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Framework Guidelines on Electricity System Operation

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Agency for the Cooperation of Energy Regulators
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This Document contains the Framework Guidelines on Electricity System Operation, which the Agency for the Cooperation of Energy Regulators (ACER) has prepared pursuant to Article 6 of Regulation (EC) No 713/2009 and on the basis of the request from the European Commission.

Related Documents

ACER/CEER/ERGEG documents

- "Framework Guidelines on Electricity Grid Connections", 20 July 2011, Ref: FG-2011-E-001; http://www.acer.europa.eu/portal/page/portal/ACER_HOME/Public_Docs/Acts%20of%20the%20Agency/Framework%20Guideline/Framework%20Guidelines%20On%20Electricity%20Grid%20Connections/110720_FGC_2011E001_FG_Elec_GrConn_FINAL.pdf

- "Framework Guidelines on Capacity Allocation and Congestion Management for Electricity", 29 July 2011, FG-2011-E-002; http://www.acer.europa.eu/portal/page/portal/ACER_HOME/Public_Docs/Acts%20of%20the%20Agency/Framework%20Guideline/Framework_Guidelines_on_Capacity_Allocation_and_Congestion_M/FG-2011-E-002%20(Final).pdf

- "ERGEG Guidelines of Good Practice for Operational Security in Electricity ", ERGEG, 27. November 2008, Ref. E08-ENM-02-04, http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_PAPERS/Electricity/2008/E08-ENM-02-04_GGP-OpS_2008-11-28.pdf

- "Implementing the 3rd Package: next steps", CEER/ERGEG, 18 June 2009, Ref. C09-GA-52-06a, http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_PAPERS/Cross-Sectoral/2009/C09-GA-52-06a_Imlementing_3rdpackage_18-Jun-09.pdf

- "The lessons to be learned from the large disturbance in the European power system on the 4th of November 2006", ERGEG, 7. February 2007, Ref. E07-BAG-01-05, http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_PAPERS/Electricity/2007/E06-BAG-01-06_Blackout-FinalReport_2007-02-06.pdf

- ACER Work Programme 2011, http://www.acer.europa.eu/portal/page/portal/ACER_HOME/The_Agency/Work_programme/ACER%20Work%20Programme%202011.pdf

- System Operation, Initial Impact Assessment, http://www.acer.europa.eu/portal/page/portal/ACER_HOME/Stakeholder_involvement/Public_consultatations/Closed_Public_Consultations/PC-05%20-%20FG%20on%20System%20Operation/Consultation_document/SO_IIA_15072011.pdf

External Documents

- European Commission: mandate for starting the work in the area of system operation, Reference ENER B2/MS/mta/1074923, 22 December 2010

- Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC.
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:211:0055:0093:EN:PDF

- Regulation (EC) No 713/2009 of the European Parliament and of the Council of 13 July 2009 establishing an Agency for the Cooperation of Energy Regulators.
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:211:0001:0014:EN:PDF

- Directive 2008/114/EC on the identification and designation of European critical infrastructures and the assessment of the need to improve their protection, 8 December 2008.
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:345:0075:0082:EN:PDF

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1 General Provisions

1.1 Scope

These Framework Guidelines aim at setting out clear and objective principles for the development of network code(s) pursuant to Article 6(2) of Regulation (EC) No 714/2009 (henceforth referred to as the “Electricity Regulation”).

The network code(s) developed according to these Framework Guidelines will be applied by electricity *system operators* and *significant grid users*, taking into account possible public service obligations and without prejudice to the regulatory regime for cross-border issues pursuant to Article 38 of Directive 2009/72/EC (henceforth referred to as the “Electricity Directive”) and to the responsibilities and powers of regulatory authorities established according to Article 37(6) of the Electricity Directive.

The network code(s) will be evaluated by ACER, taking into account their degree of compliance with these Framework Guidelines and the fulfilment of the following objectives: maintaining security of supply, supporting the completion and functioning of the internal market in electricity and cross-border trade, delivering benefits to the customers and facilitating the EU’s targets for penetration of renewable generation.

The Framework Guidelines focus on issues of electric power system and network operation (henceforth referred to as “System Operation”), covering the areas pursuant to Article 8 (6) (a), (d), (e), (f) of the Electricity Regulation.

All *Transmission System Operators*’ (*TSOs*) actions with regard to *system operation* within a *synchronous area* or between them could bear cross-border character due to law of physics. Rulebooks on *system operation* already exist in the different *synchronous areas*, but the debate with the Expert Group[1] revealed problems that have not been tackled by these rules – prominent example is the event on 4 November 2006[2] – hence, a more coherent framework is needed.

Table 1 below is an important part of the Initial Impact Assessment (IIA) document and displays the level of harmonisation for each of the System Operation topics.

[1] Ad Hoc Expert Group for electricity system operation, http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_ACTIVITIES/Input_to_Framework_Guidelines/Electricity/Operational%20Security/Ad%20hoc%20expert%20group

[2] Cascading line trippings, initiated in Germany, resulted in splitting of the UCTE synchronous zone into 3 areas. A severe frequency drop in the Western part of the UCTE grid caused an interruption of supply for more than 15 million European households.

<table>
<tr><th colspan="2" rowspan="2">Objectives</th><th colspan="6">Topics (from high to low priority)</th></tr>
<tr><th>Operational Security</th><th>Operational Planning & Scheduling</th><th>Load-Frequency-Control</th><th>Staff Training & Certification</th><th>Emergency & Restoration</th><th>New Applications</th></tr>
<tr><td>1</td><td>To operate the electrical system in a safe, secure, effective and efficient manner</td><td rowspan="4">(C1): Full EU-wide harmonisation provides strong frame for the more detailed System Operation topics.</td><td>(A): Different historical development paths will be considered by standardisation on synchronous area level.</td><td>(A): Standardisation on synchronous area level is reasonable and has progressed far, but some gaps are still left to cover.</td><td rowspan="3">(C1): Full EU-wide harmonisation builds a strong base for cooperation and coordination, but also development of System Operation tasks on European level.</td><td>(A): Standardisation on synchronous area level is reasonable and has progressed far, but some gaps are still left to cover.</td><td rowspan="4">(C2): Full EU-wide harmonisation builds a strong base for future development of System Operation tasks on European level. Due to the strategic character of this topic the issues to be harmonised are more structured processes than detailed terms.</td></tr>
<tr><td>2</td><td>To apply same principles for different systems</td><td>(C1): Full EU-wide harmonisation builds a strong frame for the Operational Planning & Scheduling details.</td><td>(C1): Full EU-wide harmonisation builds a strong frame for the Load-Frequency-Control details.</td><td>(C1): Full EU-wide harmonisation builds a strong frame for the Emergency & Restoration details.</td></tr>
<tr><td>3</td><td>To enable the integration of sustainable technologies</td><td rowspan="2">(A): Standardisation on synchronous area level is reasonable, especially as sustainable technologies (e.g. generation from renewables) are strongly depending on the natural resources and compensation for the volatile generation profile has to be solved synchronous area-wide.</td><td rowspan="2">(B): Some crucial issues have to be agreed on EU level.</td><td rowspan="2">(B): Some crucial issues have to be agreed on EU level.</td></tr>
<tr><td>4</td><td>To make full use of information and communication technologies</td><td>(B): Level of freedom for specific synchronous area tools by nevertheless stating common European principles.</td></tr>
</table>

Policy options
(A) Standardisation at synchronous area level
(B) Partly standardisation at EU level
(C1) Full EU-wide harmonisation with detailed framework
(C2) Full EU-wide harmonisation with a structured process

Table 1: Levels of harmonisation (for details refer to IIA document)

The network code(s) for System Operation shall elaborate on relevant subjects that should be coordinated between *TSOs*, as well as between *TSOs* and *Distribution System Operators* (*DSOs*); and with *significant grid users*, where applicable.

The network code(s) for System Operation shall ensure provision of an efficient functioning of the interconnected transmission systems to support all market activities.

1.2 Structure

The basis for the issues covered in these Framework Guidelines is the Initial Impact Assessment (IIA), especially the identified problems, related objectives and preferred policy options for achieving the objectives and solving the problems. Here we provide a brief summary of the problem identification, policy objectives and preferred policy options. These are explained in more detail in the related IIA document.

The debate on System Operation problems with the dedicated Expert Group revealed specifically the growing amount of distributed and intermittent generation capacity, influencing *system operation* up to the transmission network, and more generally the increasing interdependence of *control areas* and both resulting in the need for more information.

Therefore, focus is to be laid on the three key challenges:

- To define harmonised security principles;
- To clarify and harmonise *TSOs*' roles, responsibilities and methods; and
- To enable and ensure adequate data exchange.

The following objectives for these Framework Guidelines were set out, to address the identified challenges:

- To operate the electric power system in a safe, secure, effective and efficient manner;
- To enable the integration of innovative technologies;
- To apply same principles for different systems;
- To make full use of information and communication technologies in a safe way.

These Framework Guidelines are structured to cover five main topics. The Operational Security embodies some of the core aspects of these Framework Guidelines and will, for this purpose, be deemed as umbrella topic, covering high level principles, procedures and relations while also overarching the following more detailed topics:

- Operational Planning and Scheduling;
- Load-Frequency-Control;
- Staff Training and Certification;
- Emergency and Restoration.

It is expected that some strategic issues will further evolve over the coming years (e.g. due to higher proportion of RES, higher demand responsiveness, development of new technologies related i.a. to storage), which will impact *system operation*. Therefore, a separate section, New Applications, addresses the need for an appropriate flexibility of the network code(s) in relation to innovation in electric power *system operation*, maintenance and control.

The structure and the development flow of these Framework Guidelines are presented in Figure 2 below.

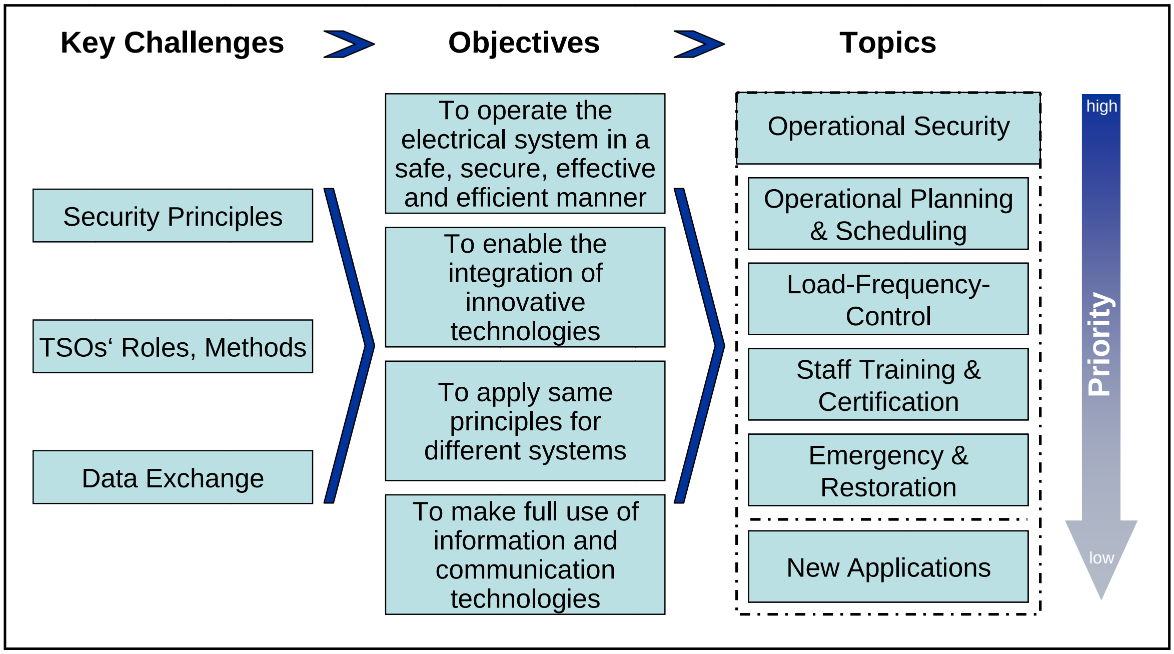

Figure 2: Structure and development flow of the Framework Guidelines on Electricity System Operation

Hence, the provisions in these Framework Guidelines on minimum standards and requirements for System Operation are organised around the following topics and priorities:

Priority 1
- Topic 1: Operational Security

Priority 2
- Topic 2: Operational Planning and Scheduling
- Topic 3: Load-Frequency-Control
- Topic 4: Staff Training and Certification
- Topic 5: Emergency and Restoration

Priority 3
- New Applications

Each topic is presented in a table, characterised by the following aspects:
- Scope and Objectives
- Criteria
- Methodology and Tools
- Roles and Responsibilities
- Information Exchange
- Implementation Issues

1.3 Links and dependencies

There is close interrelationship between issues related to System Operation, grid connection, cross-border capacity allocation and congestion management, grid development and maintenance, obligations for data provision and the functioning of *balancing* and reserve power markets. In drafting the network code(s) the European Network of Electricity Transmission Operators for Electricity (ENTSO-E) should take into consideration, at least, the following existing requirements and proposed separation of issues in drafting the network code(s):

- **Grid connection -** Issues affecting mainly *system operators*, with less role for *grid users*, are addressed in these Framework Guidelines. Issues involving the active participation by *grid users* are mainly addressed in the Framework Guidelines on Electricity Grid Connections (EGC FG).

- **Cross-border capacity allocation and congestion management -** Issues dealing with the integration, coordination and harmonisation of congestion management regimes in order to facilitate cross-border electricity trade are addressed in the Framework Guidelines on Capacity Allocation and Congestion Management for Electricity (CACM FG). An exception is the technical aspects of scheduling and date interoperability which are dealt with in these Framework Guidelines.

- **Balancing and reserve power markets -** Issues dealing with the integration, coordination and harmonisation of balancing and reserve power markets are addressed in the Framework Guidelines on Electricity Balancing (EB FG). Nonetheless, optimising the use of reserve power and *balancing*, and integrating balancing and reserve power markets require a strong coordination between *TSOs* operating the system and may necessitate an improved operational cooperation in terms of load-frequency-control and operational planning and scheduling, which should be taken into consideration when drafting the relevant network code(s).

- **Network development and maintenance -** The requirement for ENTSO-E to produce non-binding Community-wide and regional ten-year network development plan(s) (EU-TYNDP) in accordance with Article 8 of the Electricity Regulation and for *TSOs* to produce national ten year network development plan(s) (N-TYNDP) in accordance with Article 22 of the Electricity Directive.

- **Obligations for data provision -** there are several pieces of existing and proposed legislation which place obligations for data provision on *system operators* and *significant grid users*. These Framework Guidelines deal primarily with the sharing of data between *system operators* and between *system operators* and *significant grid users* to ensure *operational security*, for *operational planning and scheduling* and to enable *TSOs* within a *synchronous area* to have a complete view of the real-time status of (the relevant part of) the transmission network within that *synchronous area* in all *operating states*.

Issues which are relevant to more than one Framework Guidelines are as a minimum mentioned in all the relevant Framework Guidelines and specified in more detail where necessary. This approach, in the interests of completeness and clarity on important issues, may result in some duplication amongst different Framework Guidelines.

In drafting the relevant network code(s) ENTSO-E shall ensure that they are appropriately coherent and compatible.

1.4 Definitions

For the purposes of these Framework Guidelines, the definitions contained in Article 2 of the Electricity Directive and Article 2 of the Electricity Regulation shall apply. Within that context, the terms 'network', 'system' or 'grid' refer to both transmission and distribution. Where applicable, the difference is explicitly emphasised. The following definitions are intended to clarify the provisions of these Framework Guidelines and are without prejudice to definitions included in the network code(s).

- **Alert Operating State** – an operating state of the power system which entails that all demand is met and that the frequency, voltage and load flows are within the defined technically permitted limits/thresholds, but not all reserve margins' requirements are fulfilled and disturbances (unplanned outages) could lead to further deterioration of system state. In this *operating state*, the power system is stable and all operational reserves (transmission capacities and remedial actions) are mobilised. There is no specific time frame for the system to return from this *operating state* to *normal operating state.*

- **Ancillary Services** - services necessary to support transmission of electric power between generation and load, maintaining a satisfactory level of *operational security* and with a satisfactory quality of supply. The main elements of ancillary services include active and reactive power reserves for balancing power and voltage control. Active power reserves include automatically and manually activated reserves and are used to achieve instantaneous physical balance between generation and demand. Further elements of ancillary services may include black-start, inertial response, trip to houseload, spinning reserve and islanding capability. In the liberalised market, many *ancillary services* are contracted by *TSOs* from selected *grid users* that qualify for providing these services.

- **Balancing** - all the actions and activities performed by a *TSO* in order to ensure that in a *control area* total electricity withdrawals (including losses) are equalled by the total injections in a continuous way, in order to maintain the system frequency within a predefined stability range.

- **Blackout** – a state of the power system characterised by partial or total absence of voltage in the transmission power system with consequences abroad and triggering *TSOs restoration* plans. A blackout can be partial (if a part of the system is affected) or total (if the whole system is collapsed). From this state, *restoration* is undertaken with stepwise reenergising and resynchronising of the power system.

- **Common Grid Model** – a computational model of the grid which, as a minimum, shall be suitable for EU-wide application and cover an area appropriate for the capacity calculation method used, at least the *synchronous area*. The *common grid model* shall include a detailed description of the transmission network, including the location of generation units and demand as well as the configuration of all switchable or adjustable elements.

- **Control Area** - a coherent part of a *synchronous area*, operated by a single *TSO* (*control area* responsible), physically delimited by the power interexchange metering points, providing *load-frequency-control* and *ancillary services* to physical loads and generation units connected.

- **Critical Operating State** – an *operating state* of the power system entailing that the system security constraints are violated, there are no measures left and any further disturbance (e.g. unplanned outage) can lead to a system breakdown or *blackout*. Furthermore, automatic load shedding might have been applied to some degree and that further loss of generation or parts of network may occur.

- **Distribution System Operator (DSO)** – see *System Operators*

- **Grid Users** – all users connected to the transmission or distribution grids.

- **Interconnection** - line (circuit) or a set of lines (circuits) between two *control areas* or between two different *synchronous areas*; an *interconnection* between two *control areas* can be an AC or a DC one, whereas an *interconnection* between two *synchronous areas* can only be a DC one or a back-to-back converter station.

- **Load-Frequency-Control** – aims at maintaining balance between generation and load, measured by the quality of frequency (i.e. keeping frequency as close as possible to the nominal value). *Load-frequency-control* consists of manually activated (e.g. tertiary control in ENTSO-E Continental Europe) and automatically activated (e.g. primary and secondary control in ENTSO-E Continental Europe) control actions.

- **New Grid Users** – *grid users* not considered as *pre-existing grid users*.

- **Nominal Frequency** – 50.00 Hz. Outside exceptional periods for the correction of deviations recorded between electrical clocks following system frequency and astronomical (UTC) time, the set-point or scheduled frequency coincides with the *nominal frequency*.

- **Normal Operating State** – an *operating state* of the electric power system entailing that all generation and load are in balance, requirements on *ancillary services* and framework conditions are met. Moreover in the *normal operating state* frequency, voltage and load flows are within their predefined and allowed technical limits and reserve margins are sufficient.

- **Operating State** – the conditions of electric power system in real-time and are characterised by the degree of fulfilment of *operational security criteria*. There are three *operating states* (*normal, alert and critical*). When the power system is returning from *alert* or *critical operating state*, it is in *restoration*.

- **Operational Planning and Scheduling** - activities and tasks which are conducted prior to real-time operation. These activities include preparation of schedules for exchanges of power across *control area* borders and planning within *control areas*, *transmission capacity calculations*, preparation of re-dispatch measures where applicable, coordination of protection settings, planned outages (maintenance) and any necessary grid topology/configuration changes.

- **Operational Security** – a measure of the electric power system operational parameters' against the defined normal operating conditions and of the electric power system capability to return to the *normal operating state* as soon as possible. Security limits define the acceptable operating boundaries (thermal, voltage and stability limits).

- **Pre-existing Grid Users** – *grid users* connected to the transmission or distribution *grids* before entry into force of the first release of network code(s) developed according to these Framework Guidelines.

- **Restoration** – a transition from the *alert* and *critical operating states* to the *normal operating state*. During *restoration* after a major disturbance or supply interruption, demand is re-connected at a pace which the restored network and generation resources can accommodate.

- **Security Analysis** – analysis to determine the *operational security* ex ante or during the real-time operation. *Security analyses* include e.g. contingency analyses, which compute the impact of unplanned outages on *operational security*, according to relevant *security criteria*, using load-flow algorithm, voltage stability analyses (steady state or transients), etc.

- **Security Criteria** – requirements and framework for the electric power system *security control*.

- **Security Control** – control actions aiming to maintain the power system in the *normal operating state* or as close as possible to the *normal operating state*, contributing to the maintenance of the *operational security*. In the event of security degradation, it aims at returning the system as close, fast and efficiently as possible to the *normal operating state*.

- **Significant Grid Users** – *pre-existing grid users* and *new grid users* which are deemed significant on the basis of their impact on the cross border system performances via influence on the *control area's* security of supply including provision of *ancillary services*.

- **Synchronous Area** – an interconnected electric power system, characterised by a common operating frequency and implemented as a set of synchronously interconnected transmission *networks* (*control areas*)

- **System Operators** – the *Transmission System Operator (TSO)* and the *Distribution System Operator (DSO)*, in their roles and responsibilities to implement and enforce the relevant network code(s). This term refers also (when written in normal case) to the operating staff at the control room, e.g. control engineers and shift leaders.

- **System Operation** – all activities for operating an electric power system, including security, control and quality in terms of relevant technical standards, principles and procedures, but also the synchronous operation of interconnected power systems.

- **System Protection** - all measures (activated automatically and manually) to prevent or minimise damage to the environment (i.e. persons, nature, business, etc.) caused by the failures and/or unplanned outages in the electric power system and to protect its functioning and components. *System protection* also includes special protection schemes.

- **Transmission System Operator (TSO)** – see *System Operator*

- **Transmission Capacity Calculation** – the determination of the cross-border capacity available to the market, based upon the electrical and physical realities of the network.

All definitions and terms are in *italic* applied throughout the document.

1.5 Application

The network code(s) shall establish minimum standards and requirements related to System Operation. In developing the network code(s) ENTSO-E should take into consideration the rulebooks on System Operation that already exist for each *synchronous area*. The network codes on system operation shall be drafted with due attention to the network code amendment process. In particular, ENTSO-E shall ensure that where possible the rules are sufficiently generic to facilitate incremental innovation in technologies and approaches to system operation being covered without requiring code amendments.

The network code(s) shall take precedence over the relevant national codes and international standards and regulations, without prejudice to the Member States' right to establish national rules which do not affect cross-border trade. Where there are proven benefits, and if compatible with the provisions of the network code(s), any national codes, standards and regulations which are more detailed or more stringent than the network code(s) should retain their applicability.

Where the minimum standards and requirements, introduced by the network code(s) deviate significantly from the current standards and requirements, there should be a cost-benefit analysis performed by ENTSO-E that justifies this deviation and demonstrates additional benefits from the proposed standard or requirement.

The cost-benefit analysis should be provided to stakeholders when ENTSO-E consult on the network code(s). The cost-benefit analysis should be submitted to ACER alongside the network code(s) and will be taken into consideration by ACER in providing its opinion on the network code(s).

1.6 Roles and responsibilities

The network code(s) shall apply to *system operators* and all *significant grid users* already, or to be, connected to the transmission or distribution network. Any *grid user* not deemed to be a *significant grid user* shall not fall under the requirements of the network code(s).

For the purpose of these Framework Guidelines *DSOs* shall be treated as *grid users* where they have to comply with the *TSO's* requirements in the network code(s). They are treated as *system operators* where they implement network code(s) provisions with respect to *significant grid users* connected to the distribution system or in undertaking *system operation* actions. Unless otherwise stated, reference to *DSO* implied *DSO* as *grid user*.

The approach to establishing *significant grid users* is set out in the Framework Guidelines on Electricity Grid Connections, and relevant details shall be set out in the network code(s) developed according to the Framework Guideline on Electricity Grid Connections.

1.7 Derogations

For minimum standards and requirements that impact on *significant grid users*, the derogation process set out in the Framework Guidelines on Electricity Grid Connections, and to be established in the network code(s) developed accordingly, shall apply.

For *system operators* there shall be no possibility for a derogation from the requirements of the network code(s) developed according to these Framework Guidelines.

The network code(s) may state that the provided requirements are not applicable for a specific system operator or a group of system operators (e.g. an isolated system or a synchronous area). These cases must be duly justified by ENTSO-E.

1.8 Adaptation of existing arrangements to the network code(s)

System operators and relevant *significant grid users* shall amend all relevant clauses in contracts and/or all relevant clauses in general terms and conditions in accordance with the terms of the network code(s) on System Operation. The relevant clauses shall be amended within a fixed time limit after entry into force of the network code(s), defined in the network code(s), but not exceeding three years. This requirement shall apply regardless of whether the relevant contracts or general terms and conditions provide for such amendment.

The network code(s) shall provide a transition time within which *system operators* and relevant *significant grid users* have to apply the new standards and requirements. The transition period shall be consulted on with relevant stakeholders. In general the transition period should not exceed two years. Different transition periods for compliance can be set for *new grid users* and for *pre-existing grid users* and also for different minimum standards and requirements.

2 Minimum Standards and Requirements for System Operation

The key topics of System Operation cover diverse activities across varying ranges of the timeline and involve different level of detail. Operational Security includes overlaying issues such as security principle, voltage control, short circuit currents and angle stability. Other topics are more specific and go further into detail: Operational Planning and Scheduling are activities and tasks conducted prior to the real-time operation and include outage scheduling, day ahead congestion forecast (DACF) and intraday/extended real-time contingency analysis (which could be complemented with other *security analyses* e.g. voltage stability analysis), but also the commercial and *TSO* scheduling processes. Load-Frequency-Control covers all control aspects, namely primary, secondary and tertiary control. Staff Training and Certification deals with the specific human resource requirements for the operating staff. Emergency and Restoration includes awareness of the system *operating states*, defence plans and *restoration* of the system after a major disturbance or a *blackout*, but also the analyses of events afterwards. Finally, the issue of New Applications is concerned with future developments impacting System Operation, but due to the strategic, long-term aspect it remains less detailed.

Figure 3 below shows the key topics of System Operation and their relevant temporal ranges.

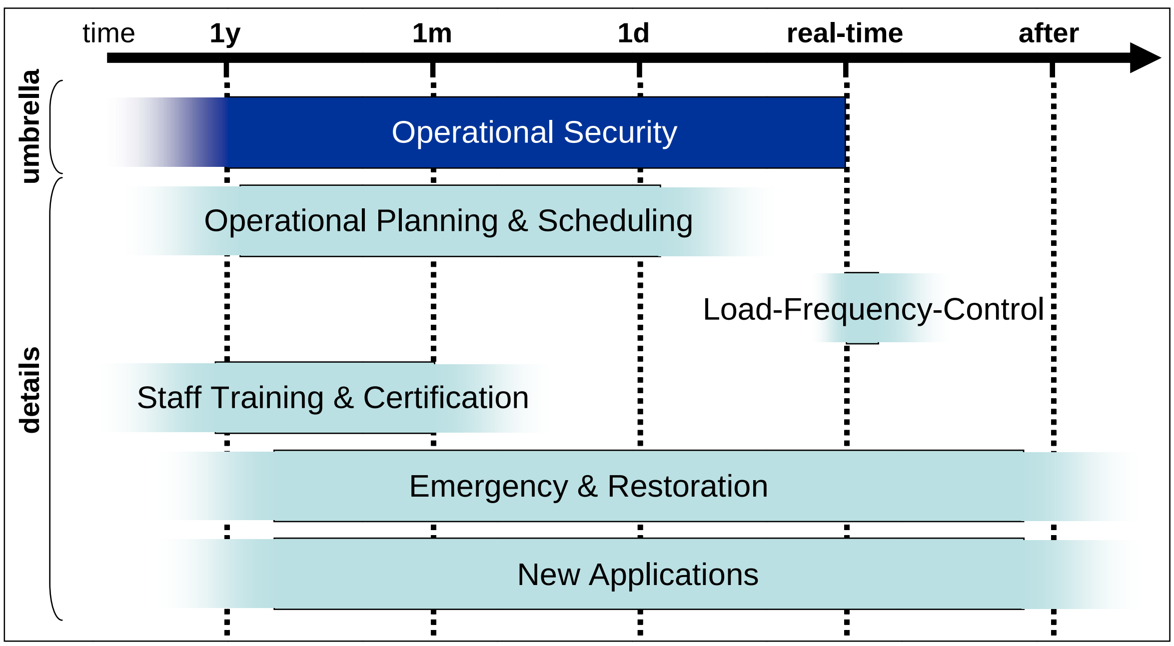

Figure 3: Key System Operation topics in time

General System Operation Characteristics	
Scope and Objectives:	Achieving and maintaining normal functioning of the power system with a satisfactory level of security and quality of supply, as well as efficient utilisation of infrastructure and resources.
Criteria:	The network code(s) shall provide criteria (performance indicators) against which the quality of System Operation can be monitored. In particular, adequate criteria should be proposed for security of supply, quality of supply and for the quality of the data delivered as input for congestion management in comparison with the effective use of the transmission system represented by real-time data. The network code(s) shall foresee the publication of a yearly report by ENTSO-E on the evolution of *system operation* performance. This report shall provide a detailed assessment of the performance per country, including the selected performance criteria and their evolution over time. The format and content of the report shall be approved by ACER.
Methodology and Tools:	The network code(s) shall define common principles, requirements, standards and procedures within *synchronous areas* throughout the EU. Network code(s) shall be in line with experiences, best known operational practices and lessons learnt from experiences. No provision in the network code(s) shall prevent market arrangements being used for the provision and use of *ancillary services*.
Roles and Responsibilities:	In addition to provisions set out in Chapter 1.6 the network code(s) should further clarify the roles and responsibilities related to System Operation, especially considering differences in the tasks of *TSOs* and *DSOs* (e.g. caused by national obligations).
Information Exchange:	The network code(s) shall define a harmonised standard for timing and content of information (real-time and other) between *TSOs* and/or *DSOs* within ENTSO-E as well as outside of ENTSO-E, where applicable. The network code(s) shall set the requirement for *DSOs* to execute the instructions given by the *TSOs*. Further, the network code(s) shall define for every *significant grid user* • which information it is obliged to provide to the *TSO* or *DSO* that, it is connected to, and how this data shall be provided, • requirements to be able to receive and to execute the instructions sent by the *TSO* and/or *DSO* to ensure the *operational security* of the system. The *TSO* and the *DSO* shall agree how these instructions are delivered in practice. This applies also for those *DSOs* connected to another *DSO's* network. Obligation for data delivery: The *significant grid users* are obliged to provide the *TSOs* with information required for System Operation. The network code(s) should lay down the necessary enforcement measures in case of non-compliance of the *significant grid users* with this obligation. The *TSOs* are obliged and entitled to exchange the information provided by *significant grid users* with other *TSOs* for reasons of *operational security*. In doing that, the *TSOs* should fully respect data protection laws and regulation, most notably the requirement of not disclosing the received data to any market participant but only to the affected and responsible *TSOs*. *System operators* should

	be allowed to establish an equally reliable and credible information exchange regime by considering other data sources in a more efficient way. Network codes shall set out the transparency requirements for TSO's actions with a significant impact to market functioning and to ensure non-discrimination between grid users.
Implementation Issues:	The network code(s) shall be elaborated and be modified in a coherent and coordinated way, taking into account forthcoming changes and challenges caused by increasing cross-border exchanges, changes in technology and socio-economic developments.

Topic 1: Operational Security	
Scope and Objectives:	Ensuring – on a high level – coherent and coordinated behaviour of interconnected transmission networks and power systems in each *control area* and between *control areas* under *normal operation state*, in *alert* as well as in *critical operating states.* Achieving and maintaining a satisfactory level of *operational security* allowing for efficient utilisation of the power system and resources, including, but not limited to, the necessary inputs to congestion management and *balancing.* Avoiding further deterioration of *operational security* in cases, where security constraints are violated and systems are not in *normal operating state*.
Criteria:	The network code(s) shall provide criteria (performance indicators) against which the Operational Security can be monitored.
Methodology and Tools:	The methodology used in the network code(s) shall be fully transparent and obligate the *TSOs* relevant to the matter to cooperate in relevant issues. The network code(s) shall define: • Coherent minimum *security criteria*, which are mandatory within a *synchronous area;* • *Operational security* rules, which shall be aligned as far as technically possible and economically beneficial throughout the EU, irrespective of *synchronous area* borders; • Appropriate minimum technical and organisational standards and requirements applicable for *operational security*, covering e.g. aspects of state estimation; *security analyses*, data exchange and SCADA (Supervisory Control and Data Acquisition) *systems*; • Roles and responsibilities of *TSOs* and *significant grid users* in all *operating states*, including actions to be taken; • Coordination requirements with other *TSOs* and other *significant grid users;* • Requirements in relation to the relevant system parameters, criteria and technical aspects in order to contribute to *operational security*, in particular referring to: - *Security criteria* (e.g. contingency analysis); - *Normal* vs. *alert* vs. *critical operating state;* - Frequency and voltage parameters; - Requirements for voltage and reactive power management; - Short-circuit current requirements, provisions and coordination; - Rotor angle stability requirements, provisions and coordination; - Requirements for coordination and information on protection settings. The definitions of *operational security* requirements shall always include the essential aspect of need for security of persons and goods. In order to perform efficient and effective *operational planning* and *transmission capacity calculation*, it is essential that the network code(s) provide for a unique timing and contents of the *common grid model* and harmonised schedule for individual *TSO* data exchange. The network code(s) shall also contain all the necessary provisions

	applicable to *significant grid users* that are connected to distribution networks, so far as they affect the *operational security* of the *network*. These provisions shall be agreed upon by the *TSO*s and the concerned *DSO*s (i.e. in order to ensure applicability for the *significant grid users* connected at *DSO* level, in which case the *DSOs* has an obligation to submit the positive results of the conducted compliance tests to the *TSOs*). To achieve coherent and coordinated behaviour of, particularly but not limited to, each *synchronous area* under *alert operating states* as well as in *emergency operating states* the network code(s) shall provide for *TSO*s` coordination in terms of joint remedial and *restoration* action plans.
Roles and Responsibilities:	The network code(s) should aim at a minimum set of *operational security* provisions that must be met by any affected *TSO, DSOs* or *significant grid user*. *TSOs'* coordinated remedial action plans including cost sharing principles shall be submitted to national regulatory authorities (NRAs) for approval.
Information Exchange:	The network code(s) shall define the timing and content of data exchange between TSOs, among *TSOs and DSOs,* between *TSOs/DSOs* and *significant users* and among adjacent *DSOs* for: • The *common grid model*; • Issues related to secure *system operation*, such as detection of *security criteria* violation; • Real-time information on network configuration and the status of *significant grid users*; • Matters of significance for the security of supply, such as information from *TSO*s regarding when they can no longer comply with an *operational security* provision (i.e. real-time and mid-term).
Implementation Issues:	The network code(s) must consider existing differences in *operational security* requirements between the *synchronous areas* and hence, define the procedure for smooth and undisturbed transition to a harmonised state. The network code(s) shall list all links necessary from *operational security* perspective to other relevant network code(s).

Topic 2: Operational Planning and Scheduling	
Scope and Objectives:	Ensuring coherent and coordinated behaviour of transmission networks and power systems in preparation of real-time operation. Achieving and maintaining a satisfactory level of *operational security* and efficient utilisation of the power system and resources.
Criteria:	The network code(s) shall provide criteria (performance indicators) against which the Operational Planning and Scheduling can be monitored.
Methodology and Tools:	The network code(s) shall define: • Principles, requirements and methodology for: - Performing security analyses (contingency analysis, voltage stability analysis, etc.) at each relevant stage of operational planning. The provisions shall ensure that System Operation meets *security criteria* under any simulated operating conditions consistent with security assessment, and that the operation of the interconnected *control areas* is not jeopardised; - State estimation, to be implemented as required for supporting the *security control* and maintaining the *operational security*, including periodical (with sufficiently short time periods) checks in order to ensure a consistent and errorless input data set for other computations like load-flows, *security analyses*, etc; - Determining the specific reliability margin, required to cope with uncertainties relevant to System Operation, and which uncertainties are covered by the reliability margin. Consistency between reliability margins for *system operation* and *transmission capacity calculations* shall be ensured; - Prevention and/or remedy of disturbances and blackouts on incidents which can affect neighbouring *control areas* or the *synchronous areas*; - Scheduling planned outages and relevant maintenance works of transmission network, significant generation and *DSOs*' elements, including a coordinated and agreed (among the affected *TSOs*) scheduling process for long-term and short-term planning; - Ensuring access to an adequate level of *ancillary services* (e.g. active and reactive power reserves, balancing power) in real-time to meet *security criteria* and the requirements set at *synchronous area* level, for each *operational planning* stage; - Calculation of requirements on different categories of control reserves with the aim to optimise these requirements within synchronous area to meet the *security criteria* with minimum costs; - Exchange of *ancillary services* across *interconnections* in terms of technical principles; - Coordination of reactive power control with significant cross-border impact; - Coordination of short circuit current between *TSOs* at *interconnections*; - Coordination of commissioning and entering into operation of active and reactive power control network elements with significant cross-border impact. In particular, reactive power control elements installed

	at each end of cross-border lines shall be coordinated; • Obligation for data delivery → See Information Exchange. • In relation to the CACM FG and the respective network code(s), principles and requirements for the implementation and operation of the *transmission capacity calculation* methods at the different time frames. In this respect, the coherence between the preparation of a *common grid model* and the assessment of relevant reliability margins shall be ensured. Specifically, reliability margin calculations shall take into consideration all pertinent assumptions made in due course of preparation of the *common grid model* and *transmission capacity calculation* in order to cope with model/method inaccuracies and relevant uncertainties efficiently.
Roles and Responsibilities:	The network code(s) shall foresee that the *TSOs* coordinate their *operational planning* activities at regional, *synchronous area* and EU level – as technically necessary and within the most appropriate entities – in order to ensure meeting the objectives of secure System Operation and applying the most appropriate measures to prevent and/or remedy system disturbances.
Information Exchange:	The network code(s) shall describe - for the different time frames - the principles for exchange of all necessary information between *system operators* to handle the different planning and scheduling activities in a coordinated and cooperative manner. This includes all necessary data to construct a proper *synchronous area*-wide *common grid model*. *TSOs* shall be provided with up-to-date information on the development of *grid* components and configuration, also by *significant grid users*, especially as regards planned and unplanned outages and their technical ability to provide *ancillary services*;
Implementation Issues:	The network code(s) for Operational Planning and Scheduling are related to the CACM FG and EB FG, and the respective network code(s); thence, the overlapping issues shall be dealt with consistency.

Topic 3: Load-Frequency-Control	
Scope and Objectives:	Real-time operation of an electric power network requires a balance between generation and load, whereas deviations impact the system frequency. Hence, Load-Frequency-Control is a core task of System Operation, with the main features: • Ensuring coherent and coordinated behaviour of transmission networks and power systems in real-time operation; • Achieving and maintaining a satisfactory level of frequency quality and efficient utilisation of the power system and resources.
Criteria:	The key criteria for the adequacy and effectiveness of the *load-frequency control* shall be the quality of frequency, in terms of range of frequency deviations from the nominal value and how often within a defined time period these deviations occur. Criteria shall be defined in terms of technical needs, taking market requirements in due consideration.
Methodology and Tools:	The network code(s) on system operation provide a set of basic frequency and active power control requirements (i.e. ensuring that comparable conditions apply for all *significant grid users* and for all *control areas*) as far as technically possible and economically beneficial throughout the EU, irrespective of *synchronous area* borders. These should respect the interactions between load frequency control, balancing mechanisms and intraday markets. A detailed, common specification of these requirements should apply for the EU mainland, but is not necessarily applicable to 'small isolated systems', as described in Article 2.26 of the Electricity Directive as well as to small *synchronous areas* with a weak *interconnection* - network code(s) shall define these latter areas, exclusively applicable as regards technical System Operation scope. The network code(s) shall define: • Definitions of the various terms used in relation to *load-frequency-control* within the different *synchronous areas* (e.g. primary, secondary and tertiary control in ENTSO-E Continental Europe or manual and automatic reserves in ENTSO-E Nord); • Technical features of different levels of *load-frequency-control* in terms of timeframes, reserve power used and the reaction times in the different *synchronous areas*; • Frequency quality criteria; • Appropriate minimum standards and requirements applicable to *system operators* and *significant grid users* - so as to monitor, control and secure each *synchronous area's* operation and minimise deviation from *nominal frequency* resulting from imbalance between generation and demand; • Requirements for the *system operators* with regard to implementation of e.g. controllable generation, load characterisation and demand side management. For cross-border usage of *load-frequency-control* reserves (e.g. usage of secondary and tertiary control in ENTSO-E Continental Europe) the *operational planning and scheduling* provisions from these Framework Guidelines shall apply too.
Roles and	The network code(s) shall foresee that the *TSOs* coordinate their *load-*

Responsibilities:	*frequency-control* activities at regional, *synchronous area* and EU level – as technically necessary and within the most appropriate entities – in order to ensure meeting the objectives and applying the most appropriate measures to prevent and/or remedy system disturbances.
Information Exchange:	The network code(s) shall describe the principles for exchange of all necessary information between System Operators to handle the different *load-frequency-control* activities in a coordinated and cooperative manner. This includes lessons learnt from the event of 4 November.2006 (see 'related documents').
Implementation Issues:	The application of minimum standards and requirements to *significant grid users* predating network code(s) implementation should be defined in terms of both cost-benefit and organisational analysis. The network code(s) for Load-Frequency-Control are related to the Framework Guidelines and network code(s) on Electricity Balancing and hence, the overlapping issues shall be harmonised.

Topic 4: Staff Training and Certification	
Scope and Objectives:	The transmission system operators working at control rooms must be properly trained to make decisions in ensuring secure and efficient network operation. The aim is to develop and maintain the transmission system operators' skills adequately. Common training principles and standards – and finally certification – shall enable better cooperation and coordination up to European level. The certification shall extend to the *TSO* organisation and lead transmission system operators in charge (control room shift staff). Where appropriate, and to improve joint understanding of common processes *TSO*s shall invite *DSOs* and *significant grid users* (such as generators) to participate in the training.
Criteria:	The key criteria for Staff Training and Certification shall include the following: • Control room staff has sufficient skills to maintain the secure network operation at all times and in different network conditions. • The transmission system operators concerned have appropriate knowledge of market effects and sufficient skills in English language to carry out their tasks in cooperation with neighbouring TSOs' transmission system operators.
Methodology and Tools:	The network code(s) shall define: • The necessary competencies, qualifications and experience for control room staff and staff responsible for the training of control room staff. Role profiles and responsibility levels shall be defined and documented at least in English. • A training and certification process, including: - An assessment by the responsible *TSO* of the qualification of a candidate to perform the tasks of a transmission system operator*;* - Minimum requirements for the training content (initial and continuous training) and qualification criteria obligatory for all *TSOs*; - A training plan, containing theory, simulator training, practice lessons and on-the-job training for network operation under different network situations - inter-*TSO* sessions should also be part of the programme; - Training schedules, considering initial and continuous training, but also other educational activities. Continuous training programme shall include advanced theory, training on extreme and exceptional situations, more simulator work and 'lessons learnt'; - Evaluation of training progress and success, featuring a written document as a base for the certification; accompanied by regular assessments of knowledge, skills and performance; - Criteria, issuing process and validity period for the certification (initial and renewed), which authorises the transmission system operator to work in the control room; - A proper 'train the trainer' process, to ensure that trainers have adequate training both in their specific area and in pedagogical skills; - A high-level flow chart of all training processes as an overview; - Requirements for resources (e.g. staff and time).

	• Standards and requirements for system models and tools, covering all *synchronous areas*. The training simulators (working environment plus models and tools) should, as far as necessary and appropriate, resemble the control room equipment including the comprehensive national database with respective data from neighbouring networks at a sufficient level; • English as standard common language for communication related to the documentation and exchange of information in pursuance of the network code(s); • A process for monitoring the effects of training and common HRD (human resources development) activities and adjusting procedures and processes where appropriate; • Co-ordination and co-operation needed among the *TSOs* resulting in: - Regular inter-*TSO* trainings, workshops, visits and secondments, especially for neighbouring *TSOs;* - Regular meetings on European level aiming at distributing operational knowledge, exchanging lessons learnt and discussing upcoming challenges. • Training requirements for *TSO-DSO* (and other market participants, where applicable) co-ordination and co-operation, including workshops on specific topics, where needed. • Retention of evidence of training for monitoring. The certificates shall be issued either by a qualified, independent organisation, or alternatively a process shall be defined by the respective *TSOs* adhering to the key requirements in the network code(s) and ensuring high level of quality, objectivity, independence and sufficient transparency for regular compliance. Each *TSO* shall define further details (e.g. advanced qualification criteria) and where required, additional measures.
Roles and Responsibilities:	The *TSOs* are responsible for the assessment, selection, advancement and adequate assignment of their operating staff. ENTSO-E shall actively coordinate (e.g. develop a framework for coordination and monitoring) the training and certification tasks at European level.
Information Exchange:	*TSOs* shall exchange operational experience within ENTSO-E, and especially with their neighbouring *TSOs*. This exchange of information includes regular joint training between neighbouring *TSOs* to improve knowledge of characteristics of neighbouring grids as well as communication and coordination between transmission system operators of neighbouring *TSOs*.
Implementation Issues:	The network code(s) shall define the implementation process and timeline including the transition period (e.g. initial training needs' analysis and assessment, pilot training plan, initial role profiles) and regular monitoring.

Topic 5: Emergency and Restoration	
Scope and Objectives:	The remedial actions may include e.g. the activation of active or reactive power reserves, automatic load shedding or any other emergency measure. Recovery or *restoration* from the *alert* or *critical* to the *normal operating state* shall occur as fast, effectively, reliably and efficiently as possible in order to avoid new disturbances and/or further deterioration of system security. Ensuring that all efforts in *restoration* after a major disturbance or a blackout are well coordinated and led by the *TSOs* within a *synchronous area* and that no individual measures or attempts to *restoration* of supply adversely affect the overall common goal of the re-establishment of System Operation as soon as possible.
Criteria:	The key criteria for emergency and *restoration* shall include at least the following: • Share of alert situations – and finally severe disturbances and *blackouts* – handled in an optimised manner, based on the existing power system and resources; • Evidence of training, simulations, tests and exercises executed to demonstrate proper emergency and restoration plans; • Emergency prevention and *restoration* plans shall – besides technical needs – consider cost-benefit issues on macroeconomic and market level.
Methodology and Tools:	*TSOs* shall maintain emergency and *restoration* plans and have regular training for emergency and *restoration*, including actions across borders, where appropriate. The network code(s) shall define: • The criteria for assessing when the power system is in the *normal operating state* and when it diverges from the normal state. This shall be defined for each *synchronous area* and shall be communicated between the *synchronous areas* and EU-wide, respectively within ENTSO-E; • The process, principles and main characteristics for the elaboration of predetermined emergency and *restoration* plans and related activities on *synchronous area* level. The principles should be agreed at EU-level. Specific needs of *grid users* based on national regulation should be taken into account with a high priority level in the elaboration of *restoration* plans (e.g. fast power restoration on nuclear plants). • Application of the *restoration* plans and procedures for remedial actions; • Principles and characteristics which cause the *operating state* to differ from the *normal operating state*, e.g. out-of-range disturbances, flows in the transmission network and on *interconnections*; active power reserves (automatically and manually activated reserves); reactive power reserves; status of network control system and stability of the system (voltage, frequency and angle); • Load shedding procedures, involving *DSOs* where necessary, including criteria and taking into account local islanding provisions, responsibilities and efficiency evaluation, but also the design of automatic load shedding systems. A non-discriminatory, transparent and efficient manner of the load shedding shall be ensured;

	• Common principles in *system protection* settings to ensure system security, efficient usage and reliability (also during *critical operating state* and *restoration state*); the related procedures shall be co-ordinated among *TSOs* to ensure interoperability within and between *synchronous areas*. *System protection* shall limit the consequences of operational disturbances to a minimum; • Minimum requirements to inform *significant grid users* in case of *alert* and *critical operating states*. Duties of *significant grid users* in such situations shall be clearly stated. • Procedure for restoration of regular market operations after technical *restoration*. *TSOs* shall ensure access (contracted or otherwise procured) to sufficient black-start capacities and islanding capabilities to allow for the efficient and fast *restoration*. The *restoration* plans are to be evaluated and maintained/adjusted by *TSOs* regularly and their operating staff shall be trained to manage these exceptional incidents. *TSOs* shall develop procedures to test the *restoration* plans. The process for this shall be described transparently and communicated to all involved parties by *TSOs*.
Roles and Responsibilities:	The *TSOs are* responsible for remedial actions in the case of disturbances within their power systems and shall enforce orders (within the context of maintaining the electric power system *operational security* and integrity) to *significant grid users* in order to efficiently restore the *system operation.* For each *interconnection TSOs* shall define a procedure and who is responsible, including responsibility boundaries. *Restoration* related organisation and procurement of black-start and islanding capabilities, as well as *ancillary services* shall be assigned exclusively to the *TSOs*, which shall have the duty and power to decide on any subsequent applicability at the *DSO* level. This is important in order to prevent any contradictory measures which might occur if *restoration* is attempted at the same time from the transmission and distribution level. The *DSOs* shall support the *restoration* according to the plan. In a *critical operating state* the *significant grid users* shall comply with instructions from *TSOs* and participate in emergency planning, *restoration* procedures and exercises planned and carried out by *TSOs*. *TSOs'* coordinated *restoration* plans shall be submitted to regulatory authorities for opinion.
Information Exchange:	The network code(s) shall foresee minimum requirements for *blackout*-proof communication in case of emergency and *restoration*. Any synchronous system-wide event shall be analysed by the *TSO*s and communicated to ENTSO-E, market participants and relevant regulatory authorities (ACER and NRAs). The requirements and the data to be transmitted to the *TSO* are specified in the agreement concluded between the *significant grid users* and the *TSO* (or *DSO*) concerning connection and access to the grid.
Implementation Issues:	The network code(s) shall take in due account the obligations for *TSOs* in existing legislation at national and European level.

2.1 New Applications

The network code(s) shall be elaborated in such a way not to be detrimental to innovation in electric power *system operation*, maintenance and control. Where, forthcoming changes and challenges caused by further market integration and innovation in technology and organisation can be foreseen, they should be recognised and considered in network code(s) so as to ensure that system operation rules are in place to accommodate their integration. Among such trends the following issues should be taken into account:

- Integration and operation of a DC power-transport lines, used for "collecting" the massive wind power generation in the North and solar-thermal generation (CSP) in the South of Europe;
- Methods and tools enabling high-level and efficient *TSO* coordination during the *operational planning and scheduling* and real-time *system operation*. In particular, the adequate operational observability and control of electric power system, during the transition to low carbon society;
- Dynamic rating of power cables and overhead transmission lines;
- Close interaction of the future integrated electricity balancing markets of Europe with the intraday trade and manually activated (tertiary) reserves;
- Coordinated usage of FACTS for active load flow control and system stability augmentation;
- Advanced storage technologies;
- Smart applications (e.g. pooling of distributed generation, storage and demand response).

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