Final Guidelines of Good Practice on Electricity Grid Connection and Access

Ref: E09-ENM-16-04

10 December 2009

INFORMATION PAGE

Abstract

On 24 March 2009, ERGEG launched a public consultation on Draft Guidelines of Good Practice on Electricity Grid Connection and Access (Ref: E08-ENM-09-03). The draft GGP outlined a number of proposals to ensure consistent grid connection and access across Member States.

This document (E09-ENM-16-04) contains the Final GGP on Grid Connection and Access after the evaluation of responses to the public consultation.

Target Audience

The target audience of this document includes energy suppliers, traders, gas/electricity customers, gas/electricity industry, consumer representative groups, network operators, Member States, academics and other interested parties.

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Treatment of Confidential Responses

In the interest of transparency, ERGEG

i) will list the names of all respondents (whether confidential or not) or, alternatively, make public the number (but not the names) of confidential responses received;

ii) requests that any respondent requesting confidentiality submit those confidential aspects of their response in a "confidential appendix". ERGEG will publish all parts of responses that are not marked confidential.

For further information on ERGEG's rules, see ERGEG's Guidelines on Public Consultation Practices[1].

[1] http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_CONSULT/E07-EP-16-03_PC-Guidelines_2009-Mar-11.pdf

Related Documents

CEER/ERGEG documents

- "ERGEG Draft Guidelines of Good Practice on Electricity Grid Connection and Access", ERGEG, 11 March 2009, Ref. E08-ENM-09-03, http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_CONSULT/CLOSED%20PUBLIC%20CONSULTATIONS/ELECTRICITY/GGP%20Electricity%20Grid%20connection%20%20Access
- "ERGEG Guidelines on Consultation Practices", ERGEG, 11 March 2009, Ref. E07-EP-16-03, http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_CONSULT/E07-EP-16-03_PC-Guidelines_2009-Mar-11.pdf
- "ERGEG Final report, The lessons to be learned from the large disturbance in the European power system on the 4th of November 2006", ERGEG, February 2007, Ref. E06-BAG-01-06, http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_ERGEG_PAPERS/Electricity/2007/E06-BAG-01-06_Blackout-FinalReport_2007-02-06.pdf

External documents

- "Study on the Technical Security Rules of the EU Electricity Networks", PB Power for the European Commission, February 2006, Ref. 62236A/001 REV 2, http://www.docstoc.com/docs/961385/Study-on-the-Technical-Security-Rules-of-the-European-Electricity-Network

- Directive 2003/54/EC for internal market in electricity http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:176:0037:0055:EN:PDF

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EXECUTIVE SUMMARY

Past experience from critical situations and large disturbances in the European electric power systems indicates a number of drawbacks and problems which originate from the insufficiently coordinated and coherent framework and from insufficiently standardised procedures for grid connection and access. The latter, in particular, has resulted in the lack of a uniform approach for grid connection and access for European grid users, with technical and organisational provisions being diverse. This situation is exacerbated by the growing maturity of the EU electricity market and other factors, including among others:

- the massive deployment of existing and new intermittent and distributed generation; and
- the participation of demand response in network and market operations.

In contrast to the common rules for operational security that have existed for decades in the European synchronous areas (such as UCTE, Nordel), the issues of grid connection and access have not been addressed in a common way. This is understandable given that grid connection and access were not a critical issue for vertically integrated utilities, as they are today for unbundled grid and market operations. Transmission System Operators (TSOs) and Distribution System Operators (DSOs) are migrating from having a role as infrastructure undertakings towards being user-oriented service providers employing a plethora of new concepts, and interacting with different actors and a variety of independent grid users.

As stated in the ERGEG report on the November 2006 disturbance[2] and in its 2008 and 2009 Work Programmes, ERGEG has undertaken to analyse the needs of, and draft the key concepts for, common grid connection and access approaches throughout the EU electricity grids. This includes designing and consulting upon Guidelines of Good Practice (GGP) on Grid Connection and Access.

The results of previous analyses and studies have been used in ERGEG's preparatory work, for example the "Study on the Technical Security Rules of the EU Electricity Networks"[3].

The first draft of this document was discussed with different stakeholders[4] at a common workshop on 6 October 2008. The issues raised during the discussion were taken into account in the draft GGP on grid connection and access, where appropriate. The public consultation on the draft GGP conducted by ERGEG from 24 March to 2 June 2009 further sought the views of all interested stakeholders. The public consultation and key positions of various stakeholders were also discussed at the workshop on 15 May 2009[5].

The evaluation of the responses to the public consultation (Ref: E09-ENM-16-04a) contains a detailed analysis of the views received during the public consultation and is the basis for the finalisation of the draft GGP. The evaluation document (document Ref: 09-ENM-16-04a) accompanies the final GGP contained in this document.

[2] "ERGEG Final report, The lessons to be learned from the large disturbance in the European power system on the 4th of November 2006", ERGEG, February 2007, Ref. E06-BAG-01-06, http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_ERGEG_PAPERS/Electricity/2007/E06-BAG-01-06_Blackout-FinalReport_2007-02-06.pdf

[3] "Study on the Technical Security Rules of the EU Electricity Networks", PB Power for the European Commission, February 2006, Ref. 62236A/001 REV 2, http://www.docstoc.com/docs/961385/Study-on-the-Technical-Security-Rules-of-the-European-Electricity-Network

[4] Stakeholders attending the workshop included COGEN Europe, UCTE, NORDEL, ETSO, IFIEC, GEODE, EURELECTRIC, EWEA and EPIA.

[5] ERGEG Workshop, ERGEG Consultation paper "Draft GGP on Electricity Grid Connection and Access, Friday 15 May 2009, http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_CONSULT/CLOSED%20PUBLIC%20CONSULTATIONS/ELECTRICITY/GGP%20Electricity%20Grid%20connection%20%20Access/Public%20Hearings

The final GGP on Electricity Grid Connection and Access could in future contribute to the work of the newly established Agency for the Cooperation of Energy Regulators (ACER) when exercising its duties as regards future framework guidelines, in accordance with the provisions of the 3rd Package[6].

Furthermore, the final GGP, together with the accompanying evaluation document, will feed into ERGEG's work on the pilot framework guideline on electricity grid connection, which aims also to test the end-to-end process for developing framework guidelines as foreseen in the 3rd Package. Further detailed information on the Pilot and ERGEG's overall work on framework guidelines is available at:

http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_FWG

[6] The 3rd Package of the European Commission with proposals for the European Internal Market in Energy which was announced on 19 September 2007, included 5 legislative proposals: 2 amended Directives on the Directives of the European Parliament and of the Council amending Directive 2003/54/EC and Directive 2003/55/EC concerning common rules for the internal market in electricity and the internal market in natural gas, respectively; 2 amended regulations on the European Parliament and of the Council Amending Regulation (EC) No 1228/2003 on conditions for access to the network for cross-border exchanges in electricity and Regulation (EC) No 1775/2005 on conditions for access to the natural gas transmission networks; and a new Regulation establishing an Agency for the Cooperation of Energy Regulators. The Package was finally adopted on 13 July 2009. http://eur-lex.europa.eu/JOHtml.do?uri=OJ:L:2009:211:SOM:EN:HTML
In this document for the sake of consistency reference is made to the old Regulation 1228/2003.

1 Introduction

1.1 Problem identification

Recent experiences during large disturbances in European power systems have indicated that the security of the power system has been in danger when generation and consumption units have tripped from the system in an uncoordinated and uncontrolled manner due to different national requirements on tolerating voltage and frequency variations. These different frequency and voltage requirements within national grid connection and access rules increase the probability of more severe disturbances when national power systems become more interlinked through market integration. Emerging disturbances are therefore more likely to spread across several countries. Thus some minimum requirements should be set for the voltage and frequency variations of generation and consumption units to be connected within a synchronous area.

The recent large disturbances have shown that uncoordinated reconnection of generation units, especially distributed generation, when the system is in a disturbed operating state has endangered the rapid restoration of the power system to normal operating state. This has partly been due to the lack of real time information on the status of this generation. The secure operation of the power system requires information exchange between the Transmission System Operator (TSO) and distributed generation connected to the Distribution System Operator (DSO) network.

The problems identified above will be further amplified by the growing maturity of the EU electricity market and other factors including, among others, demand response, smart grids and the massive deployment of existing and new distributed and intermittent generation.

These problems can be solved by harmonising, to a certain extent, the rules for grid connection and access set by the TSOs for DSOs and generation and consumption units. This harmonisation ensures that rules for connection and access which have the greatest effect on the security of power systems are consistent across all Member States.

2 General Provisions and Objectives

The grid connection and access conditions that should apply to all the users of electricity transmission and distribution grids (including here generation units, consumption units, interconnections and also the DSOs in their position as the TSOs' "grid users") throughout the EU are specified in this document. Within that scope, it must be ensured that the TSOs, each being responsible for their control area, also have a responsibility for the definition and implementation of specific provisions which must be met by the grid users at the transmission level and which must also be duly followed by all other grid users.

Issues of coordinated planning and operation of the EU transmission grids are addressed in a separate document: the ERGEG GGP on Operational Security[7].

It is envisaged that future framework guidelines will provide a framework for EU network codes. However, those EU codes will not replace the national grid codes (or equivalents), but will instead need to be specific enough to ensure EU-wide equal, non-discriminatory and balanced treatment of all grid users and grids.

This document provides the final GGP on electricity grid connection and access. The GGP take into account the results of the ERGEG reports on past large disturbances and blackouts in the EU as well as the ERGEG public consultation on the draft GGP

[7] "Guidelines for Good Practice for Operational Security in Electricity ", ERGEG, November 2008, Ref. E08-ENM-02-04,
http://www.energyregulators.eu/portal/page/portal/EER_HOME/EER_CONSULT/CLOSED%20PUBLIC%20CONSULTATIONS/ELECTRICITY/GGP%20Operational%20Security/CD/E08-ENM-02-04_GGP-OpS_2008-11-28.pdf

3 Roles and Responsibilities of Different Stakeholders and Market Players

3.1 Member States

3.1.1 While complying with all the EU legal provisions for the electricity market in the related Directives and Regulation, the Member States shall pay particular attention to ensuring objective, transparent and non-discriminatory implementation of a system of regulated Third Party Access (rTPA).

3.2 National Regulatory Authorities (NRAs)

3.2.1 According to the Electricity Directive (2003/54/EC the NRAs shall be responsible for fixing or approving, prior to their entry into force, at least the methodologies used to calculate or establish the terms and conditions for connection and access to the electricity grids[8].

3.2.2 The NRAs shall monitor the effects of the terms, conditions and procedures for grid connection and access.

3.2.3 The NRAs shall have the authority to require Transmission System Operators (TSOs) and Distribution System Operators (DSOs) to modify the terms and conditions as well as the procedures for grid connection and access, if necessary, to remove any discriminatory practices.

3.2.4 The NRAs shall have the power to settle disputes related to connection and access to the grid.

3.3 Transmission System Operators (TSOs)

3.3.1 The TSOs shall submit the terms and conditions as well as the procedures for grid connection and access to their networks for ex-ante approval by the NRAs. When submitting these terms and conditions to the NRAs, the TSOs shall enclose, where applicable, the results of the consultation with stakeholders.

3.3.2 The TSOs shall provide the system users with the information they need for efficient access to the system. TSOs will also provide all non-confidential data and information necessary to evaluate the connection and access conditions. The TSOs shall have connection agreement/contract models publicly available for those requesting grid connection and access.

3.3.3 The TSOs shall deliver a proposition offering a connection agreement to any grid user requesting a connection to the grid. This proposition shall expose the technical, organisational (e.g. timeline and time limits) and financial aspects of the adopted solution. The proposition of connection agreement shall contain all relevant justifications.

3.3.4 The TSOs shall oversee that all users connected to their grid meet the requirements set in the approved terms and conditions for grid connection and access.

[8] Member States may have implemented the Electricity Directive in national legislation so that the terms and conditions for connection and access do not include technical terms and conditions.

3.4 Distribution System Operators (DSOs)

3.4.1 The DSOs shall submit the terms and conditions as well as the procedures for grid connection and access to their networks for ex-ante approval by the NRAs. When submitting these terms and conditions to the NRAs, the DSOs shall enclose, where appropriate, the results of the consultation with stakeholders.

3.4.2 The DSOs shall provide system users with the information they need for efficient access to the system. The DSOs will also provide all non-confidential data and information needed to evaluate the connection and access conditions. The DSOs shall have agreement models publicly available for those requesting grid connection and access.

3.4.3 The DSOs shall deliver a proposition offering a connection agreement to any grid user requesting a connection to the grid. This proposition shall expose the technical, organisational (e.g. timeline and time limits) and financial aspects of the adopted solution. The proposition with connection agreement shall contain all relevant justifications.

When appropriate, TSOs and DSOs shall coordinate to establish such a proposition offering a connection agreement without undue delay.

3.4.4 The DSOs shall oversee that all users connected to their grid meet the requirements set in the approved terms and conditions for grid connection and access.

3.4.5 The DSOs shall meet the terms and conditions for connection to the transmission grid.

3.5 Generation Units

3.5.1 The generation units shall meet the requirements which are set out in the terms and conditions and contractually agreed upon with the relevant TSO or DSO.

3.5.2 The generation units shall provide all necessary data and information needed by the TSO/DSO to evaluate the connection and access conditions.

3.5.3 The generation units shall provide the TSO and/or DSO with the data (e.g. feed-in power, state of operation) that are required to ensure secure real-time operation of the system.

3.5.4 The generation units shall ensure the proper functioning of all services to the extent they have committed to, so that the TSO/DSO can use those services whenever needed.

3.6 Consumption units

3.6.1 The consumption units shall meet the requirements which are set out in the terms and conditions and contractually agreed upon with the relevant TSO or DSO.

3.6.2 The consumption units shall provide all necessary data and information needed by the TSO/DSO to evaluate the connection and access conditions.

3.6.3 The consumption units shall provide the TSO and/or DSO with the data (e.g. withdrawal of power, state of operation) that is required to ensure secure real-time operation of the system.

3.6.4 The consumption units shall ensure the proper functioning of all services to the extent they have committed to (e.g. load shedding and demand response), so that the TSO/DSO can use those services whenever needed.

4 General Provisions

4.1 Connection Procedures

4.1.1. The connection procedures shall be elaborated and / or approved by the NRAs as part of the terms and conditions for connection and access to the grid, after appropriate consideration of stakeholders' interests. These terms and conditions shall enter into force only after consultation with stakeholders.

4.1.2. The grid connection procedures shall comply with the principles of regulated Third Party Access and be transparent and non-discriminatory.

4.1.3 As part of the grid connection procedures, connection agreement/contract models (i.e. standard agreements) shall be prepared and published. These models shall be drafted in consultation with stakeholders – most notably grid users and DSOs – and shall be approved, where applicable, by the NRAs as a part of the terms and conditions.

4.1.4 Connection procedures shall not lead to undue connection delays. The TSO and/or DSO must be transparent about the connection time schedules to those requesting the connection. Any delay and reasons for it must be transparently communicated to those requesting the grid connection. The solutions to overcome the delays in grid connection access shall be jointly agreed between the TSO and/or DSO and the grid user.

4.1.5 Connection procedures shall define the information and data (including technical data) that the applicant for grid connection has to provide to the TSO and/or DSO. Connection procedures shall also describe the measures to be taken in case of modifications to the TSO's, DSO's and grid users' installations. Furthermore, all the connection procedures, connection time schedules and required information for grid connection and access must be publicly available.

4.2 Connection Requirements

4.2.1 The technical requirements for connection shall be elaborated and approved by the respective authority (regulator) as part of the terms and conditions for connection and access to the grid, after appropriate consideration of stakeholders' interests. These requirements shall enter into force only after consultation with stakeholders. Moreover, the TSOs and DSOs will (beyond the technical requirements) define rules (to be approved by the NRAs), on the treatment of the grid connection applicants awaiting connection, particularly in relation to the duration of connection application process.

4.2.2 The connection and access requirements apply to new installations and to the modified parts of existing installations. Parts of existing installations which have not been modified shall retain the technical features described in a previous connection arrangement and not be affected by the new connection and access requirements. This needs to be ensured by regular tests, where appropriate. This applies for generation and for consumption units and the TSOs and/or DSOs shall follow this provision (defining the treatment of new and existing installations) swiftly and without delay.

4.2.3 The TSOs and/or DSOs shall design the technical solution for connection under transparent and non-discriminatory conditions, in cooperation with the applicant for grid connection.

4.2.4 The TSO and DSO shall have transparent and non-discriminatory conditions for checking the compliance with connection requirements. There shall be a process and a body responsible for settling disputes between the TSO/DSO and the grid user about diverging positions on the possibility to connect.

4.3 Information Exchange

4.3.1 The TSO and DSO shall provide the information on technical requirements for grid connection at the connection point – in compliance with harmonised standards, where applicable – including among others:

(1) Short circuit capacity levels indicating maximum and minimum short circuit capacity;

(2) Protection concept with time frames for fault recognition and relay tripping;

(3) Insulation co-ordination;

(4) Grounding;

(5) Requirements for parallel operation with the power system;

(6) Maximum permitted electromagnetic perturbations;

(7) Highest and lowest operating voltage in normal and disturbed operating states;

(8) Highest and lowest operating frequency in normal and disturbed operating states; and

(9) Devices required for metering and information exchange.

4.3.2 Every significant generation unit or consumption unit shall provide the TSO or DSO where it is connected with all information and technical data necessary to ensure the operational security of the system, including an efficient co-ordinated system with access to real-time information.

4.3.3 Every significant generation unit or consumption unit shall be able to receive and to execute the instructions sent by the TSO and/or DSO, either on a contractual basis or in critical operating state.

4.3.4 TSOs shall inform each other about the commissioning of significant generation and consumption units. This implies that adjacent TSOs shall agree on the criteria (e.g. a power threshold) for defining units as significant. With the growing importance of distributed generation, this provision applies also to the DSOs with significant installed distributed generation capacity; for that matter, the affected DSOs and TSO shall coordinate and inform each other in a coherent way and with appropriate timing.

4.4 Access Limitations

4.4.1 The TSO and DSO shall put in place rules to handle access limitation situations. The reasons for such curtailments, the methods for estimating their extent and their effect on grid users shall be described in detail. These rules shall be communicated transparently to the grid users and market participants and approved by the NRAs.

4.4.2 Access limitations shall be considered only if operational security is at stake and no other solution is available. Planned access limitations shall be agreed with the grid user.

5 Technical Framework for Grid Connection and Access

5.1 General Requirements

5.1.1 Operating Frequency

5.1.1.1 The TSOs interconnected within a synchronous area shall jointly specify the normal operating frequency range.

5.1.1.2 The TSOs within a synchronous area shall jointly also set pre-defined frequency deviation levels that the grid users shall be able to sustain (at least for a pre-defined time period). In particular, these levels will define the frequency ranges within which the significant generation units shall be able to remain connected and support the grid in disturbed operating conditions.

5.1.1.3 When setting these ranges and levels, grid users shall be informed about the defined thresholds and requirements and – where applicable and justified – any necessary adjustments conducted in line with operational security requirements and with non-discriminatory Third Party Access.

5.1.1.4 Where applicable, a TSO may apply a wider range of frequency deviations than those set in accordance with 5.1.1.2. Justification for this shall be transparently communicated to the grid users and those requesting connection.

5.1.2 Operating Voltage

5.1.2.1 The TSO and DSO shall define the nominal operating voltage for each voltage level applied in the network. TSOs across interconnections and TSOs and DSOs within the same control area shall co-ordinate and co-operate when defining voltage levels and nominal operating voltage.

5.1.2.2 The TSO and DSO shall specify the normal operating voltage range for steady state conditions. The equipment connected to the grid shall remain connected during the voltage deviations within the specified normal operating voltage range, as far as no damage to the equipment is foreseen.

When setting levels of voltage deviations grid users shall be consulted and consideration given to harmonised standards.

TSOs and DSOs are allowed to use a wider voltage range than that set in accordance with this paragraph if this is necessary to ensure operational security of the respective control area. Reasons for this requirement have to be transparently communicated to the grid users and those requesting connection.

5.1.2.3 Within the terms and conditions for connection and access, TSOs and DSOs shall define for the equipment to be connected, the allowed:

(1) Highest operating voltage;

(2) Lowest operating voltage;

(3) Withstanding voltage for lightning and switching surges; and

(4) Withstanding voltage for specified time period under various frequency regimes (according to the applicable standard).

5.1.2.4 Within the terms and conditions for connection and access, TSOs and DSOs shall define for the equipment to be connected, the allowed range and duration of:

(1) Fast voltage variations and voltage dips;

(2) Overvoltages; and

(3) Voltage imbalances and harmonics.

The ranges and durations shall comply as far as possible with the existing technical standards in this field.

Specific requirements may be applied to different equipment (e.g. generation units, consumption units).

5.1.3 Protection Scheme

5.1.3.1 Generation units, consumption units and distribution grids shall be equipped with protection devices which shall disconnect the units from the network – or disconnect the distribution grid from the transmission grid – in case of unacceptable operating states, i.e. in case of failures in the units or in the distribution grids or when the frequency and voltage of the power system is outside the defined permitted range.

5.1.3.2 The settings of protection devices shall be coordinated with the protection systems of the TSO and/or DSO to prevent non-selective activation. Protection settings have to be set after agreement with the TSO and/or DSO; they shall ensure the secure operation of the system and protect the connected units from damage. The unit owner shall provide the TSO and/or DSO with the actual settings, where appropriate.

5.1.3.3 Protection systems of the generation and consumption units shall be equipped with back-up protection devices. These back-up protection devices can either be within the units or, if agreed, between the TSO/DSO and the grid user, be part of the network protection systems.

5.2 Generation Units

5.2.1 Characteristics of Generation Unit

5.2.1.1 The TSO and/or DSO shall define in a transparent way those generation units which shall be equipped with (depending on the technology and the size of the unit):

(1) Main circuit breaker;

(2) Synchronisation facilities;

(3) Voltage control equipment;

(4) Frequency control equipment;

(5) Power control equipment, where appropriate;

(6) Protection equipment; and

(7) Devices for metering and information exchange.

5.2.1.2 The technically and economically feasible generator impedance shall be agreed by the TSO and/or DSO and the producer in such a way that the stability of the generation units and stable and secure operation of the system are ensured. The criteria which the TSO and/or DSO apply for assessing the generator impedance shall be published.

5.2.1.3 The TSO and/or DSO shall define in a transparent way the requirements affecting the technical characteristics of the synchronous generators, in relation to the P/Q diagram. The generators involved shall be capable of operating continuously at the rated active power within the power factor range thus defined by the TSO or the DSO.

5.2.1.4 The TSO and/or DSO shall define requirements for step-up transformers affecting the design and the operation of the transmission or distribution network.

5.2.1.5 Every significant generation unit shall be equipped with a device or system suitable for damping the oscillations of the generation unit and of the power system. This device or system shall allow for damping of inter-area oscillations and damping of oscillations between the generation unit and the power system. The settings of this device or system shall be agreed between the generation unit and the TSO and, where applicable, with the DSO.

5.2.1.6 The operators of generation units shall inform the TSO/DSO of the enhanced capabilities of their installation for remaining connected to the network to sustain the grid beyond the frequency and voltage deviations defined according to 5.1.1 and 5.1.2. Reconnection after tripping shall be coordinated with the TSO and (if applicable) with the DSO, under transparent procedures compatible with the operational security of the system.

5.2.1.7 The generation unit and its control system shall be designed so that the unit will not be tripped due to transient phenomena occurring in the network to which the unit is connected. The characteristics and thresholds of these phenomena shall be agreed by the TSOs and DSOs.

5.2.1.8 The generation unit shall be designed to withstand the electrical and mechanical stresses associated with any kind of faults occurring in the transmission or distribution network. This shall include a malfunction occurring at the time of physical (re)connection to the grid, such as out-of-phase reclosing, which must be handled appropriately with the necessary protection devices.

5.2.1.9 The generation unit shall remain connected to the transmission or distribution network after a nearby network fault, as far as it is possible according to the configuration of the remaining network after the fault. The TSOs within a synchronous area shall define the maximum clearing time for network faults to be applied in designing the generation units.

5.2.1.10 Requirements for the capability of reactive power generation and absorption at normal voltage levels and of reactive power output in undervoltage conditions shall be defined by the TSO (or, if applicable, by the DSO). Each TSO or DSO shall determine the reactive power generation or absorption capabilities of generation units, taking into account the specific power system characteristics including specifications and control schemes for step-up transformers and for generators. Those requirements shall ensure that sufficient reactive power generation capabilities are available at the request of TSOs to prevent system collapse during disturbances.

5.2.1.11 All technical and design data necessary for power system stability studies shall be provided to the TSO and/or to the DSOs by the generation units. The specifications for data shall be transparently communicated by the TSO and/or DSO to all generation units requesting connection.

5.2.1.12 Generation units must comply with the maximum electromagnetic perturbations requirements set in accordance with 4.3.1(6). No perturbations resulting in an unacceptable level of interference with other units connected to the grid or other equipment shall be permitted. The TSO and/or DSO are responsible for taking measures to administer this requirement in a non-discriminatory way.

5.2.2 Requirements for Voltage Control and Reactive Power Management

5.2.2.1 The TSO and DSO shall clearly and transparently define the technical requirements related to the contribution to voltage control and reactive power management that should be met by the generation units. The technical requirements may vary according to the generation technology and to the size of the unit, as far as this is technically justified and does not create undue discrimination.

5.2.2.2 The design parameters of every significant generation unit shall contribute to voltage control, either at the generator voltage level or at the voltage level of the network connection point. In normal operating mode voltage should be controlled automatically, in order to ensure secure power system operation during disturbances. Other control types, like control according to power factor or reactive power output, whenever applied, shall have a lower priority than the automatic control of voltage. When there is a predefined voltage change, automatic voltage control mode shall be introduced automatically.

5.2.2.3 The provisions regarding the actual contribution of a generation unit to voltage control and reactive power management shall be agreed with the concerned TSO and/or DSO. These provisions shall be clearly and transparently set by the TSO and/or DSO. This includes the dynamic and static behaviour of the voltage control equipment and how this is verified.

5.2.3 Requirements for Frequency and Active Power Control

5.2.3.1 Generation units that contribute to balancing services and automatically activated reserves have to fulfil the related technical and organisational requirements and follow the instructions given by the control area manager (i.e. the TSO).

5.2.3.2 The input to the automatic frequency control unit of the generator is the frequency at the connection point – unless agreed otherwise with the TSO.

5.2.3.3 The TSOs shall clearly and transparently define the technical requirements related to the contribution to frequency and active power control. These requirements shall be in line with the technical rules set at the synchronous system level for operational security. Technical requirements may vary according to the generation technology and the size of the unit, as far as this is technically justified and does not create undue discrimination. When setting technical requirements, the following issues need to be considered:

(1) Operational characteristics, including minimum output, overload capacity and starting time;

(2) Power control equipment characteristics, including operational modes, limiter for power step change and power control during normal operation and disturbances;

(3) Power response capability during normal operation of the power system, including load following and power response rate and range for different generation technologies; and

(4) Power response capability during power system disturbances, including instantaneous power response, power step change for different generation technologies and subsequent power response rate after power step change for different generation technologies.

5.2.3.4 Generation units shall be able to execute their control activities in normal and in alert (disturbed) operating states, whereas specific parameters for operation outside these operating states will be agreed separately between generation units and TSOs.

5.2.4 House Load Operation

5.2.4.1 Every significant generation unit shall be able to change from parallel operation with the network to house load operation depending on the frequency and voltage conditions specified in the requirements set in the terms and conditions for connection and access. Exceptionally, if tripping into house load operation is not possible, the generation unit shall be capable of reconnecting to the system at the request of the TSO (and if applicable, in coordination with the DSO) within a determined timeframe.

5.2.4.2 In case of house load operation, the generation unit and its auxiliary system shall be designed so that a safe changeover to house load operation can take place after disconnection from the network.

5.2.4.3 Requirements for house load operation including the minimum duration of house load operation shall be clearly and transparently set by the TSO and/or DSO.

5.2.5 Black Start Capability and Island Operation

5.2.5.1 Generation units with black start capabilities are able to provide voltage to the network without any support from the network (most notably with no external supply of voltage and frequency). Each TSO shall contract for a sufficient number and capacity of generators required for a black start within its control area.

5.2.5.2 Every black start generation unit shall have the ability to control voltage and frequency during isolated operation. This enables generation units to provide black start capability to the TSO and DSO.

5.2.5.3 The TSO and DSO may have contracts with generation units for island operation if the security of the system and fast restoration after disturbances require island grid operation.

5.2.5.4 Control systems of generation units that have been contracted for island grid operation have to be set in a way that allows load following above minimum power.

5.2.5.5 Contracts with generation units capable of island operation shall specify the duration for maintaining the operation of an incidental island.

5.2.5.6 The requirements set for black start and island operation by the TSO and DSO must be unambiguous and transparent.

5.2.6 Verification

5.2.6.1 Production units are responsible for testing that requirements set for the connecting installation, including electrical safety, are met.

5.2.6.2 The specifications and requirements must be verified at commissioning. The TSO and/or DSO may also request verification after commissioning. Measurements from actual operation shall be reviewed if necessary in order to prove compliance with the specifications set for the generation unit.

5.2.6.3 The contents of the verification shall be clearly and transparently defined by the TSO and/or DSO, and if necessary also in cooperation with other affected TSOs and DSOs. Type tests and validated behaviour simulation models may also be included, as well as other applicable methods.

5.3 Consumption Units

5.3.1 General

5.3.1.1 The consumption unit shall be equipped with:

(1) Main circuit breaker;

(2) Protection equipment; and

(3) Devices for metering and, where applicable, for information exchange.

5.3.1.2 The consumption unit is responsible for its equipment compliance with the requirements set by the TSO and/or DSO.

5.3.2 Requirements for Reactive Power

5.3.2.1 Consumption units shall compensate as far as possible their need of reactive power within the defined range.

5.3.2.2 Reactive power generation and/or absorption by consumption units outside the range set by the TSO and DSO shall be accounted for by the consumption unit and may result in the application of economic sanctions. The limits for production and consumption of the reactive power and the economic sanctions shall be transparently communicated to grid users.

5.3.2.3 The TSO and DSO shall establish mechanisms that enable the participation of consumption units in voltage control (i.e. producing and consuming reactive power for the needs of the network).

5.3.3 Interference and Electromagnetic Perturbations / Emissions

5.3.3.1 Consumption units must comply with the maximum electromagnetic perturbations requirements set in accordance with 4.3.1(6). No perturbations resulting in an unacceptable level of interference with other consumption units or other equipment shall be permitted. The TSO and/or DSO are responsible for taking measures to administer this requirement in a non-discriminatory way.

5.3.3.2 The TSO and / or DSO are responsible for ensuring that there are publicly available methodologies for the establishment and assessment of the emission limits for both distorting (resulting in harmonics and/or interharmonics and voltage dips and surges) and fluctuating (resulting in flicker) loads directly connected to the networks. The corresponding thresholds – in compliance with harmonised standards, where applicable – shall be defined and published accordingly.

5.3.3.3 The purpose of the methodologies is to set limits for the perturbations injected into the networks by distorting and fluctuating installations in order to respect the established networks reference levels for voltage quality. When the TSO and/or DSO are setting the emission limits, the propagation of these disturbances between the different voltage levels must be considered.

5.3.3.4 When assessing and controlling the perturbations levels, the TSO and DSO shall separate and quantify the contribution from each installation. In cases where this is not possible, the evaluation shall be made, as a last resort, by successively monitoring the network area, having each one of the polluting installations connected and disconnected. The time period during which each installation is to be disconnected shall be agreed between TSO/DSO and installation owners.

5.3.3.5 The established emission limits are applied to all the installations and shall be respected from the moment the installation is connected to the network.

5.3.3.6 The TSO/DSO may disconnect an installation every time it does not respect the established emission limits, and when crossing emission limits results in the immediate threat for the safe and secure operation of the grid or other installations connected to the grid. The reconnection of the installations in these cases shall be subject to proof that the identified problem has been solved.

5.3.4 Demand Response

5.3.4.1 The TSO and DSO shall involve consumption units on a voluntary basis when designing and contracting ancillary services, as far as reasonably practicable and economically feasible. In that context, consumption units may contribute by decreasing consumption during peak load or during the restoration phase after a disturbance.

5.3.5 Load Shedding

5.3.5.1 The TSO or DSO may agree with consumption units on actions to be performed during critical operating states, upon request by the TSO or DSO to restore system to normal operating state such as:

(1) Adapt or curtail the load; and

(2) Modify the power factor if technically possible (not every consumption unit is able to or needs to be able to modify the power factor).

5.3.5.2 The consumption unit connected to the transmission network and, where appropriate, to the distribution network, shall be equipped with an automatic load shedding system. This system can be used by the TSO and/or DSO in case the power system is in danger and under conditions that are transparent and agreed by the NRA.

5.3.5.3 Besides automatically activated load shedding, there must be a possibility for the TSO and/or DSO to perform manual load shedding if operational security is endangered.

5.3.6 Verification

5.3.6.1 Consumption units are responsible for testing that requirements set for the connecting installation, including electrical safety, are met.

5.3.6.2 The TSOs and/or the DSOs are responsible for verifying all the requirements set in the terms and conditions for grid connection and access before the connection of a consumption unit to the network is allowed. Regular reviews shall be applied in order to prove compliance with the specifications set initially.

5.4 Distribution System Operators (DSOs)

5.4.1 General

5.4.1.1 The connection point between networks of transmission and distribution system shall be equipped with:

(1) Main circuit breaker;

(2) Protection equipment; and

(3) Devices for metering and, where applicable, information exchange.

5.4.1.2 The DSO has the responsibility for transposing the requirements set by the TSO (or DSO) and ensuring that generation and consumption units (and also other connected distribution networks) within the distribution network meet these requirements.

5.4.1.3 The DSO shall be able to execute (manually or automatically, depending on the purpose) the instructions given by the TSO. The TSO and the DSO shall agree how these instructions are delivered in practice. This applies also for those DSOs connected to another DSO network.

5.4.2 Requirements for Reactive Power

5.4.2.1 Voltage control and reactive power management are critical for the security of grid operation. Voltage range requirements at the interface between TSOs and DSOs shall be defined to maintain the voltage in acceptable ranges in the grid and to prevent voltage collapse.

5.4.2.2 Reactive power flow between TSO and DSO networks should be avoided in the normal operation state.

5.4.3 Load Shedding

5.4.3.1 Load shedding systems are crucial in preventing system collapse when frequency declines below allowed operating levels during the critical operating state. Load shedding may be activated either manually or automatically. The DSOs shall install dedicated systems allowing for either automatic and / or manual load shedding, as agreed with the TSO.

5.4.3.2 The DSOs shall design load shedding systems according to the requirements set by the TSOs. This includes load shedding stages, amount of shed load and settings for load shedding systems. The load shedding shall be non-discriminatory, as far as possible.

5.4.3.3 The TSOs may ask the DSOs to perform selective manual load shedding. For that purpose, the TSOs together with the DSOs shall establish plans and agreements in order to minimise the impact on the consumption units. These plans, which shall be revised periodically and integrated under existing operating protocols between the TSOs and the DSOs, shall at least specify the involved substations, the affected switchgears and the estimated load to be interrupted. Selective manual load shedding may be applied only if automatic load shedding is not feasible.

5.4.3.4 Load shedding systems and load shedding plans shall be designed to allow distributed generation to support the system.

5.4.3.5 After load shedding, the DSOs shall design and execute the reconnection of loads on the instruction of the TSOs and ensure quick recovery of normal operating state.

5.4.4 Specific Requirements for Distributed Generation

5.4.4.1 The TSOs of a synchronous area among themselves and with the DSOs shall exchange all necessary information and data relating to distributed generation. The TSO shall define clearly and transparently the necessary information, including real-time data, and agree with the DSOs and with distributed generators how this information will be exchanged. When appropriate, the DSOs shall ensure that the significant distributed generation units receive and execute the instructions sent by the TSOs.

5.4.4.2 Protection schemes and settings shall aim at avoiding that a fault on the transmission grid or disturbed operating conditions lead to a sudden simultaneous tripping of distributed generation units.

5.4.4.3 Coordinated protection schemes and settings are crucial for secure network operation. In particular, DSOs shall define transparently protection schemes that prevent any fault on distribution networks from affecting the transmission network and allow distributed generation units to support the system.

5.4.4.4 If islanded operation is considered, the situations when it can occur and the role of distributed generation shall be defined and formally agreed.

5.5 Exemptions under Article 7 of the Regulation (EC) 1228/2003

5.5.1 Exempted interconnections (as to Article 7 of Regulation (EC) 1228/2003) shall follow the connection requirements set by the TSOs. These requirements shall be non-discriminatory. They shall be clearly and transparently communicated to those requesting connection.

6 Glossary of Terms

The descriptions of terms provided here serve mainly for the purpose of common understanding of different subjects and apply in the first instance to the issues addressed in this document. Beyond that, for any other issue of general importance or of common understanding, the definitions in the existing legal framework, including Directive 2003/54/EC and Regulation (EC) 1228/2003 apply.

Therefore, some differences to the already existing definitions in use in other situations and / or specifications are possible.

The → symbol indicates definition of the term in italics elsewhere in the glossary.

Alert (disturbed) operating state ..... an operating state which entails that all consumption is met and that the frequency, voltage and transmission system are within the predefined acceptable limits / thresholds. In alert state, the reserve (margins) requirements are not fulfilled and faults in network elements or in generation (i.e. unforeseen disturbances / outages) will lead to further deterioration of system state.
In alert state, the power system is stable and all operational reserves (for transmission and generation balance) have to be mobilised. It is not clear if (or in which time frame) it will be possible to fully return to security limits (it depends on the gravity of the alert and the possible risk of cascading events). The system is viable and operated within the acceptable operating constraints, however, in this case the system parameters are very close (still within or just beyond) to the security limits. The dispatchers have difficulties returning to a normal state due to existing network or load/generation margin constraints, and the situation is potentially dangerous.

Back-up Protection ..... protection device(s) which form part of the overall protection scheme, with the purpose of taking over protection functions for (one or more) network elements, in case of malfunction of primary protection or in case of primary protection being blocked for any operational reason.

Black Start Capability..... the capability of a generator to start operation and produce electric power without external voltage source.

Connection point ..... point in the network at which the grid user installation is to be connected; this point is defined and agreed upon by the TSO or DSO and grid user.

Critical operating state ..... an operating state entailing that compulsory load shedding has been applied and that further production shedding and network divisions may occur.

In the critical system state, the system is not stable and its ”natural” evolution (phenomena such as tripping in cascade, frequency drop, loss of synchronism, power cuts, islanding may occur) tends to bring it to an insecure and uncontrollable situation. Global security of the whole interconnected power system is endangered. Exceptional actions such as load shedding may be further necessary to limit spreading of the dangerous phenomena and prevent the collapse of part of or the whole power system. In this state, the system goes rapidly towards highly endangering conditions of operation with system parameters out of the limits fixed for operational security.

Frequency control ..... capability of a generation unit to control frequency and maintain stable operation.

Generator ..... an active element of the electric power system. A generator is a device which transforms mechanical or other energy sources into electric energy.

House load operation ..... operation of a generation unit with its own auxiliary system as its only load, when the unit is disconnected from the external power system.

Island Operation ..... operation of a generator (or a group of generators) without synchronous connection (i.e. disconnected) from the grid.

Interconnection ..... a line (circuit) / or a set of lines (circuits) between two control areas or between two synchronous areas. An interconnection between two control areas can be an AC or a DC one. If the connection is a DC one it is always necessary to have an AC/DC and DC/AC conversion at both ends of the line. An interconnection between the two synchronous areas is assumed to be a DC one.

Isolated grid operation ..... independent operation of a part of the power system that is isolated after its disconnection from the interconnected system, having at least one generation unit in operation with the ability to frequency control.

Load shedding ..... the disconnection of load from the synchronous power system, usually performed automatically, to control the system frequency in emergency situations.

Network collapse ..... after network collapse, all loads in one or more parts of the control area are shed and further production shedding and network divisions can occur.

Normal state ..... an operating state entailing that all consumption and production is in balance and requirements on ancillary services and framework conditions are met, frequency, voltage and electric power flows are within their predefined and allowed limits (thresholds) and reserve margins are sufficient. In normal state, the electric power system can withstand disturbances like unplanned outages without losing its functionality and without supply interruptions.

Operating states ..... are → *normal state*, → *alert (disturbed) operating state*, and → *critical operating state*; when the electric power system function and synchronous operation are interrupted, it is the state of → *network collapse*; an improvement of system operating states towards the normal state is achieved by → *restoration*.

Regulated Third Party Access (rTPA) the way of access to the electric power transmission and distribution networks, where the rules and procedures for access are specified in advance, the access process is under the supervision of the NRA and the agreed and pre-defined standards and rules are in place and apply for any grid user; with the rTPA, there is no individual negotiation on any part of the grid access procedures.

Restoration state ..... a transition between the → *operating states* characterised by the normal operating conditions in the network being restored, production being regulated, and frequency, voltage and/or transmission being restored to within predefined and allowed thresholds. During restoration, consumption is connected at a pace which the restored network and generation resources can accommodate.

Significant Consumption Unit a consumption unit which exceeds a certain size in terms of overall load within the control area. The criteria for the definition of the significant consumption unit shall be agreed upon within the control area and communicated to the TSOs across the synchronous area.

Significant Generation Unit Significant generation unit refers to those generators which are specified as of particular importance for power system operation for one or more of several reasons: provision of the ancillary services, size in terms of installed generation capacity vs. overall installed capacity in the control area, primary energy source, or others. The criteria for the definition of the significant generation units shall be agreed upon within the control area and also to the highest possible extent within the synchronous area.

Annex 1 – ERGEG

The European Regulators for Electricity and Gas (ERGEG) was set up by the European Commission in 2003 as its advisory group on internal energy market issues. Its members are the energy regulatory authorities of Europe. The work of the CEER and ERGEG is structured according to a number of working groups, composed of staff members of the national energy regulatory authorities. These working groups deal with different topics, according to their members' fields of expertise.

This report was prepared by the Electricity Network and Market Task Force of the Electricity Working Group.

Annex 2 – List of abbreviations

Term	Definition
ACER	Agency for the Cooperation of Energy Regulators
3rd Package	new Electricity Directive 2009/72/EC, ACER Regulation (EC) 713/2009 and new Electricity Regulation (EC) 714/2009 of the European Parliament and of the Council
CEER	Council of European Energy Regulators
DSO	Distribution System Operator
ENTSO-E	European Network of Transmission System Operators for Electricity
ERGEG	European Regulators Group for Electricity and Gas
FG	Framework Guidelines according to the 3rd Package
GGP	Guidelines of Good Practice
NRA	National Regulatory Authority
PSS	Power System Stabilizer
rTPA	regulated Third Party Access
TSO	Transmission System Operator