# P5 – Policy 5: Emergency Operations

## *Chapters*

**A. Awareness of system states**

**B. System Defence plan**

**C. System Restoration**

## *Introduction*

In an extremely complex and highly-meshed system, disturbances may be propagated over a wide area within a very short period of time. Whatever precautions, the short-term occurrence of insecure operating conditions can take place at any time due to a cascade of contingencies. Experience has shown that even a simple incident can degenerate very rapidly into a large-scale breakdown. Transmission System Operators (TSOs) will therefore need to apply any measures required to ensure that the consequences of any type of incident will be contained within the frontiers of their respective control area as far as possible. However, since electrical phenomena know no frontiers, consultation and coordinated actions between neighbouring systems will be required for the establishment of effective preventive and curative measures.

Therefore, it is necessary in the “Emergency Operations” to act urgently either before the activation of the automatic defence devices triggered at the last resort, or afterwards during restoration. In the system, emergency situations can also occur as a consequence of an out of range event (Cf. Policy 3). Accordingly, TSOs will provide specific alarms and information on how to deal with a partial or total blackout of the transmission system, and to ensure that the necessary procedures and facilities are in place to support rapid restoration of the collapsed parts and to restore supply to customers. A partial or total blackout represents one of the most serious failures likely to occur on the interconnected transmission system, having a major effect on both active users of the transmission system (generators and distribution system operators – DSOs) and on customers. Due to the significance of such incidents and the urgency in restoring supply to all customers, it is imperative that all TSOs maintain a high level of communication, of system awareness and of dispatching operators training with respect to power system integrity.

This new Policy 5 based on the recommendation of the investigation reports provided after the collapse of Italy in 2003, and the Europe-wide incident of 2006 focuses more in-depth on the responsibilities of TSOs that are supported by the emergency requirements for generators and DSOs. The main issues concern (i) the awareness of the system states, followed by (ii) the defence plans at national level - which enables inter-TSO coordination - and at the last stage (iii) the restoration processes to return to normal operation.

The Policy 5 “Emergency Operation” complements the Policy 3 “Operational Security” dealing only with normal/alert states. Consequently, Policy 5 investigates all abnormal and insecure operational situations that are not ruled in the Policy 3, mainly in emergency and blackout states with the restoration process.

Due to the fact that TSOs cannot ensure the security of operation irrespective of the conditions of operation of power plants and distribution networks, TSOs call for a regular coordination at the level of generation and distribution and for a sufficient performance of equipment connected to their grids with robustness to face normal or severe disturbances and to help to prevent or at least limit any large disturbance or to facilitate restoration of the system after the collapse. In addition to the standards of the Operational Handbook of

ENTSO-E RG CE, the proposals for rules related on the one hand, to the behaviour of generation units with house-load operation capability and black start capabilities (ENTSO-E RG CE – requirements to generators) and, on the other hand, to the operation of distribution networks, including load-shedding (requirements to DSOs as developed in the appendix) shall contribute to a secure power system operation and to this aim be considered in the national regulations (grid codes).

## *History of changes*

| | | | |
|---|---|---|---|
| V0.1 | draft | 03-2008 After Brussels meeting | DT P5 |
| V0.2 | draft | 04-2008 | For WG OS of Warsaw, 24th April 2008 |
| V0.3 | draft | 04-2008 After Winterthur | DT P5 + WG OS –2008 |
| V0.4 | draft | 06-2008 after Madrid | |
| V0.5 | draft | 07-2008 after Vienna | |
| V0.6 | draft | 11-2008 after Paris | |
| V0.7 | draft | 12-2008-after Lisbon | |
| V0.8 | draft | 01-2009 | After WG O&S of Bled + ad-hoc Cologne |
| V0.9 | draft | 02-2009 Budapest | For WG OS 03-2009 |
| V0.10 | draft | 04&05-2009 Rome/Paris | |
| V0.11 | draft | After WG OS remarks | Ad-hoc Vienna 10-2009 |
| V0.12 | draft | After linguistic revision and internal consultation 01-2010 | |

# A. Awareness of system states

## *Definitions*

**A - D1. System States classification.**

Regarding the objective of the use of these definitions, the numbers of the ENTSO-E RG CE system states is related to four situations. These are classified in relation with the grid or load/frequency risk levels and urgency of actions related to risks of propagation.

- **Normal**: *No risk* for interconnected system operation. All consumption and production are in balance and requirements on ancillary services and framework conditions are met; frequency, voltage and power flows are within their predefined and allowed limits (thresholds) and reserve (margins) are sufficient to withstand pre-defined contingencies. Operation is within normal limits, taking into account remedial actions effects (Cf. policy 3).
- **Alert**: *Risk* for interconnected system operation. System within acceptable limits. A contingency or a deterioration of the system (that can endanger one of the following operational limits: power flows, voltage, generation balance related to frequency) has been detected, for which, in case of occurrence, the available remedial actions are not sufficient to cope with. TSO has *uncertainties* to come back to a normal state after this contingency.
- **Emergency**: Deteriorated situation (including a network split at a large scale). Higher risk for neighbouring systems. Security principles are not fulfilled. At least one of the operational limits is outside of the acceptable ranges and makes the system not viable. *Global security is endangered*. Defence plan actions (load shedding, voltage reduction, etc.) are undertaken. No guarantee of total efficiency of remedies to limit propagation to neighbouring systems or to the whole ENTSO-E RG CE system. From this state once stabilised it can be undertaken restoration of parts of the system (e.g. after load shedding or system split)
- **Blackout**: Characterised by the almost or total absence of voltage in the transmission power system with consequences abroad and triggering TSOs restoration plans. A blackout can be partial (if a part of the system is affected) or total (if the whole system is collapsed). From this state, restoration is undertaken with stepwise reenergising and resynchronising of the power system.

**A - D2. Awareness Inter-TSO information.**

Tools of awareness or procedures are set up to increase the knowledge of the state of the system and accordingly to launch alarms to neighbours rapidly.

## *Standards*

**A - S1. Appreciation of TSO system states.**

The system state is determined by the constrained TSO according to its N-1 security assessment, based on potential influence on neighbouring systems taking into account the efficiency of remedial actions.

**A - S2. Information between control rooms by the constrained TSO.**

The constrained TSO has to inform at least all direct neighbouring TSOs about the state of its own system.

#### A - S2.1. Content of information.

TSO informs firstly on system state and in a second step with more details on critical operational conditions including remedial actions taken by its own and call for help if needed (refer to bi-multilateral TSOs agreements).

##### A - S2.1.1. Case of Alert state.

TSO informs about the expected time delay to come back to normal state (*Cf. ASAP in Policy 3)*.

#### A - S2.2. Means of communication

The constrained TSO communicates the system state by well-prepared and tested means, e.g.

- ENTSO-E RG CE or regional awareness tools (real-time information),
- Preformatted messages (tape recorder, Fax, e-mail, web-based, etc.),
- Phone calls to complement messages.

### A - S3. Inter-TSO Contact lists for system operation.

Inter-TSO agreements shall include a list of functional positions directly involved in the system operation to be contacted at any time with phone numbers, fax numbers and e-mail addresses that shall be provided by all TSOs and regularly updated. This list includes desks of control rooms and the relevant staff. All critical information about real-time operation shall be sent to these TSO counterparts.

### A - S4. Secured telephone line.

Whatever the state of the system, the telephone contacts between neighbouring TSOs' control rooms shall be designed to guarantee a high level of availability.

### A-S5. Selection of system states

**A-S5.1. Alert.** A TSO shall at least select the alert state if a contingency or a deterioration of the system (that can endanger one of the following operational limits: power flows, voltage, generation balance related to frequency) has been detected, for which, in case of occurrence, the available remedial actions are not sufficient to cope with. Additionally the loss of a control room shall cause the alert state for the while of the activation of the back-up functions.

**A-S5.2. Emergency.** The Emergency state shall be selected if at least one of the operational limits is outside of the acceptable ranges and makes the system not viable or defense plan actions (load shedding, voltage reduction, etc.) are undertaken.

**A-S5.3 Black out.** The Black out system state shall be selected if at least some parts of the own grid are not supplied due to a disturbance and if the TSO restoration plan is triggered

## *Guidelines*

### A - G1. Information to grid users.

In accordance with grid codes or national requests, TSOs keep the generating units and DSOs (at minimum) involved in the defence and subsequent restoration process informed of critical system states.

# B. System Defence plan

## *Definitions*

### B - D1. Under-frequency load shedding (UFLS): TSO's individual scheme

Each TSO's UFLS plan is based on the ENTSO-E RG CE general plan of UFLS (see B - G1.1) and can be extended by additional steps for frequencies below 48.0 Hz (see B -G 1.2).

## *Standards*

### B - S1. Inter-TSO co-ordination.

For emergency issues TSOs have to agree in writing on bilateral/multilateral procedures with all their neighbours.

### B - S2. Emergency measures.

Each TSO shall implement preventive and/or curative measures in accordance with Policy 3 to cope with the most serious phenomena (voltage collapse, overload and serious balance problems - see Appendix 4.2) and if in line and applicable with the legislation.

### B - S3. Issue of infrastructure – Secured functions of control rooms

#### B - S3.1. Back-up of control room functions.

The control room functions shall be backed up to face any damage to the main installations. This shall be activated within less than three hours and tested for operation at least once a year.

#### B - S3.2. Back-up supply sources.

In the dispatching centres the supply of the main auxiliaries shall be guaranteed with internal independent power supply sources to enable vital functions (e.g. remote control, telecommunication, computer installations, etc.) to be operable also in case of failure of the surrounding power systems. The operation ability of back-up energy sources shall be tested at least once a year.

#### B - S3.3. Reliability of control systems.

TSOs have to assure, during any disturbance in the grid, full functionality and reliability of:

- SCADA/EMS system
- Communication system for dispatching in control rooms
- Load frequency control equipments

### B - S4. Coordination for inter-TSO appropriate common actions.

In case of alert or emergency system state, the constrained TSO adopts urgently all internal measures and asks for coordinated measures from neighbours and other TSO with which cooperation is agreed to relieve the constraint whether these measures are prepared for the expected occurrences of the contingency list or not (Cf. policy 3).

**B - S5. Maintaining the interconnection of systems.**

TSOs are supposed to provide maximal assistance through tie lines in case of an emergency situation experienced by neighbouring TSO and tie lines between control areas are considered the backbone of the interconnected system.

**B - S5.1. Role of neighbouring TSOs in preventing any spreading of collapse.**

In case the TSO is in trouble and is no longer capable of facing the critical situation, the neighbouring TSOs shall offer maximal possible assistance to support the constrained TSO and, with respect to the security of their systems, to limit the propagation of disturbance.

**B - S5.2. Tie lines opening policy.**

Disconnection from the synchronous system will be considered the ultimate remedial action and will only be undertaken after coordination with the neighbouring TSOs ensuring that this action will not endanger the remaining synchronous area.

- Keeping the interconnection in operation as long as possible is of utmost importance, but shall be consistent with the operating constraints. Therefore any manual emergency opening of tie lines shall be announced in advance, predefined and duly prepared in a coordinated way with the neighbouring TSO.
- Opening of a tie line has to be assessed and agreed upon in advance in a transparent way; automatic opening may be performed when given events occur and if certain thresholds are exceeded (e.g. overload damage of the equipment).
- Urgent opening can be carried out in case of physical danger to human beings or installations without prior information to neighbouring TSOs involved.

**B - S6. Management of ENTSO-E RG CE system frequency.**

Actions that cope with frequency deviation, prevent further deterioration and contribute to quicker restoration to normal operation shall be undertaken.

**B - S6.1. Frequency deviation management and Load Frequency secondary control. Deviation higher than 200 mHz from the reference system frequency set point: Freezing.**

In case of frequency deviation higher than 200 mHz lasting more than one minute, the individual load frequency secondary controllers has to be frozen (keeping the last signal of control) by direct manual or automatic actions or by other ways relying on TSO devices or generating units devices. TSOs are allowed to manually override the frozen output signal of load frequency secondary controllers to use its communication/signalling channels to power plants in order to speed up the stabilisation of the system[1]. Refer to C-S3.3 for the return to normal operation.

1 For peripheral control areas like Italy, having an automatic override that contributes to stabilisation of the system is allowed.

**B – S6.1.1. Generation units set points coordination**. TSOs shall establish procedures with power plants to keep their current set points of generation units or take over the new set points given by TSOs.

### B - S6.2. Volume of activated reserve in case of frequency deviation higher than 200 mHz.

TSOs have to activate manually their secondary control reserve taking care of the frequency evolution and taking care not to create congestion.

### B - S6.3. Management of ENTSO-E RG CE over-frequency.

In case the system frequency is still higher than a dedicated threshold (50.2 Hz), TSOs shall take additional manual (or automatic if available) actions to decrease the frequency (i) through starting pumped-storage power plants or (ii) decreasing the level of generation of active power by activating extra primary reserve if available (next steps under the leadership of the frequency leader - refer to §C).

### B - S6.4. Management of ENTSO-E RG CE under-frequency.

In case the system frequency is lower than a dedicated threshold (49.8 Hz), TSOs shall take additional manual (or automatic if available) actions to increase the frequency (i) through stopping pumped-storage power plants or (ii) increasing the level of active power generation by activating extra primary reserve if available (next steps under the leadership of the frequency leader - refer to §C).

#### B - S6.4.1. Automatic Under-Frequency Load-Shedding - UFLS.

##### B - S6.4.1.1. Load shedding capabilities.

For cases where there is a major frequency drop, automatic function for load shedding in response to a frequency criterion must be installed in order to prevent a further frequency drop and the collapse of the system.

##### B - S6.4.1.2. Load shedding criterion.

At 49.0 Hz the automatic load shedding of customer consumption shall start and will reach at least 5% as the first step.

The total control area consumption has to be considered in the stepwise percentages to shed on the basis of individual evaluations by TSOs.

##### B - S6.4.1.3. Load shedding plan – checks.

TSOs organise in common with DSOs (or with other involved parties) the regular checking (at least once a year) of the load shedding plan in order to ensure the predicted load shedding when applied.

## *Guidelines*

### B - G1. Under-Frequency Load shedding.

#### B - G1.1. ENTSO-E RG CE general plan.

- Load shedding of customer consumption is allowed at 49.2 Hz and mandatory at 49.0 Hz and a stepwise 50 % (in total) of the nominal load should be operated under load shedding relays in the range 49.0 to 48.0 Hz.
- At 49 Hz at least 5% of total consumption should be shed, which should be complemented for each individual TSO according to the loss of generation at this stage induced by the frequency drop due to non-compliance with grid requirements.
- Below 49.0 Hz, the stepwise load shedding plan should be complemented by an individual mitigation of the loss of generation. TSOs should adapt their own load shedding plan in order to compensate for the additional loss of generation.
- Frequency steps should be smaller than or equal to 200 mHz (depending on number of steps and characteristic of load shedding relays).
- In each step of UFLS, a disconnection of not more than 10% of the load is advised (depending on number of steps and characteristic of load shedding relays) except if considering the additional loss of generation.
- Maximum disconnection delay should be 350 ms including breakers operation time. No intentional time delay should be added.
- Frequency measurements for load shedding should be maintained at a maximum inaccuracy of 100 mHz.
- Automatic disconnection of pumps should be activated below 49.8 Hz:
  - If 49.2 Hz < frequency < 49.8 Hz, then delay <= 10 s;
  - If frequency <= 49.2 Hz, then delay = 0 s.
  - Below 49.2 Hz all pumps should be disconnected.

#### B - G1.2. Additional UFLS for TSO individual use.

At national level, automatic or manual under-frequency load shedding (UFLS) requisites can be implemented in addition to the ENTSO-E RG CE solidarity demands to cover regional needs inside each TSO’s control area if needed. It is up to the TSO to complement the general ENTSO-E RG CE UFLS plan by additional steps for frequencies below 48.0 Hz for its own purposes.

### B - G2. UFLS Geographical distribution.

Load shedding should be implemented in a regionally evenly distributed way.

### B - G3. Preventing automatic tripping of feeders with dispersed generation.

The UFLS plan should avoid disconnecting feeders with connected dispersed generation above a MW threshold whose value should be defined bilaterally between TSO and DSO.

### B - G4. Additional manual or automatic load shedding.

For specific issues, like to prevent voltage collapse or instability or to alleviate congestions on transmission equipment, manual or automatic (local/regional) load shedding can be activated by TSOs.

Under-Voltage Load Shedding (UVLS) can be implemented within DSOs grids.

## B - G5. Automatic tripping of generating units.

This should be prohibited between 47.5 Hz and 51.5 Hz. This takes into consideration the technical capability of machines to keep stability and the operating limits of equipments (preventing damages) – see requirements to generators.

## B – G6. Activation of reserve of generation.

### B – G6.1. Volume of activated reserve in case of frequency deviation higher than 200 mHz.

TSOs can activate more than secondary control reserve while aiming not to create congestion and taking care of the frequency evolution.

### B – G6.2. Case of congestion.

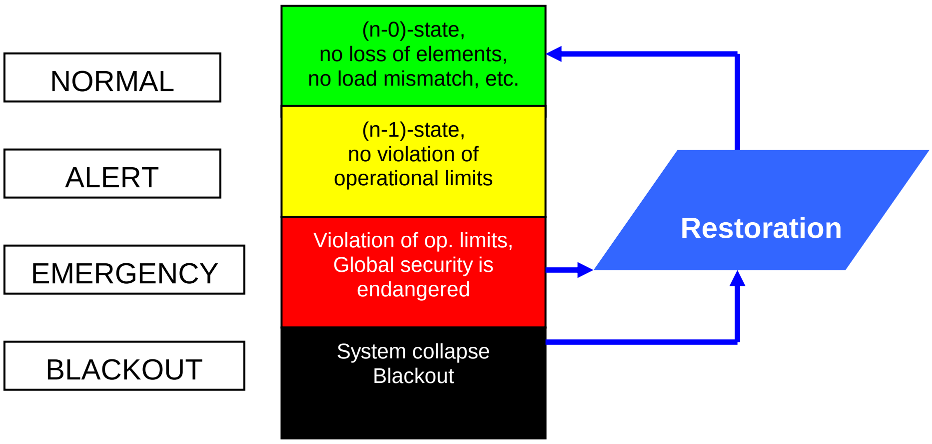
It is not forbidden for a TSO to activate secondary control reserves in the "wrong direction" for frequency management (voluntary increase of ACE value) if this is the only solution to solve congestions (a rare but possible situation).

# C. System restoration

## *Definitions*

### C - D1 System restoration.

A set of actions implemented after a disturbance with large-scale consequences to bring the system from EMERGENCY or BLACKOUT system state back to NORMAL state. Actions of restoration are launched once the system is stabilised. Restoration of the system consists of a very complex sequence of coordinated actions whose framework is studied and, as far as possible, prepared in advance.




### C – D2. Islanded operation capability.

A generating unit can bring stability into an island and during steps of load pickup in case of reenergising the current island. This implies that the automatic voltage regulator and governor are able to balance the reactive and active power surplus or deficit after load pickup or load shedding in small islands in order to feed-in line, to regulate voltage, frequency and power, and to reenergise in isolated operation.

### C – D3. Black-start Capability.

Black-start capability is the ability of a generating unit to go from a shutdown condition to an operating condition, to start delivering power without assistance from the electric system and includes islanded operation capability.

### C - D4. Reenergisation.

The related restoration process for reenergisation is based on two main principles:

- *Bottom-up*: from self reenergising of parts of its own control area to be ready for resynchronisation with another area (that can be with the ENTSO-E RG CE main system)
- *Top-down*: using external voltage sources from tie lines (the power from a secure system that can be the main ENTSO-E RG CE system) to reenergise a separated severely disturbed system

**C - D5. House load operation of units.**

House load operation is the capability of a generation unit to continue to supply their in-house loads after disconnection from the grid. The TSO has to take into account that some units can maintain this kind of operation only for a limited duration.

**C - D6. Leadership for coordination of the restoration.**

Inside an area in trouble with at least two TSOs, as far as the process of restoration is concerned, two kinds of leaderships shall be selected regarding the situations: one for frequency management of areas in trouble and one for the resynchronisation process of areas (see below C-D6.2).

**C - D6.1. Frequency leader.**

The frequency leader has the task of coordination for the frequency management within one synchronous area, based on the limits of its available means and those of each TSO respectively. This frequency leader coordinates the activation of generation reserve within the area in trouble, together with TSOs in his area, in order to recover and maintain a frequency in this disturbed area near to 50 Hz, with a maximum tolerance of ±200 mHz. The frequency leader defines the amount of power (upwards and downwards) to be requested from each TSO of the concerned area. Criteria for choosing a frequency leader are given in C – S3.2)

**C - D6.2. Resynchronisation leader.**

The Resynchronisation leader is in charge of coordinating frequency leaders during the Resynchronisation process of two neighbouring areas (Refer C - S4.1) and to execute the Resynchronisation of these two areas, based on the limits of its available means and those of each TSO respectively. In case of numerous splits, the areas are resynchronised stepwise.

**C - D7. Disturbed Area.**

(This area is adjacent to a secure control area). This is the area in trouble due to an incident. It can be either a part of the control area of a TSO, its full control area, a disturbed zone comprising several TSOs' control areas partly or totally included. This area shall be considered a small or large synchronous island. That means also that a TSO can work simultaneously on two asynchronous grids when the split line cuts its control area e.g. into two parts. The disturbed area is asynchronous compared to the (other) synchronism(s) of the (other) main system(s) alive at the same time. This area is the wide ENTSO-E RG CE system itself when kept integer (unsplit) after a large disturbance or just after its final resynchronisation.

## *Standards*

### 1 - Overall considerations

**C - S1.1 Restoration process.**

The TSO shall start the restoration process based on procedures after all the defence measures ruled in chapter B, once the grid is in a stabilised situation.

### C - S1.2. TSO restoration plan.

Each TSO has to prepare in advance and update regularly a restoration plan**.** This restoration plan includes a bottom-up approach and a top-down approach.

#### C - S1.2.1. System requirements to reenergise.

Each TSO has to develop proper reenergisation procedures allowing the progressive restoration back to normal system state.

**C - S1.2.1.1.** Such procedures have to be proved at least by simulation or off-line calculations.

**C - S1.2.1.2.** Each TSO has to evaluate the number of units capable of black start and islanded operation to contribute to the restoration and to get knowledge of units in house load operation.

**C – S1.2.1.3.** Black start capabilities of units shall be tested regularly on-site at least once per three years.

### C - S1.3. Communication in emergency or blackout states.

Dispatchers have to focus on the exchange of information directly dealing with the operation of the power system, meaning defence and restoration plans issues. In these cases, crisis communication for non-operational purposes has to be managed by the TSOs in a separate way (to disseminate information e.g. to the media).

### C – S1.4. Inter-TSO coordination.

Neighbouring TSOs have to prepare and agree in advance common written bilateral principles with adequate information exchanges to be applied in case of system restoration.

## 2 - Reenergisation from Blackout

### C - S2.1. Knowledge of the internal power system status after a blackout.

TSOs have to know the status of any component of their power system after a blackout e.g. tripped grid elements, islanded areas, blacked-out areas, generation units in correct house-load operation and ready to reenergise, units having difficulty in supplying their house load and thus in urgent need of an external source of voltage, black start capabilities.

### C - S2.2. Reenergisation process.

This process is to be implemented in case of a blackout. Two strategies can be implemented and shall be chosen regarding the existing situation (availability of black start units and house-loaded units within its control area, expected duration of both strategies, situation of the voltage in the neighbouring grid):

#### C - S2.2.1. Top-down reenergisation using external voltage sources.

In cooperation with a neighbouring TSO, which remained secure and stable, the grid shall be reenergised step by step starting from tie lines.

#### C - S2.2.1.1. Active and reactive flow limits.

During the restoration phase, the constrained TSO has to guarantee that they will respect the agreed limits of active and reactive flows on interconnection line(s).

### C - S2.2.2. Bottom-up reenergisation based on internal sources capabilities.

TSOs manage the restoration of the system with the black start capabilities and/or with the units in house load operation. These units provide the capability of controlling voltage and speed/frequency during supplied isolated operation and stable operation in an islanded network.

### C – S2.3 Choice of Load Frequency controller modes or states in case of blackout.

In case of blackout, the load frequency secondary control mode switching depends on the reenergisation strategy.

For the bottom-up strategy, it is up to the TSO to choose the load frequency secondary controller in stopped control state (or in frequency control mode) in order to share the contribution to frequency regulation with all the units of the control area.

For the top-down strategy, the frequency secondary controller shall be in stopped control state in the area that called for reenergising.

## 3 - Frequency management

### C - S3.1. Identifying the extent of the area with the same synchronism.

Each TSO has to identify

- the situation of its control area (with one or more separated asynchronous areas)
- the extent and border of its synchronous area including neighbouring TSOs in coordination with neighbours.
- the state of the available power reserve in its own control area (with possibly separated areas)

### C - S3.2. Frequency leader criterion.

After a severe disturbance with a frequency deviation higher than the maximum permissible (refer to P1-A-D2.2) or in case of system split, the frequency leader shall be chosen within each synchronous area, based on the following criteria (see also C – G3):

As a default the TSO with the highest K-factor under operation (or referring to the most recent published value) within its control area will be appointed as the frequency leader, besides this the following criteria (see also C – G3) shall be considered:

- High amount of generation reserve that can be mobilised within a very few minutes (upward in case of under-frequency situation, downward in case of over-frequency situation), and a large free secondary reserve capability (its half band in the perspective to be in a frequency control mode);
- Capacity margin of tie lines (in export in case of under-frequency situation, in import in case of over-frequency situation);
- Acquisition of frequency values at least of direct neighbouring grids, and if possible of non-direct neighbouring grid that are parts of the same (a)synchronous system by measurements (phone calls, conference calls, etc.).

**C - S3.3. Load Frequency secondary control management for frequency deviation higher than 200 mHz.**

The frequency leader's load frequency secondary control is switched to frequency control mode (refer to §B – S6.1), the other load frequency secondary controllers remain in (or, if not yet, manually switch to) frozen control state. The frequency leader coordinates mobilisation of generation reserve within the synchronous area, in order to recover the frequency, with respect to potential congestions of the grid. Each TSO shall support the frequency leader, even far from its area, when requested.

**C - S3.4. Load Frequency secondary control management in case of grid split.**

The frequency leader's load frequency secondary control is switched to frequency control mode; the other load frequency secondary controllers are put in frozen control state. The frequency leader coordinates mobilisation of generation reserve within the synchronous area, in order to recover the frequency *till the full resynchronisation (Refer C – S 4.3)*, with respect to potential congestions of the grid. In case of a very large asynchronous area, each TSO shall support the frequency leader, even far from its area, when requested.

**C - S3.5. Consumption/production balance.**

During the reenergising processes, consumption and production are balanced with the aim of returning near to 50 Hz, with a maximum tolerance of ±200 mHz, under the coordination of the area's frequency leader.

**C – S3.5.1. Reenergising of (shed) load.**

In case of lost load, the TSO reenergises the (shed) load not when frequency is below 49.8 Hz, for the main system (except for regional islands) keeping a generation margin sufficient at least to cope with the next block of load to reenergise. The reenergising of the load is managed step by step in order to minimise the impact on the frequency deviation and the reserve margins. The process of reenergising customers has to be done stepwise in block loads of maximum size defined by the TSO with respect to the load of the TSO's grid.

**C – S3.6. Coordination with DSOs for reconnection of shed load.**

TSOs have to coordinate the reconnection of shed load with DSOs. Local and remote reconnection of customers' loads has to be agreed in advance in cooperation between the TSO and its DSOs. Automatic reconnection has to be avoided.

**C – S3.7. Reconnection of generators after abnormal frequency excursion.**

The TSO has to coordinate the reconnection of generators tripped due to abnormal frequency excursion.

In this case of loss of generation, the TSO orders the reconnection of generators, based on the instructions of frequency leader, keeping adequate margins of the downward balancing reserve sufficient at least to cope with the next generation power to reconnect. The reconnection of generators is managed step by step in order to minimize the impact on the frequency deviation and the reserve margins. The process of reconnecting generators has to be done stepwise in blocks of maximum power defined by the TSO with respect to the operating reserve of the own TSO's grid.

The TSOs define the criteria for reconnection and disconnection with the constraint to avoid over-frequency conditions.

For installation connected to DSOs grids the local and remote reconnection has to be agreed in advance in cooperation between the TSO and DSOs for the main units. Automatic reconnection of all generators has to be forbidden when in accordance with legislation.

## 4 - Resynchronisation

### C - S4.1. Selection and role of the resynchronisation leader.

For split situations, resynchronisation leader(s) have to be selected for different synchronous areas (one leader for two areas) to resynchronise these areas. In case of numerous splits, the areas are resynchronised stepwise two by two, in a successive way. The resynchronisation leader has to coordinate the resynchronisation process. He will have the following capabilities (requirements):

- Have at least one substation under his responsibility with a “high capacity” line to reconnect both areas
- Be able to acquire the values of both areas’ frequencies (by measurement or at least by phone)
- Be able to acquire the value of the voltage of both substations of the point of connection (by measurement)
- Be able to manage voltage deviation at least for the point of connection

- The resynchronisation leader fulfils the following actions:
- He coordinates frequency leaders
- He chooses the substation for resynchronisation which is one under his responsibility, and is equipped with PSD (parallel switching device) see below
- He coordinates other lines available for a quick reconnection after the reconnection of the first line to strengthen rapidly the link between both areas

### C - S4.2. The resynchronisation process under leadership.

The resynchronisation leader of the concerned areas and in collaboration with the two frequency leaders of their respective areas will apply the required actions in order to operate the resynchronisation under the following criteria:

- Both systems must be in a stable state and both frequencies must be near to 50 Hz, with a maximum tolerance of ±200 mHz to 50 Hz, to resynchronise as securely as possible. A frequency difference between two areas shall be below 150 mHz before using PSDs for synchronisation of areas. Both voltages shall be in the range of 380 - 420 kV.
- Use of 380 - 400 kV line(s) of high loadability.
- Make provisions for closing immediately a second line that is electrically close to the first line.
- To choose by preference a line for synchronisation not in the vicinity of large thermal units in operation.
- The resynchronisation leader gives orders to frequency leaders for actions in the proper direction to minimise the frequency and voltage deviation between both areas just at the time of resynchronisation.

### C - S4.3. Load Frequency secondary control and frequency management after resynchronisation of two areas.

Prior to reconnection, one frequency leader is selected for the rest of the system recovery. If the load frequency secondary controllers of both frequency leaders were previously in frequency control mode, one of the two frequency leaders has to switch its load frequency secondary control to frozen control state to avoid staying with two load frequency secondary controllers in frequency control mode.

## 5 - Final recovery

### C – S5.1. Return to normal LFC mode

- ACE of each control area shall be returned near zero.
- If one frequency leader has been designated, he orders the return to normal load frequency secondary control mode for all TSOs.
- Frequency leader is the last to switch back to normal LFC mode.

## *Guidelines*

### C - G1. Reenergisation by black start units and/or by in-house load units in a collapsed system (bottom-up).

In addition to on-site tests, each TSO should take care of testing capability of black start units to energise line, to regulate voltage and frequency.

Reenergisation paths connect black start or in-house load generating units to:

- the in-house loads of other generating units, important due to their size or location
- predefined blocks of loads (to mitigate over-voltage problems).

In particular, the Reenergisation path should be pre-set:

- to provide restoration facilities (other plants, lines, voltage control equipments, parallel switching devices, etc.) for each part of its own control area
- to supply strategic load.

Redundant Reenergisation paths should be prepared for the most important facilities (nuclear power plants, etc).

### C – G2. Priority to reenergise.

After a blackout, the installations (e.g. remote control centres, TSO critical installations, auxiliary services of power plants, etc.) – which, if unavailable, could compromise the continuation of the successive switching sequences or which are of importance for guaranteeing stability of the grid - should be given priority to be resupplied in a time delay compatible with their energy autonomy.

### C – G3. Choice of the frequency leader.

In cases where a frequency leader might be helpful, TSOs launch a conference call to determine whether a frequency leader is really needed and who it should be, considering the split line, based on criterion mentioned in C – S3.2.

### C – G4. Frequency management in reenergising load within an island.

The isolated TSOs should reenergise the (shed) load keeping the frequency of the island between 50.0 Hz and 50.2 Hz for a generation margin sufficient at least to cope with the next block to reenergise.

### C – G5. Load frequency secondary control and exchanges programs during final recovery

- Based on previous exchanges programs, the TSOs coordinate a manual rescheduling (agreement on new exchanges program schedules)
- TSOs activate generation in order to draw back ACE near zero

## SYSTEM SITUATIONS and LOAD FREQUENCY SECONDARY CONTROL - Chapter C

SC = load frequency secondary control

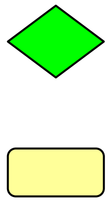
FL = frequency leader

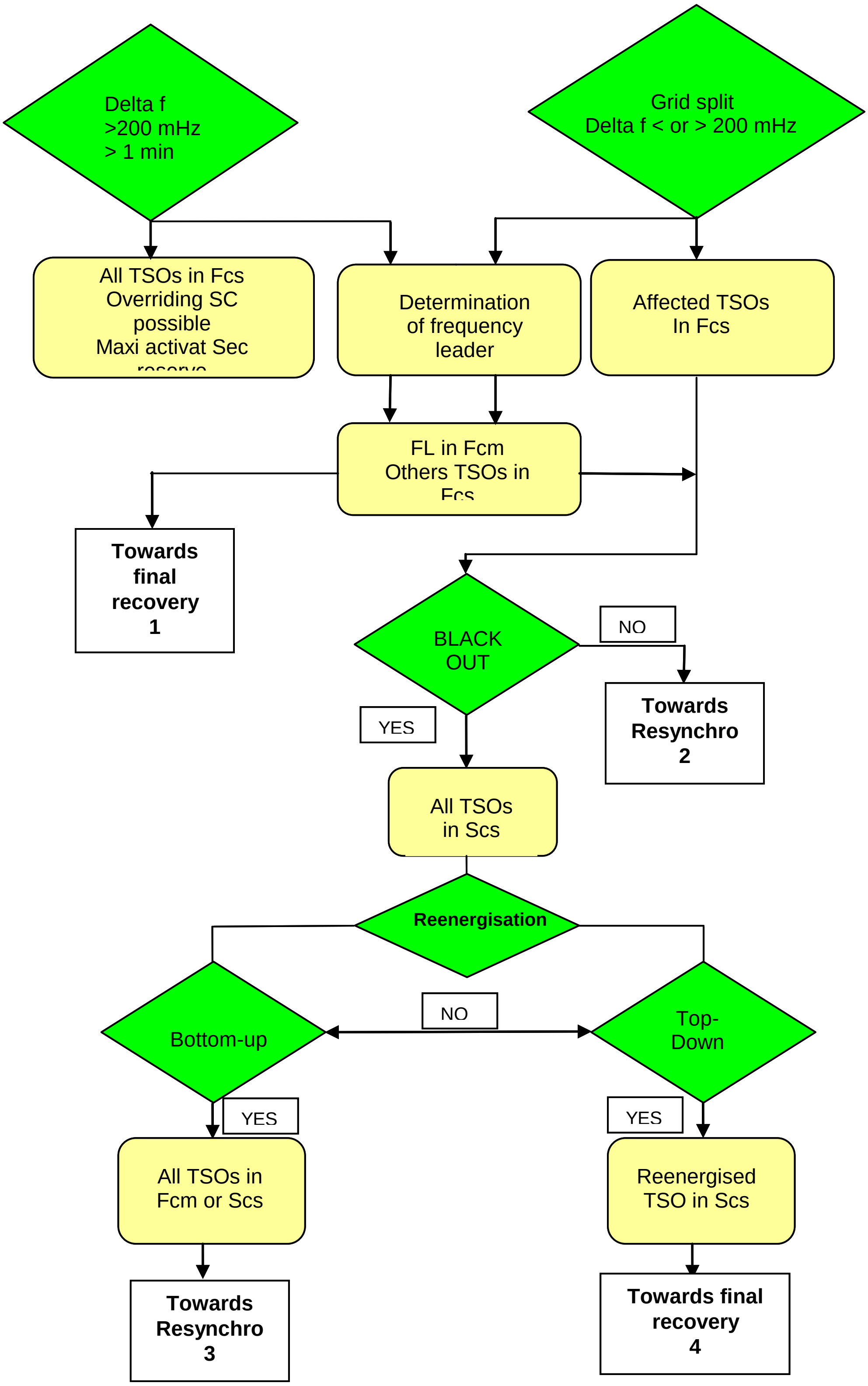
RSL = resynchronisation leader

Fcm = frequency control mode

Fcs = frozen control state

Scs = stopped control state



**SYSTEM SITUATIONS and LOAD FREQUENCY SECONDARY CONTROL - Chapter C (Continued)**

SC = load frequency secondary control

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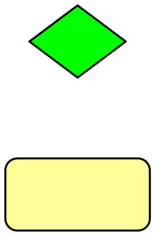
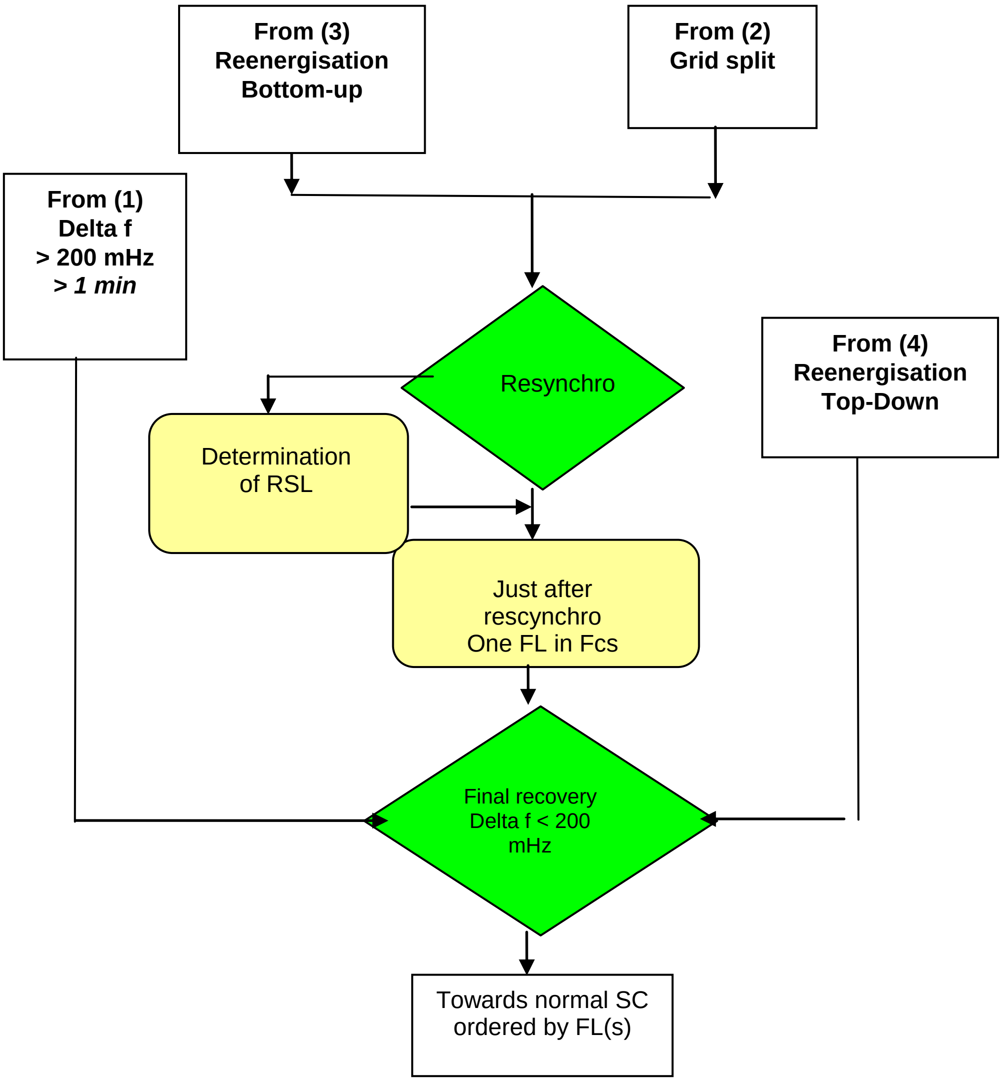


system state or situation

Actions



## CHAPTER C

### Load frequency secondary control modes or states / frequency leader

| Secondary control modes/states | Definitions Cf. Policy 1 | P5 Rules | B - System defence plan / C - System restoration |
|---|---|---|---|
| Frequency control mode | P1-B-D 3.1 | C - S2.3 | In case of bottom-up Reenergisation, up to reenergised TSO to choose frequency control mode |
| | | C - S3.2 | Determination of a frequency leader for disturbed area |
| | | C - S3.3 | If Delta f > 200 mHz<br>Frequency leader in frequency control mode - Other TSOs in frozen control state |
| | | C - S3.4 | If grid split, frequency leader in frequency control mode – other TSOs in frozen control state |
| | | C - S4.3 | Before resynchronisation both frequency leaders in frequency control mode<br>After resynchronisation, only one frequency leader in frequency control mode |
| Frozen control state | P1-B-D 3.3 | B - S6.1 | If Delta f > 200 mHz and >1 min<br>All TSOs in frozen control state<br>Possibility to override secondary control to speed-up frequency stabilisation |
| | | B - S6.2 | If Delta f > 200 mHz, manual activation of secondary reserve |
| | | C - S3.3 | If Delta f > 200 mHz, once frequency leader determined:<br>- Frequency leader in frequency control mode<br>- Other TSOs in frozen control state |
| | | C - S3.4 | If grid split and Delta F < or > 200 mHz, affected TSOs in frozen control state before order of frequency leader (in frequency control mode) |
| | | C - S4.3 | Just after resynchronisation, one frequency leader in frozen control state |
| Stopped control state | P1-B-D 3.4 | C - S2.3 | After blackout<br>In case of top-down reenergisation, reenergised TSO in stopped control state<br>In case of bottom-up reenergisation, up to reenergised TSO to choose stopped control state |
| Normal secondary control | P1 – B | C - S5.1 | Final recovery: return to normal secondary control ordered by frequency leader |

## CHAPTER C

### System states or situations / secondary LFC modes or states and frequency leader

| System states or situations | P5 Rules: | LFC control mode/state and frequency leader |
|---|---|---|
| Frequency deviation > 200 mHz | B - S6.1 | If Delta f > 200 mHz and >1 min<br>All TSOs in frozen control state<br>Possibility to override secondary control to speed-up frequency stabilisation |
| | B - S6.2 | If Delta f > 200 mHz, manual activation of secondary reserve |
| | C - S3.2 | Determination of a frequency leader for disturbed area |
| | C - S3.3 | If Delta f > 200 mHz, frequency leader determined:<br>- Frequency leader in frequency control mode<br>- Other TSOs in frozen control state |
| Grid split and frequency deviation < or > 200 mHz | C - S3.2 | Determination of a frequency leader for disturbed area |
| | C - S3.4 | If grid split and Delta F < or > 200 mHz, affected TSOs in frozen state before order of frequency leader<br>Frequency leader in frequency control mode<br>Other TSOs in frozen control state |
| Blackout state | C - S2.3 | Frequency control mode switching depends on the re-energisation strategy |
| Reenergisation | C - S2.3 | After blackout:<br>- For Top-down Reenergisation, stopped control state for TSO reenergised<br>- For bottom-up, up to reenergised TSO to choose stopped control state or frequency control mode |
| Resynchronisation | C - S4.1 | One resynchronisation leader to resynchronise two areas |
| | C - S4.3 | Just after resynchronisation, one frequency leader in frozen control state |
| Final recovery | C - S5.1 | Return to normal LFC mode ordered by frequency leader |