REPORT CONFIDENTIAL APPROVED VERSION 1.0

INTERCONNECTION GRID CODE FOR THE PAN ARAB ELECTRICITY MARKET

OPERATION CODE

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Shaping a Better Energy Future

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OC 1 Principles of the Operation of Interconnected Electricity Systems

J [1]. Even though each **TSO** has perfect knowledge of the **Operation** techniques, the interconnected **Operation** requires the adoption of key principles that shall be assumed as a common reference. Above all, this Chapter aims at avoiding misunderstandings about the scope and the responsibilities covered by this **Code**. The scope of this Chapter is to set a minimum but real harmonization of rules, tools and technical levels.

OC 1.1 Object and Scope

OC 1.1.1 The object of this **Code** is the **International Interconnection** in the Pan Arab **Region**. Its scope is the **Functional Operation** of the **Electricity Systems** in relation to the **International Interconnections**. The **Functional Operation** (hereinafter referred as "**Operation**" in the following of this **Code**) is related to the control of energy flows, the regulation of frequency and voltage, and any other activity of dispatching in real-time and **Operational Planning**. The **Physical Operation** is not part of this **Code**. The **Physical Operation** remains a responsibility related to the ownership of the assets and concerns maintenance procedures, safety, switching and the relations with the territory.

OC 1.1.2 The **Operation** of the tie lines and the portion of the **Transmission Systems** at the borders, affecting the **TTC** of the cross-border are part of this **Code** and the **National Grid Codes**. **TSOs'** internal matters, not affecting the **International Interconnection**, are regulated exclusively by the **National Grid Codes.**

OC 1.1.3 The aspects of the **National Grid Codes** affecting an **International Interconnection** shall be harmonized by the involved **TSOs.**

OC 1.2 Responsibility

OC 1.2.1 **TSOs** are responsible for the **SoS**, **SoO**, and economy of **Operation** of the **Electricity Systems**, under their competence in any phase of the **Operation** and any **Operating Condition** of the **Electricity System**. Their responsibilities concretely materialize in the decisions they take in the last phases of the **Operational Planning Process** and in real-time.

OC 1.2.2 **TSOs** are responsible for the effects of **Operation** of their own systems against other **TSOs** as far as balancing and the **Relevant Grid (RG)** are concerned, being

[1] **J**: Justification

the **Relevant Grid** the portion of the **TSOs' Grid** whose behavior most affects the security of the neighboring **Grids**.

OC 1.3 Solidarity, reciprocal support, mutual trust and cooperation

J. The cooperation in an interconnected framework can be carried out with a variety of attitudes and mind-sets. This code requires that **Member States** shall operate their **Electricity Systems** with a spirit of cooperation, fairness, and solidarity, showing readiness

OC 1.3.1 **TSOs** shall operate their **Transmission Systems** to pursue the technical advantages of the interconnected **Operation**, complying with the **Operation Security Standard** (**OSS**), as specified in OC 3.3.2of this **Code,** and to create the best conditions for cross-border energy trading according to the **General Agreement**. To this purpose, each **TSO** shall:

a) Use all internal resources to avoid spreading to the rest of the **Interconnected Members** any contingency that occurred in its **Electricity System**.

b) Bring back the cross-border **Actual Energy Transfers** as soon as possible but not later than a given time to the **Scheduled Energy Transfers** values in **Normal State** conditions – when imbalances occur in its **Electricity System** – and in **Emergency State** conditions – according to agreed procedures.

c) Keep intact the **International Interconnections** as much as possible in any **Operating Condition** of the interconnected **Electricity System**.

d) Agree with the neighboring **TSOs** on dedicated procedures to regulate if and when to open cross-border **International Interconnections**, both in **Normal** and **Emergency State** conditions, according to the line opening policy of this **Code**.

OC 1.4 Requirements

OC 1.4.1 Despite the technical and economic advantages that having **International Interconnections** brings to the **PAEM Electricity System**, the **Member States** shall use their **Best Effort** for reaching the highest levels of interoperability and a comparable rank to technical quality, mostly in controlling their **Electricity Systems**, in organization, skills and adopted tools.

OC 1.5 Relations with Regional Central Entities

OC 1.5.1 In a **Region** or a **Synchronous Area**, a central entity with the role of **Regional Coordination Entity** (RCE), defined as **Regional TSO/Market Facilitator** in the **GA** in Section 3.6, can be established. In this case, the **TSOs** continue to be responsible for the **Operation** against the rest of **TSOs** outside the **Region**, without prejudice of Article 3.6.2 of the **GA**.

OC 1.5.2 As per Sections 3.6 and 3.8 of the **GA**, the responsibilities in matter of **International Interconnection** toward the **TSOs** belonging to the same **Region** and sharing the same **RCE**, are governed by the regulations of the **RCE.** In such conditions, **TSOs** shall make aware in writing the rest of **TSOs** of the rules governing the **RCE** and the parts of **Operation** performed by the **RCE** on behalf of the **TSOs**.

OC 1.6 Policies on Security of Operation (SoO)

OC 1.6.1 *General Concepts*

OC 1.6.2 The **Security of Operation** (**SoO**) is the precondition to guarantee a seamless development of the **PAEM** and the quality of supply needed for the welfare of the Pan-Arab **Region**. **TSOs** shall guarantee the **SoO** according to standards compliant with **Security Policies** commonly agreed to in this **Code**.

OC 1.6.3 **SoO** shall be independent of the adopted market regimes. Security standards shall depend on the physical characteristics of the assets and the capability of the **TSOs** for controlling their **Electricity Systems**. Market objectives shall never induce the **TSOs** to infringe the **SoO** rules.

OC 1.6.4 **TSOs** shall never use the **SoO** rules to favor any participant to the **PAEM**. **TSO** members of an **RCE** may adapt the application of the **SoO** rules of this **Code** to the peculiarities of their **Regions**, if they are isolated **Synchronous Areas**. Such peculiarities include the degree of development of the **International Interconnection**, the criticality of the electricity services and the development phase in which the **Region** lies in a given period. The conditions and the adaptations of the security rules must be made known to the **TSOs**.

OC 1.6.5 Procedures for security assessment shall be agreed at **Synchronous Area** level or **Regional** level. As a norm:

a) Steady state load flow analysis should be adequate for routine and systematic day-by-day applications.

b) **Dynamic Security Assessment** (**DSA**) studies are recommended and confirmed at **Regional** level, at least for periodical verifications. **DSA** is recommended in situations where the **Electricity Systems** are extremely unloaded, and sources are far from loads. **DSA** shall include angle, frequency, voltage stability according to the latest **Good Utility Practices** and standards[2] and **PMU** analysis.

c) Short circuit studies are prescribed at least yearly or in particular cases in protection setting activity.

OC 1.6.6 *Gradual Compliance*

OC 1.6.6.1 **TSOs,** which are not fully complying with the requirements of this **Code,** shall self-certify their incompliances. They shall prepare an action plan to achieve the full compliance with this **Code**, its timeline and define actions for bridging the gap between the current situation and the fully compliant status. The action plan will specify the time needed for interfacing the **National Grid Codes** with this code and/or the adaptation of procedures and tools.

OC 1.6.6.2 Therefore, and in the spirit of a harmonic growth of the interoperability, **TSOs** accept a regulated **Compliance Monitoring Process** (**CMP**) to audit **TSOs** and assess:

a) the degree of compliance reached by the gradual implementation of the action plan; and,

b) the implementation of **Security Policies** of this **Code**.

OC 1.6.6.3 Only personnel of non-neighboring **TSOs** of proven skill are admitted to the audit activities

OC 1.6.6.4 If the national regulations are, directly or indirectly, the barrier to a full compliance on given topic, the time to solve the noncompliance shall take into consideration the time needed to harmonize this **Code** and the **National Grid Code**.

OC 1.6.6.5 Pursuant to Paragraph 3.3.1.3 of the **GA**, the **Pan-Arab ARC,** supported for the technical aspects and auditing activities by the **Arab TSOs Committee,** are entitled to perform the assessments of compliance of **TSOs** with this **Code.**

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[2] IEEE/Cigré JTF 2003

OC 1.6.7 *Tie-line Opening Policy*

OC 1.6.7.1 The **International Interconnection** links shall remain closed as much as possible. To this purpose:

a) The voluntary disconnection of a tie-line, even if temporary, cannot be implemented by the **TSOs** without consulting the neighboring **TSOs** due to the effects on the rest of the interconnected **PAEM Electricity System**.

b) The voluntary (manual or automatic) disconnection of tie-lines is permitted for maintenance and when the principle not to spread a contingency prevails over the principle of keeping the **International Interconnection** intact. In this case opening the line should be either the last resort to avoid generalized blackouts or a necessity of higher level.

OC 1.6.7.2 A tie-line may be open:

a) by fault protections;

b) for maintenance;

c) for safety and urgent environmental issue;

d) in case of fire, bush fires;

e) to perform islanding in the framework of the **Defense Plans**.

OC 1.6.7.3 Condition for permitting tie-lines to be open are:

a) that all cases are agreed and communicated before operating the circuit breakers;

b) that the neighboring **TSO** is warned in a traceable way before operating manual disconnections;

c) that, if automatic, settings and logics have been previously agreed.

OC 1.7 Control Matters Regulated by this Code

OC 1.7.1 To ensure the reliability of the interconnected **Operation** with minimum impact on **National Grid Codes**, the application of this **Code** concerns the following:

a) The rules on topics affecting the **LFC** in a **Synchronous Area** apply to the completely interconnected **Synchronous Area**, regardless to the voltage level.

b) The rules concerning the load flow control at the borders apply to the **Relevant Grid.**

OC 1.7.2 The extension of the **Relevant Grid** shall be agreed among the neighboring **TSOs.** The selection shall be based on the influence that it has on the security and on the cross-border congestions. The following aspects apply to the **Relevant Grid**:

a) The **Unavailability Plans**.

b) The **Contingency List**.

c) The **ATC/NTC** calculations.

d) The **SoO** standards,

e) The **WAPS**.

OC 1.8 Organization and Resources

J. As anticipated in the **GA**, sketching an organizational structure is crucial to give concreteness to the application of the **Code**. The following is a proposal without prejudice to the committees established at the **GA** level.

OC 1.8.1 Pursuant to Paragraph 3.4.2.2 of **GA**, and the **Arab TSOs Committee** decisions, it is recommended to share the activity in three streams. In the following Chapters, working streams are generically indicated as **Working Groups** for sake of clarity only.

a) **WG1-Operational Planning Working Group** tasked with the coordination of **Operational Planning**. **WG1**, in executing its duty can organize its activities by **Regions** or **Synchronous Areas**.

b) **WG2-Operation Committee Working Group** tasked with real-time control and related issues. The scope of **WG2** should include control room activities, training of physical operators, **AGC**, protection settings, **WAMS**, **WAPS** and operating procedures.

c) **WG3-ICT Committee Working Group** tasked with **ICT** matters and cybersecurity of the **SCADAs** and common **WAN** for **Real-Time Data Exchange**.

OC 1.8.2 The above-mentioned **Working Groups** have no **Operational** duties.

OC 2OPERATIONAL PLANNING

J. For the purposes of the market, the forecast of the **NTC** across the borders is as important as the forecast of the **Demand** for **TSOs**. The assessment of **NTC** depends on the **Maintenance Plans** of the **Grids** and the **Generation Fleet**. The complex interrelation among these factors requires coordination and optimization.

OC 2.1 General Requirements

OC 2.1.1 **Member States** shall keep the highest attention to the forecast activities and **Operational Planning** activities to cope with the high volatility of large volumes of energies exchanged by the **PAEM Operation**, and to prevent and manage shortage periods. For this purpose, simulations and intense exchange of reliable **Information** are required as well.

OC 2.1.2 Based on forecast, **Member States** are responsible for providing the coverage of the **Demand** and the amount of the necessary **Ancillary Services**. **Ancillary Services** include at least **Reserves**, frequency and voltage regulation, congestion management. This implies that the forecast processes shall take into account not only the **Demand** coverage but also the commitment of **Power-Generating Modules** needed in parallel to guarantee the **Ancillary Services**.

OC 2.1.3 An **Operational Planning Process** (**OPP**) shall be adopted by each **TSO** and should include two basic parts:

a) The process internal to each **TSO,** which is not requested to be shared**.**

b) The coordination of **Operation** with all the **TSOs** of the same **Region**, which has impact on **International Interconnection** as per this **Code**.

OC 2.1.4 The **OPP** shall guide the **TSOs** to issue and share, as far as the **International Interconnection** are concerned, the following:

a) The **Demand Forecast**.

b) The **Maintenance Plan** and the **Unavailability Coordination** of the **Elements** of the **Relevant Grid**.

c) The **Maintenance Plan** and the **Unavailability Coordination** of the **Power-Generating Facilities** only for the purposes of the **Adequacy** required to the **TSOs** according to Section 2.5 of the **GA**.

d) The **System Adequacy Forecast** i.e. the forecast of the ability of each control area to cover its **Demand**, including **Reserve** requirements and the agreed cross border **Energy Transfers** and the same for the whole **Synchronous Area**, considering the cross–border **Energy Transfers**, in the limits expressed in the following of this Chapter.

e) The measures to be taken in order to cope with any contingency and trips in the **Relevant Grid.**

f) The calculation of the **NTC**.

OC 2.1.5 Some guidelines on internal processes are also given in this **Code** to the sole purpose of making the results of various **TSOs** homogeneous and comparable.

OC 2.2 Demand Forecast

OC 2.2.1 The **Demand Forecast** is the primary input of the **OPP**. All **TSOs** shall share the **Demand Forecast** for its **Control Area** among the **TSOs** of the same **Synchronous Area** or **Region** according to the **Data Exchange** principles.
The **Demand** shall be predicted in daily, weekly and longer time horizons. **Demand Forecast** shall include values in energy and power, maxima and minima hourly, at least.
Daily **Demand Forecast** shall be at least at hourly detail (24 energy mean values).

OC 2.2.2 **TSOs** should perform the forecast of various kinds of **Demand** for their **Control Area**:

a) The physical **Demand**, losses included, i.e. the **Demand** to be covered by the sum of all the active power supplied by the **Power-Generating Facilities** installed in the **TSOs Control Area** plus the cross-border **Energy Transfers**.

b) The **Demand** covered by the conventional power **Generation** and the one covered by the embedded power **Generation**.

c) The **Demand** covered by the market, i.e. the one covered by the day ahead market.

OC 2.2.3 The forecast shall be based on historical series of data. Hence, the **TSO** shall acquire power **Demand** data from the **SCADA** and store them in **Operation** databases according to the kind of **Demand** to be calculated.

OC 2.2.4 The measures acquired by the **SCADA** can be complemented by the ones acquired from the **Metering Equipment**, especially for the embedded **Generation** forecast and actual values.

OC 2.2.5 The embedded power **RES**-based **Generation** can be calculated adopting correlation methods.

OC 2.2.6 The physical **Demand Forecast** shall be made available at **Bidding Zone** and disaggregated at node level to allow load flow simulations for security evaluations, when required by agreed market or security simulations at **Synchronous Area** level.

OC 2.2.7 In performing the duties related to security, **TSOs** can size the **Ancillary Services** based on their own independent **Demand Forecast**, but they shall never voluntarily overestimate the **Demand** to compensate a minor request of **Ancillary Services** or increase the security levels beyond the necessity.

OC 2.3 Maintenance Plan

OC 2.3.1 Each **TSO** shall guarantee the highest availability of the elements of the **Relevant Grid** also applying the **Good Utility Practices** and preserve at the best their assets.

OC 2.3.2 To this purpose each **TSO** shall elaborate its own **Maintenance Plan,** i.e. the coordinated schedule of maintenance works set up to reach the availability levels, that fit for the purpose. To avoid misunderstandings the maintenance activity, remains full responsibility of **TSOs** that are not obliged to disclose in detail.
The **Maintenance Plan** shall be scheduled in a coordinated **Unavailability Plan** which takes into account all the needs of the **International Interconnection** (e.g. **Demand** coverage, trading).

OC 2.3.3 ***Maintenance Management Guidelines***

OC 2.3.3.1 Each **TSO** shall schedule any maintenance work on the **Relevant Grid** with the following priorities as far as possible:

a) Concentrating, as far as possible, the maintenance activity in periods in which the **Energy Transfers** are statistically the lowest.

b) Pursuing the objective of the maximization of the cross-border **NTC/ATC**.

c) Minimizing the down time of the **Elements** of the **Transmission System**.

d) Avoiding causing more than once the same outage or the same capacity reduction for works that can be performed in parallel at the same time.

e) Avoiding causing scheduled outages at the borders in periods in which one or more of the **Interconnected Member States** are in under-capacity regime and asked the **TSOs** of the neighboring **Interconnected Member States** for support.

OC 2.3.4 *Types of Maintenance*

OC 2.3.4.1 For the purpose of this **Code**, maintenance includes two categories the **Preventive Scheduled Maintenance** and the **Corrective Maintenance**[3].

OC 2.3.4.2 The **Corrective Maintenance** can be in turn classified as:

a) *Deferrable*, if activity execution is performable at least one week later from detection of the anomalies without hazard for safety, environment or **Security of Operation**.

b) *Undeferrable*, if activity execution must be performed within the week, to avoid dangers to people, equipment or toward fault situation.

c) *After fault*, if a reparation activity is needed as a consequence of a fault.

OC 2.3.4.3 The **Elements** of the **Relevant Grid** are subject to the coordination process of the **Preventive Scheduled Maintenance**. **Corrective Maintenance** is regulated on weekly basis.

OC 2.3.4.4 The schedules are subject to the annual **Preventive Scheduled Maintenance** on the **Elements** of the **Relevant Grid** inter-**TSO** coordination and have to be included in the yearly schedules.

OC 2.3.4.5 Without prejudice to the respective **National Grid Codes, TSOs** shall assume the same priorities as per the **Relevant Grid** in the approval of the **Unavailability Plans** of the **Power-Generating Facilities**.

OC 2.4 Unavailability Coordination (Maintenance Requirements)

J. A high level of availability of the **Networks** is crucial for the security issues and for the development of the **PAEM**.

OC 2.4.1 Neighboring **TSOs** are obliged to guarantee with a coordinated schedule of the maintenance activity the continuity of the transmission services and the compliance with the applicable national laws.

OC 2.4.2 **TSOs** shall:

a) Never constrain the maintenance activity to services different from the electricity (e.g. optical fiber for public telecom service), i.e. priority to the electricity service has to be given.

[3] Cf. Cigré. Technical Brochure 660

b) Adopt efficient forecast and scheduling methods based on monitoring and historical data to increase efficacy of the maintenance processes.

c) Provide timely first aid support and reparations in case of unpredictable failures.

d) Be respectful of environmental sustainability.

e) Never disclose information that could turn out to be discriminatory of any participant to the **PAEM**.

OC 2.5 Unavailability Plan

OC 2.5.1 *Coordination Policies*

OC 2.5.1.1 At **Regional** level or **Synchronous Area** level, **TSOs** agree to fix the **Annual Maintenance Period (AMP)**.

OC 2.5.1.2 Within **WG1**, the **TSOs** of the **Region** appoint one of the **TSOs** of the **Region** or **Synchronous Area**, called **Area Coordinator of Planning (ACOP)**. The **ACOP** may be a **Regional Coordination Entity (RCE)**. In this case, and as long as the **Region** remains isolated, the involved **RCE** will present the conclusion of the plan of its area

OC 2.5.2 *Yearly Unavailability Planning*

OC 2.5.2.1 Each year, three (3) months before the beginning of the **AMP**, **TSOs** should provide their **National Annual Unavailability Plans (NAUPs)** to the **ACOP** for better coordination and information exchange only.

OC 2.5.2.2 An **Unavailability Plan** consists of the schedule of the **Outages** – regardless to the reasons – of the **Elements** of the **Relevant Grid** and the **Generation Fleet**. This schedule is optimized to cover the expected **Demand** with the associated needs for **Reserves** and the maintenance needs.

OC 2.5.2.3 Each **NAUP** should report under reasonable hypothesis on the available energy import, on weekly basis, if the internal resources will cover the **Demand** of each national **Electricity System,** guaranteeing the **Security of Supply** without jeopardizing the **Security of Supply**.

OC 2.5.2.4 The **NAUPs** shall include optimized unavailability schedules of the **Generation Fleet** and **Relevant Grid** lasting more than a number of days agreed among **TSOs** of the **Synchronous Area,** but not longer than 1 week. Such a schedule should coordinate the outages on the **Transmission System** with the ones on the **Generation Fleet** in order not to limit inefficiently the **Adequacy** and the cross-border **Transfer Capacity.**

OC 2.5.2.5 The **NAUPs** shall contain exhaustive information on every outage affecting the cross-border **Energy Transfers**. The information shall highlight at least the identification of the **Elements** of the **Electricity System**, the nature of the outage, its duration, the amount of MW involved and the estimated reduction of the **NTC/ATC**.

OC 2.5.2.6 Information on the **Generation** shall be in aggregated form, unless more detail is allowed by the **National Grid Codes** and agreed at **Regional** level if refer to third parties. In no case confidentiality may be breached.

OC 2.5.2.7 The **ACOP** and the representatives of each **TSO** of the **Region** shall collect and process the **NAUPs –** merged as a whole – with the twofold objective:

a) Facilitating the **TSO** cooperation to synchronize different interventions or shifting them.

b) Maximizing the **NTCs** border by border during the non-maintenance periods. The outcome of the process shall be the **Regional Annual Unavailability Plan** (**RAUP**).

OC 2.5.2.8 The **RAUP** is not binding. It is approved and issued by the **Arab TSOs Committee** under proposal of **WG1** and after the due iterations to guarantee the **Adequacy** of the **PAEM Electricity System** and published in an electronic bulletin edited by **WG1** one month before the beginning of the **AMP**. The **RAUP** includes non-binding indications to the **TSOs** to synchronize the **Outage** periods of the cross-border tie lines and **HVDC Systems**, in case of missing agreement on synchronization proposals.

OC 2.5.2.9 In cases where **Adequacy** is at risk, the **Arab TSOs Committee**, supported by **WG1**, triggers an alert procedure according to Sections OC 2.9 and OC 2.10.6.

OC 2.5.2.10 The **RAUP** shall become the reference for the weekly plans. As such any future change shall not penalize the involved **TSO** if declared 3 months in advance, or more.

OC 2.5.2.11 The **RAUP** shall be the basis for the final identifications of the periods of the year when the **NTC** may be reduced without penalties for the increased costs of the **Ancillary Services**.

OC 2.5.3 *Weekly Update of the Unavailability Plan*

OC 2.5.3.1 **TSOs** update the **Unavailability Plan** weekly. Every week "*w*", the **TSOs** shall:

a) Take in the list the new interventions to be carried out from *w+3* to the end of the **RAUP**.

b) Take into consideration the changes scheduled for *w+1* and *w+2* of those interventions already approved.

c) Cancel the approved maintenance works, which for any reasons cannot be processed as scheduled.

OC 2.5.3.2 Every week *w*, **TSOs** handle the **Corrective Maintenance** schedule by taking under consideration the works allocated during *w+1* or *w+2*, considering the evaluations of urgency. The following steps should be applied:

a) Coordination shall be guaranteed by video call chaired by the **ACOP**, if necessary.

b) Recommendations on safety shall be taken into consideration:

   i. pressure of market or continuity of supply never shall induce **TSOs** to infringe national safety rules and applicable **Operation** practices;
   ii. neighboring **TSOs** shall agree and be engaged to respect specific procedures for authorization;
   iii. other minimum requirements are reported in Chapter OC 10.

c) Every Wednesday by 4 p.m., the updated **RAUP** is published in the electronic bulletin.

OC 2.5.4 *Intraday Updating*

OC 2.5.4.1 Changes in programs, delays, and **Corrective Maintenance** urgencies are published in coordination with the market sessions. An open access repository is recommended to make all **TSOs** aware of the status of the **Electricity System**.

OC 2.6 NTC Calculation

OC 2.6.1 As per the **Scheduling & Dispatching Code**, the annual **NTC** calculations are part of the annual schedule. To this purpose, initially, at least four (4) values of **NTC** for import and four (4) values for export across each border should be calculated, assuming that the **Transmission System** is 100% available: peak and off-peak hour values in winter period (or other period to be agreed on) and peak and off-peak hour values in summer period (or other period to be agreed on).

The **NTC** represents the maximum transfer capacity that can be allocated across the borders of a **TSO**, in N-1 conditions. The calculation of **NTC** starts from the calculation other **TTC** and shall conform to the following:

a) Based on historical data of the previous year a typical hour of typical day is selected (**Snapshot**);

b) on the base of such hour the **Operation** data are retrieved, and each **Member State** builds up an **Individual Grid Model**;

c) the **Grid Models** shall consider the generators and elements of the **Relevant Grid** that will be unavailable for long period or will enter in **Operation** in the year under consideration;

d) The load flow shall consider the seasonal loadability limits;

e) The **Individual Grid Models** are merged in a **Common Grid Model**;

f) The **TTC** is increased by simulating an increase of **Generation** in the exporting **TSO** and a decrease of **Generation** in the importing **TSO** until no **Remedial Action** of the **Contingency List** is able to keep the systems in N-1 conditions.
The **NTC** is the **TTC** minus the **TRM**. In case a **TSO** has more than one border for the allocation purposes, the **NTC** has to be split among the borders.

OC 2.6.2 The annual period reductions of **NTCs** should be indicated in the days in which the **Relevant Grid** is intensely subject to maintenance. Annual values and days in which the **NTC** should be reduced, shall be published for the benefit of a transparent market operation by the **Arab TSO Committee**.

OC 2.7 Adequacy Assessments

J. The **Adequacy Assessments** is the evaluation of the indices of risk not to meet the **Demand**. The probabilistic approach in the adequacy assessments is preferable to correctly disseminate the concepts behind the **Operational Planning**.

OC 2.7.1 The **Adequacy Assessment** is the final step of the **Operational Planning** once the **Demand Forecast**, the **Unavailability Plans**, and the **NTC** have been made available.

OC 2.7.2 **Adequacy** in each **Control Area** level is fulfilled when the **Demand** is covered in energy and power, with a given probability, at any hour of the period with the resources of internal **Generation** available and import, plus adequate **Reserve** margins.

Adequacy is measured in terms of **LOLP** and **LOLE**. Target values in each **Synchronous Area** are agreed by **TSOs** within **WG1.**

OC 2.7.3 The **Adequacy Assessment** shall be considered a prerequisite for the strategies on reciprocal support and the **Load** curtailment preparation. Pursuant to Section 2.5 of the **GA**, assessments are carried out at any iteration of the planning process.

OC 2.7.4 **Adequacy Assessments** shall be based on reliable data, forecast and scheduling decisions at single **TSO**, **Synchronous Area**, **Regional** levels, and will result from the combination of the **Demand Forecast**, the availability of the **Power-Generating Facilities**, the availability of the **Transmission System**, and the market conditions.

OC 2.7.5 The degree of coverage of the **Demand** can be assessed by means of:

a) probabilistic methodology, viz. the **Reserves** associated to the fulfilment of pre-agreed levels of risk not to cover the load;

b) temporarily, by alternative simplified deterministic methods of analysis of the **Reserve** margins.

OC 2.7.6 Ad hoc studies should support the simplified methods proving the relation between the amount of **Reserve** needed and **Demand** and **Generation** mix.

OC 2.7.7 Methodologies based on probabilistic approach to assess **Adequacy** shall be put in operation no later than 2 years, after the date this **Code** enters into force. By the same deadline, the forecast **Adequacy Assessments** shall be based on the same definitions of the variables and comparable methodologies.

OC 2.8 Reserve Margins Assessment

OC 2.8.1 *Reserve Sizing*

OC 2.8.1.1 Each **TSO** is responsible to keep under control and procure resources to cope with unavailability of the **Power-Generating Facilities**, **Demand Forecast** errors, **RES** uncertainties and other probable events.

OC 2.8.1.2 **Reserves** in **Operation** are meant to be in both directions:

a) The **Upward Reserves** is defined as the difference between efficient power of **Generation** available minus the peak **Load** of the period. **Upward Reserves** are to be used to balance the **Electricity Systems** of the **Control Area** when the forecast shows that the **Load** could be higher than the available power **Generation** or to counteract **Generation** unavailability.

b) The **Downward Reserve** is defined as the difference between the minimum **Load** minus the sum of the technical minima of the **Power-Generating Facilities**, used to reduce the power **Generation** when the minimum **Demand** during off peak hours is expected to be lower than the minimum allowable **Generation** and to cope with overproduction of **RES**.

OC 2.8.1.3 **TSOs** in addition to the regulation of the **Reserves** to cover the **Demand,** shall assess the need of **Downward Reserve** also in relation to the penetration of **RES** which are not programmable and sometimes not even possible to be curtailed in case of overestimation, if small size **Power-Generating Facilities** are spread and embedded in the **Distribution System**.

OC 2.8.2 *Reserves for the Interconnected Operation*

OC 2.8.2.1 **Electricity Systems** of **Control Areas** may not be run without the **Reserves** needed for regulation (**Primary Reserve** or **Primary Spinning Reserve** and **Secondary Reserve** or **Secondary Spinning Reserve**) even in times of shortage. Therefore, they have to be included in the **Demand** in the calculations and in case of lack the **TSO** is justified if it applies the rotating **Load Shedding** in order to restore the needed amounts for the regulation.

OC 2.8.2.2 The needed amounts of **Reserves** shall be verified since the yearly planning stage.

OC 2.8.2.3 In addition to the **Spinning Primary** and **Spinning Secondary Reserves** a given amount of **Upward Reserve**, not necessarily **Spinning,** is needed to replace the **Tertiary Reserve** and to cope with long lasting unexpected unavailability of **Power-Generating Modules** (cold standby).

OC 2.8.2.4 Articles OC 3.4.2 and OC 3.4.3 give the order of magnitude reference values of **Spinning Reserves**. On the **Tertiary Reserve** and **Cold Standby Reserve**, unless probabilistic simulation shows different values and if the lead time is of the order of months, a margin of 10 to 15% of the installed capacity (all sources) should be left available.

OC 2.8.2.5 When the **Upward Cold Standby Reserves** are less than the ones needed to keep **LOLP, LOLE** or margins within the target values, the affected **TSO** shall warn the other **Member States** and open a discussion for studying countermeasures of support and mitigate the consequences of probable shortage crisis. In case of shortage and without prejudice to the **National Regulations**, the affected **TSO** should be supported by the rest of **TSOs** by

increasing import by activating contracts of mutual support periodically signed. Such contracts shall never bias the market rules and they shall specify quantities, prices and conditions when the support cannot be fulfilled.
In case the support was not sufficient, the affected **TSO** should be allowed to recover the missing amounts of **Reserves** by applying the rotating **Load Shedding** available in its **Electricity System**.

OC 2.8.2.6 When the **Downward Reserve** is less than a given threshold, the affected **TSO** should disconnect **Power-Generating Facilities**, but it is justified to keep running enough internal **Generation** to cope with inertia, voltage regulation and restoration capabilities in case of separation. To this purpose the involved **TSO** is justified if it:

a) reduces the **NTC** or curtail the scheduled import;

b) curtails the non-regulating resources. In this case also **Dynamic Security Assessments** must be run, and the import should be reduced according to the priorities given by the regulations or when the reduction of internal resources would hamper the functioning of the **Defense Plans**.

OC 2.8.2.7 In the situation of overproduction (e.g. due to **RES**), neighboring **TSOs** should support the affected **TSO** by increasing the import from it, applying mutual support contracts, similar to the ones stipulated in case of lack of **Upward Reserves**.

OC 2.8.2.8 The amounts, and the share of **Reserves** for regulation, are agreed among **Members States** of the **Synchronous Area**.

OC 2.8.2.9 The evaluation of the needed **Reserves** highly depends on the failure rates of the **Generation Fleets** and on uncertainty of the **Demand**, hence it depends, among others, on the lead time of the **Forecast Demand**. This should be the result of probabilistic approach. Nevertheless, close to real-time simplified rules can be adopted for sake of readiness.

OC 2.8.2.10 In both cases, a reference for the acceptable risk not to supply the **Load** must be agreed at **Regional** level.

OC 2.8.2.11 The **Reserves** should be calculated in terms of power, (MW) and verified in terms of energy (MWh), if from hydro resources or storage.

OC 2.8.2.12 Non-programmable **RES** should not be included in the **Reserves**, but the probability distribution of their production should be taken into account in assessing the abovementioned **Reserves**.

OC 2.9 *Management* of Shortage Crisis

J. Analyzing in advance the shortage crises is the best way to mitigate the consequences of them. That is why experienced **TSOs** will have to cooperate and jointly make the **Best Effort** to adopt exceptional countermeasures. Crisis analysis can send price signals to the market.

OC 2.9.1 *Main Actions to Cope with Shortages*

OC 2.9.1.1 Each **Shortage** situation generates a crisis. In case of **Shortage**, the affected **TSO** shall warn the rest of the **TSOs** of the **Region** as soon as possible. **WG1** oversees the coordination of any possible action should support the affected **TSO**.

OC 2.9.1.2 The **TSO** affected by shortage of **Reserve** shall be ready to apply the rotating **Load Shedding** plan and warn other **Interconnected Member States**, if the cross-border support is not sufficient to solve the **Shortage**.

OC 2.9.1.3 In case of crisis, the affected **TSO** can ask the **Market Facilitator** to suspend the market activities, if allowed by the applicable norms, cancel maintenance schedules, order the urgent and anticipated conclusion of unavailability of **Power-Generating Facilities** and / or **Grid Elements.**

OC 2.9.1.4 All **TSOs** shall have a well proven contingency plan to cope with suspension of the market if serious under capacity situations arise and in more general critical situations.

OC 2.9.1.5 In exceptional situations and for a limited number of hours, the **WG1** can allow to moderately derogate from N-1 security and quality standards or loadability limits invoking **Emergency State** of the system to avoid the application of the rotating **Load Shedding.** Decision on terms and conditions for the derogation is made case by case, unanimously among the affected **TSOs** and under the coordination of **WG1**.

OC 2.9.2 *Further Focuses in Operational Planning*

OC 2.9.2.1 The **Scheduling & Dispatching Code** deals with the **Operational Planning** matter. Hereinafter some focuses are recalled.

a) In *w-1*, **TSOs** shall verify the adequacy and the expected load flows for the week *w*. A bulletin summarizing the unavailability, the expected **Demand**, and the major expected issues shall be circulated among **Members States**. A weekly videoconference at the **Regional** level is considered a good practice to share timely actions in case of major criticalities.

b) In *d-2* the main activity concerning the cross-border relationships is the preparation of data on **Grid** and power **Generation**, to calculate the **NTC** to be allocated in *d-1.*

c) In *d-2*, **TSOs** set up the **Individual Grid Model**, the confirmation of availability of the **Contingency List,** the associated **Remedial Actions,** and the **Generation** shift key for **NTC** calculation purposes.

OC 2.10 Seasonal Outlooks

J. Even though the **Adequacy** is controlled in every step of the **Operational Planning Process**, establishing biannual appointments to check the status of the Pan-Arab **Region** and the capability to support each other is an important approach, in line with practices adopted by other interconnected **Electricity Systems**.

OC 2.10.1 Twice a year, in periods that are significant for the peak load, and falling in two different semesters, to be agreed on, within **WG1**, each **TSO** shall perform dedicated seasonal outlooks aiming to predict and alert the **TSOs** of a **Region** about potential issues, in terms of **Load** coverage and alerting the **Market Facilitators** on what could be the framework.

OC 2.10.2 Seasonal outlooks shall be formulated at least as far as the scenarios of weather forecast and general energy crisis are concerned.

OC 2.10.3 **TSOs** of a **Synchronous Area** or **Region**, within **WG1**, elect and staff **Synchronous Area Adequacy Coordinator** to collect the **TSOs'** contribution and draft an outlook valid for the **Synchronous Area**, where cross-border **Energy Transfers** and mutual support are highlighted.

OC 2.10.4 **TSOs** transmit the seasonal outlook to the **Synchronous Area Adequacy Coordinator** two months before the beginning of the considered period.

OC 2.10.5 **RCEs** can present the conclusions on their **Synchronous Area** directly to the **Synchronous Area Adequacy Coordinator**, on behalf of the **TSOs** of such area.

OC 2.10.6 **Synchronous Area Adequacy Coordinator** collects the contributions and one month later issues a **Regional Seasonal Outlook** in which:

a) Each **TSO** reports are summarized country by country;

b) The mitigation plans of expected crisis are proposed, and the contribution of cross-border **Energy Transfers** for mitigation of critical under capacity periods are highlighted;

c) The expected **Reserve** margins available in the **Region** are declared;

d) The **Operation** key risk indicators are assessed.

OC 2.10.6.1 Once the potential risks are verified, **WG1** decides how and how often the **Operation** and market evolution must be monitored.

OC 3REAL-TIME MONITORING AND CONTROL

J. The energy transition and the development of the market increase the complexity of the **Electricity Systems** in terms of volatility and introduces new technical challenges like the lack of inertia. Modern **Electricity Systems** are compelled to keep the pace in adopting enhanced tools, clear security standards and strong cooperation. This Chapter focuses on the minimum requirements of the tools and the most consolidated security standards to comply with.

OC 3.1 Monitoring and Control Standard tools

OC 3.1.1 Monitoring and control are based on various layers of the activities and require an efficient communication infrastructure. As far as this **Code** is concerned, **TSOs** should comply with a minimum standard capability to monitor and control the balancing and the flows. On this regard, they should adopt the same solutions as far as the **Relevant Grid** is concerned.

OC 3.1.2 *ICT Platform*

OC 3.1.2.1 **Information and Communications Technology (ICT)** platforms are required for **Operational** coordination among the **TSOs** of a **Synchronous Area**, at least for real-time supervision and **Operational Planning**.

OC 3.1.2.2 Considering the perspectives of expansion of the **International Interconnection**, all **Member States** should adopt highly interoperable solutions according to the most recent and updated **Good Utility Practices**.

OC 3.1.2.3 **TSOs** shall:

a) guarantee the widest interoperability at Pan Arab level.

b) adopt protocols in common and aligned to relevant **Good Utility Practices**.

c) take the engagement to cooperate for upgrading the **ICT** platform, whenever efficiency or interoperability is at stake.
TSOs in **WG3** shall issue technical guidelines for harmonized solutions and for the day by day practices of the **ICT** platform.

OC 3.1.2.4 In this regard, active participation in the standardization bodies is recommended.

OC 3.1.2.5 The **ICT** platforms shall guarantee high dependability and redundancy. Communication part of this platform is the **WAN** linking the **National Control Centers** and dedicated to the **Operation Data Exchanges**.

OC 3.1.2.6 **TSOs** only may have access to the Pan-Arab **WAN**. They are responsible for the protection of the **WAN** against external intrusions and threats. In particular **TSOs** shall ensure that their **WAN** comply with the security requirements and performance standards. **RCEs** shall have the permission and the endorsement of **TSOs** to have access to the **WAN** and shall comply with the same protection standards.

OC 3.1.2.7 All **TSOs** and **RCEs** having access to the communication platform shall be subject to confidentiality obligations.

OC 3.1.2.8 **TSOs** and **RCEs** are not allowed to exchange directly information with external networks, internet included. **TSOs** shall interpose intermediate gateways to guarantee the security if information with external networks is necessary.

OC 3.1.2.9 **TSOs**, within **WG3**, activities, shall agree on:

a) Protocols (e.g. TASE.2, FTP, CIM).

b) Administration Staff.

c) Location of servers.

OC 3.1.2.10 To keep the Pan Arab **WAN** dependable, each **TSO** shall be connected to the **ICT** communication system and host two connections for routing the information from and to two different **TSOs** of the **Interconnected Member States**. The connections shall consist of private links operable at 10-100 Mbit/sec.

OC 3.1.2.11 The dedicated, protected communication structure is required to exchange **Operational Data** and real-time information. Voice IP and **WAPS** signal are not allowed to be exchanged by means of the Pan Arab **WAN**.

OC 3.1.2.12 **Real-Time Data Exchange** is the priority. The Pan Arab **WAN** shall be mostly dedicated to:

a) The **Warning System**.

b) The measures and the points of the switchgears mostly concentrated in the **Relevant Grid**.

c) The **Elements** of the **Grid**.

OC 3.1.2.13 Second priority are the **Data Exchange** typical of near real-time **Operation**, e.g. **Grid Models** for intraday activities, unpredicted unavailability of elements.

OC 3.1.2.14 Last is the exchange of **Operational Planning** data, that is:

a) **Individual** and **Common Grid Models**.

b) **NTCs**.

c) **Unavailability Plans**.

An equivalent **WAN** for market activity is out of the scope of this **Code**.

OC 3.1.3 *SCADA*

OC 3.1.3.1 The application part of the **ICT** platform encompasses the **SCADA** and the **EMSs**.

OC 3.1.3.2 **TSOs** shall adopt an efficient, reliable and dependable system of **SCADA**.

OC 3.1.3.3 As far as the **International Interconnection** is concerned, the **SCADA** shall import / export the statuses of the switchgears to reproduce the topology and the associated tele-measures of the **Relevant Grid** to guarantee the most efficient visibility. Visibility of the actions on the **Relevant Grid** shall be considered vital for coordinated and individual emergency actions.

OC 3.1.3.4 The general requirements of the **SCADA** shall concern:

a) Sampling period, as much as possible uniform (e.g. 2-4 sec) in the same **Synchronous Area.**

b) **LFC** as specified in this **Code**.

c) **SCADA** shall perform at least the following applications:

d) Efficient **HMI** and alarming systems.

e) Comparison forecast against actual at 15 minutes intervals of mean powers regrouped at various internal zone levels, at **Bidding Zone** level and total **Control Area**.

f) Dedicated displays for **RES** productions.

g) **State Estimator**.

OC 3.1.3.5 **SCADA**s are subject to cyber security guidelines and self-assessments at least to verify the security level and cyber risk across the **TSOs** connected in the information exchange **WAN**.

OC 3.1.4 *Energy Management System (EMS)*

OC 3.1.4.1 The **EMS** is the package of applications strongly connected to the **SCADA** encompassing complex computer-based tools designed to support the decisions of the **TSOs** in the control rooms.

OC 3.1.4.2 **TSOs** shall adopt efficient **EMSs** according to the principle that the better they run their **Electricity System** the more secure is the **Operation** of the whole **PAEM Electricity System**.

OC 3.1.4.3 In addition to the applications for internal **Operation** (e.g. real-time optimal power flow), it is recommended to include in the **EMS** package at least the following applications, with focus on **International Interconnection** issues.:

a) N-1 security checks at time intervals between 5 and 15 minutes.

b) The **Dynamic Security Assessment**.

c) Command systems to record the dispatching orders to the generators and to the trading rooms of the **Power-Generating Facility Owners**.

OC 3.1.4.4 Concerning the **International Interconnection**, the **EMS** shall also include a **Warning System (WS)** to alert and make aware the **TSOs** simultaneously and in real-time the incoming or in progress criticalities. The **WS** shall consist in a series of synoptic pages of displays representing the **Control Areas** of the **Synchronous Area** with frequency, amount of actual cross-border **Actual Energy Transfers** compared with the **Scheduled Energy Transfers** and voltages in the pivotal nodes of the **Transmission System**. Such pages are the same for each **TSO** and intend to immediately alert the operators at the same time when security thresholds are violated by means of different colored maps.

OC 3.1.5 *Recording of the Electrical Behavior of the Assets*

OC 3.1.5.1 In order to analyze the behavior of the **International Interconnections**, tie-lines shall at least be equipped with fault recorders associated with the protection system and event recorders associated with the **Synchronous Area** of the substations.

OC 3.1.5.2 The tie-lines shall be equipped whit **Fault Locators**, in order to alert immediately the crews on the side of the border where the fault has occurred and accelerate the urgent repair activity.

OC 3.1.5.3 It is recommended to complement the conventional monitoring system with **PMUs** in such a way to build up an efficient monitoring network of the dynamic phenomena in **Synchronous Areas**. The gathered data shall be shared among all **Member States** of the **Synchronous Area** and feed the **DSA**.

OC 3.2 Control Room Activity in National Control Centers

OC 3.2.1 Neighboring **TSOs** are constantly in contact to control their **Control Area** and the **International Interconnection** 24 hours per day, 7 days per week. **National Control Centers** are the corresponding entities entitled to take coordinated decisions about the interconnected **Operation**.

OC 3.2.2 In case **RCE** is operative, the existing structure of control may apply as long as the **Region** is isolated. In case of connection with other systems, which do not apply to be part of the same **Region**, **TSO** and **RCE** should comply with the **Code** in this matter.

OC 3.2.3 Regarding real-time control neighboring **TSOs** shall:

a) Agree on a common language to adopt.

b) List in written form the most used and /or critical dispatching instructions with complete descriptions in native languages and in English.

c) Have redundant hot lines between control rooms of the **National Control Centers**.

d) Agree on protocols to perform complex activities in autonomy under specific conditions (e.g. **Restoration** sequences).

OC 3.2.4 Neighboring **TSOs** shall reciprocally exchange the **Contingency List** and corresponding **Remedial Actions** available at the moment in order to allow **DSA**.

OC 3.2.5 **TSOs** guarantee the skill of their own physical operators and their diligent, professional attitude.

OC 3.2.6 For protection of the behavior of the operator, without prejudice to labor laws and national regulation, it is recommended to record the telephone calls between operators, protect them and retrieve them only in case of formal inquiries. Notwithstanding the labor laws in each of the **Member States**, a legal procedure is needed to tackle this matter correctly.

OC 3.2.7 Regarding the routine applications that the operators in the **National Control Centers** shall perform, the following applies to:

a) exchange the **Individual Grid Models** and merge them in a **Common Grid Model** for **Networks** analysis.

b) perform the security analysis at regular intervals and on **Demand**, when the **Operational** conditions require it.

c) manage the **LFC** and the balancing **Reserves**.

d) warn as soon as they can, about criticalities arising in their **Control Area**.

e) perform the **Restoration Plan** in cooperation with the neighboring **TSOs**.

OC 3.3 Operational Security

OC 3.3.1 *Operational Limits*

OC 3.3.1.1 **Operational Limits** can be determined by the physical characteristics of an **Element** (loadability limits) or by the conditions of the systems, if more stringent than the previous ones. **Operational Limits** can be permanent and transient, and both can vary with the season. For the internal elements **TSOs** shall keep updated the inventory of them and their characteristics. As far as the **Relevant Grid** is concerned, such characteristics have to be shared among the neighboring **TSOs**.
Operating ranges for **Power-Generating Facilities** and **HVDC Systems** are specified in the **Connection Code**.

OC 3.3.2 *Operation Security Standard (OSS)*

OC 3.3.2.1 The following apply to the **Relevant Grid** as far as voltage and currents are concerned, and to the whole **Synchronous Area** as far as frequency and balancing are concerned.

OC 3.3.2.2 An **Electricity System** is considered compliant with the **Operation Security Standard** adopted in this **Code** if:

a) It continues to work within its permanent admissible limits of voltage, frequency and current in any part of it after the occurrence of any single **Normal Contingency**, of a **Contingency List**, followed by the application of the corresponding **Remedial Action**.

b) Between the occurrence of the contingency and the application of the corresponding **Remedial Action,** the admissible permanent limits are violated but the **Operation** limits are kept below the transient acceptable limits for a given length of time.

This state of functioning of the **Electricity System** is also called **Normal State**. In **Normal State** there is no risk for the **International Interconnection**.

OC 3.3.2.3 The **OSS** is also called N-1 **OSS***,* being N the number of elements in service. For its application, **TSOs** shall guarantee the **SoO** by simulating periodically the occurrence of the contingencies and verifying that the **Remedial Actions** in real-time are available and effective.
Load Shedding cannot be included in the **Remedial Action** list, against **Normal Contingencies**, unless a contract states this possibility. Without prejudice to the applicable national regulation in matter of market, cross-border **Energy Transfers** should be the last to be reduced in the **Remedial Actions** list.

OC 3.3.2.4 In addition to the compliance with the N-1 **OSS**, **TSOs** shall also strive for the resilience of the **Electricity System** in case of occurrence of multiple contingencies or contingencies more severe than the ones in the **Contingency List**. To this purpose, **TSOs** shall design and carry out **Defense Plans** and **Restoration Plans** to be applied to counteract such events with the objective of limiting their consequences in terms of severity (MW and MWh lost) and duration of the power cuts.

OC 3.3.2.5 **TSOs** shall assess the security conditions applying methods under their responsibility, but reflective of verifications in steady state and transient conditions.

OC 3.3.3 *Contingency Analysis and Remedial Actions (Security Assessment)*

OC 3.3.3.1 **TSOs** shall perform regular **Network** studies to define the most probable and the most complex contingencies and analyze the effects of them on the security of the **Electricity Systems** which are interconnected. Against the contingencies **TSOs** shall:

a) Design the **Remedial Actions** (manually or automatically operated) able to neutralize or mitigate the consequences of them.

b) Adopt strategies to recover from disasters.

OC 3.3.3.2 **TSOs** shall group contingencies in three categories: **Normal**, **Exceptional**, **Out of Range Contingencies**.

OC 3.3.3.3 The **Normal Contingencies** are contingencies implying the loss of single lines or double circuit lines on the same towers, single transformers, loss of a single **Power-Generating Modules**, a single **DC** link both in import and export, with a subsequent imbalance less than or equal to the **Reference Incident**, being the **Reference Incident** the largest loss of **Load** or **Generation** that could happen as a single event in a **Synchronous Area**. Each **TSO** has the right to include the simultaneous trip of the double circuit lines (on the same tower) in the category of **Normal Contingency** on the base of the protection and the percentage of length on the same towers.
The list of the **Normal Contingencies** is the **Contingency List**.

OC 3.3.3.4 The **Exceptional Contingencies** are contingencies implying the loss of more than one **Element** due to a common cause (e.g. a fault between a CT and a CB triggering the breaker failure protection, loss of o bus bar).

OC 3.3.3.5 The **Out of Range Contingencies** are contingencies implying the simultaneous occurrence of more contingencies even without functional common causes (e.g. caused by exceptional weather conditions) followed by loss of **Generation**, **Load** and other major catastrophic consequences. The **Out of Range Contingencies** are also those contingencies whose effect exceeds the capability of system to withstand.

OC 3.3.3.6 Against each contingency the responsible **TSO** shall study the most effective countermeasures that manually or automatically it manages to apply in real-time in order to avoid the **Electricity System** to work out of its limits in case of **Normal Contingencies** or to avoid spreading the negative consequences until the blackout in case of **Exceptional** or **Out of Range Contingencies**.

OC 3.3.3.7 The responsible **TSO** shall group the remedial actions corresponding to each **Normal Contingency**. Such countermeasures shall fulfil the **SoO** and shall be agreed with the adjacent **TSOs** if involved in the actuation of them or relevant for the **Transfer Capacity** across the borders.
Normal Contingencies and related **Remedial Actions** are simulated for the calculation of the maximum **Transfer Capacity** across the borders.

OC 3.3.3.8 **TSOs** shall adopt **Defense Plans** to face as much as possible with the negative effects of **Exceptional** and **Out of Range Contingencies**. **Defense Plans** can use **Load Shedding** techniques for balancing the **Electricity System** and minimizing entity and duration of the power cuts.
Most significant **Exceptional Contingencies** shall be used in the **DSA** to assess the response of the **Defense Plans** against such stresses.

Out of Range Contingencies are used to evaluate possible extreme disaster scenarios.

OC 3.3.3.9 Notwithstanding the right of each **TSO** to decide what is the best **Operation** rules for its **Electricity System**, transparent and technically consistent criteria for security assessment and adopted tools should be shared at **Synchronous Area** or **Regional** level at least. Even if different, they shall be declared and technically discussed.

OC 3.3.4 ***System States***

J. Despite their high reliability the interconnected **Electricity Systems** could pass from a **Normal State**, as defined above, to others where the security of **Operation** is not guaranteed. It is important to classify the **System States** to trigger immediately the pre - set agreements.

OC 3.3.4.1 Hereinafter, the *de facto* standard rank[4] of such **System States** (or **Operating Conditions**) is reported together with the associated definition, identification, special powers given to the **TSOs**, inter **TSOs** cooperation and actions to bring the **Electricity System** back to a secure **System State**.

OC 3.3.4.2 The **Alert State** is the **System State** in which, the interconnected **Electricity System** is still within acceptable limits, but no **Remedial Action** is available to cope with a contingency of the **Contingency List**. Reasons could be forecast errors or lack of unexpected unavailability of a **Remedial Action**. The affected **TSO** shall timely warn all the **Interconnected TSOs** of the results of the security analysis if a contingency in its **Control Area** could cause cascading outages in the neighboring **Control Areas**.
The identification of the **Alert State** is possible on the base of the simulations of N-1 that should show if one or more contingencies of the **Contingency List** could affect the **International Interconnection**.

OC 3.3.4.3 The **Emergency State** is the state in which the interconnected **Electricity System** is deteriorated at various levels of severity, because the **Operational Limits** are no more fulfilled and/or **Grid** splits or power cuts could be in progress. In this state, regardless to the location of the deterioration, the risk for the **Electricity Systems** of **Interconnected Member States** is considered high, also in terms of propagation of the contingency. Security standards cannot be fulfilled by the affected **TSO** and ordinary **Remedial Actions** would result without effects. Reasons could be forecast errors, **Exceptional Contingencies**, **Out of Range Contingencies**, malfunctioning of protections.
The affected **TSO** shall warn and continuously keep informed the **TSOs** of the **Region** and ask for support.

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[4] Classification commonly used in Europe (UCTE and ENTSO-E) and in Cigré.

The identification of the **Emergency State** is the observation throughout the **SCADA** of the phenomena that characterize the state itself and the evaluations of the contingencies.

OC 3.3.4.4 In **Emergency State** the affected **TSO** is responsible of the fast application of the **Defense Plans**, the communication with the neighboring **TSOs** but the guarantee to respect the **Operational Limits** is suspended.

OC 3.3.4.5 The **Emergency State** includes the **Blackout State** and the **Restoration**.

OC 3.3.4.6 The **Blackout State** is characterized by the absence of voltage in a large number of busses of the **Grid**.
Reasons could be **Exceptional**, or **Out of Range Contingencies** followed by the failure of the **Defense Plans**. Human errors and combinations of more than a cause could be the root causes of a blackout. The blackout can be more or less wide, but in any case, the risk for the **International Interconnection**, if still intact, is high.
TSOs of a **Region**, agree on the conventional identification of blackout in terms of extension and maximum time to identify it. It is recommended to make a difference between an ordinary power cut (local and controllable) and a blackout, characterized by the total absence of voltage in large areas of the **Electricity System** of a **Member State**, involving the bulk **Electricity System** and lasting more than 5 minutes. In case of blackout and under request of the affected **TSO**, the **Restoration Plan** is triggered and the neighboring **TSOs** shall cooperate to the re-energization. Safety rules are unbreakable, and the market activities are suspended shall be regulated by special contingency procedures.

OC 3.3.4.7 The **Restoration** is a transition phase from blackout back to **Normal State**. It consists of the series of **Operation** coordinated by the **TSOs**, aiming at reenergizing the **Grid** and synchronizing **Islands** to provide electricity and satisfy the **Demand**.

OC 3.3.4.8 Priority of the **Restoration** strategy and practices shall be to energize the bus bars and the house **Load** of the **Power-Generating Modules** as fast as possible.

OC 3.3.4.9 The involved **TSO** is responsible for the application of the best tools to restore the system if available, with priority to the **Restoration** procedures. The **TSO** cannot guarantee the **Restoration** times, due to the impossibility to forecast all the combinations of the blackouts.

OC 3.3.5 ***Stability Studies***

OC 3.3.5.1 Regular security assessments are **Network** analyses performed in steady state regime by mean of **AC** load flow calculation. This is considered acceptable in the **Good Utility Practices** as long as the transient acceptable limits are more stringent than the ones deriving from a complete stability study. If not, the transient acceptable limits shall be reduced by the **TSO**.

OC 3.3.5.2 Stability studies shall include transient stability, dynamic stability and voltage collapse. **TSOs** shall run such studies periodically. The methodology to set up dynamic **Common Grid Models** should be ready in two years since the date of entering into force of this **Code**.

OC 3.3.5.3 **TSOs** shall perform stability studies to assess the security in general beyond the normal events, and:

a) To design the **Defense Plans**, in case of contingencies more severe than the ones of the **Contingency List**.

b) To verify the needs or the sufficient amount of **Defense Plans.**

c) To cope with multiple contingencies.

d) To prevent collapses in the particular cases where the inertia is considered scarce and / or the transmission distances increase due to the displacement of **Generation** respect to the loads.

OC 3.4 Operational Reserves and Load/Frequency Control Management

OC 3.4.1.1 **TSOs** shall make available enough active power **Reserves** to keep the total cross-border **Energy Transfers** constantly at the scheduled values and frequency in the **Synchronous Area** at the nominal frequency, according to sharing principles and taking into account the evolution of the **Synchronous Areas**.

OC 3.4.1.2 **Reserves** and their characteristics (e.g. in terms of promptness and duration) shall aim at keeping the frequency quality targets as much as possible under control.

OC 3.4.1.3 The **Frequency Quality Targets** and the pro quota contribution to cope with frequency deviations shall be calculated for each area in a coordinated way. **WG2** should be the coordination **Working Group** for this activity. Parameters and **Reference Values** are given in OC 12 ANNEX A – FREQUENCY CONTROL REFERENCE VALUES.

OC 3.4.1.4 In the following Articles, default criteria of sizing **Reserves** are prescribed, without prejudice to different solutions agreed to and formalized in written form in the same **Synchronous Area**.
TSOs shall reserve the **TRM** in order to engage the **Reserves** without causing overloads at the borders.

OC 3.4.1.5 The accuracy of the measurements of the frequency and the links across all the borders of the **Control Areas** have to be the same and declared. **Reference Values** are given in OC 12 ANNEX A – FREQUENCY CONTROL REFERENCE VALUES.

OC 3.4.2 *Primary Reserve*

OC 3.4.2.1 The total need of **Primary Reserve** in each **Synchronous Area** shall be not less than the active power imbalance caused by the largest single incident (reference incident) in both directions: loss of in-feed and loss of out-feed.

OC 3.4.2.2 The **Reference Incident** determines the max instantaneous frequency deviation as well, which is the reference threshold above which the **UfLS** is not allowed. Reference Values are given in OC 12 ANNEX A – FREQUENCY CONTROL REFERENCE VALUES.

OC 3.4.2.3 Each **TSO** shall contribute to share pro quota the imbalances in the **Synchronous Area** based on the average power production of the **Member State** divided by the average production of the **Synchronous Area**. **WG2** shall coordinate the calculation per single **Synchronous Area** of the share of each **Member State** on regular basis (6-12 months) on the base of the largest incident that can occur in the **Synchronous Area** as a single event. Additional amounts in each **Control Area** are allowed for any internal needs (e.g. to cope with **Islanding**).

OC 3.4.2.4 Alternatively, the shares of the **Primary Reserve** may be based on the maximum **Generation**.

OC 3.4.2.5 **TSOs** of the same **Synchronous Area** and referring to the same **RCE** may agree on different sharing criteria and shares.

OC 3.4.2.6 **Primary Reserve** shall respond to frequency deviations without intentional delays and in such a way to activate the whole amount of power in 30 seconds. The full power shall be supplied for 15 minutes at least. In case of deviations lasting more than 15 minutes, **TSOs** shall not reduce their contribution voluntarily.
The adoption of a deadband is common practice to limit the activation of the

Primary Control. Reference Values are given in OC 12 ANNEX A – FREQUENCY CONTROL REFERENCE VALUES.

OC 3.4.2.7 At the maximum steady state frequency deviation, the whole **Primary Reserve** shall be activated. Each **TSO** shall verify the speed governors of the **Generation Fleet** in its **Control Area**.

OC 3.4.2.8 At **Control Area** level, each TSO shall contribute with a minimum share calculated as the product of the **Overall Primary Control Reserve** of a **Synchronous Area** multiplied by a **Contribution Factor** (c_i), being the ratio between the energy produced in a **Control Area** and the total energy produced in the **Synchronous Area** in the time period under consideration. **TSOs** within **WG2** may agree on different minimum duration of **Primary Control** and/or differentiating it by technology or source. **Reference Values** are given in OC 12 ANNEX A – FREQUENCY CONTROL REFERENCE VALUES.

OC 3.4.2.9 Default values, including the amount of **Primary Reserve** for internal needs, could be around 2-3% of the total **Generation**, uniformly distributed among the **Generation Fleet**. In case of remarkable penetration of **RES** (non-regulating inverted technology) this percentage could result in 5% of the **Nominal Power** of the conventional regulating **Power-Generating Modules**.

OC 3.4.3 *Secondary Reserve*

OC 3.4.3.1 According to the principle that each **TSO** of a **Synchronous Area** shall use all internal resources to avoid spreading to the rest of the **Interconnected Member States** any contingency that occurred in its **Electricity System**, the **Secondary Reserve** of the **TSO** itself shall:

a) Be sufficient to replace the amount of imbalances caused by loss of **Generation** or forecast **Load** errors in its **Control Area**.

b) Recover the frequency in the **Synchronous Area** to its nominal values.

OC 3.4.3.2 **TSOs** of the same **Synchronous Area** shall agree on the methods of calculation of the minima amounts of **Secondary Reserves** that each **TSO** is obliged to make available. In case of no agreement, they shall fix the target to have sufficient resources in 99.9% of time, at least. Consolidated convolution integral method between forecast error of **Demand** and the probability of **Generation** unavailability should be adopted in such a case.
In case of lack of data (e.g. failure rate of **Generation** or statistics on the **Load**) empirical formulas can be adopted. In no case the **Secondary Reserve** shall be less than the **Nominal Power** of the largest **Power-Generating Module** in the **Control Area**.

OC 3.4.3.3 Default values depend on the lead time of the forecast. Close to real-time the **Outage** of the largest unit could be enough, while the day before the uncertainty of the **Demand Forecast** and the **RES** could rise up to 5% of the peak load, if greater than the **Nominal Power** of the largest **Power-Generating Module** in the **Control Area**.

OC 3.4.3.4 **TSOs** shall control the use of the **Secondary Reserve** resources by means of an automatic **Load Frequency Control** system. Only in particular cases **Secondary Reserve** can be carried out manually. Hence TSOs shall adopt a coordinated **Automatic Generation Control** system including a central regulator in the **SCADA**, telecommunication links between the central regulator and the regulators on board of the **Power-Generating Module**. If, despite the exhaustion of the **Secondary Reserve** the **ACE** is still too high, **TSOs** may put in place manual interruptible **Loads** or **Generation** run back.

OC 3.4.3.5 The **LFC** shall be proportional – integral type driven in input by the **ACE** – i.e. a linear combination of system frequency deviation and power deviation, according to the following:

$$ACE = \Delta P + k\,\Delta F$$

OC 3.4.3.6 In 30 seconds, the **LFC** must start to reduce till zero the **ACE** as soon as possible but no later than 15 minutes without overshooting.

OC 3.4.3.7 The cycle time of the **LFC** shall be set between 1 and 5 seconds.

***k*-Factor** is calculated on regular basis (6 – 12 months), as a percentage of the regulating energy of the **Synchronous Area.** The **Member States** of the same **Synchronous Area** shall coordinate to share the algorithms to adopt, data and calculations for approval. Unless the **TOSs** belonging to the same **Synchronous Area** agree on different calculation the **K_i-Factor** for each **Control Area** *i* is the product of **the Contribution Factor c_i** multiplied by the **Overall Network Power Frequency Characteristic**.

OC 3.4.3.8 Different **share and p**arameters **are subject** to agreement among **TSOs** w**ithin WG2 or Synchronous Area.**

OC 3.4.3.9 The **AGC** shall **allow the following special control modes (in** ac*cordance with UCTE*[5] *policies):*

a) *Frequency Control Mode, that is the operator does not activate the ΔP component of ACE;*

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[5] UCTE was established in 2000 as a spin-from UCPTE and disbanded in 2008.

b) *Tie–Line Control Mode*, that is the frequency control error is not included in the **ACE**;

c) *Frozen Control State*, no set points of the **Secondary Control** are activated and no **ACE** is controlled till the normal functioning mode is re-activated;

d) *Stopped Control State*, that is in extreme conditions the **AGC** system is disabled and the set points are reinitialized.

OC 3.4.4 *Tertiary Reserve*

OC 3.4.4.1 **Tertiary Reserve** size is the same order of magnitude of the **Secondary Reserve** (at least the largest loss of power), being used for replacement when **Generation** outages or forecast errors last more than a given time and ACE cannot be reduced to zero. The **Tertiary Reserve** is activated by rescheduling the production in a **Control Area** where regulating resources are exhausted, or **Load** has been cut. **Tertiary Reserve** can be partially or totally supplied by non-spinning units. For non-spinning units a mix of units with startup times between 30 minutes and 6 hours is recommended. The **LFC** minimum requirements are subject to be adapted by agreements at **Synchronous Area** level and managed by the **RCE.**

OC 3.5 Voltage Control and Reactive Power at the Borders

OC 3.5.1.1 Voltage at the busses of the **Relevant Grid** shall be regulated in the range of ±5% of rated voltages. Exceptionally and for short time less than 30 minutes, neighboring **TSOs** should accept higher ranges between ±10% unless the **National Grid Codes** prescribe different values.

OC 3.5.1.2 Neighboring **TSOs** shall limit the reactive power flows across the borders to avoid potential reduction of **NTC** due to excess of power factor.

OC 3.5.1.3 In case of adoption of phase shift transformers in the **Relevant Grid**, the tap position of the transformer shall be agreed among the TSOs and its use as **Remedial Action** shall be indicated.

OC 3.6 Synchronous Areas

OC 3.6.1 *Synchronous Areas Identification*

OC 3.6.1.1 At the date of this **Code**, **Synchronous Areas** are:

a) **Maghreb** Area, synchronous with Europe (Morocco, Algeria, Tunisia).

b) Central Area (Lebanon, Syria, Iraq, Palestine, Jordan, Egypt, Libya).

c) **GCCIA** 50 Hz (Kuwait, Bahrain, Qatar, U.A.E. and Oman).

d) **GCCIA** 60 Hz (Kingdom of Saudi Arabia).

OC 3.6.2 ***Definition of the Characteristics of the Synchronous Areas.***

OC 3.6.2.1 The identification of the fundamental parameters affecting the correct behavior of the **Control Areas** interconnected to form a **Synchronous Area**, is crucial when the frequency regulation, the power exchanges and the **Defense Plans** are at stake. The definition of such parameters has to reflect the peculiarities of each **Synchronous Area** and **TSOs** shall cooperate for the purpose. OC 12 ANNEX A – FREQUENCY CONTROL REFERENCE VALUES summarizes and suggests the main parameters and some **Reference Values** helpful to define in a cooperative way the **Automatic Generation Control**, the **Operating Reserves** and the **UFLS**. The **Member States** shall use their **Best Effort** to adapt the principles expressed in this **Code** to the peculiarities of the (4) four **Synchronous Areas** considered in this **Code** (i.e. MAGHREB, Central Area, GCCIA 50 Hz, and GCCIA 60 Hz).

OC 3.6.2.2 The time control is dealt in the **Scheduling & Dispatching Code**.

OC 4NETWORK PROTECTION AND DEFENSE PLANS

J. For the same reasons stated in Chapter 0, keeping intact the **International Interconnection** becomes more complex than before when ordinary faults or complex contingencies occur. Strict rules of coordination of automatic tools of protection and control are the best guarantee to support **Member States** of the same **Synchronous Area** and be supported by neighboring **TSOs**.

OC 4.1.1 Each **TSO** should be aligned to the same protection standards as far as the whole bulk system is concerned and should transfer the obligations on requirements to their **Grid Users**. **TSOs** of **Interconnected Member States** shall stipulate for each tie line a **Connection Agreement** (**CA**) regulating, among others, management of the protection.

OC 4.1.2 This **Code** prescribes the minimum requirements of the protection system leaving their application to the responsibility of the **TSOs**.

OC 4.2 Fault Protection

OC 4.2.1 Fault clearing time shall be the minimum between the requirements prescribed in the **National Grid Codes** of the **TSOs** of a **Synchronous Area**. **TSOs** specify the clearing times with and without circuit breaker failure which should not exceed 80 and 300 milliseconds, 120 and 400 milliseconds for the EHV grids for HV grids respectively.

OC 4.2.2 Selectivity must be guaranteed. Bus bar and breaker failure protections are prescribed at the sending and ending substations of the tie lines.

OC 4.2.3 Redundancy shall be prescribed by back up or *main 1, main 2* at local level and by remote to cope with failures of any element of the chain of the local protection system. An intentional time delay of 300 – 500 milliseconds should be granted to allow the best possible selectivity.

OC 4.2.4 Automatic reclosing functions are recommended. Agreements shall be made case by case and reported in the **Connection Agreement** considering the number of shots, poles (three or single pole) and adoption close to **Power-Generating Modules**, pursuant to respective **National Grid Codes**.

OC 4.2.5 The **Relevant Grid** should be at the same protection standard level adopted for the tie lines.

OC 4.3 Defense Plan Coordination

OC 4.3.1 The **Defense Plans** are defined as those control actions exclusively dedicated to limit the consequences of major disturbances whose severity goes beyond the effects of the **Normal Contingencies** of the **Contingency List**, and impossible to prevent in **Normal State** conditions. **TSOs** are responsible for the design, control and application of the **Defense Plans**. In particular, no one besides the relevant **TSO** is allowed to order the **Restoration** of **Loads** after **Defense Plan** activation.

OC 4.3.2 No use of **Defense Plans** other than those listed above should be allowed (e.g. for increasing cross border **Transfer Capacity**).

OC 4.3.3 The necessity for the coordination of **Defense Plans** lies on the fact that

a) Their **Operation** creates unbalances that could negatively affect the functioning of one or more Interconnected **TSOs** of the same **Synchronous Area**.

b) It might be necessary to equip the tie lines with special devices that have to be previously authorized and agreed also in terms of line opening policies.

c) By virtue of the solidarity principle, like the regulation for ordinary events, also the **Load Shedding** sensitive to the frequency should be shared among the **TSOs** of a given **Synchronous Area**.

d) All **TSOs** of a **Synchronous Area** shall be informed the potential effects of the **Defense Plans** in other systems as well.

OC 4.3.4 According to the principle that no **TSO** may cause damage to another member of the **International Interconnection**, some of the prescriptions in the following intend to protect the **International Interconnection** from maloperation.

OC 4.3.5 In the security assessment applications, the **Defense Plans** must be simulated to assess their effectiveness to limit the consequences of **Exceptional** and **Out of Range Contingencies**.

OC 4.3.6 In case of lack of available resources for the **Defense Plans**, if simulations show their ineffectiveness of them in daily **Operation**, **TSOs** are required to inform other **TSOs** of the **Region / Synchronous Area** and are allowed to take measures, including the reduction of the **Energy Transfers** at the borders.

OC 4.3.7 Any system dedicated to the defense of the **PAEM Electricity System** has to be verified in adequacy and tested every 1 or 3 years.

OC 4.3.8 The following applications are defined **Defense Plans**:

a) **WAPS** (**Wide Area Protection Systems**, also known as **Special Protection Schemes**) to control overload of lines.

b) **UfLS** (**Underfrequency Load Shedding**) the **Load** shed by frequency deviations.

c) **UVLS** (**Under Voltage Load Shedding**) the **Load** shed by voltages in conditions close to voltage collapse.

d) **PSS** (**Power System Stabilizer**) to damp dynamic stability problems.

e) Manual Load Shedding.

f) **Islanding** to segregate healthy portions from the rest of the Electricity Systems.

OC 4.3.9 *Wide Area Protection Systems (WAPS)*

OC 4.3.9.1 **WAPS** are automatic control schemes triggered by specific contingencies and acting directly on the topology of the **Grid** or on the **Load** or on the **Generation** separately or in combination.

OC 4.3.9.2 **WAPS** are allowed if they are designed and carried out under strict requirements of dependability (availability when needed) and security (no **Operation** when not needed).

OC 4.3.9.3 Coordinated **WAPS** between neighboring **TSOs** are allowed if they pursue the goal of saving the integrity of **International Interconnections** against **Exceptional** or **Out of Range Contingencies**. Typical is the case of interruptible **Load Shedding** to avoid a line to trip for overload.

OC 4.3.9.4 Given the devastating effect that a wrong operation of the **WAPS** could have, **TSOs** shall:

a) Apply strict procedures to monitor and authorize the status of on / off of a **WAPS** in the **SCADA**.

b) Prescribe the adoption of warnings in the substations, on board of the cubicle where **WAPS** are installed and the circuitry.

OC 4.3.9.5 If the effects of a **WAPS** modifies the cross-border **Energy Transfers**, its scheme shall be coordinated with the **LFC** and agreed among all the **TSOs** of the **Synchronous Area**.

OC 4.3.9.6 Events in an **Electricity System** of a **Member State** triggering the **Operation** of **WAPS** shall never shed the **Load** or run back **Generation** in an **Electricity System** of another **TSO** (or cause imbalances) unless specific and clear agreements are signed.

OC 4.3.9.7 Position of circuit breaker and switches shall be made visible and made available by remote on request to the neighboring **TSOs** that wants to associate a **WAPS** to the topology of the **Grid** of the **Interconnected Member States**.
In this case, maintenance control and cautions to avoid unwanted **Operation** of the **WAPS**, must be guaranteed and dedicated agreements must be signed and attached to the **Connection Agreement.**

OC 4.3.9.8 Responsibility remains on the **TSO** who designs, proposes and manages the **WAPS** of its competence.

OC 4.3.9.9 The actions on the **Power-Generating Modules** can be of run-back type or tripping. In both cases the reaction times of the **Power-Generating Module**s have to refer to the **Connection Agreement** between **TSO** and the **Power-Generating Facility Owner**.

OC 4.3.9.10 **WAPS** schemes shall be confidential but shared among the **TSOs** for correct dynamic simulations.

OC 4.3.10 *Underfrequency Load Shedding (UfLS)*

OC 4.3.10.1 Frequency thresholds to be set on the frequency relays shall be within the limits of frequency agreed and implemented by the TSOs of the same Synchronous Area. The total amount of **Load** available for being shed shall be distributed among a number of steps aiming at containing the frequency decay without causing overshooting. OC 12 ANNEX A – FREQUENCY CONTROL REFERENCE VALUES gives **Reference Values** adoptable unless specific studies show other values. Energy storage facilities can be shed before reaching the first frequency limit.

OC 4.3.10.2 **UfLS** should be implemented in the following order: energy storage first, then interruptible **Load**, industrial **Load** and residential **Load** last.

OC 4.3.10.3 The essential facilities like hospitals, civil and military protection facilities, as better defined by national public authorities, should be never subject to **UfLS**.

OC 4.3.10.4 At least 50-60% of the peak **Load** shall be available for **UfLS**, including the quota for internal national needs, unless overvoltage problems arise. The **Load**

dedicated to coordinated **Defense Plans** of a **Synchronous Area** should be at least between 40 and 50% of the peak **Load**.
The total amount of such **Load** shall be distributed almost uniformly among the steps, without prejudice to more accurate studies, jointly performed at **Synchronous Area** level.

OC 4.3.10.5 In sizing and designing the **UfLS** plan, probable system splits have to be taken into consideration as events to cope with.

OC 4.3.10.6 The share of **Load** available to shed for generalized frequency decays should be proportional to the peak **Load** of the **Member State**.

OC 4.3.10.7 Frequency thresholds may be differentiated **TSO** by **TSO** according to the inertia of each area and the splits of **Grid** considered.

OC 4.3.10.8 **UfLS** plans should be revised when:

a) new **TSOs** are connected to a **Synchronous Area,** or two or more **Synchronous Areas** merge; and,
b) every three (3) years.

OC 4.3.10.9 The **UfLS Plan** should be designed taking into account priorities of load to be shed (e.g. storage first) and objectives. Suggested default **UfLS plan** is given in

OC 4.3.10.9 OC 12 ANNEX A – FREQUENCY CONTROL REFERENCE VALUES. Values in OC 12 ANNEX A – FREQUENCY CONTROL REFERENCE VALUES refer to 50Hz nominal frequency. For 60 Hz **Synchronous Area** the frequency values should be adapted to the ratio 60/50.

OC 4.3.10.10 **UfLS** has to be selective. To his purpose the circuits driven by the frequency relay have to open the MV feeders. The design of the **UfLS** should avoid shedding **Load** mixed with embedded **Generation**.
UfLS should never shed feeders essential for the auxiliary service of power plants and substations.

OC 4.3.10.11 **UfLS** should be blocked when voltages reach a given upper threshold to avoid overvoltage due to the sudden drop of **Load** in the **Grid** or when voltages are too low to avoid false operations. These blocking thresholds shall be checked by the **TSO** taking into account the type of relay and the site where it is installed. OC 12 ANNEX A – FREQUENCY CONTROL REFERENCE VALUES gives **Reference Values**.

OC 4.3.10.12 The **UfLS** plan may be implemented – under responsibility of the relevant **TSO** –, by combining the frequency thresholds with the derivative of frequency in order to anticipate the operation of the relays for the benefit of a fast containment of the frequency.

OC 4.3.11 *Under Voltage Load Shedding (UVLS)*

OC 4.3.11.1 **UVLS** could be applied at the borders to prevent the **International Interconnection** from the separation or to prevent voltage instability. **TSOs** adopting or having the intention to adopt **UVLS** for this purpose should inform the neighboring **TSOs**. **UVLS** shall never operate for voltages greater or equal 90% of nominal voltages.

OC 4.3.12 *Power System Stabilizers*

OC 4.3.12.1 **PSSs** are part of the **Defense Plans** for damping low frequency oscillations. All the involved **TSOs** shall carry out simulations to re-tune the settings periodically or before a new system is added to a **Synchronous Area** or two **Synchronous Areas** are merged.
To this purpose **WG2** shall promote ad hoc campaigns, evaluate the needed time and scope a dedicated procedure to accomplish the revision task. The procedure shall take into account the time needed to involve the **TSOs'** organization and perform the technical work of revising settings.

OC 4.3.12.2 In case of poorly damped episodes in a **Synchronous Area**, **TSOs** shall immediately call for actions within **WG2**.

OC 4.3.13 *Manual Load Shedding*

OC 4.3.13.1 **TSOs** shall have a manual **Load Shedding** plan, operated by remote. The manual **Load Shedding** can overlap the **UfLS** plan. The amount of the total **Load** manually or automatically subject to be shed should not be less than 90% of the peak load.
Manual **Load Shedding** practice can complement the **Defense Plans** in:

a) Balancing the **Electricity System** in **Emergency** and relief overloads.

b) In a rotating way, to share the discomfort in case of power cuts lasting more than the average.

OC 4.3.14 *Islanding*

J. Despite the solidarity principle and mutual support commitments, when major disturbances could lead a **Synchronous Area** to a total blackout, the principle of not spreading the disturbance outside the border should prevail.

OC 4.3.14.1 **Islanding** is the controlled separation of an area from the rest of the interconnected **Electricity System**. This kind of **Defense Plan**, if applied, has to be considered the last resort for the protecting the system against the total blackout and have resources ready for immediately re-energize the faulty adjacent parts of the **Electricity System**.

OC 4.3.14.2 The following minimum requirements should be guaranteed:

a) Its trigger and its **Operation** shall be automatic

b) The detection of the conditions of **Islanding** has to be reliable (e.g. out of step relays) and shared in **WG2**.

c) The portion of system to be islanded shall not be across the border. Separation points shall be at the **Connection Points** of the tie lines or other cross-border linking **Element**.

d) The edges where to cut the **Island** shall be well defined and stable from the topological point of view (e.g. stretched systems are more adapting to **Islanding** than the meshed ones due to the number of circuit breakers to be controlled and open.

e) The **Island** shall be robust and in average well balanced (neither large surplus nor large deficits).

f) The **Power-Generating Modules** of the **Island** shall have a high capability of regulating frequency and voltage.

OC 4.3.14.3 The protection scheme triggering the **Islanding** procedure and the capabilities of regulating provided by the **Power-Generating Modules** shall be periodically tested.

OC 4.3.14.4 **TSOs** including **Islanding** strategies should inform the rest of the **TSOs** about the possible maximum unbalance created by the isolation of the **Island**.

OC 4.4 Restoration Plans

OC 4.4.1 Each **TSO** member of a **Synchronous Area** or a **Region** is required to have **Restoration Plans**.
The **Restoration Plan** has to be:

a) Described in detail in classified documents.

b) With clear role assigned to each **Grid User**.

c) With agreed terms of cooperation with the neighboring **TSOs**.

d) Periodically tested.

OC 4.4.2 Priority of the **Restoration** strategy and practices shall be to energize the bus bars and the house **Load** of the **Power-Generating Modules** as fast as possible.

OC 4.4.3 In case of reenergization from abroad, the involved **TSOs** have to make their **Best Effort** to cooperate in design the procedures, in testing them and in executing in case of need.

OC 5 EMERGENCY AND RESTORATION

J. Solidarity and operating advantages in accelerating the service find concrete application in the **Restoration**. **Restoration** could mean in fact the recovery of internal **Loads** and the reconnection with the rest of the **Synchronous Area**. Being prepared and coping with rare but possible undesirable events requires joined experience, common simulations and training.

OC 5.1 Emergency Awareness

OC 5.1.1 The terms of cooperation shall be inspired by the sense of solidarity first, but terms and limits of cooperation shall be concretely agreed in specific procedures and multilateral agreements by the **Member States.**

OC 5.1.2 Alert procedures and tools shall aim at spreading the knowledge on the state of the **Synchronous Area** among all the **TSOs** of **Interconnected Member States** in a fast and secure way. To this purpose:

a) In addition to the **Warning System**, each control room shall communicate and have access to contact lists, with names of physical operators, telephone numbers and position to contact in case of need.

b) Secure and protected communication channels (telephone, fax, e-mail) shall be available.

c) A hotline always active during emergencies shall be available

d) Operators shall make aware, preferably with formatted messages, the state of the system, the expected duration of the **Emergency** and request of support.

e) Facilitate the crisis management at least avoiding that involuntary actions of one **TSO** could worsen the status of an **Electricity System** of another **Member State**.

OC 5.1.3 Open crisis permanent conference during emergency among all the **TSOs** of the same **Synchronous Area** should be common practice, previously agreed in the modalities and tested periodically.

OC 5.2 Cooperation in Emergency to Save the System

OC 5.2.1 The terms of cooperation shall be inspired by the sense of solidarity first, but terms and limits of cooperation shall be concretely agreed in specific procedures and multilateral agreements by the **Member States.**

OC 5.2.2 In case one or more **TSOs** are in **Alert** or **Emergency States** and their resources are no longer sufficient to face with the situation, the rest of the connected **TSOs** have to cooperate to avoid the contingency to spread till the collapse.

OC 5.2.3 The support from the **TSOs** is mandatory as long as the **TSOs** had previously agreed, prepared and possibly tested defined actions and plans.

OC 5.2.4 In addition to the commitment to keep the integrity of the **International Interconnection** as much as possible, frequency management is crucial to contain the risk of deterioration.

OC 5.3 Cooperation in Restoration to Recover the Functionality of the System

J. Fulfilment of security standards affect the reduction of risk and must be pursued systematically. In case of **Out of Range Contingencies**, after the **Defense Plan** activations and stabilization of the **Electricity System**, fundamental contribution to the resilience is given by the application of fast and well-prepared **Restoration** procedures.

OC 5.3.1 **TSOs** are obliged to cooperate each other if the re energization procedures are agreed, well prepared and periodically tested.

OC 5.3.2 In the choice of the reenergization strategy, **TSOs** shall take into account that:

a) The success of the top down strategy depends on the availability of carrying capacity of the cross-border tie lines, the **Reserve** margins of the **TSOs** leading the **Restoration** and its capability to communicate.

b) The success of the bottom up approach depends on the availability of internal resources for black start, voltage and frequency regulation capability, **Load** management ability. This strategy involves other **TSOs** in the last phase of resynchronization.

OC 5.3.3 The design of the reenergization sequences shall comply with the following criteria:

a) As far as the frequency management is concerned:

i. **Frequency Leaders** have to be chosen in both cases: (A) *Frequency Deviation* if the **Electricity System** is connected and the frequency is outside ±200 mHz for more than one minute or (B) *Split Situation* there are 2 or more portions of the **Synchronous Area** split.

ii. The **Frequency Leaders** may be more than one if the **Electricity System** results split in more than two **Islands**.

iii. The **Frequency Leader** commute the **Secondary Control** to **Primary Control** mode, while the other **TSOs** freeze the **Secondary Control** and move the set points of **Power-Generating Modules** manually, under the directions of the **Frequency Leader** to restore the frequency fast.

iv. In case (A) the **Frequency Leader** complete the **Restoration** until the **Secondary Control** is reactivated.

v. **Frequency Leaders** have to be chosen among the ones:

- with the highest *k* factor of the **LFC** regulator;
- with large amount of **Reserve** that it can mobilize;
- with enough margins on the lines;
- with visibility of frequencies from the other **TSOs**.

b) As far as the resynchronization of split area is concerned:

i. In case (B) *Split Situation*, when the conditions allow, the resynchronization of all the split areas has to be performed. This is done two split portions by two. For each couple of portions, a **Resynchronization Leader** is selected between the two **Frequency Leaders** of the two couple of areas to be resynchronized.

ii. **Resynchronization Leaders** play the role of coordinating the **Frequency Leaders** and have to be chosen among the ones:

- which have substations under their responsibility;
- which are able to acquire frequency and voltages from the areas to be resynchronized.

c) As far as the return to normal **LFC** mode is reached:

i. Once all the split areas are resynchronized, the **Synchronous Area** has been restored, the frequency is back within the ±200 mHz, the last **Frequency Leader** gives the green light for the restoration of **LFC**.

ii. The **Frequency Leader** is the last to switch to normal **LFC**.

OC 6DATA, DOCUMENTS AND INFORMATION EXCHANGE

J. Reporting the analysis of the **Operational** facts and figure is not an exercise of media communication. It is the opportunity to enter common data experiences, interpretation of root causes of events and quantitative elements helpful for improving the **Operation**. Statistics are an important heritage of the day-by-day **Operation** for future choices and decisions.

OC 6.1.1 General applicable rules to **Data Exchanges**, formats and supports are reported in the **Data Exchange Code**. Hereinafter recommendations on reporting and statistics are regulated.

OC 6.2 Annual Operation Report

OC 6.2.1 The aim of the annual report is to promote among **Member States** and external entities the value of **International Interconnection**, highlighting progress in **Operation** and market.

OC 6.2.2 Notwithstanding the policies and obligations on confidentiality, **TSOs** shall cooperate to regularly issue the **Annual Operation Report** at Pan Arab level with details of **Synchronous Area** and isolated **TSOs**. The **Annual Operation Report** should be issued no later than the first quarter of Y+1 in an extended version for internal use and another one, reduced, for media relation use.
The **Annual Operation Report** shall at least deal with the following topics.

a) Main facts and figures.

b) **Demand** in energy and power;

c) Amount of exchanged **Energy Transfers** border-by-border;

d) Production balances per source;

e) **RES** penetration progress;

f) Relevant facts and events including major disturbances manage crises.

g) Any other topic that a **TSOs** jointly decide.

OC 6.2.3 **WG2** shall coordinate the data collection and drafting activity for issuing a quarterly report on frequency and power exchanges.

OC 6.3 Data for Fault Analysis

OC 6.3.1 Ordinary faults on the cross-border tie lines are considered routine activity regulated by the **Operation Agreements**.
In case of large disturbances involving more than one **TSO** it is recommended

WG2 to appoint a technical investigation team to draft a common shared report. To this purpose **TSOs** shall exchange data for analysis in the format and detail requested by such a team.
Such report should analyze at least:

a) Pre-fault conditions.

b) Inception fault and its evolution.

c) Protection and **Defense Plan** behavior.

d) Operators' behavior.

e) Root causes and lessons learned.

The **Annual Operation Report** remains internal and confidential and it is forwarded to the involved **TSOs** for the actions of their competence.

OC 6.4 Data for Statistics

OC 6.4.1 Statistics are the basis of forecast both in **Operation** and planning. Historical data shall be stored in the common database and maintained by the **TSOs** themselves.

OC 6.4.2 The collection of statistical data shall be done regularly and certified. Any change after collection shall be registered and approved.

OC 6.5 Documentation

OC 6.5.1 The **Connection Agreement** is the main technical document necessary to safely manage the **International Interconnection** facilities. It is a formal, registered document and any change of it shall be agreed in advance and properly recorded.

OC 6.5.2 The **Connection Agreement** refers to a single **International Interconnection** facility. For each of them the **Connection Agreement** shall include:

a) all data on property and identification of the **Connection Point**, i.e. the interconnector including the sending and ending substations;

b) the physical (i.e. ownership) and operational boundaries;

c) the list of **Elements**;

d) all nominal (physical) characteristics of the single **Element** in steady state and transient conditions;

e) the certification of all tests passed at the acceptance of the facility from the manufacturer to the **TSO**;

f) the names and addresses of personnel, classified per position and role (e.g. responsible, operator in shift, etc.) attending the substation and the same for the personnel of the **National Control Centers**;

g) single line diagram of the substations included position of switchgears and measuring transformers;

h) the full fault protection scheme;

i) the setting cards of the fault protections;

j) automatisms;

k) **WAPS** (if any);

l) the **Metering Equipment**;

m) the safety rules and safety procedures;

n) the maintenance responsibilities.

o) the operation of **FACTS** or **HVDC Systems** in terms of control modes and the reactive power compensation.

OC 6.5.3 The full protection scheme setting coordination that shall be carried out jointly, according to coded procedures.

a) Maintenance procedures (what kind, periodicity, repairing and replacement of devices or parts of them).

b) Tele-protection testing and channel rents.

OC 7TESTING AND PERFORMANCE MONITORING

J. Periodic tests are crucial for the reliability of the Pan Arab **Electricity System**. It has to be reminded and become a traceable and transparent obligation.

OC 7.1.1 The commitments and obligations that each **TSO** take against other interconnected **TSOs** mostly rely on the efficiency of machinery, equipment and procedure of third parties of its **Control Area**, so called **Grid Users**. To support the **TSOs** in performing their own responsibility against the interconnected **Operation**, this **Code** prescribes to rely on the performances of the **Grid Users** by means of regular periodic tests. The frequency, the testing modalities and in general the performance control are regulated and organized by the **TSOs** according to the agreements in force.

OC 7.1.2 Notwithstanding the rules of the respective **National Grid Codes** in matter of performance control, **TSOs** are required to perform or cause **Grid Users** to perform periodical tests on:

a) The **Restoration Plans**, including **Black-Start Capabilities** of **Power-Generating Facilities** and reconnections of **Demand Facilities**.

b) The **Emergency** procedures.

c) The frequency regulation capabilities of **Power-Generating Modules**.

d) The **UfLS** or **UVLS** relays to be shed.

e) Any other device, procedure or computer-based application according to a testing plan that **TSOs** consider vital for the **SoO**.

f) Methods of testing are decision and full responsibility of the **TSOs** who periodically report to **WG2** the status of such tests.

OC 7.1.3 It is good practice, recommended by this **Code**, the **TSOs** to keep updated internal inventories of the **Power-Generating Module**s tasked to provide **Black-Start Capabilities** and other services in **Restoration**. **TSOs** should associate to the inventories, registers where the tests and their outcomes should be recorded. **TSOs** should keep limited the access to the **Information** of such registers.

OC 8TRAINING AND CERTIFICATION

J. Modern trend require continuous training and certification of the operators. In particular, the joint training involving neighboring **TSOs** and **RCEs** is of paramount importance.

OC 8.1.1 Selection and training of the appropriate skilled personnel employed as operators in **National Control Centers** and in **Operational Planning** is responsibility of each **TSO** and it is required to guarantee the correct **Operation** of the **International Interconnection** against the rest of the **Member States** of it.

OC 8.1.2 In discharge to its duty, **TSOs** shall provide their operators with two categories of training:

a) the initial training for the newly recruited personnel; and,

b) the continuous training for those already on duty.

Both categories shall concern the interconnected **Operation** topics.

OC 8.1.3 Operators should have a degree of technician or above in power system-related topics.

OC 8.2 Initial Training

OC 8.2.1 Before having access to the control room of the **National Control Centers**, and assume **Operational** responsibility, candidate operators should have:

a) Successfully passed psycho and physical attitudinal tests.

b) Attended to classes divided into modules on:

i. basic theory on electric power systems;
ii. **Elements**, **Electricity System** structure, **HVAC** and **HVDC System** technology;
iii. regulation, **International Interconnection** and basics of power system control.
iv. **Network** analysis, forecasting methods;
v. voltage and frequency control, protection and automation, **Defense Plans**;
vi. control room procedures;
vii. market, economic dispatch;
viii. safety, environmental protection;
ix. practices on control and monitoring;

c) On site visits to substations, lines and other **Facilities**.

d) Training simulator sessions (if available).

e) Training on the tools available in the control room.

f) Training on the job (shadow shift) for six (6) months at least.

OC 8.2.2 Training simulators should reproduce as much as possible the real **Operational** environment of the control rooms.

OC 8.2.3 **TSOs** shall organize joined inter-**TSO** training sessions at least among the neighboring **TSO** operators and the operators of the **Regional Coordination Entities**.

OC 8.3 Continuous Training

OC 8.3.1 Continuous training consists of the same topics and modules as applied to the initial training, with more emphasis on the latest updating and on points OC 8.2.1.b)-vi and OC 8.2.1.d) and with special emphasis on new available technologies.

OC 8.3.2 **TSOs** shall certificate their competences, after providing them with training hours on the **Operation** topics. The HR department of the **TSOs** company shall register the number of given training hours.

OC 8.3.3 **TSOs** shall commit themselves to give at least 60 - 100 hours pro capita per year in refreshing and updating sessions.

OC 8.3.4 The training cycle should be 2-3 years.

OC 8.4 Trainers

OC 8.4.1 Trainers' technical background should be prevalent, but pedagogical basic elements are needed as well.

OC 8.4.2 Trainers shall be selected together with the HR department, among **TSO** company's engineers, former operators, senior operators and, if considered appropriate, external experts.

OC 8.4.3 Regular feedback on the effectiveness of the training processes are required.

OC 8.4.4 An ad hoc internal committee of the **TSO** company shall assess the personnel at the end of the training courses. Periodical assessment during the training courses are required.

OC 8.4.5 Trainers, in cooperation with the dispatching department and the HR shall set up a program and the tuition material.

OC 8.5 Certification

OC 8.5.1 Self-certification issued by the **TSO** is preferable if the company operates in quality regime.

OC 9CYBERSECURITY

OC 9.1.1 The bulk **Electricity System** shall be considered a mission critical infrastructure by the **Member States**. As such the cybersecurity of the single **TSO** of the **International Interconnection** shall comply with the respective national policies and their confidentiality requirements.

OC 9.1.2 As far as the **ICT** infrastructure in common adopted to **Real-Time Data Exchange** and **Operational Planning Process** are concerned, **WG3** shall issue guidelines including:

a) The self-assessment of the vulnerability and resiliency capabilities proven by resilience tests.

b) The analysis of cyber threat scenarios, risk assessment and security plans.

c) The organization of physical mitigation measures.

d) Procedures of response to attacks.

OC 9.1.3 **TSOs** shall self-certify the application of requirements (holistic approach) about physical and functional segregation, and access control to structures and applications to infrastructures in common for **Operation**.

OC 10 RECOMMENDATION ON SAFETY

OC 10.1.1 This **Code** does not intend to give safety rules – which are a set of approved rules for safe access to substations, switchyards and other **Elements** of the **Grid** and keep workers safe when they are exposed to the hazards of working on the **Transmission System** –, as it does not deal with the **Physical Operation** of **International Interconnection**. Safety is responsibility of the **TSOs**. **TSOs** shall apply them.

OC 10.1.2 In no case shall the **Code**:

a) Neither replace nor intend to modify the safety rules in force at the involved **TSOs**.

b) May be as direct or indirect induction to infringe the safety rules and procedures agreed at the moment of the intervention on the interconnectors.

OC 10.1.2.1 Safety always prevails on any other issue of the interconnected **Operation**.

OC 10.1.2.2 As far as the scope is concerned, the recommendations of this **Code** are limited to the inter-safety part of the safety discipline and apply:

a) to the safeguard against electrical hazard;

b) to the cross-border **Elements** of the **Transmission System** where at least two **TSOs** are involved;

c) in maintenance and / or testing activities.

OC 10.1.3 The neighboring **TSOs** shall attach to the **Connection Agreement** the safety procedures and the reference safety rules adopted. The procedure and the agreed forms for that specific interconnector shall be attached as well. The same documents shall be agreed with, updated and notified to whom it may concern at any change of rules and layout of the assets.

OC 10.1.4 This **Code** recommends:

a) The availability of safety coordinators (requesting and implementing) for all the sites where safety procedures have to be applied.

b) The formal authorization of the safety coordinators.

c) Coded recording and traceability of the **Safety Precautions** from the requests to the cancellation **RISSPs**.

d) Unambiguous identification of the parts of substations object of **Safety Precautions**.

OC 10.1.5 In **Emergency State** condition this **Code** recommends:

a) To report the status of switchgears to the safety coordinator.

b) To ask for the permission to restore the apparatuses.

c) The safety coordinators to agree on a).

OC 11 REQUIREMENTS FOR SYNCHRONIZATION OF ELECTRICITY SYSTEMS

J. Requirements for properly connecting and operating **International Interconnections** based on **HVAC Systems** between two or more asynchronous **Electricity Systems** are necessary to check and align the performances of the **Electricity Systems** to be interconnected and prevent instabilities or other adverse impacts on the **Electricity Systems**.

OC 11.1.1 Whereas:

a) The technology of **HVDC System** allows to connect two **Asynchronous Areas** with a limited problem of compatibility of **Operation**. In addition, **HVDC Systems** allow to supply **Ancillary Services** like equivalent **Power-Generating Facilities**. Hence there is the need to regulate in the **Connection Code** their characteristics. As far as **AC** lines are concerned, a fairly high degree of compliance of the two connected areas is required, but **HVAC Systems** do not provide **Ancillary Services.** Hence, they are not considered as objects to be regulated in the **Connection Code.**

b) An exception has to made when a **HVAC Systems** have to connect two **Asynchronous Areas**. In this case the synchronization problems prevail over the connection specification of the line.

c) This chapter is dedicated to the synchronization, that is to the activity needed to make the future **Synchronous Area**, which results from the interconnection of the previous **Asynchronous Areas**, reliable and fit for the purposes of the **Operation**.

OC 11.1.2 The synchronization of two **Control Areas** consists in a set of actions needed when such areas are connected in AC for the first time. This Chapter recalls the main points to be verified, tested and agreed during the synchronization phases. Moreover, it provides a list of studies and a list of tests to be performed in isolated and interconnected **Operational** conditions when implementing an **International Interconnection** based on an **HVAC System** between two or more **Electricity Systems** belonging to **Asynchronous Areas.** The synchronization is in fact an event involving all the **TSOs** of the areas to be synchronized. This implies that the **International Interconnection** has to be accepted by the **TSOs** of the areas only as far as the effect on the interconnected operation is concerned.

OC 11.1.3 In this Chapter, the terms "**TSO**" and "**Grid**" refer only to the system operators and the **Transmission Systems** of the asynchronous **Electricity Systems** to be interconnected, respectively. The term **HVAC System** refers to an **International Interconnection** based on a **HVAC** line or other **HVAC** equipment.

OC 11.2 Harmonization of the Operational Procedures

J. The synchronization of two or more **Electricity Systems** requires the harmonization of the **Operational** procedures and the fine tuning of the settings of protections and automatisms.

OC 11.2.1 Before implementing the **HVAC System**, the **National Grid Codes** and the on-field practices of the **TSOs** shall have been harmonized and adapted to the requirements of the **Arab Grid Code**. Part of the assessment is the selection of rules, obligations and procedures that are mandatory to be conformed since the beginning and the timeline to complete the compliance path.

OC 11.2.2 In addition to the neighboring **TSOs**, a devoted team of **TSOs** led by the **Arab TSO Committee** should be part of the process with the main tasks of guaranteeing the **TSOs** of to the involved areas on the correct application of the principles of the **Arab Grid Code**. The **Arab TSO Committee** is also supervisor of the programs and the time schedules.

OC 11.2.3 In addition to the technical matters, **TSOs** shall sign a series of contracts and agreements on the market rules, which are not part of this **Code**.

OC 11.2.4 The harmonization process shall be concluded before the first commercial **Operation** of the first **International Interconnection** of the **Electricity Systems**.

OC 11.2.5 The devoted team of **TSOs** shall report on the following main activities:

a) Review of the **TSOs** regulations.

b) Performing gap analyses.

c) Drafting guidelines for harmonization and full compliance to this **Code**.

d) Visiting and training activities.

OC 11.2.6 Final decision for synchronization and connection shall be taken at the unanimity by all **TSOs** involved in the **Synchronous Areas** on the basis of the proposal of the **Arab TSO Committee**.

OC 11.3 Load-Frequency Control

OC 11.3.1 When connecting two or more asynchronous **Electricity Systems**, each relevant **TSO** shall guarantee to respect its own obligations concerning **LFC** within its **LFC Area** according to the requirements set in this **Operation Code**.

OC 11.3.2 The **TSOs** shall develop and agree upon the terms and conditions or methodologies for defining the **LFC** structure for the **Synchronous Area**.

OC 11.3.3 Each **TSO** is responsible for implementing and operating according to the **LFC** structure of its **Synchronous Area**.

OC 11.3.4 Some of the principles and obligations to be defined in the agreement of **LFC** for each **TSO** operating an **LFC Area** are:

a) collect and calculate the **Scheduled Energy Transfers** between the areas in accordance to the **Scheduling & Dispatching Code**;

b) measure and monitor the **Actual Energy Transfers**;

c) calculate (or measure) the **Area Control Error (ACE)**; and

d) operate the frequency restoration process.

OC 11.3.5 The **TSOs** shall agree, under coordination of the **Arab TSO Committee** upon the definition of the total amount of **Primary Reserve** and its share between the two interconnected **Member States**. In particular:

a) The basic dimensioning criterion of the **Primary Reserve** is to withstand the **Reference Incident** in the interconnected **Electricity System** by containing the system frequency within the maximum instantaneous frequency deviation and stabilizing the system frequency within the maximum steady-state frequency deviation. The definition of the **Reference Incident** shall take into account the maximum expected instantaneous power deviation between **Generation** and **Demand** caused by an N-1 contingency and can be determined by taking into account at least:

   i. the loss of the largest **Power-Generation Module**;
   ii. loss of a line section;
   iii. loss of a bus bar;
   iv. the loss of the largest **Demand Facility**.

b) The primary frequency control and minimum target performance shall include the definition of:

   i. the required accuracy of local frequency measurements;
   ii. the **Frequency Response Deadband** of the governor of the regulating units (see CC 10 ANNEX B of the **Connection Code**);

iii. the minimum value of **Nominal Power** above which each **Power-Generating Modules** shall be included in group of regulating **Modules;**
iv. the physical deployment time of the **Primary Reserve** at the occurrence of frequency deviation from its nominal value;
v. the minimum duration for the capability of primary control delivery;
vi. the frequency deviation for full activation of **Primary Reserve**;
vii. the cycle for measurements of the system frequency.

OC 11.3.6 To restore the frequency to its scheduled value following a disturbance, the **Secondary Reserve** shall be activated. The **TSOs** shall develop and agree upon the terms and conditions or methodologies for the definition of the total amount of **Secondary Reserve** and its share between the two interconnected **Member States**.

OC 11.3.7 The **TSOs** shall avoid manual procedures and shall implement an automatic control of frequency and **Energy Transfers** when operating in synchronous parallel **Operation** according to a power-frequency controller which considers deviations of power exchange as well as frequency from the corresponding set points. The automatic controller shall be integrated in an **Automatic Generation Control** (AGC) to achieve the following primary objectives:

a) To maintain frequency at the scheduled value.

b) To maintain the net **Energy Transfers** with the neighboring control area at the scheduled values.

The control signal of **AGC**, called set-point, is divided among the **Power-Generating Facilities** under control by using participation factors.

OC 11.3.8 In case of observed or expected sustained activation of **Secondary Reserve**, the **Tertiary Reserve** shall be activated. The **TSOs** shall develop and agree upon the terms and conditions or methodologies for the definition of the total amount of **Tertiary Reserve. TSOs** are responsible for making available the total amount of **Tertiary Reserve** within the **Electricity System** that they operate.

OC 11.4 Voltage and Reactive Power Control

OC 11.4.1 Under parallel **Operation**, each **TSO** shall ensure reactive power reserve with adequate volume and time response, in order to keep the voltages on interconnectors and neighboring busses within the ranges set out on the **National Grid Codes**.

OC 11.4.2 The dispatching centers of the **TSOs** shall jointly specify the adequate voltage control regime and shall determine the voltage control actions in order to ensure that the common **Operational** security limits are respected and to prevent a voltage collapse of the interconnected **Electricity System**.

OC 11.4.3 The dispatching center of each **TSO** shall agree with the **Power-Generating Facility Owners** connected to its **Grid** on the reactive power set points of **Power-Generating Modules**, power factor ranges, and voltage set points for voltage control at the **Connection Point**. The **TSOs** should have the right to give voltage control instructions to **Power-Generating Facility Owners** and each **Power-Generating Facility Owner** shall use its reactive power sources to ensure that those parameters are maintained.

OC 11.5 Interconnected Defense Plan

OC 11.5.1 The **TSOs** shall design a **Defense Plan** taking into account the **Operational** security limits, the characteristics of their **Grids**, and the behavior and capabilities of **Demand Facilities** and **Power-Generating Facilities**.

OC 11.5.2 The **Defense Plan** shall include at least the following technical and organizational measures:

a) System protection schemes including at least:

   i. Automatic under frequency control scheme.
   ii. Automatic over-frequency control scheme.
   iii. Automatic scheme against voltage collapse.

b) System Defense Plan procedures, including at least:

   i. Frequency deviation management procedure.
   ii. Voltage deviation management procedure.
   iii. Interconnection power flow management procedure.
   iv. Manual **Demand** disconnection procedure.

OC 11.5.3 *Frequency limits*

OC 11.5.3.1 The **TSOs** shall harmonize the limits of frequency deviations in **Normal State Operation**, by identifying at least two sets of frequency deviation:

a) The variation range under **Normal State** conditions that shall be equal for the **Grids**.

b) The upper and lower maximum values of frequency and the time duration in **Emergency State Operation**.

OC 11.5.3.2 The acceptable lowest frequency values need to be harmonized determining a maximum instantaneous low frequency threshold common to the **Grids** based on an evaluation of a target minimum frequency at which the cascading failure, namely frequency collapse, begins.

OC 11.5.3.3 The acceptable highest frequency values need to be harmonized and shall be compliant with the high frequency relay settings of **Power-Generating Facilities** connected to the **Grids**.

OC 11.5.4 *Underfrequency Load Shedding (UfLS)*

OC 11.5.4.1 Before operating the **HVAC System**, the **TSOs** shall perform a dedicated study for a joint **UfLS** design for their **Electricity Systems**. The main scope the study will be to evaluate the strategies for the coordinated **UfLS** plans with the aim to arrest frequency decays and restore frequency in the interconnected **Grids** and to prevent unbalanced **UfLS** which may cause a high loading of the line of the **HVAC System**.

OC 11.5.5 *Measures Against Voltage Drop or Increase*

OC 11.5.5.1 The **TSOs** shall set an agreement for the control of the voltage and reactive power at the **International Interconnection** line[6] of the **HVAC System** with the objective of keeping the voltages within a narrow bandwidth as required by the **National Grid Codes** and a minimal reactive power flow across the line of the **HVAC System**.

OC 11.5.5.2 The TSOs shall perform a dedicated study addressing the reactive control over their **Electricity Systems** in **Normal State** and **Emergency State Operation**. The study objectives shall include at least the following items:

a) In **Normal State** conditions, definition of the reactive power reserve requirements, distribution and dispatching of the reactive power, and possible issues due to reactive balances in peak and off-peak **Demand** conditions.

b) In **Emergency State** conditions, definition of a series of countermeasures to avoid violations of the processes of **Demand Facility Owners**, loss of auxiliary of **Power-Generating Facilities**, **Facilities** trips up to voltage collapse. The countermeasures may include **Load Shedding** due to low voltages, on-load tap changer blocking scheme, and the implementation of system protection schemes for voltage management in form of undervoltage **Load Shedding** scheme.

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[6] In the following referred to as "line" of the **HVAC system**

c) For the line of the **HVAC System**, definition of the main settings of an automatic protection for line trip in case of high or very low voltage levels. The logic of the **International Interconnection** trip shall consider the amount of reactive power flow and its direction.

d) Evaluation of the possible power frequency overvoltages on the **HVAC System** and the overvoltage protection coordination, otherwise known as insulation coordination, in order to minimize the number of insulation failures and therefore the number of interruptions.

e) Definition of the settings of automatic overvoltage protection to be provided at the substations of the **HVAC System** to prevent electric equipment damages.

OC 11.5.6 *Measures to Avoid Major Disturbances*

OC 11.5.6.1 The TSOs shall perform a dedicated study for implementing the **WAPS** to protect their **Electricity Systems** in **Emergency State** conditions.

OC 11.5.6.2 Before starting the test of **HVAC System**, the **TSOs** shall study the risk of appearance of both inter-area or local oscillations. The main objective of the study is the assessment of the steady state stability of the interconnected **Electricity System** by:

a) Assessment of the risk of inter-area oscillations between the asynchronous **Electricity Systems** to be connected in interconnected **Operation**, during all **Demand** scenarios and **Energy Transfer** levels.

b) Identification of the inter-area and local electromechanical oscillations and corresponding worst (least-damped) modes.

c) Tuning of **PSSs** of major **Power-Generating Facilities** as the most important damping measure against the risk of inter-area oscillations.

d) In case of persisting stability problems due to poorly damped inter-area oscillations affecting the **Grids** even in presence of **PSS**, definition of other preventive measures to be considered in order to ensure stable **Operation** of the **Transmission System** after the **International Interconnection**.

OC 11.5.7 *Measures Against Loss of Synchronism*

OC 11.5.7.1 Before starting the **Operation** of a **HVAC System**, the **TSOs** shall perform a **DSA** to identify the stability limits and possible stability problems in the interconnected **Transmission System**. The study shall use, in a complementary manner, small signal (steady-state) and transient stability analyses. Simulation studies shall assess and monitor the dynamic stability of the **Transmission**

System in all system configurations that are likely to occur. When performing coordinated **DSAs**, both **TSOs** shall determine:

a) Scope of the coordinated **DSA** in terms of a **Common Grid Model**.

b) List of agreed scenarios concerning the coordinated **DSA**.

c) List of agreed contingencies or disturbances whose impact shall be assessed through the coordinated **DSA**.

d) Definition of preventive measures against loss of synchronism, such as the calculation of stability margins on the critical cut-sets. If the critical cut-set turns out to be the line of the **HVAC System**, these margins are to be included in the calculated maximum active power capacity over the line of the **HVAC System**.

e) Definition of **Remedial Actions** in order to avoid the consequences of the loss of synchronism. If the only feasible **Remedial Action** is the opening of the line of the **HVAC System**, the study should examine the consequences of the **Grids** separation.

OC 11.6 Protection Systems

OC 11.6.1 Highly reliable **Transmission Systems** protection systems are a key issue for **Electricity System** reliability, so independent primary and backup line protection systems are a requirement for the line of the **HVAC System**. The protection system to be applied shall be capable of detecting all types of faults, including maximum expected arc resistance that may occur at any location on the protected line.

OC 11.6.2 The following protections shall be verified with particular attention to the **Relevant Grid**:

a) Primary and back up network protection, which provide high-speed and selective fault clearing for all combinations of faults with and without ground.

b) Coordination of the protection of the **Generation** against the fault external to the **Power-Generating Modules** and their **Fault-Ride Through** capabilities.

OC 11.6.3 The minimal necessary defense measures shall include the installation of protections for the line of the **HVAC System** that can detect whether the power flow is attaining the maximum transmissible power or has already exceeded it, or can detect whether the **Electricity System** is evolving towards a dangerous **Operating Condition** in terms of voltage or phase angle difference. These protections can be based on a measurement of transferred power, voltage or impedance. The following system protection should be installed on both sides of the line of the **HVAC System**:

a) Power flow protection based on measurement of the power flow amount and direction.

b) Loss of synchronism tripping devices.

c) Minimum frequency protection combined with a time delay, to ensure the **Grids** separation to restore the **Demand** and **Generation** balance in each of the separated **Electricity Systems** in an independent way.

OC 11.6.4 The **TSOs** shall determine the settings of system protection of the **HVAC System** through appropriate studies to ensure that the settings will not result in **Elements** tripping in case of recoverable **Operation** conditions.

OC 11.7 Process of Synchronization

OC 11.7.1 For the synchronization process, the **TSOs** within the **Arab TSO Committee** shall prepare an agreement regarding the **Synchronization Leader** and define the procedures for the first trials or for synchronization actions to be performed after an emergency trip of the line of the **HVAC System**. This agreement shall describe the conditions under which synchronization takes place.

OC 11.7.2 The **Synchronization Leader** shall apply the required actions in order to operate the synchronization under the following criteria to be satisfied before closing the circuit breaker across the **HVAC System**:

a) The **Electricity Systems** must be in a stable state and the frequencies shall be near to the nominal frequency, within a maximum tolerance agreed upon by the **TSOs**. A frequency difference between the **Asynchronous Areas** shall be below a value agreed upon by the **TSOs** before synchronizing the areas.

b) The voltages shall be in the range agreed upon by the **TSOs** with respect to the nominal voltage. The difference in voltage across the open circuit breaker shall be below a value agreed upon by the TSOs before synchronizing the **Asynchronous Areas**.

c) The voltage phase angle difference across the tie lines shall guarantee the circuit breaker re-closure.

d) The **Synchronization Leader** gives orders to **Frequency Leaders** (i.e. dispatching operators at the **National Control Centers**) for appropriate actions to minimize the frequency and voltage deviation between the **Synchronous Areas** at the time of synchronization.

OC 11.8 Trial Period

OC 11.8.1 The trial period shall be performed once the cross-border **HVAC System** has been energized.

OC 11.8.2 Before the energization, it is recommended to set special protection schemes able to separate the two areas in case of **Emergency State** condition. In this period, no obligation of mutual support is required.

OC 11.8.3 The trial period shall be organized in two phases:

a) Phase "A", lasting at least 6 months, with **Energy Transfers** limited below agreed thresholds and not constrained by commercial operation;

b) Phase "B", lasting at least 6 months, with **Energy Transfers** deriving from commercial agreements or power market operation.

OC 11.8.4 The **TSOs** team shall propose to extend the trial period, if unsatisfactory performance on the interconnected **Electricity Systems** is detected. The **TSOs** team can decide to interrupt the trial period, if significant incidents occurred.

OC 11.8.5 The trial period shall be characterized by an intense monitoring activity. Should incidents occur and show serious noncompliance in the trial period, the phase of the trial period is extended for a length of time necessary to solve the noncompliance.

OC 11.8.6 Monitoring shall focus at least on the following aspects:

a) **Area Control Errors**;

b) **Power System Stabilizers** behavior;

c) Data recording at the occurrence of faults.

OC 12ANNEX A – FREQUENCY CONTROL REFERENCE VALUES

This annex aims at supporting the guidelines given in Chapter OC 3 with **Reference Values**. As stated in Chapter OC 3, at present, four (4) **Synchronous Areas,** grouped into three (3) **Regions,** are identified. Each of them includes different **TSOs** with a different degree of interconnection. Each one of the **Synchronous Areas** / **Regions** has already developed policies, methodologies and practices related to frequency control, load–frequency management and **UfLS** that are closely coordinated among themselves. Without prejudice to the general principle of this **Code**, the peculiarities of each **Synchronous Area** necessitate an agreement on quality targets, **Reserve** sizing, device settings among the **TSOs** of the same **Synchronous Area** and/or **Region**. The agreements should take into consideration the current status of the interconnection and include transparent calculation practices.

The following considerations apply:

1. The **Load Frequency Control** is the result of processes that are controlled and improved on a regular basis. They imply the regular and cooperative participation of the **Member States**.
2. The technological evolution of the **Electricity Systems** affecting the size of the **Generation** (e.g. nuclear **Power-Generating Facilities**), the concentration of power (e.g. **HVDC Systems**), the ability to provide inertia (e.g. Inverter-based **Power-Generating Modules**) and the evolution of the **Load** have to be taken into consideration in sizing and setting the vital functions, that are the object of this Annex.
3. The **UfLS** requires a strong coordination with the frequency control.

For these reasons, the **Operation Code** highlights principles and practices, supported by consolidated and affordable technologies. In this approach the **Operation Code** does not impose technical solutions which, among the others, would require more in-depth analysis for each of the **Synchronous Areas** and preliminary consensus.

Nevertheless, the intention of **Reference Values** is to trigger this process and enhance it towards further and operative decisions on this matter. The Table OC 1 is a simplified excerpt of parameters adopted in **UCTE**, still compatible with the EU Operation Guidelines adopted in the Central Europe Region.

OC 12.1 Frequency and Load Frequency Control

In the following, the Table OC 1 pursues the following objectives:

a) Identifying the minimum set of parameters that have to be defined and progressively adopted if different from the current ones.

b) Showing the example of **MAGHREB** which is synchronously connected with the Continental Europe Region. For this reason, it should share the same approach taken by the rest of the **TSOs** of such area. Accordingly, the numerical indications are taken from the **UCTE** policies.

c) Leaving the completion of rest of the table to the care of the relevant **Synchronous Areas**.

The Table OC 1 is structured in three parts that report three different sets of parameters:

1. The first one (Frequency Quality Targets) sets common objectives among the **Member States** of the same **Synchronous Area**. It is recommended to consolidate them, being the guide for designing the **AGC** and for sizing the **Reserves**.

2. The second one (System Parameters) concerns the behavior of the **Synchronous Area** translated in terms of parameters needed for sizing and sharing the participation to the regulation of the frequency and the control of the power exchanges.

3. The third one (Recommended Technical Standards) complements the previous one with some technical characteristics to be controlled and taken into consideration.

Table OC 1. Main parameters characterizing %=Hz Synchronous Areas.

Notes	Parameters		Reference Values	MAGHREB	CENTRAL AREA	GCCIA 50Hz	GCCIA 60Hz
	Frequency Quality Targets						
( )	**Standard Frequency Range**	[mHz]	±50	(±50)	(±50)	±50	±100
	Max Instantaneous Frequency Deviation	[mHz]	800	(800)	800		
( )	**Max Steady State Deviation**	[mHz]	200	(200)	180	150 (200)	
[a]	**Time to Recover Frequency**	[min]	1				
( )	**Time to Restore Frequency**	[min]	15	(15)		(30)	
	Max number of minutes outside the standard frequency range	[min/year]	15000	(15000)			
	ACE Average Zero Crossing Period	[min]	10	(10)			
	System Parameters						
§	**Reference Incident**	[MW]	3000	(3000)			
§	**Minimum Network Power Frequency Characteristic**	[MW/Hz]	15000	(15000)			
*	**Average Network Power Frequency Characteristic**	[MW/Hz]	19500	(19500)			
*	**Overall Network Power Frequency Characteristic (**or **Regulating Energy)**	[MW/Hz]	27000	(27000)			
	Overall Primary Control Reserve	[MW]	3000	(3000)			
	Primary Control Time	[sec]	0-30	(0-30)		0-30	0-30
	Activation of Primary Control (deadband)	[mHz]	±20	(±20)	±20	±20	±50
	Secondary Reserve minimum duration	[min]	0.5 - 15	(0.5 – 15)			0.5 - 10
	Recommended Technical Standards						
( )	Accuracy of frequency	[mHz]	10	(10)	10	(10)	

	measurement (for regulation)						
	Accuracy of MW measurement of the Tie lines (for ACE control)	[%]	1-2	(1-2)		1.5	

Notes:

§	To be updated when significant changes occur in the **Synchronous Area**.
*	To be calculated periodically on regular basis.
()	Values in brackets are taken from the grid code of one of the **TSOs** of the **Synchronous Area**. They shall be considered as tentative values.
[a]	Optional, to be defined and agreed upon by the **Member States** of the same **SA**
B	Terms in **Bold** are defined in the **Glossary and Definitions**

OC 12.2 Under Frequency Load Shedding

Typical **Under Frequency Load Shedding** plan, as prescribed in Central Europe Synchronous Area (ENTSO-E) under EU Operation Guidelines.

Table OC 2. Default UfLS plan.

TYPICAL LOAD SHEDDING ARRANGEMENT				
49.8	Special threshold	Pumping Load only	Condition	Objective
49.2 (*)	Allowed first step	Pumping Load exhausted		
49.0 (**)	1st Mandatory step	Shed 5% of total consumption at least	No more pumping **Load** to be shed	
48,8	2nd step	Shed no more than 10% of total load		Compensate of loss **Generation**
48,6	3rd step	Shed no more than 10% of total load		
48,4	4th step	Shed no more than 10% of total load		
48,2	5th step	Shed no more than 10% of total load		
48,0	6th step	Shed no more than 10% of total load		
< 48.0	Steps for national needs			

NOTES
(*) lower than the Max Instantaneous Frequency Deviation
(**) to be lower than the Max Instantaneous Frequency Deviation with sufficient margin.

Hypothesis at max step of 200 mHz
Max disconnection time: 350 milliseconds No intentional delay should be set.

RECOMMENDED TECHNICAL STANDARDS
UfLS max limit of operation 120-140% of the nominal voltages (to avoid overvoltage)
UfLS min limit of operation 20-60% (to avoid unwanted shedding due to non-significant measures).
The underfrequency relay shall guarantee an accuracy equal or better than ±10 mHz.