ACER
Agency for the Cooperation of Energy Regulators

Framework Guidelines on System Operation

Draft for consultation

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

The draft Framework Guidelines contained in this document are issued for consultation of ENTSO-E and other relevant stakeholders, who are invited to submit their comments by:

15 September 2011

by sending them to the following address:

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Related Documents

ACER/CEER/ERGEG documents

- "Pilot Framework Guidelines on Electricity Grid Connection", 7 December 2010, Ref: E10-ENM-18-04. http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_ACTIVITIES/Input_to_Framework_Guidelines/Electricity/Grid_Connection/Overview/E10-ENM-18-04_EGC-FG_7-Dec-2010.pdf

- Draft "Framework Guidelines on Capacity Allocation and Congestion Management for Electricity", 3 February 2011, Ref: E10-ENM-20-03; http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_ACTIVITIES/Input_to_Framework_Guidelines/Electricity/Congestion%20Management/Overview/E10-ENM-20-03_FG%20CACM_3-Feb-2011.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_ERGEG_PAPERS/Guidelines%20of%20Good%20Practice/Electricity/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_ERGEG_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_ERGEG_PAPERS/Electricity/2007/E07-BAG-01-05_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/Open_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 Codes pursuant to Article 6(2) of Regulation (EC) No 714/2009 (Electricity Regulation).

The Network Codes adopted according to these Framework Guidelines will be applied by electricity Transmission System Operators (TSOs) and other affected stakeholders, taking into account relevant public service obligations and without prejudice to the regulatory regime for cross-border issues pursuant to Article 42 of Directive 2009/72/EC and to the responsibilities and powers of regulatory authorities established according to Article 41(6) of Directive 2009/72/EC.

These Framework Guidelines focus on issues of electric power system and network operation, covering the areas pursuant to Article 8 (6) (a), (d), (e), (f) of Regulation (EC) No 714/2009.

All TSOs actions with regard to System Operation within a synchronous area or between them bear cross-border character due to law of physics. Rulebooks 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.

The Network Codes for System Operation adopted according to these Framework Guidelines will be evaluated by ACER, taking into account the 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, especially in relation to the development of the European day-ahead, intra-day and balancing markets;
- Delivering benefits to the customers;
- Facilitating the targets for integration of variable and distributed (renewable and other) generation.

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.

Objectives		Topics (from high to low priority)					
		Operational Security	**Operational Planning & Scheduling**	**Load-Frequency-Control**	**Staff Training & Certification**	**Emergency & Restoration**	**New Applications**
1	**To operate the electrical system in a safe, secure, effective and efficient manner**	(C1): Full EU-wide harmonisation provides strong frame for the more detailed System Operation topics.	(A): Different historical development paths will be considered by standardisation on synchronous area level.	(A): Standardisation on synchronous area level is reasonable and has progressed far, but some gaps are still left to cover.	(C1): Full EU-wide harmonisation builds a strong base for cooperation and coordination, but also development of System Operation tasks on European level.	(A): Standardisation on synchronous area level is reasonable and has progressed far, but some gaps are still left to cover.	(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.
2	**To apply same principles for different systems**		(C1): Full EU-wide harmonisation builds a strong frame for the Operational Planning & Scheduling details.	(C1): Full EU-wide harmonisation builds a strong frame for the Load-Frequency-Control details.		(C1): Full EU-wide harmonisation builds a strong frame for the Emergency & Restoration details.	
3	**To enable the integration of sustainable technologies**		(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.	(B): Some crucial issues have to be agreed on EU level.		(B): Some crucial issues have to be agreed on EU level.	
4	**To make full use of information and communication technologies**				(B): Level of freedom for specific synchronous area tools by nevertheless stating common European principles.		

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 Codes for System Operation must further consider:

- The TYNDP (Ten Years Network Development Plan) as general framework according to Regulation (EC) 714/2009 (7) and Chapter V, Article 22.1 of the Directive 2009/72/EC
- Aspects of balancing and reserve power markets and systems according to the Regulation (EC) 714/2009 (Art. 6.2 and 8.6)
- Aspects of maintenance cf. Chapter IV Article 12.a of Directive 2009/72/EC
- Grid connection issues according to the Article 14.1 of the Regulation (EC) 714/2009
- Congestion management aspects in line with the Article 16.3 of Regulation (EC) 714/2009 and the Capacity Allocation and Congestion Management (CACM) Framework Guidelines and related codes

The Network Codes 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 Codes for System Operation shall ensure provision of an efficient functioning of the interconnected transmission systems to support all market activities.

1.2 Application

These Framework Guidelines apply to System Operators of electric power transmission networks and all *significant grid users*.

The Framework Guidelines address the electric power transmission networks of the European Union (EU).

The Network Codes developed and entered into force upon Framework Guidelines have a prevailing character with regard to the relevant national and international codes. Where it is reasonable to do so, and as long as it is compatible with the provisions in the EU codes, national codes, standards and regulations which are more detailed or more stringent to the respective *System Operation* codes at EU level should retain their applicability.

1.3 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 criteria
- To clarify and harmonise TSOs' roles, responsibilities and methods
- 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

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 end Restoration

It is expected that some strategic issues will further evolve over the coming years (e.g. due to EU binding renewable energy targets, or following the recent political decisions towards shut-down of nuclear generation), which will impact System Operation. Therefore, New Applications shall cover the need for early harmonisation of future trends as far as possible today, leaving room for additional issues to be included later.

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

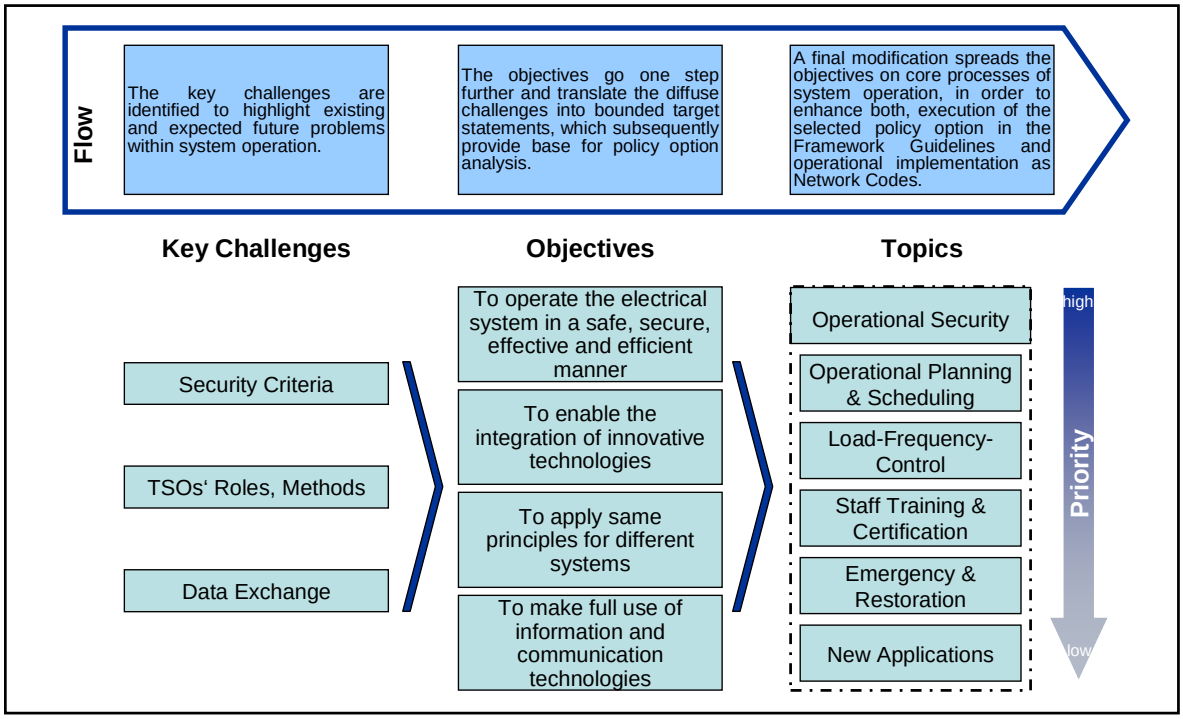

Figure 2: Structure and development flow of the System Operation Framework Guidelines

Hence, the provisions in these Framework Guidelines are organised in the following sections:

- Definitions and terms;
- Minimum standards and requirements for system operation

  The requirements are differentiated by topic and prioritised in terms of importance and urgency:

  Priority 1
  - o Topic 1: Operational Security

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

  Priority 3
  - o Topic 6: New applications

  Each topic is presented in a table, characterised by the following aspects,:
  - o Scope and Objectives
  - o Criteria
  - o Methodology and Tools

- Roles and Responsibilities
- Information exchange
- Implementation issues

1.4 Interfaces to other Framework Guidelines

Due to the close relations between a number of issues related to system operation, grid connection as well as capacity allocation and congestion management, the following criteria have been applied in deciding whether a specific issue is dealt with within these Framework Guidelines, the Framework Guidelines on Grid Connection (GC) or the Framework Guidelines on Capacity Allocation and Congestion Management (CACM):

- Issues affecting only System Operators, with no role for grid users, are addressed in these Framework Guidelines on System Operation;

- Issues involving active participation of grid users are addressed in the Framework Guidelines on Grid Connection and System Operation;

- Issues dealing with the integration, coordination and harmonisation of the congestion management regimes in order to facilitate cross-border electricity trade are addressed in the Framework Guidelines on CACM, with an exception of technical aspects of scheduling and data interoperability which are dealt with in these Framework Guidelines on System Operation;

- Issues which are relevant for more than one topic (SO, GC and/or CACM), are referred to in the relevant Framework Guidelines and, where applicable, also specified in more detail. Whereas this approach leads to some redundancy priority has been given to not omitting any important aspects.

- Real-time information sharing refers to information which is also within the scope of the Fundamental Electricity Data Transparency comitology guidelines. The purpose here is different, i.e. the information is primarily used by system operators and not by market participants. The Network Codes for System Operation should take account of information already required as part of these comitology guidelines, and only set out requirements for data and information that go over and above this. Moreover, the real-time information is also relevant for the Framework Guidelines on Grid Connection and will be addressed accordingly.

Furthermore, the European Network of Transmission System Operators for Electricity (hereafter referred to as ENTSO-E) shall ensure coherence and compatibility of the Network Codes with the provisions of the Framework Guidelines on Electricity Balancing Market (not yet issued).

2 Definitions and terms

The definitions and terms provided here serve the common understanding of different subjects addressed in these Framework Guidelines without prejudice to the Network Codes' definitions.

- **Alert (Disturbed) 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. In alert state, not all reserve margins' requirements are fulfilled and disturbances (unplanned outages) could lead to further deterioration of system state. In the alert state, the power system is stable and all operational reserves (transmission capacities and remedial actions) are mobilised. It is not clear in which time frame it will be possible to return to *normal operating state.*

- **Ancillary Services** - services necessary in support of transmission of electric power between generation and load, maintaining satisfactory level of *operational security* and with a satisfactory quality of supply. The main 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 ancillary services include black start and islanding capability. In the liberalised market, many ancillary services are procured by *TSOs* from the qualified and selected *grid users*, generators or loads.

- **Available Transfer Capacity** (**ATC)** - is a measure of the transfer capability remaining in the physical transmission network for further commercial activity over and above already committed uses. ATC is the part of *NTC* that remains available after each phase of the allocation procedure for further commercial activity.

- **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.

- **Bidding Zone** - an area which could be a part of the *control area* (in which case the respective balancing markets / systems must be aligned with the congestion management / redispatch systems), exactly the same as a *control area* or encompass several *control areas*, where market participants submit their bids for capacity allocation and congestion management between the bidding zone borders.

- **Black-Start Capability** - is the ability of a generating unit to go from a shutdown condition to an operating condition and start delivering power without assistance from the electric power system, it is connected to.

- **Common Grid Model** - as a minimum, the *common grid model* 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** - is 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. A *control area* may be a coherent part of a *control block* that has its own subordinate control in the hierarchy of *load-frequency-control.*

- **Control Block** - A *control block* comprises one or more *control areas*, working together in the load-frequency-control, with respect to the other *control blocks* of the *synchronous area* it belongs to.

- **Critical (Emergency) Operating State** – 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, the *critical (emergency) operating state* of the power *system* entails that 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 Operator*

- **Flow Based Capacity Calculation** – makes use of locational information in the grid model for the assessment of *system* security at the allocation stage without arbitrary assignment of capacity per border, and thus allows for better utilisation of transmission *network*.

- **Grid Users** – all users connected to the transmission or distribution grids – generation (all technologies), demand (including responsive demand), closed distribution systems and DSOs (as grid users connected to the transmission grid or to another distribution network)

- **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, what is 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.

- **Network, System, Grid** - within the context of these Framework Guidelines, the terms ‘network’, ‘system’ or ‘grid’ refer to both transmission and distribution. Where applicable, the difference is explicitly emphasised.

- **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 *system* entailing that all generation and load is 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.

- **Net Transfer Capacity (NTC)** - the NTC is the maximum total exchange program between two adjacent *control areas* compatible with security standards applicable in all *control areas* of the *synchronous area*, and taking into account the technical uncertainties on future network conditions. The NTC is defined as: NTC = TTC-TRM

- **Operating States** – stand for 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 (disturbed) and critical (emergency)*) and the state of '*restoration'* which stands for the power *system* in condition of *restoration* from any other state to the *normal operating state*.

- **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 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** – is a measure of the power *system* operational parameters' distance from the defined normal operating conditions and of the 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).

- **Restoration** – a transition between the *operating states* characterised by the nominal operating conditions being restored, demand and generation adequately balanced, and frequency, voltage and/or load flows being restored to within predefined and allowed technical thresholds. During restoration after a major disturbance or supply interruption, demand is connected at a pace which the restored network and generation resources can accommodate.

- **Security Analysis** – a process using various standard software applications in the TSOs' control centres to analyse and determine the overall system *operational security* ex ante or during the real-time operation. *Security analyses* include e.g. contingency analyses, where the impact of unplanned outages to operational security, relying on a specific security criteria, is computed using load-flows algorithm, voltage stability analyses (steady state or transients), etc..

- **Security Criteria** – contain requirements and framework for the power *system security control*. Although a great deal of expert knowledge is inherent in these criteria and a large portion of that knowledge is common to most EU transmission grids, there exist at present no fully standardised approaches.

- **Security Control** – aims to maintain the power *system* in the normal state or as close as possible to the normal state, serving thus the maintenance of the *operational security*. If security degradation occurs, it is the security control task to ensure return as close, fast and efficient as possible to the normal state. Effective and successful security control results in an adequate and sufficient security level.

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

- **System Operator** (SO) – refers here to both, the Transmission System Operator (TSO) and the Distribution System Operator (DSO), in their specific roles and responsibilities to run the electric power system and transmission network – both, AC and DC - according to the defined operational security and other requirements.
  This term refers also (when written in lower case) to the operating staff at the control room, e.g. control engineers and shift leaders.

- **System Operation** – covers the complete area of activities for operating an electric power *network*, including security, control and quality in terms of fixed 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 power *system* and to protect the power *system* functioning and components. *System protection* also includes special protection schemes.

- **Total Transfer Capacity (TTC)** - is the maximum exchange program between two adjacent *control areas* that is compatible with *operational security* standards applied in each *system* (e.g. Grid Codes) if future network conditions, generation and load patterns are perfectly known in advance.

- **Transmission Reliability Margin (TRM)** - is a security margin that copes with uncertainties on the computed *TTC* values arising from unintentional deviations of physical flows during operation due to the physical functioning of secondary control, emergency exchanges between *TSOs* to cope with unexpected unbalanced situations in real-time and inaccuracies, e. g. in data collection and measurements

- **Transmission System Operator** – TSO, see *System Operator*

- **Transmission Capacity Calculation** – see *NTC* and *Flow Based Capacity Calculation*

All definitions and terms are in *italic* in the following chapters.

3 Minimum Standards and Requirements for *System Operation*

The key topics of *System Operation* cover diverse areas of the timeline. ***Operational Security*** features overlaying issues like N-1 security principle, voltage control, short circuit currents and angle stability. The following 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 (N-1) contingency analysis (which could be complemented with other security analyses like 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 disturbances afterwards. Finally the topic **New Applications** is concerned with future developments impacting *System Operation*, but due to the strategic, long-term aspect this topic is less detailed in these Framework Guidelines.

Figure 3 below shows the key topics of *System Operation* and their temporal allocation.

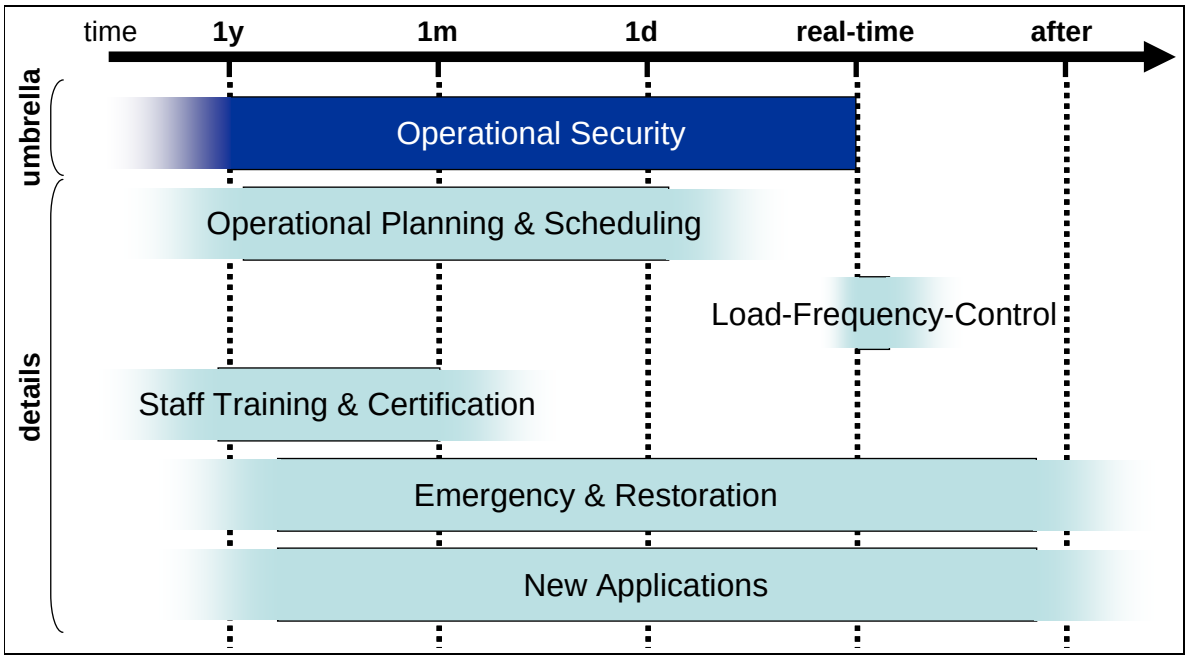

Figure 3: Key *System Operation* topics in time

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:	*System Operation* requirements shall: • Be evaluated and defined in terms of technical needs and cost/benefit and related organisational provisions. • Consider market needs. Where the minimum standards and requirements, introduced by the Network Codes deviate significantly (e.g in terms of cost- and risk-allocation) from the current international standards, procedures and requirements, there should be a cost/benefit analysis on the one hand that justifies this deviation and on the other hand demonstrates additional benefits from requiring the new standard. This could be elaborated in an impact assessment document, accompanying the respective Network Codes.
Methodology and Tools:	The Network Codes shall define common principles, requirements, standards and procedures within the *synchronous areas* throughout the EU. Network Codes shall ensure that the defined issues are in line with experiences, best known operational practices and lessons learnt, and shall be harmonised with other European and national level rules.
Roles and Responsibilities:	The Network Codes should 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 Codes shall define a harmonised standard for form and content of information (real-time and other) to other *TSOs* and/or *DSOs* within ENTSO-E as well as outside of ENTSO-E, where applicable. The Network Codes shall set the requirement for *DSOs* to execute the instructions given by the *TSO*. Further on the Network Codes must define for every *significant grid user* • which information it is obliged to provide to the *TSO* or *DSO*, 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 *grid users* are obliged to provide the *TSOs* with information required for *System Operation*. The Network Codes should lay down the necessary enforcement measures in case of non-compliance of the *grid users* with this obligation. The *TSOs* are obliged and entitled to exchange the information provided by *grid users* with other *TSOs* for security reasons.

	In that, the *TSOs* should fully respect data protection laws and regulation, most notably not disclosing the received data to any market participant but only to the affected and responsible *TSOs*.
Implementation Issues:	The Network Codes must 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. The Network Codes shall define a transition process, including at least time schedule, procedures and responsibilities. Where net benefits are negligible or enforcement cannot be justified for particular reasons (e.g. technical non-feasibility), existing users might be granted temporary or permanent exemption. This shall be documented and monitored.

Topic 1: Operational Security	
Scope and Objectives:	Ensuring – on a high level – coherent and coordinated behaviour of bulk transmission networks and power systems in each *control area* under *normal operation*, in *alert (disturbed) operating states* as well as in *critical (emergency) 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 *operational security* requirements shall be defined in terms of technical - but also market - needs and security of supply, considering cost/benefit and related organisational provisions.
Methodology and Tools:	The Network Codes 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 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. In order to perform efficient and effective *operational planning* and *transmission capacity* calculation, it is essential that the Network Codes provide for a unique format and contents of the *common grid model* and harmonised schedule for individual *TSO* data exchange. The Network Codes shall also contain all the necessary provisions applicable to *significant grid users* that are connected to distribution networks, as they affect the *operational security* of the transmission 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 Codes shall provide for *TSOs`* coordination in terms of joint remedial and restoration action plans.
Roles and Responsibilities:	The Network Codes should aim at a minimum set of *operational security* provisions that must be met by any affected *TSO* or *significant grid user*. *TSOs'* coordinated remedial action plans including cost sharing principles shall be submitted to regulatory authorities for approval.
Information Exchange:	The Network Codes shall define the timing and content of data exchange among *TSOs* 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 *TSOs* regarding when they can no longer comply with an *operational security* provision (i.e. real-time and mid-term).
Implementation Issues:	The Network Codes 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.

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 respective requirements shall be defined in terms of technical needs and efficient and effective procedures, including cost/benefit and related organisational provisions. Market needs shall be considered.
Methodology and Tools:	The Network Codes 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 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*; - 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. Principles regarding the use of cross-border capacity for active power reserves and voltage control across interconnections shall be included; - Coordination of reactive power control with significant cross-border impact; - Coordination of short circuit current between *TSO*s 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 Framework Guidelines on CACM and the underlying network codes, 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. Latter 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 Codes 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 Codes 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-wise *common grid model*. The TSOs shall be provided with up-to-date information on the development of grid components and configuration;
Implementation Issues:	The Network Codes for *Operational Planning and Scheduling* are related to the Framework Guidelines and Codes on Capacity Allocation and Congestion Management and hence, the overlapping issues shall be harmonised.

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. Requirements from the market shall be considered.
Methodology and Tools:	Frequency and active power control requirements shall be aligned at least at an abstract level (i.e. ensuring that comparable conditions apply for all *significant grid users* and for all *control areas*) as far as technically possible throughout the EU, irrespective of *synchronous areas*' borders. 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 Directive 2009/72/EC. The Network Codes shall define: • The various terms used related 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); • 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 and thresholds in detail, including tolerances • 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; • Criteria for the definition of *significant grid users*, based on a predefined set of parameters, which measure the degree of impact of these users on the system. The definitions of *significant grid users* shall be coordinated between adjacent *System Operators*; • Requirement of reserves that have to be available within the *control area* or a *control block* and within the *synchronous area* and levels of reserves that may be contracted outside of a *control area* or a *control block* – including a detailed methodology to calculate the requirements on different categories of control reserves; • TSOs' requirements for the implementation of controllable generation, load characterisation and demand side management.

	For cross-border procurement and usage of *load-frequency-control* reserves (e.g. for tertiary control in ENTSO-E Continental Europe) the *Operational Planning and Scheduling* provisions from these Framework Guidelines shall apply too.
Roles and Responsibilities:	The Network Codes shall foresee that the *TSOs* coordinate their *load-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 Codes 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 Codes implementation should be defined in terms of both cost/benefit and organisational analysis.

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 ensure smooth cooperation and coordination up to European level. The certification shall extend primarily to the *TSO* organisation and lead transmission *system operators* in charge (e.g. shift engineers).
Criteria:	Transmission *system operators* at the control rooms shall have skills to maintain the secure network operation at all times and in different network conditions. The transmission *system operators* concerned shall also have appropriate knowledge of market effects and sufficient skills in English language to carry out their tasks in cooperation with neighbouring *TSOs'* operators.
Methodology and Tools:	The Network Codes shall define: • Basic qualification and requirements, covering e.g. educational background, knowledge, skills and responsibility levels, for the role profiles of: - Transmission *system operators*, containing e.g. skills, which should be developed through practical work in the control room and through planned continuous training; - Functions needed with any *TSO* – necessary to develop, execute and monitor the training and certification process – like 'training coordination manager', 'training coordination team' and 'trainers'; • A training and certification process, including: - An assessment by the responsible *TSO* of the qualification of a candidate to perform the tasks of a *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; • 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. 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 Codes 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 and monitor) 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 system operators of neighbouring *TSOs*.
Implementation Issues:	The Network Codes 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, effective, reliable and efficient 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:	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 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 Codes shall define: • The criteria, 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; • Application of the restoration plans and procedures for remedial actions; • Principles and characteristics which cause the *operating state* to differ from the normal state, e.g. out-of-range disturbances, flows in the transmission network and on *interconnectors*; 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 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 (emergency) 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; • 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 power system operational security and integrity) to *significant grid users* in order to efficiently restore the *system operation.* For each interconnector 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 *system restoration* is attempted at the same time from the transmission and distribution level. The *DSOs* shall support the system 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 Codes shall foresee minimum requirements for black-out-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 Codes shall especially ensure harmonisation with obligations for TSOs in existing legislation at national and European level.

Topic 6: New Applications	
Scope and Objectives:	Addressing new requirements and future needs for respective consideration in the *System Operation* framework of the issues listed below should be covered by Network Codes. • Integration and operation of a DC bulk-power-transport lines, used for "collecting" the massive wind power generation in the North and solar-thermal generation (CSP) in the South of Europe that might occur in future; • Methods and tools enabling high-level and efficient TSO coordination during the *operational planning* and real-time *system operation*. In particular, the adequate operational observability and control of bulk electric power system, beyond transition to low carbon society, shall be timely ensured; • 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 needs to be specified. Also the basis for respective technical implementation should be provided; • Coordinated usage of phase-shifting transformers and / or FACTS for active load flow control and system stability augmentation. The Network Codes should also address the issues of integration of any other new technology that could be beneficial and have an influence on *System Operation*.
Criteria:	*To be defined as appropriate and when the specific New Applications are known in full detail*
Methodology and Tools:	
Roles and Responsibilities:	
Information Exchange:	
Implementation Issues:	