economic and procedural basis of grid usage and serve the technical and operational coordination between the *TSOs*, responsible for the system, and grid users.

(3) The Transmission Code's legal framework was based e. g. on the EC Regulation 1228/2003 on conditions for access to the network for cross-border exchanges in electricity on an international level [Q4] including the guidelines on *congestion management* [Q4] and the Second Act revising energy industry legislation of 07 July 2005 (EnWG - Energiewirtschaftsgesetz (Energy Industry Act)) [Q1] and the relevant regulations based on the Directive 2003/54/EC concerning common rules for the internal market in electricity [Q3] as well as the Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz - EEG) [Q6].

(4) Pursuant to Article 19 EnWG, the TSOs are obliged to define minimum requirements and publish them on the Internet. Furthermore, under Article 20 EnWG, *network operators* are required to grant access to the grid in a non-discriminatory manner and publish the relevant requirements for *grid access*.

(5) The rules of the "UCTE Operation Handbook" (UCTE-OH) [Q15] determined within the UCTE and regulation manuals developed by VDN and adjusted to current market conditions form an additional background of the Transmission Code.

(6) Many rules from the 2003 Transmission Code [Q13], that was developed on the basis of the Associations' Agreement II plus on Electricity, are carried on under the new regulatory framework of the Energy Industry Act (EnWG) [Q1]. Essential rules also result immediately from the Energy Industry Act and from the relevant Regulations or from specifications of the Federal Network Agency (BNetzA).

(7) According to the EnWG and with respect to Article 9 of the EC Internal Market Directive of 26 June 2003 [Q4], operators of transmission networks are required to maintain a secure, reliable and efficient electricity network. Therefore, the technical rules laid down in the Transmission Code are based on a disturbance-free *operation* of the transmission grid and on the control of *disturbances*. Cross-border electric power exchanges between synchronously operated transmission grids and non-discriminatory provision of data are also carried out on this basis. Furthermore, the *TSOs* ensure the complete acceptance of electricity from renewables-based plants into their networks and a Germany-wide *distribution* in accordance with the Renewable Energy Sources Act (EEG) [Q6].

(8) All these responsibilities can be fulfilled only if minimum technical requirements and rules of approach for access to and utilisation of the networks are satisfied.

(9) According to the principle of subsidiarity, these minimum requirements can be specified in greater detail by the different TSOs in exceptional cases.

(10) This Transmission Code 2007 replaces the Transmission Code 2003 – Network and System rules of the German *transmission system operators* [Q13]. The relevant current rules for the *distribution network* are given in the Distribution Code 2007 [Q12].

(11) The Transmission Code is regularly reviewed and updated whenever considered necessary. It is continuously refined in accordance with the current state of the art in terms of technical and economic developments within the energy industry and on the basis of governing legal provisions.

(12) The terms shown in italics in the present text are defined in Chapter 9. The figures in brackets refer to the bibliography in Chapter 10.

2 Implementation of the TSOs' responsibility for the system with the cooperation of DSOs

2.1 Introduction

(1) Under Article 13 of the Energy Industry Act (Energiewirtschaftsgesetz - EnWG) of 7 July 2005 [Q1] the *TSOs* are required to assume responsibility for the system. The *TSOs* have developed a common understanding concerning the implementation of their responsibility for the system under Article 13 EnWG. This understanding is based upon the following principles:

- It is exclusively the *TSO* that is responsible for the maintenance of the power balance within its *control area* in the event of imbalances attributable to *balancing groups*.
- The responsibility of *network operators* regarding the maintenance of voltage limits and loading of equipment rests with every *network operator* within the network run by him in operational terms.
- All necessary measures are implemented in a cascading manner across all network levels, starting at the transmission system.

(2) Under the Energy Industry Act (EnWG), the *TSOs* are required to carry out firstly energy-related and secondly market-related measures.

(3) Possible network-related and market-related measures pursuant to Article 13, paragraph 1 EnWG are described in Annex A.1.

(4) According to the order clearly determined by law, the *TSO* will first initiate or implement, respectively, the measures determined in Article 13, paragraph 1 EnWG. Should the measures initiated or available on principle, or the time required for their taking effect not be sufficient, the TSO shall be entitled under Article 13, paragraph 2 EnWG to adjust all electricity supplies to the network, electricity transits and electricity extractions, or to insist upon an adjustment.

(5) Pursuant to Article 14, paragraph 1 EnWG, the provisions of Article 13 EnWG shall apply accordingly to *DSOs* in terms of their distribution functions within their networks. The *DSO's* own responsibility for its *distribution network* shall not be affected.

(6) In order to discharge its obligations according to Article 13 EnWG, the *TSO* usually makes contractual arrangements with the *DSOs* concerned. The *DSO* carries out backup measures by order of the *TSO*.

(7) Under Article 14, paragraph 1a EnWG, all *DSOs* (directly connected to the *TSO* and downstream) are required to provide support to the *TSO* through their own measures taken in accordance with the *TSO's* instructions.

(8) As part of system management and the TSOs' responsibility for the system, it is for them to assess the system state. To obtain the necessary information for the assessment of the system state, the *DSOs*, energy producers and *suppliers* connected to the *control area* are required under Article 12, paragraph 4 EnWG to make the necessary information available to the *TSO*.

(9) The *network operators*' plans (described in the following sections) concerning the operational implementation of these measures according to Article 13, paragraph 2 EnWG towards network customers (*DSOs* directly connected and downstream, consumers and producers) are to be included in the contractual arrangements listed under paragraph 6 and section 2.4, paragraph 1[1].

Prime objectives are the short-term efficiency of the measures and the mutual provision of information required for this purpose (e. g. through integration into the control system).

2.2 Adjustments aiming at the maintenance of the system balance and network security

(1) As to the adjustments in concrete situations which – according to the assessment of the *TSO* – represent the least possible interference at equal physical effect according to Article 13, paragraph 2 EnWG: not verified yet [2].

[1] This shall analogously apply to the arrangements made with balance responsible parties, unless otherwise determined.

[2] Addtional details are elaborated within a network operators' task force with a view to implementing the responsibility for the system. This task force also considers the need for action and contractual arrangements according to Section 2.1, paragraph (6).

2.2.1 Adjustments aiming at the maintenance or restoration of the system balance

(1) The responsibility for the maintenance of the *system balance* rests with the *TSO*. In interconnected operation, the *system balance* is ensured by meeting the system balance in every *control area*. It can be jeopardized in the event of

- *failure* of generation or demand within a *control area*
- loss of cross-*control-area* trading transactions
- deviations of generation or demand from the forecast or
- break-up of interconnected operation

(2) For reasons of non-discrimination, possibly all producers, transiting parties and *consumers* within the *control area* must equally be called upon to assist in the case of *risks* to or *disturbances* of the *system balance* provided that this is feasible in technical terms or justifiable in terms of process engineering, and that they are equally qualified for this purpose. Possible adjustments are described below:

- ***Load disconnection***
  - is carried out manually by the *TSO* in the transmission network and by the *DSO* in the *distribution network* according to the distribution formula[3]
  - is carried out *automatically* through *frequency-dependent load disconnection* in distribution networks in accordance with the VDN 5-stage plan.
- **Voltage reduction**
  - is carried out by reducing the current voltage level at loads (usually in the medium-voltage network) and directly at customers connected to the transmission grid with a view to reducing active power consumption.
- ***Feed-in management***
  - is carried out in the transmission grid by direct command to all generating facilities in accordance with the distribution formula of the *TSO*
  - is carried out in the distribution networks by giving instructions to the upstream *network operator* according to the distribution formula.

[3] The distribution formula is to be determined between the network operators concerned in the contractual arrangement within a *control area* on the basis of the online transmission of load or power values of plants in *operation* capable of being influenced. Alternatively, maximum loads which occurred in the past or installed capacities which have to be published may form the basis for the distribution formula.

2.2.2 Adjustments aiming at the maintenance or restoration of the network security

(1) The *network security* is mainly influenced by the local conditions in the transmission or *distribution network*. *Risks* to or *disturbances* of the *network security* can be caused in particular by:

- overloading of equipment
- violation of voltage limits or
- loss of the (n-1) security.

(2) The responsibility for the removal of a *risk* or a *disturbance* rests with the *network operator* in whose network the violation of the *network security* occurred. Where the *network security* in the transmission grid is locally put at risk or disturbed through extractions or feed-in, the TSO must take appropriate remedial measures in situ. As a matter of principle, all adjustments are carried out in the order of their highest efficiency with regard to the maintenance or restoration of the *network security.* Usually, demands for adjustments are made by the *TSO* on the *DSO* in a differentiated manner according to electrically separated distribution networks or in relation to concrete *grid connection points* – where this is feasible in technical terms or justifiable in terms of process engineering and on condition of equal suitability.

(3) Should the *network security* in the transmission grid however be put at risk or disturbed through load-flows caused by *transits*, the *TSO* must take appropriate remedial measures. Possible adjustments are described below:

- **Local *load disconnection***
  - is carried out manually by the *TSO* in the transmission network and by the *DSO* in the *distribution network.* A selection is made according to the effectiveness; a partition is made only in case of equal effects.
  - is performed automatically by under-voltage relays in *distribution networks.*
- **Local voltage reduction**
  - is performed by selective reduction of the instantaneous voltage level at loads (usually in the medium-voltage network) in the *distribution network* through the *DSO* or through the *TSO* at customers directly connected to the transmission network with a view to avoiding a voltage collapse. The voltage reduction can also be performed beyond the admissible operating parameters up to *voltage-dependent load disconnection*.
- **Local *injection management***
  - is carried out directly in the transmission network by instruction of the *TSO* to the generating facilities connected to the transmission network or indirectly in the distribution networks by instruction to the *DSO*. The relevant measures are basically selected according to their effectiveness.

- **Local request for reactive power delivery**
  - is directly performed in the transmission network by instruction of the *TSO* or indirectly in the distribution networks by instruction of the DSO to the generating facilities connected to the distribution network and through the control of compensating equipment. The measures are selected according to their effectiveness.
- **Selective schedule adjustment**
  - is carried out by means of pro-rata curtailments of already accepted schedules.

2.2.3 Operational implementation of adjustments

(1) The adjustments requested by the *TSO* and implemented by the *DSOs*, balancing group managers (*BGMs*) (e.g. electricity traders) or directly connected producers/end-use customers, the following order shall apply to the best of the ability of the parties concerned (to be analogously implemented in operational terms from *DSOs* to downstream *DSOs*):

1. advance notice of the required adjustments to be given as early as possible by the *TSO*
2. *TSO*'s request for adjustments to be immediately realized
3. realization and confirmation of the required adjustments by the *DSO*, *BGM* (e.g. electricity trader) or directly connected producers/end-use customers
4. examination of the effectiveness of adjustments by the *TSO*
5. request for additional adjustments, if necessary, by the *TSO*.

(2) Steps for the withdrawal of adjustments:

1. Announcement of the revocation of the adjustment by the *TSO*
2. release for revocation of the adjustment by the *TSO*
3. confirmation and revocation of the adjustment by the *DSO*, *BGM* (e.g. as electricity trader) or directly connected producer / end-use customer
4. notification of the termination of adjustments to the *TSO* and hence return to *operation* in line with requirements.

(3) All steps taken for the realization and cessation of adjustments are to be documented as described in section 2.2.5. The measures of the *DSOs* carried out independently of the *TSO*'s request in the distribution networks pursuant to Article 14, paragraph 1, clause 1 EnWG shall thereby not be affected.

2.2.4 Obligation to inform in the event of adjustments

(1) Pursuant to Article 13, paragraph 2 EnWG, particularly *DSOs* and electricity traders affected in the case of necessary adjustments of electricity feed-in and extractions shall be informed in advance, whenever possible.

(2) If adjustments under Article 13, paragraph 2 EnWG are applied, the following chronological chain of information and evidence shall be put into practice by the *TSO*:

1. Information in advance, whenever possible, to affected *DSOs*, *BGMs* (such as electricity traders) and directly connected producers/end-use customers (form see Annex A.2).

2. Immediate information about the reasons of the adjustments to be given to the German Federal Network Agency and to the parties concerned (see section 1.) whose electricity feed-in, extractions or transits were affected in an unplanned manner, at variance with schedules and in a way that was not directly agreed by contract (form see Annex A.5).

3. Disclosure of the reasons for the implemented adjustments to the parties concerned (see section 1. above) and to the Federal Network Agency at their request. The justification to be given by the *TSO* must be appropriate to enable the necessity, volume and quality of the required measures to be subsequently verified.

(3) With a view to discharging the obligations to report and inform, the legal requirements are defined according to Table 2.1. It comprises the essential contents of the information. This applies in particular to the indication of reasons relating to the causes which can immediately be identified by the *TSO* concerned. Causal chains are not developed by the *TSOs*. This is part of subsequent disturbance clearing.

Time of information	in advance, whenever possible (information) according to Article 13, paragraph 2, last sentence		immediately (reasons) according to Article 13, paragraph 5, clause 1		subsequently on demand (evidence of reasons) according to Article 13, paragraph 5, clause 2
	who?	what about?	who?	what about?	what about?
1.) curtailments of a schedule already accepted	immediately affected *BGMs*	likely extent and duration of adjustment	immediately affected *BGMs* and Federal Network Agency	extent and duration of the adjustment and reasons (U,I)	e.g. network security calculation
2.) direct instruction of consumers in the *distribution network*	affected *network operators* and directly connected customers, all *BGMs* within the *control area* *	likely extent and duration of the adjustment	affected *network operators* and directly connected customers, and Federal Network Agency, all *BGMs* within the *control area* *	extent and duration of the adjustment and reasons (ΔP, f, U, I)	e.g. network security calculation
3.) direct instruction of producers, renewables-based plants included	affected *network operators* and directly connected producers **	likely extent and duration of the adjustment	affected *network operators* and directly connected producers ** and Federal Network Agency	extent and duration of the adjustment and reasons (ΔP, f, U, I)	e.g. network security calculation

* *BGMs only the case of load disconnections* (Internet, mailing list,...)
** Producers inform the *BGMs* concerned

Table 2.1: Chain of information and evidence to be furnished in the event of adjustments under Article 13, paragraph 2 of the German Energy Industry Act (EnWG)

(4) Should the implemented adjustments not be sufficient to avert a *disturbance* of vital requirements, the obligations to inform are to be extended according to Article 13, paragraph 6 EnWG.

(5) The form in Annex A.6 provides a description of how to discharge this obligation to inform.

2.2.5 Requirements on documentation for adjustments under Article 13, para. 2 EnWG

(1) In order to ensure that the documentation of the entire information of the TSO available at the time of the decisions taken is as complete as possible, it is necessary that the ACTUAL condition and all measures carried out to achieve the TARGET condition according to Article 13, paragraph 1 EnWG be documented in operating log sheets, daily reports, or the like. Documentation is also required if the operational application is not feasible due to time constraints or if the appropriate measures are not available.

(2) Important information contents are to be archived, whenever possible, prior to the update of adjustments by taking a snapshot of the current network condition.

(3) The invitation by phone to take action which is required for requesting an adjustment is to be documented in the operating log sheet, the daily report, or the like. Subsequently, the DSOs, *BGMs* (such as electricity traders) and directly connected producers/end-use customers will receive a written request for adjustment, stating also the reasons for this request (catchword by fax or e-mail). They have to confirm the finalized implementation of the adjustment in written form (see Annexes E.3 and E.4).

(4) It should be possible to verify the effectiveness of the adjustments on the basis of the automatically filed regular operational information or the manually archived snapshots.

(5) The request by phone required for the withdrawal of an adjustment shall be documented in the operating log sheet, daily report or the like. Subsequently, the *DSOs*, *BRPs* (such as electricity traders) will also receive a written request on the revocation or partly revocation of the adjustment. They have to confirm the finalization in written form. The time of arriving at the normal operating condition shall also be documented in an appropriate manner.

(6) All documents sent in conjunction with adjustments are to be archived.

2.3 Identification of possible risks or disturbances in the transmission network

(1) In order to be able to identify possible *risks* or *disturbances* in the transmission network according to sections 2.3.1 and 2.3.2 and request appropriate adjustments according to Article 13, paragraph 2 EnWG, the TSO needs to obtain information from the distribution networks and from producers / end-use customers directly connected.

(2) The identification of *risks* the day before, at the latest, is based on data for the following day(s) and on calculations carried out in accordance with Table 2.2:

	Information	**Update interval**	**Responsible party**
General	• Nomination of intra-control-area schedules of all balancing group managers (*BGM*) • Generation forecast of all *BGM*s within the *control area* • *DACF* data of interconnection partners • Network security calculations / failure simulation • daily/weekly planning of network elements' disconnection • messages	daily daily daily daily daily	*BGM* *TSO* *TSO* *TSO*
Generating plants according to the Renewable Energy sources Act (EEG)	• Installed capacity of all generating plants • Available capacity of generating plants with online data recording • Wind forecast and resulting forecast of electricity feed-in from wind-energy plants (forecasted *generation management* included)	annually annually daily	*DSO* Power Plant Operator *TSO*
Conventional generating plants (incl. CHP)	• Generation schedules and min/max limit values for generating units >100 MW (from all distribution networks and producers directly connected to them) • revision plans focused on *power stations* directly connected (for generating units >100 MW) • aggregated existing revision plans of generating units > 15 MW and < 100 MW	daily monthly monthly	Power Plant Operator Power Plant Operator *DSO*
Imports, exports	• Nomination / computation (incl. horizontal equalization of burdens) of cross-*control-area* schedules	daily	*BGM* and TSO
Load	Load forecast of all *BGMs* within the *control area*	daily	*BGM*
Generation	Generation forecast of all *BGMs* within the *control area*	daily	*BGM*

Table 2.2: Data and calculations enabling *risks* to be identified

(3) The identification of *risks* or *disturbances* on the same day is based on the supervision of data and the implementation of calculations according to Table 2.3:

	Information	**Responsible party**
General	• Nomination of intra-control-area schedules of all balancing group managers (*BGM)* • Network security calculations/failure simulation • Data from control systems • News (politics, weather, terrorist attacks, …)	*BGM* *TSO* *TSO*
Renew-ables-based gen-erating plants (ac-cording to the Renew-able Energy Sources Act (EEG)	• Updated wind forecast and the resulting forcast of electricity feed-in from wind-energy plants • Current extrapolations on electricity feed-in from wind-energy plants based on timely recorded feed-in from renewables-based reference plants within the *control area* • Online-data of feed-in into the transmission grid and distribution networks, i.e. power values from renewables-based plants with *injection manage-ment* or with remote-control existing at their point of connection.	*TSO* *TSO* Power Plant Op-erator
Conven-tional gen-erating plants (incl. CHP)	• Notification concerning unplanned outages of di-rectly connected power plants and power plants > 100 MW in distribution networks • Online data of feed-in into the transmission grid and distribution networks • **within the transmission grid**: all directly con-nected power plants transmitting online values (fo-cusing on individual power plants), max-min-limits • **within the *distribution network***: existing values of *power stations* transmitting online values from a capacity of 50 MW onwards	Power Plant Op-erator Power Plant Op-erator Power Plant Op-erator DSO or Power Plant Operator
Imports, exports	• Intra-Day exchange schedules	*BGM*

Table 2.3: Data and calculations enabling *risks* or *disturbances* to be identified the same day

2.4 Rules concerning the technical implementation

(1) The concepts described in the previous sections partly require technical installations within the networks and extensions of data exchanges between *DSO*/producers and *TSO*. The requirements to be derived from these concepts and the resulting payment of cost need to be settled on the basis of an agreement between the contracting parties.

3 Connection conditions

3.1 Purpose of the connection conditions

(1) The technical minimum requirements described below which have to be met for the network connection of generating plants, electricity distribution networks, facilities of customers with direct connection and connecting lines with other networks shall serve as a basis for the design and operation of the network connection facility.

(2) While taking physical laws and technical restrictions into account, they are aimed at ensuring the security and reliability of operation of the transmission grid and of all customer facilities connected to it, minimizing influences and inevitable impairments in terms of the interactions of customer facilities both with the transmission grid and between one another and, in the event of disturbances or risks, preventing the spreading of the disturbance, minimizing its impact and enabling a secure and reliable operating condition to be restored as soon as possible.

(3) When the customer facility or only parts of it are technically connected to the transmission grid, the operators of the customer facility have to make sure that all requirements of the network connection and network access rules are observed.

(4) The *TSO* shall communicate the connection procedure in an appropriate manner.

3.2 Grid connection

(1) The property line of the *grid connection* shall be determined by mutual consent between the *TSO* and the *connection owner* taking the *network operator*'s specifications into account. Details are to be stipulated by contract.

(2) The technical rules effective at the time of conclusion of the *grid connection* agreement shall apply. Current rules shall be applied to new facilities or if the connection parameters are essentially modified, and in the case of a legal obligation to carry out adjustments.

(3) The *TSO* shall, upon request by the *connection owner*, examine whether the network conditions prevalent at the existing or planned *grid connection point* (power available at the supply terminals, short-circuit power, etc.) are sufficient. To this end, the TSO shall examine whether installations can be operated without risk to the operation of the remaining installations and without unacceptable disturbances (*stability*, flicker, harmonics, step-type voltage changes, violation of short-circuit limit values) to the *TSO's* network, and the electric power/energy supplied to his network can be transferred. The values for voltage quality in subordinated networks stipulated in EN 50160 [Q9] and in the Rules for the assessment of network disturbances [Q10] shall be observed in this regard.

(4) The *connection owner*/*connection user* shall supply the *TSO* with all technical and operating data required for evaluation of the *grid connection* (e.g. rated capacities, power gradi-

ents, *reactive power* demand, *network disturbances* etc.) and shall cooperate in the search for technical solutions.

(5) Connection of the *customer facility* requires that the *n-1 criterion* as described in Chapter 6 be maintained in any case for the *TSO*'s network. The (n-1)-secure design of the connection line between the *customer facility* and the *grid connection point* shall be excluded. It requires separate agreements with the *connection owner/connection user* on a case-by-case basis.

(6) Should the system conditions at the *grid connection point* suffice for operation of the *customer facility* under the conditions stated above, the *TSO* shall specify the *grid connection* scheme required for maintenance of proper system operation in consultation with the *connection owner/connection user*.

(7) Should the network not be able to fulfil the technical requirements for the connection of the *customer facility* to the transmission grid (e.g. short-circuit power at the *grid connection point*), the *TSO* shall provide documentation hereof in the form of analyses and shall state the reasons.

(8) Should the system conditions (e.g. power at the supply terminals, *system short-circuit power*, etc.) at the *grid connection point* not be adequate for operation in accordance with the provisions and low-disturbance operation of the *customer facility*, the *TSO* shall consult with the *connection owner/connection user* with regard to modifications of the customer facility. Should the *grid connection point* be inappropriate, the *TSO* shall propose measures enabling the eligibility of the *grid connection point* to be obtained or propose the nearest suitable *grid connection point*.

(9) The *TSO* shall determine a well-supported *grid connection* scheme for the *connection owner/connection user.* To this end, the following technical data need to be agreed inter alia:

- grid connection capacity
- maximum and minimum continuous operating voltage, as well as duration and level of the short-time violations of the maximum and minimum limits
- nature and volume of the reactive power interchange
  - with customers receiving *electric power* from the network (in the absence of relevant contractual provisions) cos φ in the range of 0.95 inductive to 1.00 shall apply at the *grid connection point* or
  - with *generating units* (see section 3.3)
- maximum and minimum *network short-circuit power*
- breaking capacity
- method of neutral point connection
- electric protection scheme
- automatic synchronising conditions
- harmonic component and flicker component

- inclusion into the voltage control scheme (reference voltage, accuracy, velocity, fault-mode operation)
- behaviour under *large-scale failure* conditions
- involvement in the 5-stage plan
- involvement in *ancillary services* required for the provision of *system services*
- measuring, metering and information technology
- insulation coordination.

(10) The *grid connection* schemes shall be drawn up with due regard to the technical framework of assessment according to Chapter 6.

(11) The necessary contractual agreements shall be concluded for the *grid connection* and for the connection and network usage.

(12) Compliance with the characteristics agreed contractually between the *connection owner/connection user* and the *TSO* shall be demonstrated (e. g. through tests) to an extent to be bilaterally agreed.

(13) The personnel employed by the *connection owner/connection user* for operation of the high- and extra-high-voltage parts of the installation shall be suitably qualified (in accordance with VDE 0105 [Q11]) and shall be accessible for the *TSO* at any time.

(14) Technical modifications within the responsibility of the *TSO* or the *connection owner/connection user* which have a substantial impact on the agreements formerly concluded shall be subject to new bilateral contractual arrangements.

3.3 Special requirements governing the connection of generating units

3.3.1 General

(1) *Generating units* feeding into the transmission grid shall satisfy certain requirements (see section 3.2). Observation of these requirements and the associated commercial conditions shall be ensured by appropriate bilateral agreements. To this end, agreements shall be concluded between the responsible *network operator* and the *connection owner/connection user* in accordance with this TransmissionCode.

(2) To be connected to the transmission system, *generating units* must meet basic technical requirements.

(3) *System services* necessary for the secure operation of the transmission grid shall be provided by the *TSO*. The operator of the *generating unit* must offer adequate *ancillary services*.

3.3.2 Configuration of the grid connection

(1) Within the meaning of Article 49 EnWG [Q1], all technical facilities servicing connection of the *generating unit* must correspond to legal and official provisions and to established good practice (IEC, EN and VDE rules, DIN standards, accident prevention rules, etc.) as well as to the planning and operational principles of the TSOs. According to Article 19 EnWG [Q1], *network operators* are required to define and publish minimum technical requirements.

(2) If several *grid connections* exist, durable routing of the connections through the *generating unit*'s auxiliary system is permissible only in consultation with the TSO, even if short-term commutation measures are concerned. The responsibility for effects on the *generating* unit shall rest with the *connection owner/connection user*.

(3) In accordance with contractual arrangements, the *TSO* shall install the facilities of the *grid connection* within its area of responsibility into which the supply cables of the *generating unit* are to be routed.

3.3.3 Synchronizers

(1) For the connection of the generator, the following operational states shall be taken into consideration, and corresponding synchronizers or automatic synchronising devices need to be provided for:

- Normal *operation* (start-up of the *generating unit*)
- Synchronization following tripping onto *auxiliary service supply* taking account of the available *auxiliary service supply* concept
- Bringing onto load on a dead subsystem in order to energize it.

3.3.4 Electrical protection of the network and the generating unit

(1) Electrical protection of the *generating unit* shall take precedence over operational controls (e.g. voltage controllers, excitation equipment) and shall disconnect the *generating unit* from the network should unacceptable operational states arise.

(2) Protection schemes and settings relevant for the electrical *protective equipment* on the network and in the *generating unit* must be agreed between the *TSOs* and the operator of the *generating unit*. Consideration must be given to the following points:

- short-circuits
- load unbalance
- stator and rotor overload
- over-excitation / under-excitation
- over-voltage / under-voltage

- voltage phase (un)balance
- network oscillations
- over-frequency or under-frequency
- asynchronous operation
- torsional strain
- reverse power
- protective and breaker failures
- back-up protection
- schedule for final stage protection.

3.3.5 Power system control communication

(1) Technical facilities must be provided for exchange of information in real time or in a delayed manner through time stamping. The volume and the kind of signal exchange shall be determined bilaterally. The following information shall be exchanged inter alia:

Operator of the generating unit to the TSO:

- Circuit-breaker/disconnector/earthing disconnector/step switch settings, insofar as they are required for *operation* or for system analyses
- Measured values of the current operating mode (e.g. *active* and *reactive power*, voltage).

TSO to operator of the generating unit:

- Where applicable, reference values for control (activation/deactivation of *primary/secondary control*) and instantaneous demand value of the *secondary control*.
- Reference value of the *reactive power* in the form of *schedule* or as an instantaneous value (e.g. for *voltage and reactive power control*)
- Circuit-breaker/disconnector/earthing disconnector settings, insofar as they are required for operation of the *generating unit*
- Actual values of the *active and reactive power* and of the voltage within the feed-in control panel.

3.3.6 Active power output

(1) A deviation from the required generating unit's output to the network in accordance with Figures 3.1 and 3.2 is permissible only after consultation with the *TSO*.

(2) Each *generating unit* must be capable of operation at reduced power output. The level of minimum stable generation is agreed bilaterally between the operator of the *generating unit* and the *TSO*.

(3) Rates of power changes of at least 1% P_N/min related to the *nominal capacity* must be possible across the entire spectrum between the minimum stable generation power and the *continuous output power*. Power-station-specific particularities (e.g. for the consideration of mill switching points or inertia points) are taken into consideration. In the case of provision of *ancillary services*, these requirements may deviate from the above according to prequalification.

(4) The *generating unit* shall not reduce its predetermined *active power* output at frequency characteristics above the bold line shown in Fig. 3.2, even when operated at *nominal capacity*.

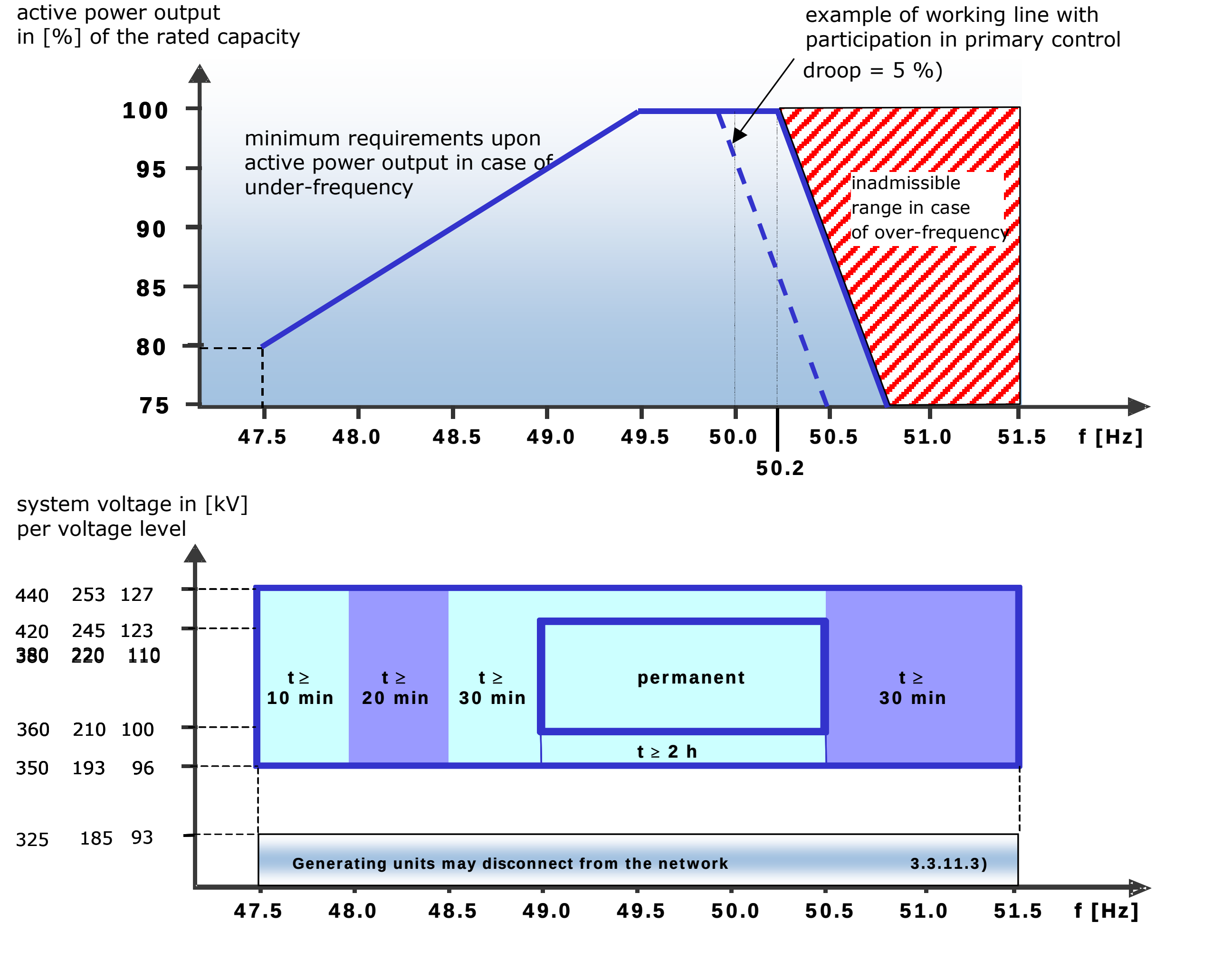


Fig. 3.1: Requirements upon feed-in from *generating units* to the network to be guaranteed for specific periods as a function of the network frequency and the network voltage (quasi-steady consideration, e.g. frequency gradient ≤ 0.5 %/min; voltage gradient 5 %/min)

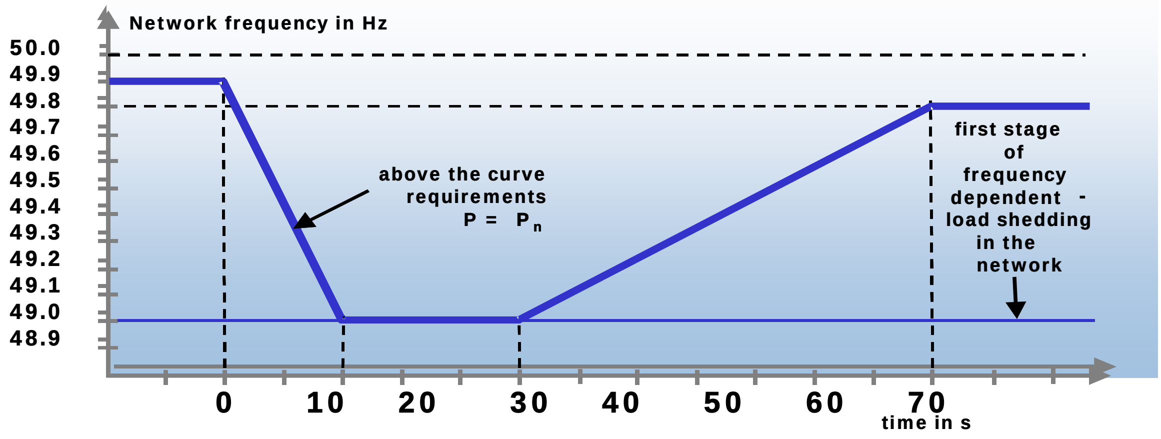


Fig. 3.2:	Requirements upon the output from *generating units* fed into the network within the dynamic short-time range

3.3.7 Frequency control

3.3.7.1 Primary control

(1) Each *generating unit* with a *nominal capacity* of ≥ 100 MW must be capable of supplying primary control power. This is a requirement for connection to the network. The *TSO* shall be entitled to waive this obligation for individual *generating units* (e. g. see section 3.3.13.6).

(2) *Generating units* with a *nominal capacity* < 100 MW may also be employed for assurance of *primary control* by agreement with the *TSO*.

(3) The following conditions shall apply to *generating units* capable of being operated under *primary control*:

- The *primary control band* must be at least ± 2 % of the active nominal capacity and capable of being activated by direction of the *TSO*.
- The *generating unit* shall be capable of activating, within 30 seconds, the total primary control power contractually agreed at a quasi-steady frequency deviation of ± 200 mHz, and of maintaining supply for at least 15 minutes.
- In the case of minor frequency deviations, the same rate of power change shall apply until the required power is reached.
- *For primary control*, the accuracy of frequency measurement shall be below ± 10 mHz.
- A flexible *dead band* and its settings can be agreed between the *TSO* and the operator of the *generating unit.*
- The power-frequency-characteristic or the droop characteristic, respectively, shall be adjustable according to the specifications of the *TSO*.

(4) All *generating units* which satisfy the necessary technical and operational requirements according to the prequalification procedure (see Annex D) and which have concluded a

framework agreement on the provision of *ancillary services*, are qualified for primary control power marketing.

(5) If a *generating unit* does not participate in the provision of primary control power, it shall nevertheless take action, though it is not capable of being operated under primary control, from a network frequency of 50.2 Hz and reduce its output (see Figure 3.1). This *generating unit* then participates with a droop within the range of 4 to 8 % in the reduction of the power surplus.

3.3.7.2 Secondary control and minutes reserve

(1) All *generating units* which satisfy the necessary technical and operational requirements according to the prequalification procedure (see Annex D) and which have concluded a framework agreement on the provision of *ancillary services* are qualified for participation in secondary control power and *minutes reserve.*

(2) Requirements concerning *secondary control reserve*, *minutes reserve*, the *secondary control band*, the rate of change and rate of occurrence of power changes, the stand-by duration, and the technical availability, etc. are determined by the *TSO* (see Annex D).

3.3.8 Reactive power supply

3.3.8.1 Reactive power supply at rated active power

(1) Each new *generating unit* to be connected to the network must meet, within the rated operating point, the requirements illustrated in Figure 3.3 at the *grid connection point*.

(2) The *TSO* shall select one of the possible variants shown in 3.3a to 3.3c on the basis of relevant network requirements. The *generating unit* must be able to pass repeatedly within a few minutes through the agreed reactive power range in the operating point $P=P_N$. It must be possible at any time to change the reactive power requirements within the agreed reactive power range. If required, the *network operator* may determine a different range.

(3) If required, additional facilities must be provided on the *generating unit*, in agreement with the operator of the *generating unit*, in order to be able to carry out voltage and reactive power control within the area of the respective *network operator*.

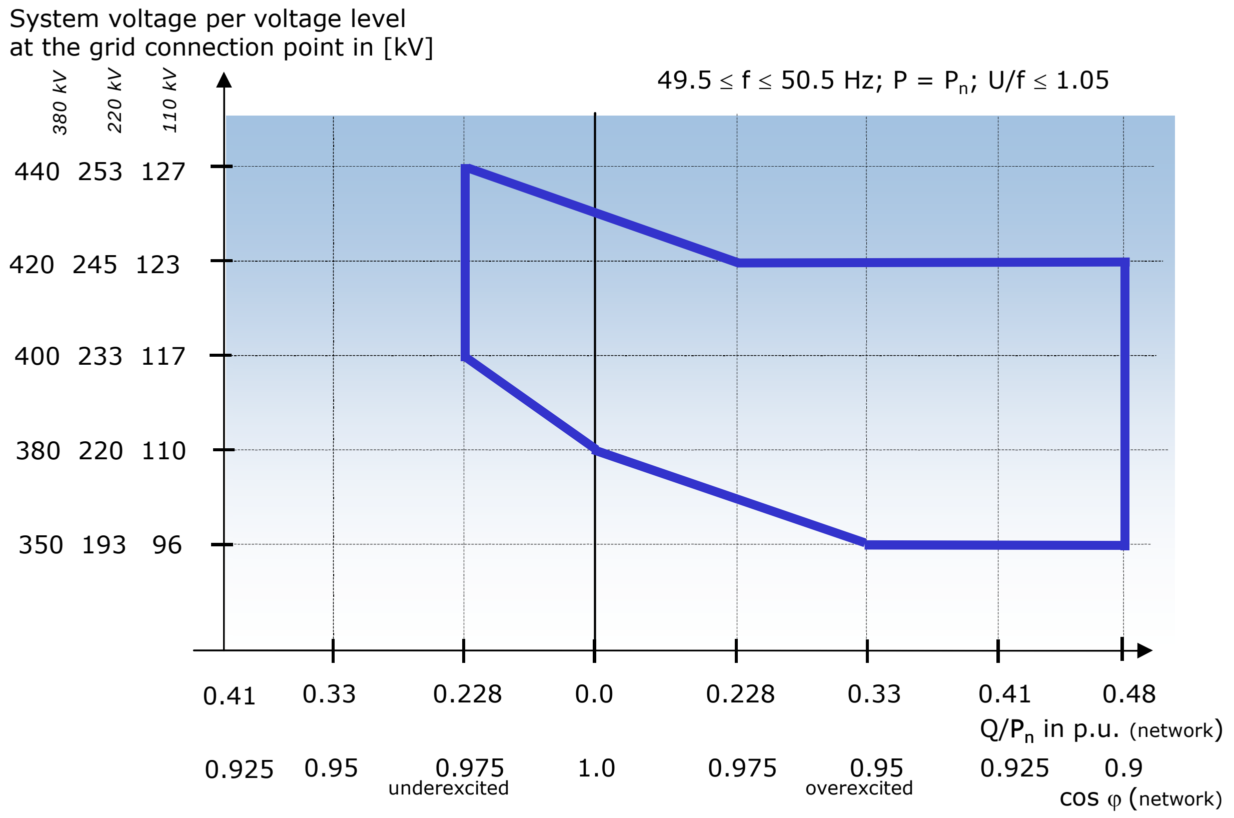
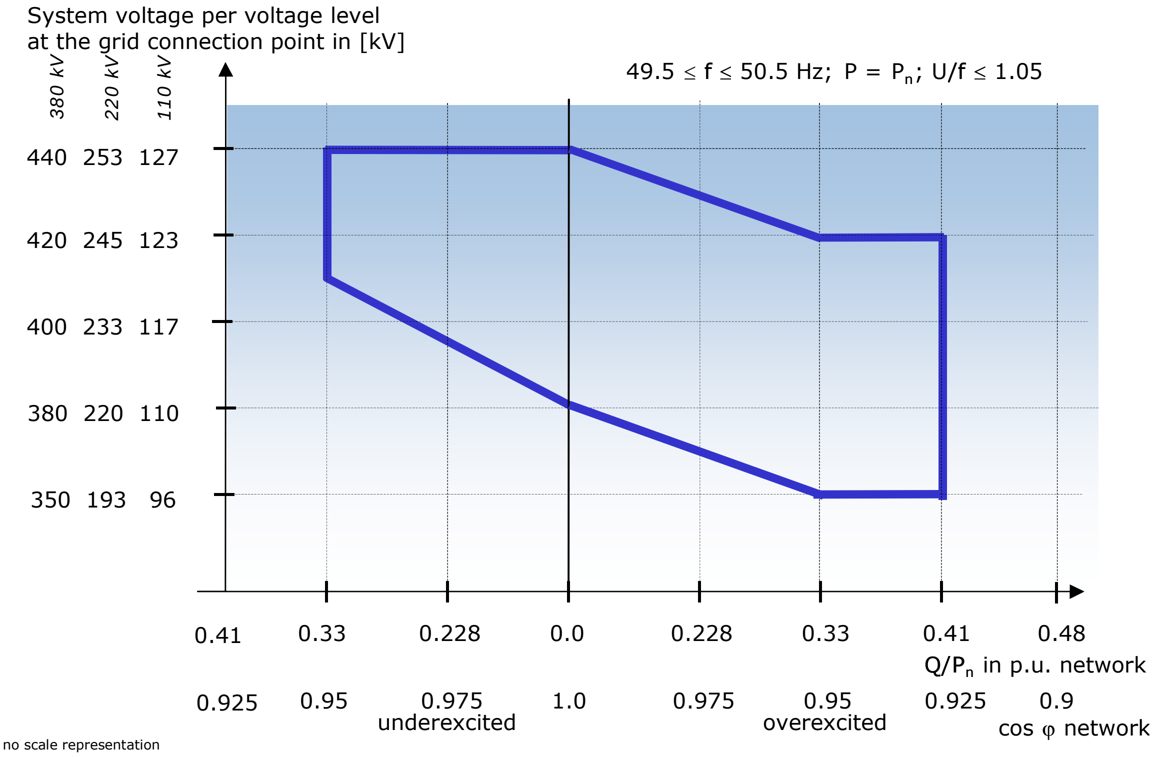


Fig. 3.3a:	Basic requirement upon the network-side supply of reactive power from generating units to the network (Variant 1)



no scale representation

Fig 3.3b:	Basic requirement upon the network-side supply of reactive power from generating units to the network (Variant 2)

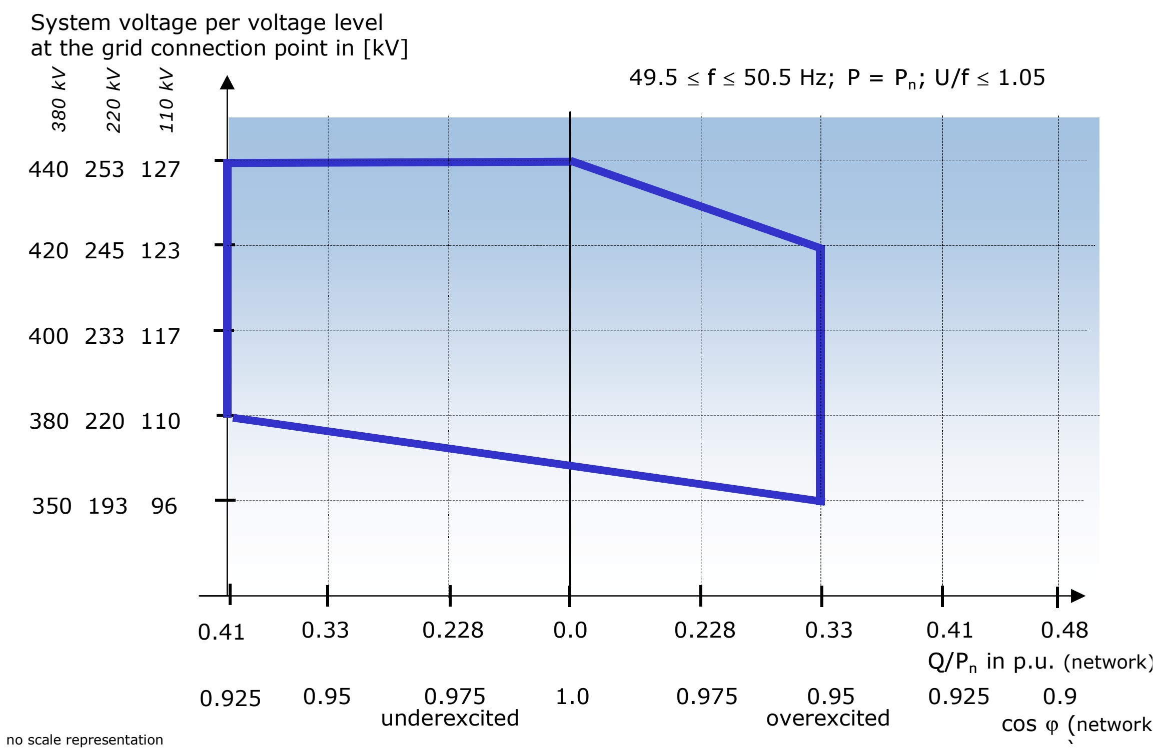


Fig. 3.3c:	Basic requirement upon the network-side supply of reactive power from generating units to the network (Variant 3)

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

(1) Apart from the requirements as to *reactive power supply* in the nominal design point of the *generating unit* ($P=P_n$) there are also requirements concerning *operation* at an active power output below the nominal active power ($P<P_n$).

(2) In this case, it must be possible to operate the generator of the *generating unit* in every possible working point in accordance with the generator output diagram. Even at reduced active power output, *reactive power supply* at the *grid connection point* shall fully correspond to the generator output diagram taking the auxiliary service power and the losses at the generator *transformer* and the machine line into account.

(3) The *generating unit* must be capable of immediately providing every *reactive power supply* resulting from the above. The relevant request can arise according to the situation on the network and imply that the provision of *reactive power* takes precedence over the supply of active power. The mode of operation is agreed between the operator of the *generating unit* and the *TSO*.

3.3.9 Design of the generator transformers

(1) The design of the *generator transformer* and the surge protection concept need to be agreed with the *TSO*. Upon demand of the *TSO*, the generator transformer is to be equipped with an on-load tap changer. In this case, the requests for *reactive power supply* are adjusted through the *generator transformer's* tapping and the direct action of the generator voltage control.

3.3.10 Generator voltage control

(1) The generator voltage control must take immediate action in the case of voltage changes and adjust the given target value of the generator voltage.

3.3.11 Disconnection of the generating unit from the network

(1) The requirements to be met by the frequency, *stability* and network voltage criteria shall be defined by the *network operator* insofar as they serve the purpose of network protection and *system security*.

3.3.11.1 Frequency

(1) At frequencies between 47.5 Hz and 51.5 Hz, automatic disconnection from the network because of frequency deviation from 50 Hz is not admissible. Differing agreements can also be made in exceptional cases by agreement between the operator of the *generating unit* and the *TSO*.

(2) If the *generating unit* is automatically disconnected from the network, secure tripping onto *auxiliary supplies* must be guaranteed.

(3) A synchronization or parallel switching of the generators must be possible within the frequency range from above 48.5 Hz to below 51.5 Hz.

3.3.11.2 Stability

(1) In the case of loss of *steady-state* oder *transien stability*, the *generating unit* shall disconnect automatically from the network in order to avoid repeated slipping.

3.3.11.3 Network voltage

(1) With falling network voltage and a risk of generator overload, the *generator transformer* shall be adjusted, according to the *TSO*'s specifications and if a tap changer exists, in the direction of a lower transmission ratio, and the active power output shall be reduced,

where necessary, in order to enable the *generating unit* in this exceptional situation to remain connected to the network as long as possible, and to support the network.

(2) Only at a quasi-steady network voltage of ≤ 85 % of the reference voltages (380/220/110 kV) at the *grid connection point*, the *generating unit* may be disconnected from the network in order to allow secure tripping on auxiliary supplies.

3.3.12 Behaviour of the generating unit in the event of network disturbances

(1) Characteristics of the turbine-generator set control relevant to the stability, i.e. the resulting effect of turbine and generator control, shall be co-ordinated between the operator of the *generating unit* and the *network operator.*

3.3.12.1 Transient stability (short-circuits)

(1) With fault clearing times of up to 150 ms, three-phase short-circuits close to the *generating unit* must not lead to instability throughout the operating range of the generator when the *initial symmetrical short-circuit power* (S''_{kN}) on the network side of the "network/generating unit" *interface* following clearance of the fault exceeds six times the numerical value of the sum of rated active powers of all *generating units* DC-coupled at the *grid connection point* of that *generating unit*.

In agreement with the network operator on a case-by-case basis, special stability calculations shall be carried out with a view to investigating and substantiating the conditions under which a *generating unit* can be connected to the network in the case of lower short-circuit powers on the network side.

(2) Under the circumstances mentioned in (1), *short circuits close to the power station* must not lead to the disconnection of the *generating unit* from the *network*. The generating unit auxiliary supply shall not be redirected automatically to reserve supply connections.

(3) With a view to controlling the voltage collapse on *auxiliary supply*, it is permitted to use a shorter fault clearing time (at least 100 ms) in agreement with the *network operator*, at which the *generating unit* must not be disconnected from the *network*. This implies that the shorter fault clearing time can be ensured through appropriate protection and switchgear facilities functioning in conformity with the concept.

Note: Due to the dynamic interactions between generator and network, a voltage collapse may occur within the *stability*'s limit range at the generator terminals and on the *generating unit*'s auxiliary supply (see also [Q18]) which can go on beyond the fault duration. This needs to be taken into consideration for the design of auxiliary service supply in order to meet the requirement mentioned above.

(4) Short-circuits which do not give rise to a drop of the generator voltage (taking the exciter ceiling voltage into account) below 85 % of its nominal value, shall not lead to a redirection of the *generating unit*'s auxiliary supply, nor to precautionary disconnection of the *generating unit* from the *network*, even in the case of fault clearance of up to 5 seconds in the final stage of network protection.

3.3.12.2 Steady-state stability (network oscillations)

(1) Experience has shown that phase swinging and network oscillations currently occur in the UCTE synchronous area at frequencies of 0.2 to 1.5 Hz. Phase swinging and network oscillations shall lead neither to tripping of the protective equipment of the *generating unit*, nor to a power reduction.

(2) Where required and requested by the *network operator* for system reasons, generators may be provided after mutual agreement with facilities for damping of phase swinging or network oscillations.

(3) The purpose of this measure is to ensure that in the event of an *initial symmetrical short-circuit power* (S''_{kN}) on the high voltage side of at least four times the numerical value of the sum of nominal active powers of all *generating units* DC-coupled at the grid-connection point of that *generating unit*, and a voltage on the high voltage side at least equal to the rated voltage of the *network*, the *steady-state stability* is ensured for any working point within the generator output diagram, and steady-state *operation* is possible.

(4) All characteristics which affect the stability must be coordinated between the *operator* of the *generating unit* and the *network operator*.

(5) The turbine/generator set control must not be conducive to phase swinging or network oscillations.

3.3.13 Requirements upon generating units using renewable energy sources

3.3.13.1 General

(1) More detailed explanations are given in the VDN Guidelines on "Renewables-based generating units connected to the high and extra-high voltage network " [Q16].

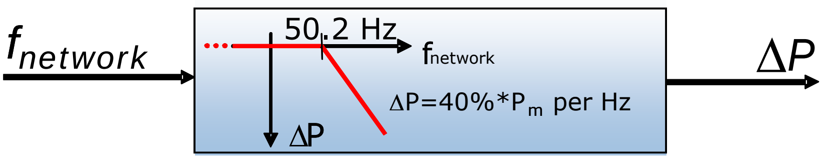
3.3.13.2 Determination of the nominal capacity

(1) The *nominal capacity* of a *generating unit* within the meaning of these regulations is obtained from the sum of individual plants (*generating units*) combined in a grid connection point (network junction). Consequently, for instance in the case of wind energy plants, the installed capacity of an entire wind farm is to be considered as *nominal capacity* (where necessary, this aggregation is to be applied to DC-isolated 110 kV network groups).

3.3.13.3 Active power output

(1) *Generating units* using renewable energy sources must be controllable in terms of active power output according to the requirements of the *TSO*s with a view to counteracting a *risk* to or *disturbance* of the system balance pursuant to Article 13, paragraph 2 EnWG. It must then be possible to reduce the power output under any operating condition and from any working point to a maximum power value (target value) defined by the *network operator*. This target value is given by the *network operator* at the grid connection node and corresponds to a percentage value related to the network connection capacity. The reduction of the power output to the signalized value must take place with at least 10 % of the network connection capacity per minute without disconnection of the plant from the network.

(2) All renewables-based *generating units* must reduce, while in *operation*, at a frequency of more than 50.2 Hz the instantaneous *active power* with a gradient of 40% of the generator's instantaneously available capacity per Hertz (Figure 3.4).



$$\Delta P = 20\,P_m \frac{50.2\,Hz - f_{network}}{50\,Hz} \quad \text{at } 50.2\text{ Hz} < f_{network} < 51.5\text{ Hz}$$

P_m instantaneously available power

ΔP power reduction

$f_{network}$ network frequency

within the range of	$47.5\text{ Hz} < f_{network} \leq 50.2\text{ Hz}$	no limitation
at	$f_{network} \leq 47.5$ Hz and $f_{network} \geq 51.5$ Hz	disconnection from the grid

Fig. 3.4: *Active power* reduction of renewables-based generating units in the case of overfrequency

(3) If the frequency returns to a value of f ≤ 50.05 Hz, the *active power* output may be increased again as long as the actual frequency does not exceed 50.2 Hz. This control is realized in a decentralized manner (at each individual generator). The *neutral zone* must be below 10 mHz.

(4) A concept for resynchronization with the network is currently developed for wind energy plants which have been disconnected from the network due to over-frequency.

3.3.13.4 Reactive power supply

(1) When exchanging *reactive power*, all *generating units* using renewable energy sources must behave in the way described in Chapter 3.3.8.

(2) After a few minutes, *reactive power* supply must equal the target value defined by the *network operator*.

(3) The working point for steady-state *reactive power* exchange shall be determined in accordance with the need of the grid. The determination shall relate to one of the following three possibilities:

- *power factor* (cos φ)
- *reactive power* value (Q in Mvar)
- voltage value (U in kV), where necessary with tolerance band.

(4) The determination can be made by means of

- an agreement on a value or, where possible, on a schedule
- a characteristic dependent on the generating plant’s working point
- online target-value specification.

(5) For online target-value specification, the new specifications for the working point of the *reactive power* exchange shall be realized after one minute, at the latest, at the *grid connection point*.

3.3.13.5 Behaviour in the event of network disturbances

(1) The operator of the generating facility shall take precautions by himself to make sure that *auto-reclosures* in the *network operator’s* network do not lead to damages at his generating facilities.

(2) The operator of a *generating unit* using renewable energy sources shall take care that possible isolated operation of the facility is securely identified and controlled when the given admissible voltage and frequency limits are not exceeded or undershot.

Apart from the system functions, such as under-voltage and over-voltage or under-frequency and over-frequency, which are in most cases capable of identifying an island effect, it is required that a start-up or „open“ order is given to the different generators of the plant from the „off“ auxiliary contacts of circuit breakers at the high or low-voltage side of the mains transformer so that isolated operation is terminated after 3 seconds, at the latest. Other identifications of isolated operation are also permitted on condition that they do not show any inadvertent operation in the event of system faults.

(3) A type 1 *generating unit* exists if a synchronous generator is directly connected to the network. A type 2 *generating unit* exists where this condition is not fulfilled.

(4) As a matter of principle, type 1 *generating units* shall meet the requirements defined in the preceding sections of Chapter 3. The requirements to be satisfied by type 2 *generating units* are described hereinafter.

(5) In the event of network faults outside the protection range of the generating facility, the latter must not be disconnected from the network. During the fault duration, a short-circuit current shall be injected into the network as described in section 2.3.10. Depending on the plant technology used, such as asynchronous generators or frequency converters, the short-circuit current contribution shall be agreed with the *network operator* on a case-by-case basis.

(6) If the voltage at the *grid connection point* decreases and remains at and below a value of 85 % of the reference voltage (380/220/110 kV, e.g. 110 kV x 0.85 = 93.5 kV) and if *reactive power* is simultaneously consumed at the *grid connection point* (under-excited *operation*) the generating facility must be disconnected from the network with a time delay of 0.5 seconds. The voltage value relates to the largest value of the three line-to-line network voltages. The disconnection must take place at the generator *circuit breaker.* This function performs the supervision of voltage support.

(7) If the voltage at the low-voltage side of each individual *generator transformer* decreases and remains at and below a value of 80 % of the lower value of the voltage range (e.g. 690 V x 0.95 x 0.8 = 525 V) one fourth of the generators must disconnect from the network after 1.5 s, after 1.8 s, after 2.1 s and after 2.4 s, respectively. The voltage value relates to the largest value of the three line-to-line network voltages. A different time graduation can be agreed on a case-by-case basis.

(8) If the voltage at the low-voltage side of each individual *generator transformer* rises and remains at and above a value of 120 % of the upper value of the voltage range (e.g. 690 V x 1.05 x 1.2 = 870 V) the generator concerned must disconnect from the network with a time delay of 100 ms. The voltage value relates to the lowest value of the three line-to-line network voltages.

(9) The reset ratio of the measuring equipment for the under-voltage and over-voltage system automatics must be ≤ 1.02 or ≥ 0.98, respectively.

(10) At frequencies of between 47.5 Hz and 51.5 Hz, automatic disconnection from the network due to the frequency deviation from 50 Hz is not admissible. If the frequency falls below 47.5 Hz, automatic disconnection from the network must take place without delay; if the frequency rises above 51.5 Hz, automatic disconnection may be carried out.

(11) It is recommended implementing the functions of over-frequency and under-frequency, over-voltage and under-voltage at the generators in one device each. In general, these functions, including the under-voltage function, shall be signalized at the *grid connection point* as system automatics.

(12) After disconnection of the generating facility from the network due to over-frequency, under-frequency, under-voltage, over-voltage or after termination of isolated *operation*, automatic synchronization of the different generators with the network is only permitted if the voltage at the *grid connection point* is higher than 105 kV in the 110 kV network, higher than 210 kV in the 220 kV network and higher than 370 kV in the 380 kV network. The voltage value is related to the lowest value of the three line-to-line network voltages. After this disconnection, the increase of the *active power* supplied to the network of the *network operator* concerned must not exceed a gradient of maximally 10 % of the network connection capacity per minute.

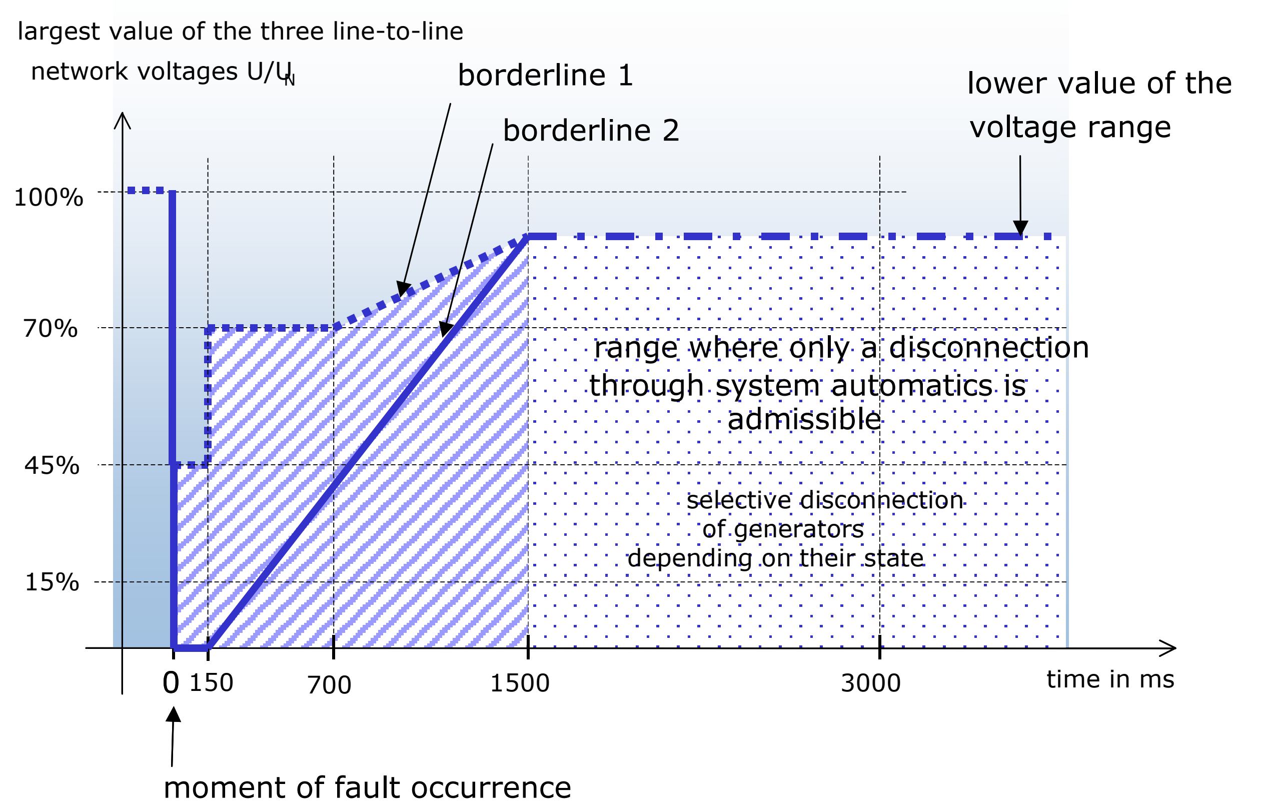


Fig. 3.5:	Limiting curves of voltage at the *grid connection point* for a generating facility using renewable energy sources of type 2 in the event of a network fault

(13) Three-phase short circuits or symmetrical voltage drops due to disturbances must not lead to instability or to a disconnection of the generating facility from the network above the borderline 1 in Figure 3.5.

(14) Within the shaded area and above the borderline 2 in Figure 3.5, the following shall apply:

- All generating facilities shall pass through the fault without being disconnected from the network. If a generating facility, due to t*he grid connection* concept (plant concept, including generators) is not capable of meeting the requirement, it is permissible to shift the borderline by agreement with the *network operator* concerned while the resynchronisation time is simultaneously reduced and a minimum reactive current feed-in during the fault is guaranteed. Reactive current feed-in and resynchronization must be carried out in such a way that the generating facility appropriately meets the respective requirements of the network at the *grid connection point*.

- Should individual generators become instable when passing through the fault, or the generator protection be activated, a short-time disconnection of the generating facility from the network is permitted by agreement with the *network operator* concerned. From the beginning of a short-time disconnection, the resynchronization of the generating facility must take place after 2 seconds, at the latest. *Active power* feed-in must be increased with a gradient of at least 10 % of the nominal generator capacity per second to the original value.

(15) Below the borderline 2 in Figure 3.5, a short-time disconnection of the generating facility from the network is always permitted. In exceptional cases and in consultation with the *network operator* concerned, resynchronization times of more than 2 seconds and an *active power* increase after fault clearance of less than 10 % of the *nominal capacity* per second are also possible.

(16) For all generating facilities which are not disconnected from the network during the fault, *active power* supply must be continued immediately after fault clearance and increased to the original value with a gradient of at least 20 % of the *nominal capacity* per second.

(17) The generating facilities must support the network voltage during a voltage drop by means of additional reactive current. To this end, voltage control according to Figure 3.6 shall be activated in the event of a voltage drop of more than 10 % of the effective value of the generator voltage. This voltage control must ensure the supply of a reactive current at the low-voltage side of the generator transformer with a contribution of at least 2 % of the rated current per percent of the voltage drop. The facility must be capable of feeding the required reactive current within 20 ms into the network (control response time). If required, it must be possible to supply reactive current of at least 100 % of the rated current.

(18) After return of the voltage to the *dead band* range, voltage control must be maintained at least over additional 500 ms according to the given characteristic.

(19) In particular within the extra-high voltage grid, continuous voltage control without *dead band* may be required.

(20) If the distances from the generators of the generating facility to the *grid connection point* are too long and thus lead to ineffectiveness of voltage control, the *network operator* shall require that the voltage drop be measured at the *grid connection point* and that the voltage be controlled there as a function of this measured value.

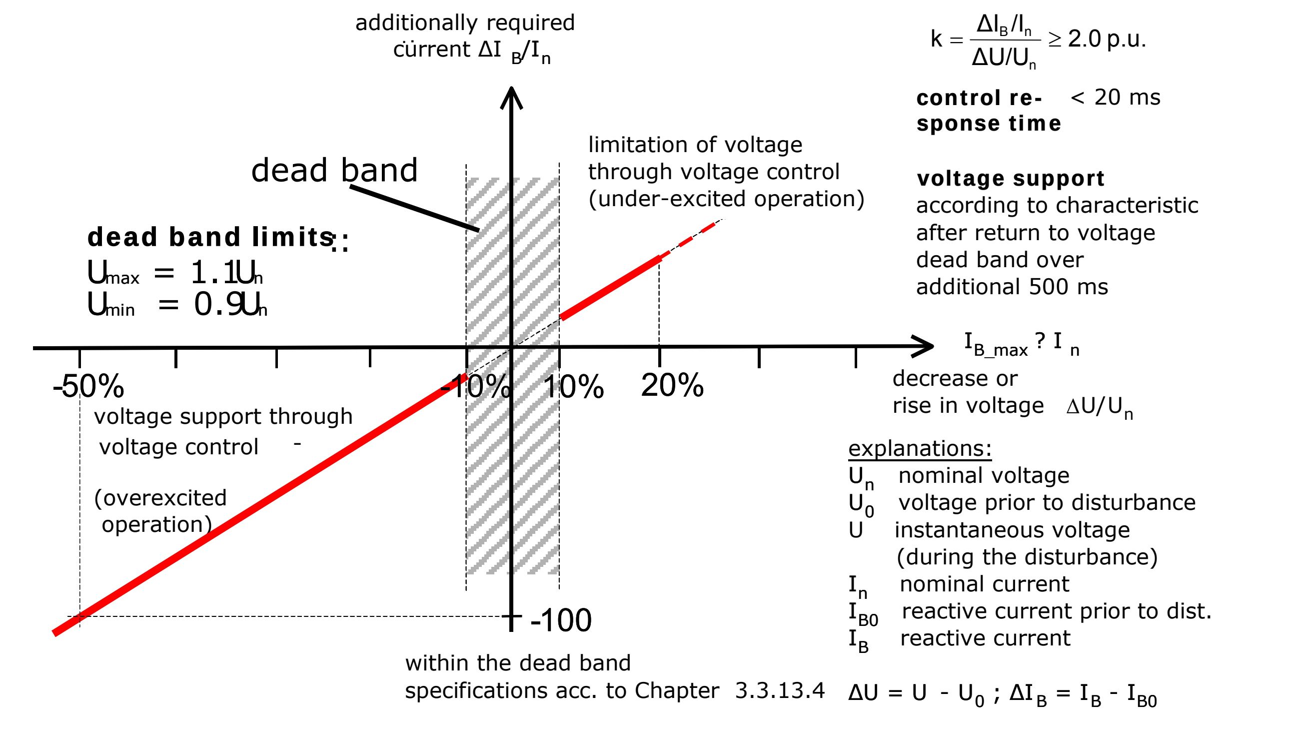


Fig. 3.6:	Principle of voltage support in the evnt of network faults with renewables-based generating facililties

3.3.13.6 Exceptional rules for renewables-based generating facilities

(1) *Generating units* using renewable energy sources may be exempted from the requirement to be capable of operation under primary control.

(2) In accordance with the capabilities of conventional *generating units* to interfere in the event of sudden power imbalances by means of network sectionalizing and islanding, and in order to contribute to network restoration, renewables-based generating facilities shall utilize control concepts which correspond to the latest state of the art.

3.3.13.7 Special requirements for the connection of renewables-based offshore-generating facilities

(1) For the connection and operation of renewables-based generating facilities in the light of the implementation of the Act on the acceleration of infrastructures planning (2006), specific additional requirements resulting from the needs of transmission from offshore wind farms to the transmission grid are used a basis.

3.3.14 Restoration of supply

(1) The disconnection of a *generating unit* from the network, both in case of need of auxiliary power and in the event of an island effect, must be internally identified in an independent manner by its control system and appropriately adjusted. Switch-position signals of power supply switches can be considered here only as an additional information.

3.3.14.1 Tripping of generating units onto auxiliary supplies

(1) A *generating unit* must be designed for reliable tripping onto auxiliary supplies from any working point permitted by the generator output diagram.

(2) The *reliability of tripping onto auxiliary supplies* must also be guaranteed when the *generating unit* is disconnected from the network in accordance with the agreed protection schemes in the event of *disturbances* in the network.

(3) Following tripping on *auxiliary supplies*, the *generating unit* must be capable of operation for at least 2 hours with the *generating unit auxiliary supply* only.

(4) Exceptional rules for these requirements upon particular kinds of *generating units* (such as run-of-river power stations) may be agreed.

3.3.14.2 Capability of isolated (network) operation

(1) Each *generating unit* ≥ 100 MW must be capable of frequency control on condition that the existing power deficit does not exceed the *primary control reserve* available in the isolated network. In the case of a power surplus, it must be possible to reduce the loading of the *generating unit* to the minimum capacity.

(2) Isolated (network) operation of this kind must be sustainable for several hours. Details shall be agreed between the operator of the *generating unit* and the *TSO*.

(3) In the case of isolated (network) operation, the *generating unit* must be capable of compensating for impulsive load connections of up to 10% of its *nominal capacity* (but not more than 50 MW). Intervals between two successive load connections should be at least 5 minutes.

3.3.14.3 Black-start capability

(1) *Black-start capability* does not represent a basic requirement. The kind and extent need to be agreed bilaterally between the *TSO* and the *connection owner/connection* user concerned of the *generating unit.* Where *generating units* capable of black-start are not directly connected to the transmission grid, an operational agreement needs to be concluded between the *TSO*, the operator of the *generating unit* and the *DSO* whose network the generating facility is connected to.

(2) *Black-start capability* must be available from the *operator* of the *generating unit* if required and requested by the *network operator* for network reasons. Site-specific conditions shall be agreed between the operator of the *generating unit* and the *TSO*.

3.3.14.4 Network restoration concept

(1) The *TSO* shall establish a concept for network restoration and coordinate the relevant activities with the operators of the *generating unit* concerned. Should generating units with black-start capability not be directly connected to the transmission system, the *TSO* shall set up a restoration concept and coordinate the relevant activities with the operator of the generating unit and with the *DSO* whose network the generating facility with *black-start capability* is connected to.

3.3.14.5 Training

(1) The *TSOs* shall take care that their own staff within the control stations is appropriately trained to cope with critical network situations. Furthermore, a network restoration concept with a detailed approach is to be developed for the control station staff and practiced in regularly held training courses.

(2) The same shall apply to the *DSOs* insofar as generating facilities with *black-start capability* are connected to the *distribution network.*

(3) In addition, the *DSOs* and the operators of generating facilities have an obligation to participate in the training measures.

3.3.15 Monitoring fulfilment of the requirements

(1) The scope and content of the technical documentation to be exchanged between the operator of the generating facility and the *TSO* shall be agreed in the grid connection contract. An example is illustrated in Appendix B.

(2) Prior to alterations to the subject-matters of the contract, at least those parts of the technical documentation agreed in the grid connection contract which are affected by the change shall be revised and made available to the contracting parties.

(3) The fulfilment of the requirements shall be proved in an appropriate form at the *TSO*'s request.

3.4 Special requirements for the connection of subordinated networks

(1) Further contractual agreements are required with operators of subordinated networks. Examples include:

- The installation of automatic synchronising devices at the *interface* between the transmission grid and subordinate networks with *generating units* provided that these are capable of isolated operation.
- Observance of the basic technical requirements for the connection of *generating units* (see Section 3.3) to the subordinated network.
- Coordination of *protective equipment.*
- Obligatory communication of the values defined in Chapter 3.
- Obligatory communication of *generating units* connected in the area with a *nominal capacity* of 5 MW and above (rated power for the purpose of technical inspection).

(2) Should the *TSO* require information about *generating units* ≥ 100 MW (such as data according to Section 3.3.5) the operator of the subordinate network concerned shall make the relevant information available. Further requirements result from Section 2.3 concerning the need for information to be able to identify possible risks or disturbances in the transmission grid.

3.5 Requirements for network protection

(1) The minimum requirements placed upon selective network protection with regard to the *interfaces* to the transmission grid are specified below. These requirements permit the disconnection of equipment subject to a disturbance and prevent the *disturbance* from spreading.

(2) Reliable, low-disturbance *operation* of the *customer facility* on the transmission grid requires each *connection owner/connection user* to install *protective equipment* for his part of the *network* which is compatible with:

- the topology and operating conditions of his *network*, and
- the conditions at the *interface* to the *transmission system*.

The *protective equipment* must be capable of handling all voltages, currents and frequencies arising in *operation*.

(3) The conditions at the *interfaces* between the *TSO's* facilities and those of *connection owners/users* shall be co-ordinated by bilateral agreement such that no danger is presented to the adjacent facilities.

(4) To this end, the scope, elements and dynamic behaviour of the primary and back-up protection system shall be specified by the *TSO* according to the specific circumstances and taking account of solution concepts developed over many years of experience, and agreed

with the *connection owners/connection users*. This shall include specification of electric characteristics for *current* and *voltage transformers* which the protective equipment is connected to.

(5) If reliable tripping of upstream protection equipment cannot be guaranteed following faults in the *customer facility* in the event of failure of switching or protection equipment, installation of circuit-breaker failure protection or suitable back-up protection shall be agreed with the *TSO*.

(6) Primary control equipment and secondary control equipment connected to it must be matched to the permissible loading of the equipment to be protected in order to prevent network congestion.

3.6 Information exchange at the interfaces

(1) The scope, mechanism and procedure for information exchange (for example definition of terminology, forms, formats, protocols, chronological procedure) are determined in an obligatory manner between the *TSO* and the *connection owner/connection user*.

(2) The *customer facilities* shall be described in a suitable manner to permit assessment of the *grid connection* scheme and to permit development planning by the *TSO*. The data to be supplied to the *TSO* for this purpose and the requisite calculations shall be co-ordinated between the *TSO* and the *connection owner/connection user*.

(3) Observance of all network criteria including *voltage control* and *reactive power* management for relevant load and switching states shall be demonstrated in the course of network planning. Details of the requirement for active and *reactive power* at the *interfaces* on days critical for the reactive power account and under characteristic switching states shall be supplied for this purpose. The *TSO* shall be responsible for documentation of the set-point values for active and *reactive power*.

(4) As a minimum requirement, information must be provided on the first mesh of the horizontally and vertically adjoining networks to the respective *TSO* for purposes of operational planning and system management as discussed in Chapter 7.

(5) Detailed technical information required for the investigation of *disturbances* need to be exchanged between the *TSO* and the *connection owner/connection user*.

3.7 Measures to be taken in the event of modifications to the TSO's and connection users' installations

(1) Changes to the system concept or substantial technical system parameters impact upon secure system operation and the *reliability of supply*. Under certain circumstances, such changes may have an effect upon the *networks* of other *TSOs*.

(2) *Connection owners/connection users* and *TSOs* must agree among one another on the nature, scope and duration of a change which extends beyond the agreed limits in good time prior to implementation of the change, and must modify the agreement if necessary.

(3) The *TSO* shall immediately notify the *connection owner/connection user* of any change in network configuration which may impact upon the operation of the *customer facility* (e. g. change in *network short-circuit power*). If measures can be planned in advance, an agreement shall be brought about.

(4) The *TSO* and, where necessary, the *DSO* whose network is affected by a change shall examine the effects of the change upon general system operation including the security of supply and the voltage quality, and shall establish in accordance with Section 3.2 the admissibility of the change and any necessary measures.

(5) Should examination of the effects not be possible with the resources available in the context of system management owing to the short notice of the planned change, the *TSO* or the *DSO*, respectively, may object to the change until the admissibility of the change has been confirmed by a planning review.

(6) The *TSO* and the *connection owner/connection user* may oppose unacceptable changes.

(7) The *TSO* may insist upon the performance of measurements in order to verify the agreed operation of the *connection* owner's/*user's* installation. This may also be necessary when a new supply connection or a change in the network of an adjacent *TSO* has been effected.

3.8 Installations for metering and metered values provision

(1) The *current transformers* on the metering points are equipped with separate cores for protection, measurement and metering. If required in technical terms, the *current transformers* have separate windings. The *current transformer* cores and the *voltage transformer* windings for metering for the purpose of accounting correspond to the accuracy class 0.2 in accordance with DIN EN 60044, and need to be standardized.

(2) Meters for the purpose of accounting for supply and extraction shall be installed by the *TSO* on the metering points for the measurement of active energy and, where technically required, of reactive energy. The energy flow directions are characterized by a clear-cut system of parameters. The *meters* used shall correspond to an accuracy class of 0.2 according to DIN EN 60687. At least two equivalent metering facilities are required on these metering points to determine the energy quantities. In this way continuous recording of energy flows is ensured even in the event of *failure* of one metering facility.

(3) For the installation and *operation* of metering facilities and for the recording and provision of metered values, the respective current version of the Metering Code [Q14] shall be applied. The metering facilities shall comply with the current regulations laid down in the Metrology and Verification Act.

(4) Where required for operational functions, metering facilities shall be installed in such a way that it is possible to provide metered values at short-cycle measurement periods (< 15 minutes), and/or to provide metering impulses.

4 Grid usage

(1) *Grid access* is granted on the basis of statutory provisions mainly contained in the Energy Industry Act (EnWG) [Q1] and in the Regulation on grid access (StromNZV) [Q2] as well as in conformity with the Federal Network Agency’s definitions of business processes. Accordingly, the extra-high voltage system can be utilized if the electricity delivery is implemented through a *balancing group* and if grid usage agreements exist with the operator of the connected network concerning the *point of injection and withdrawal* possibly used.

(2) The details of implementation are laid down in the generally binding balancing group agreements which are used as a standard throughout Germany, and in the provisions on electricity supply to customers published by the Federal Network Agency (GPKE) [Q8] as well as in the explications contained in the detailed guidelines on data exchange and balance settlement of energy quantities (DuM) [Q17].

(3) Where end-use customers are supplied, the provisions of the 2007 DistributionCode shall apply [Q12].

4.1 Operational implementation of deliveries to other countries

(1) Schedule-based electric power exchanges with foreign *control areas* are carried out according to the UCTE on the basis of the "Multi Time Frame System (*MTFS*)". According to this system, the accounting periods between the *control areas* concerned are determined on a bilateral basis. Where the relevant accounting period of the foreign TSO is a multiple of a quarter of an hour, identical ¼-hour *mean power values* shall be given within the accounting period. Schedules with foreign countries can only be nominated at a *TSO* that operates a direct physical connection with the foreign *network operator*.

(2) For modifications concerning schedules to foreign countries, the following rules and procedures need to be agreed and implemented with the foreign TSOs:

- A *1:1 nomination* of schedules going beyond control area boundaries is prescribed by the *TSO* with a view to minimizing schedule errors and inconsistencies at the nomination and enabling a timely verification to be made by the *TSO*.
- The times of realization of modifications and the rules of implementation at the neighbouring foreign TSO must be compatible with the times of modifications and the rules applied within Germany.

4.2 Transmission system congestions

(1) *Congestion* exists if the operational *n-1 criterion* cannot be satisfied as a result of the load flow on the network under consideration (see Annex C).

(2) *Congestion* also exists if the *TSO* has reason to believe that the *n-1 criterion* cannot be satisfied if all nominated or forecasted schedules are accepted (see Appendix C).

(3) If congestion occurs on the transmission system, *congestion management* is carried out which may have a limiting effect on imports and exports between *control areas*.

(4) If *congestion* occurs within a *control area*, and if the import and export area concerned can be clearly delimited in terms of measuring, such an area can also be declared a *congestion*. The demarcation of an area is defined through network elements (e. g. lines). The *TSO* shall publish in due time information about the way of managing this *congestion*.

(5) *Congestion* may also occur within a short time as a result of unforeseen operational situations or in the event of schedule nominations which are likely to give rise to load flows exceeding the available capacity.

(6) The standard balancing group agreement shall comprise rules for *congestion management*.

4.3 Active power losses in the network

(1) Active *power* losses are covered exclusively by the *system operators* for their own network.

4.4 Handling of deliveries in accordance with the Renewable Energy Sources Act (Erneuerbare Energien-Gesetz - EEG)

(1) Deliveries of the *TSO* to the *suppliers* according to the Renewable Energy Sources Act are implemented in the form of schedule-based deliveries through the existing *balancing groups*.

(2) The *Balancing Group Managers (BGMs)* are responsible for the correct nomination of acceptance schedules with a view to complying with the acceptance obligations resulting from the Renewable Energy Sources Act.

5 System services

5.1 Introduction

(1) In the context of an electrical power system, *system services* refers to the services indispensable to the proper functioning of the system which *system operators* provide for *connection owners/connection users* in addition to the transmission and *distribution* of electrical energy, and which thus determine the quality of power supply:

- *frequency control*
- *voltage control*
- *restoration of supply*
- system management/*operation management*

(2) The investments made in the design of plants (e.g. *generating unit*) for the provision of *ancillary services* for *frequency control* (*primary control*, *secondary control* and *minutes reserve*) are paid by the bidder. The investments made for the compliance with technical minimum requirements in accordance with Chapter 3 are not remunerated by the *system operator*.

(3) As part of the provision of *system services*, the *TSO* shall pay adequate remuneration for the delivery of the necessary *ancillary service*s to the bidders/providers in accordance with contractual agreements.

5.2 Provision and utilization

5.2.1 General procedure

(1) In order to ensure secure operation, the *TSO* must have control over all *system services*, i.e. the *TSO* shall specify, according to the contractual agreements with the bidders, what *ancillary services* are to be provided when and by whom.

(2) Based upon contractually agreed *ancillary services* and on service schedules of *connection users*, the *TSO* and the relevant *connection owners / connection users* (e.g. operators of *generating units* and operators of consumption units controllable for this purpose) shall

agree on the provision of *ancillary services* which are essential to the provision of *system services*. The provision of certain services may be linked in an obligatory manner to the *operation* of certain installations (e.g. for *voltage control*).

5.2.2 Frequency control

(1) For the purpose of *frequency control*, the *TSOs* shall use

- primary control power
- secondary control power and
- *minutes reserve power*

in accordance with the rules of the UCTE-OH Policy 1 [Q15-1] and shall keep sufficient reserve powers available to this end as part of their responsibility for the system.

(2) The *TSOs* shall take measures to ensure not only secure transmission of the forecast maximum load for this network, but also transmission of the primary and secondary control power and *minutes reserve power* (the primary control power being replaced successively by secondary control and *minutes reserve power* in accordance with the UCTE Operation Handbook [Q15]). The transmission capacity and infrastructure maintained in the transmission system shall thus be determined by the following tasks:

- transmission of the forecast maximum load, and
- transmission of the primary control, secondary control and *minutes reserve power*.

(3) The *TSOs* shall procure these types of control energy according to the legal provisions and the specifications of the Federal Network Agency.

(4) The *TSO*s shall publish standard prequalification requirements concerning the provision of different types of control energy (see Annex D).

(5) More detailed provisions on procedures for tendering and for the provision of the different types of control energy shall be laid down in framework agreements concluded between the *TSO*s and bidders.

(6) According to Section 6, paragraph 2 of the German grid access regulation (StromNZV) [Q2] the *TSOs* are entitled to invite tenders for a part of the control energy (core share) which is required in technical terms to gurantee the security of supply within their *control area*.

(7) The results of the tendering procedure shall be published pursuant to Section 9 of the German grid access regulation (StromNZV) [Q2] and the specifications of the Federal Network Agency.

5.2.2.1 Primary control

(1) In accordance with the UCTE OH [Q15], the primary control power of 3,000 MW required for the entire synchronously connected system shall be distributed among the different *TSOs*, who shall be responsible for continuous secure maintenance of their share in the primary control power, calculated in accordance with this provision, for their respective *control areas*.

(2) For the provision of primary control power, the *TSOs* shall ensure the homogeneous *distribution* required by the UCTE with a view to reducing the risk of loss. To this end, a maximum of 3 % per *generating unit* and of 6 % per substation may be provided related to the overall primary control power kept available within the UCTE.

(3) Each generating facility (e.g. *power plant unit*) the *nominal capacity* of which exceeds 100 MW must be capable of *primary control* in accordance with section 3.3.7.1. Primary control power can also be provided through controllable loads.

(4) Each bidder for primary control power having concluded contractual agreements with *TSOs* in accordance with section 5.2.2 (paragraphs 3 to 5) on the maintenance of primary control power, must upon request of the respective *TSO* (party to the agreement) operate the technical units under *primary control* in accordance with the UCTE OH [Q15].

(5) The *TSO* is entitled to rule that technical facilities in *operation* participate in *primary control* in so far as the control power procurable in the market is insufficient to meet the required primary control power. Financial compensation shall be settled on a bilateral basis.

5.2.2.2 Secondary control

(1) Each *control area* within the synchronous interconnected system as a whole shall assure the balance between generation and consumption in consideration of the schedule agreements concluded with other *control areas* (see UCTE OH [Q15]). The *TSOs* responsible for the individual *control areas* shall achieve this objective mainly by the deployment of *secondary control* in accordance with section 3.3.7.

(2) In order to ensure the security of supply, the *TSOs* are entitled to invite tenders for a necessary part of secondary control power (core share) from their *control area*. According to a recommendation of UCTE, this core share shall amount to at least 2/3 of the overall secondary control power needed by the *TSO*. This core share can only be kept available by bidders who have technical facilities connected within the respective *control area* of the *TSO*.

(3) The secondary control power shall be supplied by the *bidders* who have concluded contractual agreements with the *TSO.*

(4) The compliance with the technical characteristics by the technical units (e.g. control parameters, control rate, etc.) shall be verified within the scope of the pre-qualification.

(5) The bidders partaking in *secondary control* for the respective time intervals are determined through the relevant call for tenders/procurement in accordance with section 5.2.2 (paragraphs 3 to 5).

(6) On the basis of instantaneous demand, the *TSO* shall retrieve the required secondary control power from the contracted *bidders*. They shall be selected upon the basis of the concerns of operational *system security*, the principle of guaranteed power availability and minimum costs.

(7) The relevant request for delivery of secondary control power is made directly through the automatic power-frequency-controller of the *TSO*, where applicable not until after activation through the *TSO*, via the IT connection of the technical facilities for the provision of the secondary control power, for which the provision has been contracted.

(8) The *TSO* is entitled to rule that *power stations* in operation participate in *secondary control* in so far as the secondary control power procurable in the market is insufficient. Financial compensation shall be settled on a bilateral basis.

(9) In order to control the utilization of secondary control power, each *generating unit* or group of *generating units* operated under the secondary controller of a *TSO* must be integrated online into the relevant secondary control circuit. Details shall be settled on a bilateral basis between the bidder and the *TSO*.

5.2.2.3 Minutes reserve

(1) The TSOs shall deploy *minutes reserve power* in the event of large extended imbalances between generation and consumption and/or for the restoration of a sufficient *secondary control band*.

(2) In order to ensure the security of supply, the *TSOs* are entitled to invite tenders for a necessary part of minutes reserve power (core share) from their *control area*. According to a recommendation of UCTE, this core share is obtained as minimum value from the difference between half the total of the secondary control power and minutes reserve demand minus the TSO’s secondary control power commissioned within the control area. This core share can only be provided by bidders who have technical facilities connected within the respective *control area* of the *TSO*.

(3) *Minutes reserve* shall be provided by the bidders who have concluded contractual agreements with the *TSO*.

(4) Which *bidders* shall maintain *minutes reserve* for the respective time intervals is determined by the relevant call for tenders/procurement in accordance with section 5.2.2 (paragraphs 3 to 5).

(5) The request for and delivery of *minutes reserve* is implemented as schedule-based power exchange between the *balancing group* for *minutes reserve* (see also section 4.1) of the contracted bidder and the *balancing group* of the *TSO*.

(6) The request for delivery shall take the operational *network security*, sufficient power availability and the principle of minimum costs into consideration.

(7) The complete volume of the requested *minutes reserve power* has to be provided within 15 minutes. The request for delivery shall be made at a lead time of at least 7 ½ minutes at the beginning of the following quarter hour. The bidder is bound to provide the corresponding *minutes reserve* power in physical terms.

(8) Should the *TSO* not be able to cover the need for *minutes reserve* within the scope of a call for tenders, he is entitled to make energy transactions. This may be, for instance, the mutual exchange between the *TSOs*.

5.2.3 Voltage control

(1) *Voltage control* forms part of the measures for maintenance of a secure supply, for which the responsible *system operator* bears responsibility. Under the co-ordination of the responsible *system operator*, the following parties shall be involved in *voltage control:*

- the system operator's own network
- the synchronously interconnected transmission systems
- the distribution networks connected to them
- the *generating units* connected to the system operator's network
- the *consumers* connected to the system operator's network.

(2) For physical reasons, reactive power must be locally made available.

(3) The TSOs are required to ensure a balance between reactive power demand and reactive power generation. To this end, the *TSO* can make use of the following means taking operational voltage ranges into consideration:

- generating facilities
- reactive compensation installations
- transformer tapping
- modification of network topology.

For this purpose, bilateral agreements have to be concluded where necessary between the parties concerned.

(4) Therefore, each *generating unit* must meet the defined minimum requirements with regard to the *power factor* as specified in Section 3.3.8 with a view to being connected to the transmission grid.

(5) The selection of generating facilities in terms of *voltage control*/reactive power utilization shall be based upon the operational requirements of the *system operator*.

(6) Each supplier on the transmission grid shall operate the *generating units* under *operation*, as specified by the *TSO*, with the requested *reactive power*. The conditions for supply and purchase of *reactive power* shall be specified in bilateral agreements.

(7) According to the contractual agreements, the *TSO* shall be immediately notified by the respective *supplier* of restrictions in *reactive power* generation as soon as they are identified.

(8) Should the *TSO* ascertain during daily operational planning that the reactive power account cannot be balanced by the means available (its own passive facilities and contractually guaranteed *ancillary services*), it shall instruct supplementary *generating units* to supply *reactive power*. Financial compensation for that shall be settled on a bilateral basis.

5.2.4 Restoration of supply from the transmission grid

(1) As part of their responsibility for the system, the *TSOs* shall coordinate the restoration of electricity supply within the networks operated by them following *large-scale failures* cooperatively with adjacent *TSOs* or with subordinated DSOs and operators of *generating units*.

(2) The TSOs shall agree on details for preventive measures and the operational processes of a restoration of supply taking the network infrastructure into account in conjunction with the parties required to cooperate.

(3) The providers of preventive measures for the *restoration of supply* may be the *TSO*, *connection owners/connection users* and *system operators* of adjacent and subordinate networks as well as operators of *generating units*. Depending on the necessity, the providers must take technical measures for the *restoration of supply.* The efficacy of these measures shall be jointly verified.

(4) The *TSO* shall, in accordance with Section 3.3.14, resort to the *capability of isolated operation* and *black-start capability* of appropriate installations, and to other TSOs and *connection owners/connection users* for provision of the *"restoration of supply"* system service. The *TSO* shall pay the *bidders* for facilities with black-start capability adequate compensation for the contracted availability of the technical installations. Details shall be agreed on a bilateral basis.

6 Network development

6.1 Functions of development planning

(1) The *TSO* plans the development of his network such that he has at his disposal a transmission system which is adequately dimensioned for the projected transmission tasks, and which permits secure, consumer-friendly, efficient and environmentally compatible *operation* and economical system use at an adequate quality of supply.

(2) The system reserve shall be dimensioned in accordance with the *n-1 criterion.* In addition, probabilistic methods can be utilized. Owing to uncertainties in terms of forecasts, observance of the defined minimum requirements at the planning stage is essential.

(3) The *TSO* shall draw up economic network plans on the basis of the current load and generation situation and the projected development of the facilities which are already connected or which exist according to the requests for connection to the grid. *Congestion* occurring at short notice as a result of changing loop flows and *transits* cannot be taken into consideration in network development planning.

(4) The *TSO* shall be responsible for initiating the public approval procedures required for the development of his *network*, and for launching the construction measures upon the granting of approval.

6.2 The n-1 criterion in development planning

(1) The minimum criteria for application of the *n-1 criterion* for dimensioning the system reserve and specification of the permissible system capacity utilization and the unacceptable constraints and effects upon supply in the case of a single *failure* are defined below in conjunction with Appendix C. The criteria are addressed separately for the 380/220 kV transmission system and for the 110 kV system with transmission functions. The criteria represent the framework of technical evaluation for specification of the network connection scheme for *customer facilities* in accordance with Chapter 3, and for network development.

(2) Observance of the n-1 criterion [Q19] permits the provision of adequate *reliability* of supply (continuity of supply) [Q20] for all *connection owners/connection users*, secure power transfers, and provision of *system services*. The n-1 criterion addresses all issues relating to network technology, in particular the *system services* to be provided (e.g. *voltage control* including provision of reactive power), equipment utilization, the protection concept, and where applicable, stability issues. The requirements described below shall apply.

(3) At the planning stage, the *TSO* shall design his *network* in accordance with the *n-1 criterion* such that the network functions are fulfilled in accordance with Appendix C for the projected maximum transmission and supply tasks in the case of a single failure triggered by an event. In addition, maintenance work carried out in power stations and on network equipment have to be taken into consideration for selected transmission and distribution functions.

(4) Special provisions for transmission systems:

- For evaluation of the security within a network area, the *n-1 criterion* shall be applied for relevant time horizons with the generation schedule expected for that time from the instantaneous perspective (including injections from installations for HVDC transmission from plants using renewable energies) and with due regard to *transits*.
- The n-1 criterion shall be applied to networks on the basis of postulation of a forced outage of the *generating unit* having the greatest effect upon the security of supply.

(5) The *n-1 criterion* shall be fulfilled when the total feed-in capacity can still be transmitted in the event of a *failure* of an item of network equipment (except for bus-bar faults) without demonstrating the effects stated in Appendix C. Consideration shall be given to the network capacity contracted or forecasted for the subordinate voltage level.

(6) For evaluation of the security of supply of 110 kV network groups with a transmission function, the (n-1) network design criterion shall be applied to networks with a maximum and minimum power station commitment in accordance with the agreements concluded with the power station operators and the variations in power availability.

6.3 Stability of transmission systems

6.3.1 General information on stability

(1) Stable synchronous operation of the *generating units* is a prerequisite for secure and reliable interconnected operation and for customer supply. The dynamic behaviour of an *electric power system* is a product of the physical interaction between the *generating units*, the European synchronously interconnected transmission system and the *connection users* with their respective control equipment. The *TSO* must therefore have exact knowledge of the dynamic behaviour of the installations connected or to be connected to his network. To this end, the *connection owner/connection user* shall supply the requisite data upon request.

(2) Stable *operation* shall be ensured for all relevant conditions by suitable dimensioning/parameterization of the primary and secondary control equipment in *customer facilities* and in the network. A distinction must be drawn between the steady-state and transient *stability* in the evaluation of *stability* and the resulting technical requirements placed upon the network.

(3) Should the technical or operational parameters of the *customer facilities* change substantially or a new installation be connected, the *TSO* shall specify the measures required for maintenance of *stability*. For this purpose, the *generating units* connected to the network must correspond to the minimum technical requirements according to Section 3.3.

6.3.2 Special requirements for steady-state stability

(1) *Steady-state stability* is an essential prerequisite for operation of an *electric power system*, and must be ensured at all times and at every working point. *Steady-state stability* is no longer ensured if, during disturbance-free system operation, minor changes in system states (e.g. variations in power transfers, switching operations) result in steady-state *operation* no longer being maintained and in the occurrence of self-induced oscillations which may result in large-scale collapse of the system or damage to the *customer facilities*.

(2) The limit of *steady-state stability* can already be reached as a function of the transmission distance, though current-carrying capacities occur in the case of a single *failure* which are clearly below the relevant maximum thermal current-carrying capacities.

(3) The following minimum network requirements shall be met in the network development with regard to *steady-state stability*:

- Maintenance of the minimum values stated in Section 3.3.*12.2 (steady-state stability*) for the *system short-circuit power* on the network side at the *system connection point* and for the network voltage, even in the event of a constrained network (usually in consideration of the *(n-1) criterion*).

(4) Purchases, deliveries or *transits*, changes in load and injection situations (e.g. low-load operation with under-excited generators) and changes in the network configuration with a bearing upon operation (*failure*, system transfers) must not endanger the *steady-state stability*; constraints need to be imposed, if necessary, on the *generating unit*'s operational management.

6.3.3 Special requirements for transient stability

(1) *Transient stability* is no longer ensured when, following clearance of a system short-circuit, one or more *generating units* lose synchronism with respect to the transmission system. Major changes in frequency and voltage and high transient currents between the transmission system and asynchronous (pole-slipping) *generating units* may seriously impair secure *operation* of the *electric power system*.

(2) The following minimum requirements shall be met as criteria placed upon the network for *transient stability*:

- The *TSO* shall ensure in the course of network development that the minimum value of short-circuit power on the network side stated in Section 3.3.12.1 (*transient stability*) is not violated following fault clearance by the power system protection in accordance with the design in the case of *short-circuits close to the power station* on the *grid connection point*. Exceptions may be agreed upon by mutual consent with the *connection owner/connection user*.

(3) Where a number of *generating units* are operated through the same *interface* (bus-bar) on the network, the minimum *system short-circuit power* shall be calculated from the sum of the nominal active generator powers.

(4) Where a *generating unit* cannot be prevented from pole slipping following system short-circuits, the *generating unit* must be disconnected from the network by the generator protection (e.g. pole slip protection, power station decoupling relay) in order to prevent consequences which place the general network and power station operation at risk. The *network* shall withstand the effects upon it which arise during these dynamic processes (e.g. once-off slipping of the rotor as a tripping criterion for pole-slip protection); these effects must be taken into consideration as a basis for the design of the *power station*.

7 Operational planning and management of the system

7.1 Introduction

(1) Operational planning and management of the system serve to implement the responsibility for the system according to Article 13 of the Energy Industry Act (EnWG) [Q1]. Planning of system operation comprises all tasks concerned with planning of system commitment and *system balancing* while system management covers the tasks of control and supervision of the transmission system as well as *power-frequency control*.

(2) The procedures governing planning of *system balancing* are dealt with in Chapter 5.

7.2 System operation planning

7.2.1 Functions of system operation planning

(1) The purpose of system operation planning is to ensure that long, medium and short-term events such as maintenance and repair work on equipment and apparatus, constructional measures in the transmission system etc. and nominated schedules are handled reliably by system management through consideration in daily operational activities.

(2) Planning of system operation serves the long, medium and short-term planning of system management which mainly comprises

a. preparation of the annual disconnection programme and coordination with national and foreign *network operators*

b. coordination of revision plans with *power stations*

c. determination of transmission capacities at congested borders (NTC values)

d. compilation of *DACF* data sets

e. determination of the requisite system service (e.g. adjustment of control power demand)

f. forecast of demand in energy compensating network losses

g. forecast of demand in balancing power according to the Renewable Energy Sources Act

h. reactive power demand forecast

i. compensation of unintentional exchanges.

(3) On the evening of the current day, the results shall be handed over by the system operation planning to system management.

(4) An essential precondition for day-ahead system operation planning is schedule management. The schedules submitted by the *balancing groups* constitute an important basis for the *TSO's* planning as they enable conclusions to be drawn on the control area's aggregate procurement portfolio. Exchange schedules crossing *control areas*, are an indispensable element for the computation of the net balances of exchanges between the *control areas.*

(5) Apart from the nominated schedules, overhaul programs of *power station operators* and current-day changes in network topology are important input variables of *congestion* analysis. These congestions are remedied by means of preventive *congestion management* to be implemented by the *TSO*.

7.2.2 The n-1 criterion in system operation planning

(1) The *TSO* shall plan the operation of his network in accordance with the n-1 criterion such that in the case of a single failure of his system's network equipment defined in Appendix C and of those *generating units* (including HVDC feed-in) with the greatest effect upon the security of supply, the effects described in Appendix C are avoided.

(2) The review of the time range under consideration shall be based upon all nominations of schedules known at the time of planning and the forecasted feed-in and loads according to Chapter 4 as well as the planned network condition.

(3) The *TSO* may deviate temporarily from compliance with n-1 security where necessitated by service work and network modifications. The European interconnected operation must not be endangered. This implies in particular the TSOs' obligation to adhere to the *n-1 criterion* in interconnected operation according to the UCTE OH Policy 3 [Q15-3]. The restriction of n-1 security shall be performed with appropriate prior notification of affected *connection owners/connection users*.

(4) In order to maintain the n-1 security, the *TSO* shall coordinate planned disconnections of network equipment for the purpose of operation work and network modifications with the *connection owners/connection users*. Where necessary, the *TSO* may agree in advance a modified power station generation schedule in consultation with the responsible *connection owner/connection user.*

7.2.3 Schedule management

(1) *Schedule* nominations on the preceding day are indispensable to load-flow calculation, *congestion* analysis and to the determination of available capacities for trading. In the light of system operation planning, the *BGMs* must therefore nominate for each *control area* reliable separate schedules on generation (for each *generating unit* larger than 100 MW; see Table 2.2), consumption and imports and exports of a *balancing group* for inter-control-area interchange, as well as intra-control-area trade schedules on the preceding day not later than 2.30 p.m. In this context, generation and consumption schedules are not relevant to accounting.

(2) Until 5.00 p.m. the day before, the contracted bidders for primary control power, secondary control power and minutes control power reserve shall for each type of control energy notify the connecting TSO of the technical facilities from which they will provide the contractually agreed control power to him and to other TSOs, where applicable.

7.2.4 Overhauls of generating facilities

(1) Overhauls and long-term shutdown of generating facilities in the transmission system must be coordinated between the operator of the generating facility and the *TSO*. The *TSO* shall coordinate the decommissioning measures with the planned switching operations in the transmission system and agree with the operator of the generating facility upon binding dates in this respect.

(2) If the aforementioned dates are changed, technical network concerns (such as network projects of TSOs, maintenance work) shall take precedence over changes of overhaul plans. The operator of the generating facility shall transmit his overhaul plans to the connecting *TSO* not later than 31 October for the following calendar year.

7.2.5 Planning of power stations' shutdown

(1) Planning of temporary or final shutdown of *generating units* shall be communicated early enough, if possible 2 years prior to the planned shutdown, to the *TSO* so as to enable technical adjustments to be implemented on the network in due time.

7.3 Operational system management

7.3.1 Functions of system management

(1) Within the scope of continuous network security analyses, system management shall make sure that the impact of *disturbances* can be controlled or limited by means of instantaneously available operational possibilities and equipment.

(2) System management serves the secure *operation* of the entire system, the supervision and control of the transmission grid and of the connected loads and *generating units* ("today for today").

(3) System management mainly comprises the following measures:

- control of network topology
- monitoring of the observance of the operational parameters "current" and "voltage"
- supervision of the n-1 security

- utilization of control power to maintain the balance between generation and demand
- control of reactive power deployment for *voltage control*
- implementation of schedule management for the realization of the agreed power exchanges of balancing group managers (*BGMs*).
- congestion forecast and coordination and implementation of *congestion management* measures
- coordination and implementation of planned topology measures with national and foreign network operators
- network restoration after *disturbances*.

7.3.2 Normal operation

(1) All operational limit values shall be adhered to under normal operation, e.g.:

- adherence to the maximum and minimum permissible voltages,
- observance of maximum currents on the network equipment,
- compliance with admissible and agreed *system short-circuit powers*
- optimization of reactive power deployment

(2) The *TSO* shall make sure that the nominated schedules can be provided even in the n-1 case without constraints (see Appendix C); (firmness of capacity).

(3) After *failure* of an equipment, the n-1 security shall be restored by the *TSO* as soon as possible.

(4) With a view to maintaining the agreed voltage range, the *TSO* shall take appropriate measures, such as

- *operation* of compensation equipment (e.g. shunt reactors, capacitor banks, Flexible AC Transmission Systems (FACTS))
- tapping of transformers
- *reactive power provision* from *generating units* and synchronous condensers, capacitive / inductive
- line switching.

7.3.3 Operation under disturbance and risk conditions

(1) All conditions deviating from normal *operation* shall be deemed to be disturbance or risk conditions. As part of disturbance management, the *TSO* shall take the necessary technical measures to prevent a disturbance from spreading, to ensure efficient *restoration of supply* and to return as soon as possible to normal operation.

(2) In the light of his responsibility for the system, the *TSO* shall draw up, in consultation with other *system operators* (*TSOs*/*DSOs*) and operators of *generating units*, a catalogue of measures for disturbance management and to ensure that he has at his disposal e. g. sufficient *generating units* with isolated-operation and black-start capability. The details concerning the catalogue of measures for disturbance management are described in Chapter 2 and Annex A.

7.3.4 The 5-Stage Plan

(1) *Disturbances* exceeding the n-1 criterion may considerably impair the frequency and *voltage stability* of the entire system owing to deviations in the active and/or reactive power balance, and may lead to network sectionalizing. Measures to limit the extent of the effect of disturbances must also involve *customer facilities* in the case of widespread *disturbances*. One of these measures to be mentioned here is load-shedding as a function of frequency.

(2) The 5-Stage Plan for the control of *large-scale failures* with a drop in frequency is described in Table 7.1:

Stage 1:	49.8 Hz	Alerting of personnel and scheduling of the power station capacity not yet activated, according to the TSO's directions, shedding of pumps.
Stage 2:	49.0 Hz	Instantaneous load shedding of 10 - 15 % of the system load.
Stage 3:	48.7 Hz	Instantaneous load shedding of a further 10 - 15 % of the system load.
Stage 4:	48.4 Hz	Instantaneous load shedding of a further 15 - 20 % of the system load.
Stage 5:	47.5 Hz	Disconnection of all generating facilities from the network.

Table 7.1: 5-Stage Plan for the control of *large-scale failures* with a drop in frequency

(3) In Stage 1, the *DSOs* directly connected and the operators of generating facilities directly connected to the transmission system shall be alerted by the *TSO* as soon as possible, if the evolution of the *disturbance* allows to do so, in order to enable them to respond quickly and appropriately to the situation. To this end, the measures agreed in advance between the parties concerned are to be launched.

(4) Stages 2, 3 and 4 ensure that selected load shedding does not reach Stage 5, and that disconnection of the *generating units* from the network is thereby avoided. The frequency relays needed for that purpose are installed, parameterized and operated by the directly connected *DSO* after previous agreement with the *TSO*. *DSOs* not directly connected to the transmission system shall install, parameterize and operate requisite frequency relays in consultation with their upstream DSOs.

(5) Stage 5 has the function of ensuring *auxiliary supplies* and *operation* of the *generating units* for rapid commitment for the purpose of restoration of supply and avoidance of damage to the power station facilities. The design of the *generating units* shall therefore comply with Section 3.3.

(6) The *TSO* shall assure the possibility of load shedding by contractual arrangements with the network customers and shall state the requirements placed upon the requisite technical facilities in consideration of [Q21].

8 General

8.1 Legal basis

(1) The present rules were adopted by the Board of Directors of VDN. They constitute the basis of the minimum technical requirements of the German *TSOs* and therefore also serve as a basis for their bilateral agreements governing *grid access* and usage.

(2) The *TSOs* shall use these rules as a basis for bilateral agreements with market participants.

(3) Transmission systems shall generally be regarded as extra-high-voltage systems (380/220 kV operating voltage), provided they are used predominantly for electricity interchange at national level (and not merely the transport of electricity to the consumers, which is always unidirectional) and also high-voltage systems (110 kV operating voltage), provided the function of these systems is also predominantly that of transmission and, in particular, to permit synchronous parallel operation of *generating units* with the transmission system.

8.2 Refinement and modification of the rules

(1) The following tasks shall be coordinated jointly by the *TSOs*:

- Monitoring of the efficacy of the rules
- Consideration of all proposals for changes to the rules submitted for example by one or more *TSOs* or by market partners
- Formulation of recommendations for changes to the rules
- Provision of information and explanations regarding the application, content and interpretation of the rules

- Considerations regarding what changes to the rules are necessary when unanticipated events arise.

(2) The refinement of the rules is pursued in consultation with the institutions and associations of the market partners concerned.

8.3 Confidentiality of data and information

(1) The *TSOs* shall treat the data and information which they receive from the market partners in absolute confidence. This obligation shall not apply when information is publicly known, was legitimately available from the *TSO's* own work or from third parties, or was supplied by the originator of the data to third parties without restriction. Data which must be made available according to legal or regulatory obligations are exempted from that rule.

8.4 Observance

(1) The *TSO* is entitled to check the observance of the rules, and to take further steps if there is well-founded doubt about their non-compliance or if they are disregarded.

8.5 Unanticipated events

(1) Should unanticipated events arise for which no provision is made in the rules, the *TSO* shall consult all affected market partners, to the best of his ability under the circumstances, in order to reach agreement concerning the necessary measures.

Should time constraints prevent agreement from being reached, the *TSO* shall determine which measures are necessary. The *TSO* shall however take the requirements of the market partners into account as far as possible.

In cases where the German Bundestag would proclaim a state of crisis, provisions of the Transmission Code will cease to be effective, where necessary.

(2) Each market partner shall comply with the instructions of the *TSO* deriving from the measures described above, provided the instructions are consistent with the market partners' technical parameters.

(3) If any events have occurred in accordance with (1) and (2), their repercussions will be discussed within the committees of VDN.

9 Abbreviations and Terminology

9.1 Abbreviations

ACE	Area Control Error; global control deviation of the control area
BGM	balancing group manager
cos φ	displacement factor or power factor
DSO	Distribution System Operator
DACF	Day-ahead Congestion Forecast (forecast of load-flow data on the preceding day)
EEG	Erneuerbare-Energien-Gesetz [xx] (Renewable Energy Sources Act)
EC, EU	European Community, European Union
EN	European Norm
EnWG	Energiewirtschaftsgesetz [Q1] (German Energy Industry Act)
FACTS	Flexible-AC-Transmission-System
Hz, mHz	Hertz, Millihertz [frequency units]
IEC	International Electro-technical Commission (electro-technical standardization body)
KWK-G	Kraft-Wärme-Kopplungsgesetz [Q7] (German Co-generation Act)
MTFS	Multi-Time-Frame-System
NTC, ATC, TTC	Net, Avaliable or Total Transfer Capacity (categories of the transmission system’s transmission capacity)
P_{min}, P_{max}, P_N	minimum, maximum power, nominal power
PSS	Power System Stabilizer
S''_{kN}	system short-circuit power
s, ms	second, millisecond [time unit]
StromNZV	Stromnetzzugangsverordnung (German grid access regulation)
TAB	Technische Anschlussbedingungen (technical connection requirements)
TSO	Transmission System Operator
U / Q –	voltage .../ reactive power ...
UCTE	Union for the Coordination of Transmission of Electricity (Association)
UCTE - OH policy	Operation Handbook of UCTE (policy = individual rules on certain topics, cf. http://www.ucte.org/news/e_default.asp
V, kV	Volt, Kilovolt [unit of electric voltage]
VDE	VDE Verband der Elektrotechnik Elektronik Informationstechnik e.V. (German Association for Electrical, Electronic and Information Technologies); Frankfurt/Main
VDEW	Verband der Elektrizitätswirtschaft e.V. (German Electricity Association); Frankfurt/Main and Berlin

VDN	Verband der Netzbetreiber –VDN– e.V. beim VDEW (Association of network operators under the umbrella of VDEW); Berlin
W, kW, MW	Watt, Kilowatt, Megawatt [unit of active electric power]

9.2 Definitions

N-1 criterion

A network meets the requirements of this criterion if it overcomes the forced outage of a component (network equipment, generating unit) without inadmissible restrictions of its own transmission or distribution functions. In order to prevent the disturbance from spreading, the defined technical limits of the network and its equipment must not be violated.

1:1 Nomination

Registration of schedules between two balancing groups of the same name across control-area boundaries. The same applies to cross-border transactions.

Accounts co-ordination centre

These centres are administrative units charged by the *control blocks* with the accounting function, which comprises the following steps:

- Recording and validation of the interchange schedules between the *control blocks* during the planning phase;
  Recording of values from the meter readings on the interconnecting lines between the *control blocks* for calculation of the provisional energy exchange values;
- Real-time monitoring beyond specified observation lines;
- Calculation of the provisional and contractual *inadvertent interchange*;
- Calculation of the compensation schedules for each *control block*.
  Within the UCPTE, the accounts coordination centres are the main system control centre of RWE Energie AG in Brauweiler and ETRANS in Laufenburg.

Within the UCTE, these functions are assumed by the main control centre of RWE Energie AG in Brauweiler and by ETRANS in Laufenburg.

Active power

Active power is the electric *power* available for conversion to a different form of power, e.g. mechanical, thermal, chemical, optical, or acoustic power.

Ancillary Services

Ancillary services are services on the provider's side which are provided by *connection users* (e. g. power plant operators) on demand of the *TSO* These ancillary services are used by the TSO for the provision of *system services*.

Apparent power

Apparent power is the geometric sum of the *active* and *reactive power*. It is crucial to the design of, for example, electrical installations.

Auto-reclosure

An auto-reclosure facility consists of a circuit-breaker (in the case of single-end feed to the fault location) or a number of circuit-breakers (in the case of multiple-end feed to the fault location) which briefly interrupt the supply of energy to the fault location (for 100 to 1200 ms). Following this brief de-energized period, the item of equipment which suffered the fault is automatically switched on again. If the fault has been cleared (arc extinguished), the item of equipment may remain in operation (successful reclosure). If the fault is still present when the equipment is switched back on, the equipment is generally disconnected again normally by the protective equipment (unsuccessful reclosure).

Single-pole reclosure entails breaking only the pole subject to the fault in the case of a single-pole short-circuit. It is employed only in networks with a low-impedance-earthed neutral from 110 kV upwards, as it requires *circuit-breakers* with separate pole-switching capability. Three-pole auto-reclosure is the brief disconnection of all three poles.

Balancing group / Sub-balancing group

A *balancing group* consists of an arbitrary number of *injection* and/or *withdrawal points* (usually metering points for *generating units* or *power stations*, and *loads*) within a *control area*, which have to be made known to the *system operator* responsible for the grid connection and which are thus exactly defined. Within a balancing group, a balance is to be maintained between the injections from the feed-in points assigned to it and schedule-based supplies from other balancing groups (procurement), on the one hand, and withdrawals of the assigned withdrawal points and schedule-based supplies (delivery) to other balancing groups.

The sub-balancing group is a balancing group which is not responsible for the compensation of deviations to the TSO. Apart from that, handling of a sub-balancing group largely corresponds to that of a balancing group.

Balancing Group Manager (BGM)

The balancing group manager is responsible for the balance between procurement (generation imports) and delivery (consumers, exports) during every quarter of an hour. BGMs may for instance be electricity traders or sales departments, but also large industrial enterprises performing their electricity procurement at their own responsibility. The operator of the sub-balancing group must conclude a contractual agreement with the BGM about the compensation or clearing of imbalances (e.g. pool agreement or open supply contract). The BGM shall then cover the total demand of the sub-balancing group going beyond schedule-based deliveries.

Bidder for control power

Operator of technical units who is able to provide control power, and who is authorised to do so through pre-qualification and on the basis of a framework agreement.

Black-start capability

Black-start capability is the ability of a generating unit to start up in a self-supporting manner through network-independent means after disconnection from the network, to resume operation from a no-load condition and to take up load. Start-up, connection to a network and taking over of load can be controlled on the spot, or through remote control.

The network can be a sub-system that is energized or in an off-voltage condition prior to re-connection. The TSO must ensure with respect to his own control area that an adequate number of generating units with black-start capability are available.

Capability of isolated (network) operation

Isolated network operation is the operation of asynchronous subsystems which may arise from network disturbances. In isolated network operation, a subsystem is supplied by at least one generating unit.

Circuit-breaker

A circuit-breaker is a switching device that opens and closes electrical circuits under operating and fault conditions.

Common-mode failure

Common-mode failure is the simultaneous *failure* of a number of components (network equipment and generating units) as a result of the same cause.

Congestion

Congestion exists if the (n-1) criterion is not observed or if the network operator has well-founded reasons to assume that in the case of acceptance of all schedules already known or of forecasted schedule registrations the (n-1) criterion cannot be observed without a change in generation scheduling.

Congestion management

Sum of measures of the system operator taken to avoid or eliminate congestion (e. g. auctioning, re-dispatch, counter trading, market splitting).

Connection owner

A connection owner is any natural or legal person whose electrical installation is immediately connected through a supply connection to the network of the system operator (see also section 1.1 (12)).

Connection user

A connection user is any natural or legal person extracting electrical energy from or feeding electrical energy (supplier) into a system operator's network through a supply connection. (cf. definition of connection owner).

Consumer

Consumers are devices and installations which draw electrical energy.

Continuous output

The continuous output of a *generating unit* is the maximum *power* produced in normal operation without constraints which does not impair the lifespan and security of the *generating unit*.
Note: The continuous output may vary seasonally (for example owing to the coolant conditions).

Control area

The control area is the area for which a *TSO* holds responsibility for *primary control*, *secondary control* and *minutes reserve* within the context of the UCTE. Each control area is specified physically by the locations at which interchange measurement of the *secondary controller* is performed within the interconnected system.

Current transformer

Current transformers have the function of transmitting the "current" primary variable to the secondary values as accurately as possible according to its magnitude and angle.

Customer facility

A customer facility is the electrical installation of a connection user.

DACF

The forecast of load-flow scenarios and the identification of critical situations on the transmission system, that may also occur on international interconnections, require continuous information exchange among the TSOs. For the assessment of load-flow scenarios it is essential to take load-flows on neighbouring transmission systems into account. Therefore, a defined data exchange (DACF = Day-Ahead Congestion Forecast) is carried out among the TSOs within the UCTE.

Dead band

The dead band is set intentionally on a machine controller. A distinction must be drawn here between the undesired *neutral zone* which is a function of inadequacies in the design of the controller, and the dead band, which is selected intentionally.

Distribution

Distribution is the transmission of electrical energy within a physically/technically delimited region for injection into distribution stations and supply to facilities of connection users. The high, medium and low-voltage network is generally employed for distribution.

Distribution system

The distribution system is employed for distribution of electrical energy within a specific region for supply to stations and to facilities of connection users. The power flow in distribution systems is generally determined by the customer loading. Low, medium and high-voltage systems (≤ 110 kV) are generally employed in Germany as distribution systems; 380 and 220 kV network parts may also be regarded as distribution systems under certain circumstances.

Disturbance

A disturbance is an unanticipated system condition with repercussions on the system security which are remedied by curative measures.

Electric power system

An electric power system is a functional unit which can be delimited by technical, economic or other criteria within the electricity industry.

Electromagnetic Compatibility; network disturbances

Electromagnetic compatibility (EMC) is the umbrella term describing problems which have existed since the incipiencies of electrotechnology and which have considerably increased since then and particularly during the past few years. EMC comprises phenomena like radio interference, network disturbances, overvoltage, electromagnetic interferences, interspersions, etc. Modern EMC covers emitted interferences and interference resistance of electric equipment.

A deformation of the sine-curve form of voltage in the supply network attributable to pulsating power input of the connected consumer is referred to as network disturbance. Such disturbances may occur in the form of voltage fluctuations, voltage drops, harmonics or asymmetries within the three-phase system.

Facilities for the reduction of injection power

These facilties comprise all technical equipment for a temporary reduction up to an interruption of injection power (active power). The technical design of these facilities must comply with the network operator's requirements. They are also needed for the implementation of generation management under the Renewable Energy Sources Act.

Failure

The term "failure" describes the inadvertent transition, as a result of a disturbance, of a component (a network element, a *generating unit*) to the fault status.

Final customer

Final customers are feed-in suppliers and parties using final energy for their own needs.

Frequency stability

Frequency stability describes the controlling of frequency deviations as a result of imbalances between injection and withdrawal (active power control) and is achieved by *primary* and *secondary control* and by the use of *minutes reserves* in the *power stations*.

Generating unit

A generating unit for electrical energy is a *power station* installation which can be delimited according to certain criteria. The generating unit may for example be a *power unit*, a common-header power station, a combined cycle plant, the machine set of a hydro-electric power plant, a fuel cell stack, or a solar module.

Generating unit auxiliary power

The generating unit auxiliary power is the electric power required for operation of the auxiliary and ancillary equipment of a *generating unit* (e.g. for water treatment, water feed to the steam generator, fresh air and fuel supply, flue gas dust collection), in addition to the power loss from the step-up transformers *(generator transformers)*. A distinction is drawn between the generating unit auxiliary power in operation and at rest.

Generating unit auxiliary service

see *generating unit auxiliary power*

Generation management

Analogously to the dena grid study, a distinction is made between generation management (also known as network security management) according to the Renewable Energy Sources Act, which is applied as an interim solution until the finalization of network development, and injection management according to the Energy Industry Act, which ensures the influence on generating facilities (including renewables-based plants) with a view to maintaining the system balance.

Generator transformer

The generator transformer is the link between the generator and the *network*.

Grid connection

The grid connection refers to the technical connection of customer installations to a power system for general electricity supply.

Grid connection point

The grid connection point is the point at which the supply connection of a *connection user* is connected to the *network*.

Gross output

The gross output of a *generating unit* is the *power* output at the generator terminals.

Initial symmetrical short-circuit power

This value ($\sqrt{3}$ x rated system voltage x initial symmetrical short-circuit power) is employed as the operand for three-pole short-circuits in high and extra-high voltage systems. It is independent of the transformer ratio and must not be confused with the power converted in a short-circuit-arc.

Injection and withdrawal points

Injection and withdrawal points are points of incoming and outgoing supply which have to be determined by contract. The point of injection can also be a generating unit's point of supply to the network, or a point of the injection network (to be determined) that is technically suited for power transfer

Injection management

Injection management is an operationally initiated adjustment of generation according to Article 13(2) EnWG (German Energy Industry Act) applied in the event of a disturbance or risk to the system security.

Interconnecting line

An interconnecting line is a circuit (or a transformer) which connects the *transmission systems* of *TSOs*.

Interface

The interface between the network of the *transmission system operator* and the installation of a connection user is usually located at the *circuit breaker* between the *network* serving general supply and the installation directly assigned to the connection user.

Large-scale failure

A large-scale failure situation exists when voltage is lost

- throughout the transmission system of a TSO or in parts of it
- throughout the distribution system of a DSO or in parts of it
- in a number of *networks* of adjacent *system operators* or
- in network parts of one or more adjacent *transmission (distribution) systems*.

Load disconnection, automatic, frequency-dependent

Automatic disconnection of load according to the 5-stage plan by means of underfrequency relays installed on the network.

Load disconnection, automatic, voltage-dependent

Automatic disconnection of load through undervoltage tripping of protection relays to avoid a voltage collapse or for the protection of the technical equipment of consumers.

Maximum output capacity (net, gross)

The maximum output capacity of a *generating unit* is the continuous output that can be achieved under normal operating conditions. It is limited through the weakest plant component (bottleneck); it is determined through measurement and converted to normal conditions.
In the case of long-term changes (e. g. changes on individual aggregates, ageing effects) the maximum output capacity must be determined anew in accordance with the new conditions. The maximum output capacity can deviate from the *nominal capacity* by a value of $\pm\Delta P$. Plant component parts that are not operational for a short period of time do not reduce the maximum output capacity.
The auxiliary operating power is the electric power required for the auxiliary and ancillary equipment during operation of the *generating unit.* This power is the difference between the gross maximum output capacity and the net maximum output capacity.

Mean power value

The energy quantity determined during a measuring period and related to that period [kWh/t_m]

Meter

A meter is a measuring instrument which is used alone or in conjunction with other measuring devices for the determination and indication of one or several metered values.

Meters used for energy accounting must comply with legal requirements.

Minutes reserve

Minutes reserve is the power for the deployment of which the working points of generator sets participating in the provision of secondary control power are adjusted in such a way that sufficient secondary control reserve will be available.

It shall be deployed so as to make its contribution in due time to the restoration of the secondary control band.

This restoration can take up to 22 minutes!

If required, this power can also be used in addition to the available secondary control power to compensate for the failure of generating units within a matter of minutes (see remark above).

Multi-Time-Frame-System (MTFS)

The Multi-Time-Frame-System are the time periods during which power exchanges can be carried out between the different TSOs within the UCTE. Time periods amount to a quarter-hour, half an hour or one hour.

Net output

The net output of a generating unit is the power fed into the power supply system. It is obtained from the gross output after deduction of the generating unit's auxiliary supply power during operation even if this power is not made available by the generating unit itself but from other sources. Usually, this power corresponds to the power that can be actually measured at the grid connection point or at the meter installation point.

Network security

Network security in the sense of "security of supply" and "secure system operation" refers to the capacity of an electrical supply system to fulfil its supply function at a specific point in time.

Network short-circuit power

See *initial symmetrical short-circuit current*

Neutral zone

The neutral zone is the range defined by the frequency limit values in which the controller does not respond. This variable describes the interaction between the primary controller and the machine.

Nominal capacity

The nominal capacity of a *generation unit* is the *continuous output* for which it is reserved in accordance with the supply agreements. If the nominal capacity cannot be determined clearly according to the reservation documents, a power value which can be attained under normal conditions must be specified once for the new unit. In the case of combined heat and power plants, the nominal capacity refers to the electrical nominal capacity.

Operation

Operation satisfying the requirements (normal operation)

Load and generation losses of up to 3,000 MW are controlled; the n-1 criterion is fully satisfied; sufficient reserves (control and transmission reserves) available.

Operation at risk conditions

Reserves are exhausted; slight (<5 %) violations of limit values in a few cases; n-1 criterion no longer satisfied; but supply to all customers maintained (with minor decrease in quality: e.g. voltage at the lower limit); transition to fault condition is approaching.

Operation under fault conditions

no reserves available; n-1 criterion no longer satisfied, strong violations of limit values (>10 %); not all customers supplied; but large parts of the system (possibly with some restrictions) are still functioning.

Power, electric

Electric power in the physical sense is the product of current and voltage and is an instantaneous value. The point in time (date and time) must be specified in relation to instantaneous values. In the electricity industry, average powers for defined periods are used in addition to instantaneous values (integration periods of, for example, ¼ or 1 h). Power is then the quotient of the work W performed over a time interval T: P = W/T.

Power Exchange

A Power Exchange is a neutral marketplace with transparent pricing and equal conditions for all authorized participants. It does not pursue its own trade strategy. A Power Exchange constituting a commodity exchange is subject to the German law governing stock exchange transactions. Power Exchanges located in other European countries are possibly liable to other legal provisions / listing requirements.

Power factor

The power factor cos φ is the quotient of the *active power* and the *apparent power*.
Note: The power factor is a measure of the demand for *reactive power* in addition to *active power* (overexcited operation = lag; underexcited operation = lead).

Power frequency characteristic (λ)

The power frequency characteristic (λ) defines the frequency behaviour of the complete *interconnected system* and of the *control areas*.

The power frequency characteristic λ_u of the *interconnected system* is equal to the quotient of the power deficit (or surplus) ΔP_a causing the fault and the quasi-steady frequency deviation Δf which is caused by the fault.

$$\lambda_u = \frac{\Delta P_a}{\Delta f} \text{ in MW/Hz.}$$

The power frequency characteristic λ_i for a *control area* i can be measured. It is equal to the quotient ΔP_i (power change i in the *control area* i measured at the boundaries) divided by the frequency deviation Δf as a reaction to the fault (in the *control area* in which the fault has occurred, the power surplus or power deficit responsible for the fault must be added/subtracted respectively).

$$\lambda_i = \frac{-\Delta P_i}{\Delta f} \text{ in MW/Hz.}$$

The setpoint of the power frequency characteristic of a *control area* is determined by λ_{io}:

$\lambda_{io} = C_i \cdot \lambda_{uo}$.

This method is used to determine the participation of a *control area* in *primary control*.

C_i: Coefficient of participation of the *control area* in question in the *primary control*

λ_{uo}: Reference power frequency characteristic for the entire synchronous *interconnected network*.

Power frequency control

Power frequency control describes a control process with which *TSOs* maintain the mutually agreed electrical values at the boundaries of their control areas under *normal operation* and in particular under fault conditions. In this process, each *TSO* endeavours, by means of an appropriate contribution from his own *control area*, to maintain both the interchange with other *control areas* within the agreed boundaries and the system frequency close to the setpoint value.

Power plant unit

A power plant unit is a *generating unit* with a direct functional relationship between the main plant sections (for example between the steam generator, turbine and generator in thermal power stations).

Power station

A power station is a plant the function of which is to convert other forms of energy into electrical energy.

Power station operator

A power station operator controls power station capacity, by virtue of either ownership or contractual arrangement, and determines the scheduling of such capacity.

Power system stabilizer (PSS)

A *power system stabilizer* is installed to improve the damping of *transient phenomena* in the frequency range of about 0.25 Hz to 3 Hz.

Power transfer

The term power transfer is used in the electricity industry to refer to the technical and physical process of simultaneous injection of electrical energy at one or more points of supply and the corresponding withdrawal of electrical energy at one or more points of supply on a *network.*

Primary control

Primary control is the stabilizing control, operating automatically in the seconds range, of active power of the complete, coupled, synchronously operated three-phase interconnected network. It is produced from the active contribution of the *power stations* to changes in system frequency, and is supported by the passive contribution of the *loads* which depend upon the system frequency (self-regulating effect).

Primary control band

The primary control band is the range of primary control within which the primary controller can intervene automatically in both directions in the event of a frequency deviation. The primary control band is applicable to all machines, for all *control areas*, and for the entire interconnected system.

Primary control reserve

The primary control reserve is the positive region of the primary control range from the operating point prior to the disturbance up to the maximum primary control power (in consideration of the limitation function). The term primary control reserve can be applied both to machines and to *control areas* and the interconnected system.

Protection equipment

Equipment comprising one or several protection relays and, where necessary, logic devices to carry out one or several predetermined protection functions.

Note: Protection equipment is part of a protection system.

Reactive power

Reactive power is electric power required for the generation of magnetic fields (e.g. in motors or transformers) or electric fields (e.g. in capacitors). In a chiefly magnetic field, reactive power is inductive; in a chiefly electric field, it is capacitive.

Reactive power provision

Reactive power which a generating unit operated at full output or under partial load has to exchange with the network according to the requirements of the network operator.

Reliability of tripping onto auxiliary supplies

Reliability of tripping on auxiliary supplies refers to the situation in which a *generating unit*, following a sudden disconnection from the *network*, quickly reaches an operating state in which it can continue to supply its *station auxiliary requirement* and is available for reconnection.

Restoration of supply

Restoration of supply refers to the technical and organizational measures taken to limit a fault and to maintain or restore the supply quality following its occurrence. Restoration of supply also includes measures for the equipping of *generating units* and network installations with regard to the possibility of *large-scale failures* (restoration schemes).

Risk

A risk to the power system's security and reliability exists if local losses or short-term network congestion are to be anticipated or if there is cause to suspect that the maintenance of frequency, voltage or stability cannot be guaranteed to the necessary extent. Thus, a risk is an alarming system condition which shall be answered with preventive measures.

Secondary control

Secondary control is the influencing, in relation to a specific area, of *generating units* within a supply system for the purpose of maintaining the desired energy exchange of the control area with the rest of the interconnected system whilst at the same time providing integral frequency back-up control. In the Union for the Coordination of Transmission of Electricity (UCTE), secondary control is achieved by means of power frequency control.

The desired behaviour of the secondary controller over time is achieved by the control loops having a proportional-integral characteristic as shown in the following formula:

$$\Delta P_{di} = -\text{ß}_i \cdot G_i - \frac{1}{T_i} \int G_i dt$$

where

ΔP_{di} = Manipulated variable of the secondary controller acting upon the control machines in the control area i

ß_i = Proportional component (increase) of the secondary controller of the *control area* i

T_i = Integration time constant of the secondary controller of the *control area* i

G_i = Global control deviation of the control area i (ACE: area control error)

Secondary control band

The secondary control band is the control range of the secondary control power within which the secondary controller can act automatically in both directions from the operating point of the secondary control power (instantaneous value).

Secondary control reserve

The secondary control reserve is the positive region of the *secondary control band* from the operating point up to the maximum value of the *secondary control band.* The range of the *secondary control band* which has already taken effect at the operating point is termed the secondary control power.

Service reliability

Service reliability is the capability of an *electric power system* to fulfil its supply function under specified conditions over a specified time interval.

Short-circuit close to the power station

A short-circuit is deemed to be close to the power station when the component of the *initial symmetrical short-circuit current* of a three-phase short circuit on a synchronous machine (or an asynchronous machine) exceeds twice the value of its rated current.

Short-circuit remote from the power station

A short-circuit is deemed to be remote from the power station when the component of the *initial symmetrical short-circuit current* of a three-pole short-circuit on a synchronous machine (or an asynchronous machine) is less than twice the value of its rated current.

Shutdown planning

Planning of final or temporary shutdown of a generating unit.

Stability

The term stability is used here as a generic term for *steady-state* or *transient stability*: Stability is the capability of an *electric power supply system* to maintain *synchronous operation* of the generators.
In practical terms, synchronous generator operation means the absence of pole slipping.

Steady-state stability

If the *electric power system* or a synchronous machine previously in the steady state reverts to this state again following a sufficiently "minor" fault, it has *steady-state stability*. If no control equipment is involved in this process, the characteristic is described as natural steady-state *stability*, otherwise as artificial steady-state *stability*. The instabilities may be a single swing or oscillatory.

Supplier

The supplier supplies electricity to customers on the basis of an open supply agreement or through partial deliveries. A supplier can (but must not necessarily) be a (sub-) balancing group manager.

Sustained short-circuit current

The sustained short-circuit current is the actualvalue of the short-circuit current remaining when all transient phenomena have decayed. The factors upon which it is dependent include the excitation and control of the generators.

System access

System access is the basis for power stations, customers and energy utilities to conclude delivery contracts with one another, enabling them to use the network of system operators concerned for their supplies and purchases.

System balance

The system balance of a control area is settled when there is an equilibrium between power generation and consumption, with due regard to exchanges with other control areas, so that frequency stability is guaranteed.

System management

The *system service* of *system management* includes all tasks performed by the *system operator* as part of coordinated power station commitment (e.g. for *frequency stability*) and network management, and of national/international *interconnected operation* by control centres with competence for their own areas. System management also includes all measures for the creation and maintenance of the requisite preconditions for metering and charging of all services performed.

System operator

A system operator (operator of a *transmission* or *distribution system*) is responsible for secure and reliable operation of the *network* in question in a specific area and for connections to other *networks*.
In addition, the operator of a *transmission system* controls power transfer across the *network* taking account of interchange with other *transmission systems*. He ensures the provision of essential *system services* and thus assures *service reliability*.

System security

System security exists when either the system balance nor the network security are at risk or under disturbed conditions.

System services

In an electric power system, system services are the services, in some cases indispensable for proper system functioning, which *system operators* provide for *customers* in addition to the transmission and distribution of electrical energy, and which thereby determine the quality of electricity supply:

- *Frequency stability*
- *Voltage control*
- *Restoration of supply*
- *System management.*

Transient phenomena (phase swinging, power oscillation)

A transient phenomenon in the system occurs at the transition from one system state to a new system state, for example as a result of a switching operation.
Provided no limit values are violated and the transient phenomenon is adequately damped, it has no significant consequences.

Transient stability

Should an *electric power system* which has suffered a "major" failure progress through decaying *transient phenomena* to its original steady state, it demonstrates transient stability with regard to the nature, location and duration of this fault. The steady state following a fault may be identical to that prior to the fault, or may differ from it.
The nonlinear formulae for synchronous machines must be used for analysis of the transient stability. The term "overall stability" is commonly used in control technology.

Transit

Transit is a special case of *power transfer* in which both the supplying *balance group* and the receiving *balance group* are located in *control areas* which are not adjacent. A transit transaction is therefore concluded through intermediate *transmission systems*.

Transmission system operator (TSO)

A TSO is operator of a *transmission system*.

Voltage control

The purpose of voltage control is to maintain an acceptable voltage profile throughout the *network*. This is achieved by balancing of the respective reactive power requirements of the *network* and the *customers*.

Voltage stability

Recognition of critical network states at an early stage is of major importance for maintenance of the voltage stability. System security analysis is an important tool for this purpose. It provides initial information on critical voltages states in the form of calculations of network losses, regional reactive power balances, and node voltages. In at-risk states such as these, automatic control systems which are beneficial in normal operation, such as voltage control by the tap changers, may lead to further escalation, as they initiate additional reactive power flows and can force generators to their reactive power limits. It is therefore advantageous if these controls can be blocked temporarily, or lower setpoint values specified. By contrast, the automatic controllers of the *consumers*, which cause the power consumption which has dropped following a voltage collapse to rise to its original value within a few minutes, cannot be blocked centrally. Since the supply is now at a very low voltage level, additional reactive power demand is placed upon the transmission equipment. A further aggravating factor is the fact that the transmission capacity of a line with an increasing voltage drop along it increases only up to a critical limit. Once the voltage drop exceeds this limit, stable operation ceases to be possible.

Voltage transformer

Voltage transformers have the function of transmitting the "voltage" primary variable to the secondary values as accurately as possible according to its magnitude and angle.

10 References

Q1	**EnWG**	German Energy Industry Act (second Act revising energy industry legislation (Zweites Gesetz zur Neuregelung des Energiewirtschaftsrechts) of 7 July 2005.
Q2	**StromNZV**	Grid access regulation (Verordnung über den Zugang zu Elektrizitätsversorgungsnetzen (Stromnetzzugangsverordnung –

		StromNZV)) of 25 July 2005
Q3	**2nd EU Directive**	Directive 2003/54/EC of the European Parliament and of the Council of 26 June 2003 concerning common rules for the internal market in electricity and repealing Directive 96/92/EC
Q4	**EC Regulation 1228**	EC Regulation No 1228/2003 of the European Parliament and of the Council of 26 June 2003 on conditions for access to the network for cross-border exchanges in electricity
Q5	**Congestion Management - Guidelines**	Commission Decision of 9 November 2006 amending the Annex to Regulation (EC) No 1228/2003 on conditions for access to the network for cross-border exchanges in electricity
Q6	**EEG**	German Renewable Energy Sources Act (Gesetz für den Vorrang Erneuerbarer Energien (Erneuerbare-Energien-Gesetz – EEG)) of 29 March 2000
Q7	**KWK-G**	German Co-generation Act (Gesetz für die Erhaltung, Modernisierung und den Ausbau der Kraft-Wärme-Kopplung (Kraft-Wärme-Kopplungsgesetz – KWK-G)) of 19 März 2002
Q8	**GPKE**	Specifications of the Federal Network Agency on business processses for the supply of electricity to customers, of 11 July 2006
Q9	**EN 50160**	European Norm on network quality criteria; the purpose of EN 50160 is to define and describe the network quality criteria in terms of the level, shape of curve, frequency and symmetry of the three phase-to-phase voltages.
Q10	**Network Disturbances**	Technical Rules for the Assessment of Network Disturbances set up by four Electricity Associations from Austria (VEÖ), Switzerland (VSE/AES), Czech Republic (CSRES) and Germany (VDN); March 2005
Q11	**VDE 0105**	VDE 0105: Betrieb von elektrischen Anlagen; Teil 100: Allgemeine Festlegungen
Q12	**DC 2007**	DistributionCode 2007 – Rules for the Access to Distribution Sys-

		tems, May 2003
Q13	**TC 2003**	TransmissionCode 2003 – Network and System Rules of the German Transmission System Operators; August 2003
Q14	**MC 2006**	VDN Guidelines: MeteringCode 2006; July 2006
Q15	**UCTE-OH**	The UCTE Operation Handbook is a comprehensive collection of relevant technical standards for the operation of transmission systems within the UCTE; these standards relate to ➢ P1 Load-Frequency Control and Performance; final version of 20/07/04 ➢ P2 Scheduling and Accounting; final version of 20/07/04 ➢ P3 Operational Security; final version of 20/07/04 ➢ P4 Co-ordinated Operational Planning; final version of 03/05/06 ➢ P5 Emergency Procedures; final version of 03/05/06 ➢ P6 Communication Infrastructure ; final version of 03/05/06 ➢ P7 Data Exchanges; final version of 03/05/06 ➢ P8 Operational Training – under preparation
Q16	**VDN**	Renewables-based generating plants connected to the high and extra-high voltage nework – Guidelines (in addition to the network codes) for renewables-based generating plants’ connection to and parallel operation with the high and extra-high voltage network; August 2004
Q17	**VDN**	Richtlinie Datenaustausch und Mengenbilanzierung (DuM) (Guideline on data exchange and energy quantities’ balance settlement – Implementation of clearing processes as part of balancing group accounting; February 2007 (available only in German)
Q18	**DVG**	Operational Behaviour of Thermal Power Plants Necessary for a Reliable Power Supply (Das versorgungsgerechte Verhalten der

		thermischen Kraftwerke); October 1991 (English version of November 1992)
Q19	**DVG**	Das (n-1)–Kriterium für die Hoch- und Höchstspannungsnetze der DVG-Unternehmen; May 1997 (The n-1 criterion applied to the high and extra-high voltage networks of the DVG companies – available only in German)
Q20	**DVG**	Zuverlässigkeit elektrischer Versorgungssysteme, Zusammenstellung der wichtigsten Begriffe; November 1987 (Reliability of electric power systems; definitions of the most important terms - available only in German)
Q21	**DVG**	Technische Anforderungen an Frequenzrelais für den störungsbedingten Lastabwurf; November 1980 (Technical requirements upon frequency relays for load shedding due to disturbances – available only in German)

11 Annexes

Annex A: Forms for the implementation of system responsibility

Annex B: Example of the contents of a technical documentation to be exchanged between the power station operator and the TSO

Annex C: Application of the n-1 criterion

Annex D: Pre-qualification documentation for the provision of control energy to the TSOs