P5 – Policy 5: Emergency Operations

Document Control

Version Number: V 3.1

Approved By: RG CE Plenary

Date Approved: 43rd RG CE Plenary Meeting 26 of September of 2017

Cancelled: Document ENTSO-E RG CE OH Version 3.0 – Policy 5: Emergency Operations

Chapters

A. Awareness of system states and communication

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, a 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 deteriorate very rapidly into a large-scale breakdown. Transmission System Operators (TSOs) will therefore need to apply any measures required to ensure that consequences of any type of incident will be contained within the borders of their respective LFC area as far as possible. However, since electrical phenomena know no borders, consultation and coordinated actions between neighbouring systems will be required for the establishment of effective preventive and curative measures.

Therefore, it is necessary in "Emergency Operations" to act urgently either before an activation of 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 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 significance of such incidents and 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 responsibilities of TSOs that are supported by the emergency requirements for generators and DSOs. The main issues concern (i) 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.

Policy 5 "Emergency Operation" complements 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 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 a collapse.

The provisions of Policy 5 shall aim at handling with situations related to:

- Emergency System State,
- Blackout System State,
- Restoration System State.

A. Awareness of system states and communication

Definitions

A – D1. System States classification.

Regarding the objective of use of these definitions, system states are related to the following situations. These are classified in relation with the grid or load/frequency risk levels and urgency of actions related to risks of propagation.

Normal State means a situation in which the system is within Operational Security limits in the N-Situation and after the occurrence of any Contingency from the Contingency List, taking into account the effect of the available Remedial Actions.

Alert State means the System State in which the system is within Operational Security Limits, but a Contingency from the Contingency List has been detected, and in case of its occurrence, the available Remedial Actions are not sufficient to keep the Normal State.

Emergency State means the System State in which one or more Operational Security Limits are violated.

Blackout State means the System State in which the operation of part or all of the Transmission System is terminated.

Restoration State means the System State in which the objective of all activities in Transmission System is to re-establish the system operation and maintain Operational Security after the Blackout State or the Emergency State.

Wide Area State means the qualification of an Alert State, Emergency State or Blackout State when there is a risk of propagation to the interconnected Transmission Systems.

A – D2. ENTSO-E Awareness System (EAS).

EAS IT tool for real time data exchanges for pan-European use within ENTSO-E set up to increase the knowledge of the state of the system and accordingly to launch alarms.

Standards

A – S1. Assessment of "Wide Area" TSO system states.

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 TSO has to inform in real-time all TSOs within ENTSO-E RG CE about its Wide Area System State.

A – S3. Content of information.

TSO informs on Wide Area System State and in case of not being in Normal State TSO shall provide more details on critical operational conditions and at minimum to the interconnected TSOs, expected time to come back to Normal State and call for help if needed (refer to bi-multilateral TSOs agreements).

A – S4. Means of communication.

The constrained TSO communicates the information from A-S3 via the following ways:

- EAS,
- Preformatted messages (tape recorder, Fax, e-mail, web-based, etc.),
- Phone calls to complement messages.

A – S5. 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 – S6. TSO Control rooms telephone communication.

Whatever the state of the system, telephone communication between neighbouring TSOs and to/from Control Block respectively shall be designed to guarantee a high level of availability.

A – S7. Secured functions of control rooms - 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 at least once a year.

A – S8. Secured functions of control rooms - Back-up supply sources.

In control rooms a 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.

A – S9. Secured functions of control rooms - Reliability of control systems.

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

- SCADA/EMS system,
- Voice communication system for dispatching in control rooms,
- Load frequency control equipment.

Guidelines

A – G1. RG CE operational contact list.

The list of phone numbers, fax numbers and email addresses of TSO control rooms should be shared among RG CE TSOs and kept updated.

A – G2. Communication between Control Block and Co-ordination Centre.

Control Block should provide communication link (including telephone) to/from Co-ordination Centre (North and/or South) guaranteeing a high level of availability.

A – G3. Information to grid users.

In accordance with applicable regulations, TSOs keep generating units and DSOs (at minimum) involved in defence and subsequent restoration process informed of critical system states.

A – G4. Frequency deviation alarm

It is recommended to implement special alarm (sound and/or light) in a TSO control room in case of frequency deviation higher than 200 mHz from nominal value.

A – G5. Testing back-up control room functions

It is recommended to test them more often than requested in A-S7 to train dispatchers.

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 UFLS scheme (see B – S10.) and can be extended by additional individual steps for frequencies below 48.0 Hz (see B – G7.).

B – D2. Secondary Reserve Provider

A single generating unit or, an aggregation of generating units and/or loads, connected to a secondary controller.

B – D3. Total Load

Total Load (as defined in Regulation 543/2013) - including losses without power used for energy storage, means a load equal to generation and any imports deducting any exports and power used for energy storage.

Total Load within this Policy is calculated as the sum of all generations on both transmission and distribution systems (active power measured or estimated) and any imports, deducting power used for energy storage (e.g. pumps), house load of power plants and any exports.

B – D4. Demand.

Demand means the netted value of Active Power seen from a given point of the system, computed as (load – generation), generally expressed in kilowatts (kW) or megawatts (MW), at a given instant or averaged over any designated interval of time.

B – D5. Feeding back

The active power flow going through HV/MV transformer from MV level to HV level (because of a high level of active power RES generation).

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 actions.

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

B – S3. Coordination for inter-TSO appropriate common actions.

In case of Emergency State, the constrained TSO adopts urgently all internal measures and asks for coordinated measures from neighbours and other TSO with which co-operation 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 – S4. 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 LFC areas are considered the backbone of the interconnected system.

B – S4.1. 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 – S4.2. 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 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 the neighbouring TSOs involved.

B – S5. Frequency deviation management before frequency leader nomination – LFC management.

In case of frequency deviation higher than 200 mHz lasting more than one minute, individual secondary controllers have 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.

B – S5.1. Generation units set points coordination.

TSOs shall establish procedures with Secondary Reserve Providers to coordinate current set points of their generating units.

B – S6. Frequency deviation management before frequency leader nomination – LFC management – additional measures.

After implementing actions described in B – S5, TSOs are allowed to manually/automatically override the frozen output signal of secondary controllers to use theirs communication/signalling channels to power plants in order to speed up the stabilisation of the system. (Refer to C – S3.4 for the return to normal operation). These measures have to be taken with care not to create congestion.

TSOs have to take into account previously agreed coordinated actions in Normal and Alert State aimed to recover frequency.

B – S7. Frequency deviation management before frequency leader nomination – additional measures.

In case of frequency deviation higher than 200 mHz lasting more than one minute TSOs are allowed to manually and/or automatically activate additional reserve (eg. (i) through starting/stopping pumped-storage power plants and/or (ii) activating tertiary reserve and/or (iii) decreasing/increasing the level of active power generation by activating extra primary reserve if available) in order to speed up the stabilisation of the system. These measures have to be taken with care not to create congestion.

TSOs have to take into account previously agreed coordinated actions in Normal and Alert State aimed to recover frequency.

B – S8. ENTSO-E RG CE Under Frequency Load Shedding general plan – UFLS plan.

B – S8.1. Design of the UFLS plan.

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. Each TSO shall design the UFLS plan with the objective to disconnect Demand in real-time.

In case of more than 1 TSO in a country, the UFLS plan is allowed to be designed and implemented at national level when in accordance with legislation.

B – S8.2. Implementation of the UFLS plan.

For frequency in the range of 49.0 to 48.0 Hz, each TSO shall implement the UFLS plan as follows:

- **B – S8.2.1**. At least an amount of Demand corresponding to 5% of the Total Load shall be disconnected at 49.0 Hz.
- **B – S8.2.2.** In total, an amount of Demand corresponding to 45% +/- 7% of the Total Load shall be disconnected between 49.0 and 48.0 Hz.
- **B – S8.2.3**. The number of disconnection steps shall be minimum 6 (including the step triggered at 49.0 Hz).
- **B – S8.2.4.** For each step, an amount of Demand corresponding to 10% of Total Load shall be disconnected at maximum.
- **B – S8.2.5.** No intentional time delay shall be set in UFLS relays.
- **B – S8.2.6.** Additional df/dt function in UFLS relays is allowed in the range 49.8 – 49.0 Hz.

B – S8.3. Minimum technical requirement for UFLS application.

Maximum total tripping action time of UFLS considering measurement, calculation time of relays, tripping action of auxiliary circuits and circuit breaker opening time shall not exceed 300 ms.

B – S9. Coordination with DSOs for UFLS implementation.

In case UFLS is implemented at DSO level, each TSO shall apply, in coordination with DSOs, a procedure to assess the amount of Demand to be disconnected by each individual DSO at each Frequency level.

B – S10. UFLS plan – checks.

Each TSO checks in common with DSOs (or with other involved parties), at least once a year, the UFLS plan. This check is based on the best available estimations taking into account variability of load behind feeders along the year, variability of power generated by renewable energy sources.

Guidelines

B – G1. Voltage lock-out for UFLS relays.

Blocking of the UFLS relays should be possible when the voltage is within a range of 30 to 90% of nominal voltage.

B – G2. Inaccuracy of frequency measurements for UFLS relays.

It is recommended to maintain the frequency measurements for load shedding at a maximum inaccuracy of 30 mHz.

B-G3. Maximum number of UFLS scheme disconnection steps

It is recommended that maximum number of UFLS scheme disconnection steps should be 10.

B-G4. Range of frequency between UFLS scheme disconnection steps.

It is recommended that the range between UFLS scheme disconnection steps should be between 100 and 200 mHz.

B-G5. Total Load for each step of UFLS to be disconnected.

It is recommended that for each step (taking into account B-S8.2.1) , an amount of Demand corresponding from 3% to 10% of Total Load should be disconnected.

B-G6. Determination of units to be considered as load for UFLS in a scenario with dispersed generation

In Control Areas where TSOs need to take the scenario with dispersed generation into account for the determination of Demand to be disconnected in UFLS, following principles may be applied, taking into account the following four cases:

Case 1: network without dispersed generation

- This network is taken into account as load in the UFLS.

Case 2: network with dispersed generation but without feeding back

- Based on the yearly active load profile of a HV/MV-transformer, if in case of at least 8500h/a there is no feeding back, this network is taken into account as load in the UFLS.

Case 3: network with dispersed generation and temporary feeding back

- Based on the yearly active load profile of a HV/MV-transformer, if in case of X h/a to 8500h/a there is no feeding back, this network is taken into account as load in the UFLS.

Case 4: network with dispersed generation and permanent feeding back

- Based on the yearly active load profile of a HV/MV-transformer, if in case of more than X h/a there is feeding back, this network is taken into account as generation and is not included in the UFLS.

Value X should be defined by the corresponding TSO (in case of more than 1 TSO in a country it is recommended to agree value X by all TSOs of a country) as a part of procedure (B-S9) to assess the amount of Demand and verified as a part of B-S10 checking.

The TSO may decide to apply the above mentioned principles on a defined interface below the HV/MV-transformer in coordination with the relevant DSO(s).

B – G6. Voltage level for UFLS relays.

In Control Areas where TSOs need to take into account the scenario with dispersed generation, it is recommended to install UFLS relays on the lowest possible voltage level to avoid disconnecting this generation, if technically and economically feasible.

B – G7. Automatic disconnection of pumps.

Automatic disconnection of pumps should be activated as followed:

- If 49.2 Hz < frequency < 49.8 Hz: time delay should be smaller or equal than 10 s.
- If frequency = 49.2 Hz: Maximum total tripping time of pumps considering measurement, calculation time of relays, tripping action of auxiliary circuits and circuit breaker opening time should be 300 ms. No intentional time delay should be added.
- Frequency below 49.2 Hz: all pumps should be disconnected.

B – G8. Additional UFLS for TSO individual use.

At national level, automatic or manual under-frequency load shedding (UFLS) can be implemented in addition to the ENTSO-E RG CE solidarity demands to cover regional needs (example: in order to compensate additional loss of generation before next UFLS step will be reached) inside each TSO’s LFC area if needed. It is also 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 – G9. UFLS Geographical distribution.

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

B – G10. 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 – G11. 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 – G12. Automatic tripping of generating units.

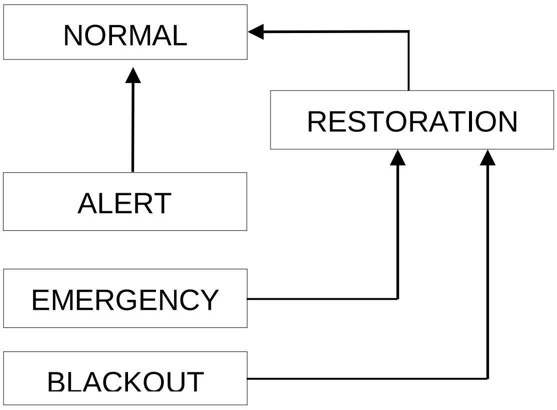
This should be prohibited between 47.5 Hz and 51.5 Hz. This takes into consideration technical capability of machines to keep stability and operating limits of equipment (preventing damages).

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 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 framework of which is studied and, as far as possible, prepared in advance.



C – D2. Island operation.

The independent operation of a whole or a part of the system that is isolated after its disconnection from the interconnected system, having at least one generating unit supplying power to this system and controlling frequency and voltage.

C – D3. Island 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 a governor and an automatic voltage regulator are able to balance active and reactive power surplus or deficit after load pickup or load shedding in small islands in order to feed-in line, to regulate frequency and voltage, and, to reenergise in isolated operation.

C – D4. Black-start unit.

Black-start unit is a generating unit with the ability to go from a shutdown condition to an operating condition, to start delivering power without external electrical energy supply and includes island operation capability.

C - D5. Reenergisation.

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

- *Bottom-up*: from self-reenergising of parts of its own LFC 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 – D6. House load operation of units.

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

C – D7. 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 – D7.2).

C – D7.1. Frequency leader.

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

C – D7.2. Resynchronisation leader.

The Resynchronisation leader is in charge of coordinating frequency leaders during the Resynchronisation process of two neighbouring areas (Refer to 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 – D8. Disturbed Area.

This area is adjacent to a secure area or to another Disturbed Area. This is the area in trouble due to an incident. It can be either a part of the responsibility area of a TSO, its full responsibility area, a disturbed zone comprising several TSOs' responsibility 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 responsibility 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.

C – D9. Frequency management.

The frequency management is a set of functions of the secondary controller that ensure the behaviour of the LFC area in case the frequency deviation is higher than 200 mHz.

The frequency management also represents behaviour of the Secondary Reserve Providers within the LFC area. In this state the change of frequency control of the units is managed by TSOs.

C – D9.1. Frozen Mode.

A functionality of the secondary controller that ensures the Secondary Reserve Providers connected to the LFC area keep the last signal of control (active power output is constant, excluding primary regulation).

C – D9.2. Switched off Control Mode.

A functionality of the secondary controller that stops and ensures the Secondary Reserve Providers connected to the LFC area do not receive signals of control.

C – D9.3. Frequency Control Mode.

A functionality of the secondary controller that regulates the output power from Secondary Reserve Providers to stabilise the frequency in LFC area without taking delta P into account (integral part of secondary control is zero, if possible).

C – D9.4. Local Frequency Control Mode.

A functionality of units that switch their controller into speed control and keep the last frequency as a reference set point, after being disconnected from secondary control (e.g. frequency deviation exceeding given thresholds).

Standards

1 – Overall considerations

C – S1.1 Restoration process.

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

C – S1.2. TSO restoration plan.

Each TSO has to prepare in advance and keep updated a restoration plan**.** This restoration plan shall include at least a reenergisation process after Blackout State (bottom-up approach and a top-down approach).

C – S1.2.1. TSO restoration plan has to be proved at least by simulation or off-line calculations.

C – S1.2.2. Each TSO has to get knowledge of units capable to work in house load operation.

C – S1.2.3. Each TSO has to evaluate the number of necessary black start units to contribute to the restoration process.

C – S1.2.4. Black start units shall be tested on-site at least once per three years.

C – S1.3. Communication in case of System restoration.

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 TSOs in a separate way (to disseminate information e.g. to the media).

C – S1.4. Inter-TSO coordination in case of System restoration.

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

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

2 – Reenergisation from Blackout State

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 units.

C – S2.2. Reenergisation process.

This process is to be implemented in case of Blackout State. The following strategies can be implemented regarding the existing situation (availability of black start units and units in house load operation within its responsibility 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 – S 2.2.1.1. Active and reactive flow limits.

During the restoration phase, the constrained TSO has to guarantee that they will respect the limits of active and reactive flows on interconnection line(s) agreed in bilateral agreements. These limits will also be subject to operational decisions made by dispatchers of concerned TSOs.

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

TSOs reenergise the system with the black-start units and/or with the units in house load operation with island operation capability.

C – S2.2.3. Top-down and Bottom-up reenergisation strategy.

If relevant, both strategies can be implemented in parallel.

C – S2.3 Frequency management within LFC area in case of blackout.

In case of Blackout State, frequency management depends on the reenergisation strategy.

For the bottom-up strategy, it is up to the TSO to set the secondary controller to Switched off Control Mode or to Frequency Control Mode in order to share the contribution to frequency regulation with all the units of the LFC area.

For the top-down strategy, the secondary controller shall be in Switched off Control Mode in the area that called for reenergising, ensuring that the change of active power output is done only manually by dispatchers. The requesting TSO shall confirm the assisting TSOs that its secondary controller is in Switched off Control Mode and inform if some units are in Local Frequency Control Mode.

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 LFC area (with one or more separated asynchronous areas) including current K-factor (*cf. P 1*),

- 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 LFC area (with possibly separated areas).

C – S3.2. Frequency leader criterion.

After a severe disturbance with a frequency deviation higher ±200 mHz lasting more than 15 minutes or in case of system split, the frequency leader shall be chosen within each synchronous area, based on the following criteria:

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

- Previously implemented coordination for frequency management;
- 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 (EAS, phone calls, conference calls, etc.).

C – S3.3. Frequency leader announcement.

The frequency leader shall announce its nomination and resignation to all RGCE TSOs using EAS.

C – S3.4. Frequency management for frequency deviation higher than 200 mHz.

The frequency leader's secondary control is switched to Frequency Control Mode, the other secondary controllers remain in (or, if not yet, manually switch to) Frozen Mode (refer to B – S5). 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, with respect to the state of its own system, even far from its area, when requested.

In case the Local Frequency Control Mode is activated on units, the concerned TSO shall inform frequency leader so that special countermeasures within the concerned TSO are implemented.

C – S3.5. Frequency management in case of grid split.

The frequency leader's secondary control is switched to Frequency Control Mode; the other secondary controllers are put in Frozen Mode. The frequency leader coordinates mobilisation of generation reserve within the synchronous area, in order to recover the frequency *till the full resynchronisation* (Refer to C – S4.4), 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.

In case the Local Frequency Control Mode is activated on units, the concerned TSO shall inform the frequency leader so that special countermeasures within the concerned TSO are implemented.

C – S3.6. 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 – S3.6.1. 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 – S3.7. 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 – S3.8. Reconnection of generators after abnormal frequency excursion.

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

In this case of loss of generation, the TSO reconnects 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 minimise 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.

For generating units connected to TSO or DSOs grids, criteria for reconnection and disconnection have to be agreed in writing in advance between the TSO and DSOs and generating units respectively.

4 – Resynchronisation

C – S4.1. Selection and role of the resynchronisation leader.

For split situations, the resynchronisation leader has 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 EAS, 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 or at least by phone).
- 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 a quick reconnection of next lines between two already resynchronized islands (even outside its LFC area) after the reconnection of the first one to strengthen rapidly the link between both areas.

C – S4.2. Resynchronisation leader announcement

The resynchronisation leader shall announce its nomination and resignation to all RG CE TSOs using EAS.

The resynchronisation leader has also to inform the frequency leaders about its appointment by phone.

C – S4.3. The resynchronisation process under leadership.

The resynchronisation leader of the concerned areas in collaboration with the two frequency leaders 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 – S4.4. Frequency management after resynchronisation of two areas.

Prior to reconnection, one frequency leader is selected for the rest of the system recovery. This frequency leader shall announce its position to all RG CE TSOs using EAS (precising resignation of the other frequency leader) If the secondary controllers of both frequency leaders were previously in Frequency Control Mode, one of the two frequency leaders has to switch its secondary control to Frozen Mode to avoid staying with two secondary controllers in Frequency Control Mode.

5 – Final recovery

C – S5.1. Return the secondary controller to Normal Mode.

- The TSOs coordinate a manual rescheduling (new exchanges program schedules) based on actual physical power exchanges after restoration.
- ACE of each LFC area shall be returned near zero.
- If one frequency leader has been designated, he orders the return to Normal Mode for all TSOs step by step.
- Frequency leader is the last to switch back to Normal Mode.

Guidelines

C – G1. Automatic reconnection of generating units.

Automatic reconnection of generating units should be forbidden.

C – G2. TSO restoration plan validation.

TSO restoration plan should be validated every 3 years at minimum.

C – G3. Test of black start capability.

It is recommended to test the capability as follows:

- Simple start test for general checking the capability of service by means of remote command or at least via phone call from the TSO control room to local power plant control room. The generating unit should be able to run to the nominal speed and voltage as quick as possible and operate in this no load operation state minimum 30 minutes.
- Complex start test in order to check the capability of full service for system restoration. In addition to simple start test the generating unit should be able to regulate the frequency and voltage on a separated network island connected to the black start unit and balance the active and reactive load switching (on and off) by means of connecting lines and suitable load (e.g. pumps, auxiliaries/house load of units or power plants, contracted load as ancillary services) in some steps. About the duration of the test and the magnitude of the load should be agreed with the participants in advance.

C – G4. Reenergisation by black start units and/or by units in house load operation 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:

- 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 equipment, 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 – G5. 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.