Addendum replacing paragraphs 5.2.3.2 and 5.4 of the Supporting Document for the Network Code on Emergency and Restoration released on the 13 October 2014

DRAFT FOR ADDITIONAL PUBLIC CONSULTATION

15 December 2014

ENTSO-E AISBL • Avenue Cortenbergh 100 • 1000 Brussels • Belgium • Tel +32 2 741 09 50 • Fax +32 2 741 09 51 • info@entsoe.eu • www.entsoe.eu

5.2.3.2. Automatic low Frequency control scheme

- **General structure of the Article**

This article provides a European framework for the design of the automatic low Frequency control scheme, which includes the automatic Low Frequency Demand Disconnection (LFDD) scheme.

In a highly meshed power system, like a Synchronous Area, frequency instability phenomena can arise as consequence of various events, like large power outages or cascading faults driving to system splitting. Especially when the system is separated along highly loaded transmission corridors, the remaining isolated areas suffer a high amount of sudden surplus or deficit of power which results in frequency deviation.

The under-frequency transients can be additionally worsened, as operation experience shows, by the loss of conventional generation and dispersed generation.

In such a case it is of utmost importance to stabilize the frequency above the disconnection threshold for generating units (47.5 Hz). This is achieved by adequate automatic Low Frequency Demand Disconnection Scheme, which creates a certain margin before definitive trip of units.

Such automatic Low Frequency Demand Disconnection Scheme is a mandatory plan that the TSO shall implement according to given parameters. Below the frequency of last mandatory load shedding level, other measures and defence strategies can be designed and implemented at TSO level in order to allow faster restoration process, ensuring of course to not endanger transmission system stability.

Additionally, demand disconnection based on frequency gradient is allowed in special cases. The basic concept of frequency gradient is to anticipate demand disconnection and avoid further frequency drop, especially in areas facing regular high import power balance and where a network splitting may lead to severe under-frequency transients. The use of frequency gradient is limited to a specific range of frequency and with gradient above a defined threshold which ensures activation in case of very huge incident or network splitting, at the condition that the characteristics of general Demand Disconnection Scheme are respected.

- **LFDD study**

The harmonisation of Automatic Low Frequency Demand Disconnection Scheme among TSO of a same SA is motivated by:

- the principle of solidarity;
- the technical development of load shedding relays; and
- the necessity to prevent over and under-compensation as a result of Demand Disconnection Scheme, leading to frequency deviation not compliant with frequency connection range of distributed generation.

An efficient Demand Disconnection Scheme shall be designed on the basis of the following general principles:

- Evenly geographically distributed and effective shed load between TSOs as well as within a TSO area,
- Same reference for frequency and shedding load steps across the interconnected system,
- Ability to compensate the maximum credible active power deficit of the system,
- System implementation ensures the effectiveness of Demand Disconnection Scheme: it means a minimal necessary shedding of load,

ENTSO-E AISBL • Avenue Cortenbergh 100 • 1000 Brussels • Belgium • Tel +32 2 741 09 50 • Fax +32 2 741 09 51 • info@entsoe.eu • www.entsoe.eu

- Compensate disconnection of dispersed generation disconnection at unfavourable frequencies
- Avoid over frequency (overcompensation), overvoltage and power transients that can lead to an additional loss of generation.
- Compensate statistical failed trip by load shedding relays and conventional generation lost during the under frequency transient,
- Avoid splitting of network by intervention of line protection and, if necessary control network splitting scenarios.

Against the background that the concept must be robust in a wide range of scenarios and taking into account the existing load shedding schemes, a study has been performed by ENSTO-E experts in order to establish exact parameters to be included for Continental Europe. Main results and recommendations of this study are presented hereunder. The full study is annexed to the Supporting Document.

The approach of the study is normative; this means that model used by ENTSO-E experts is the same adopted to study performance and requirements of regulation and effects of the Dispersed Generation over the system.

LFDD scheme design recommendations

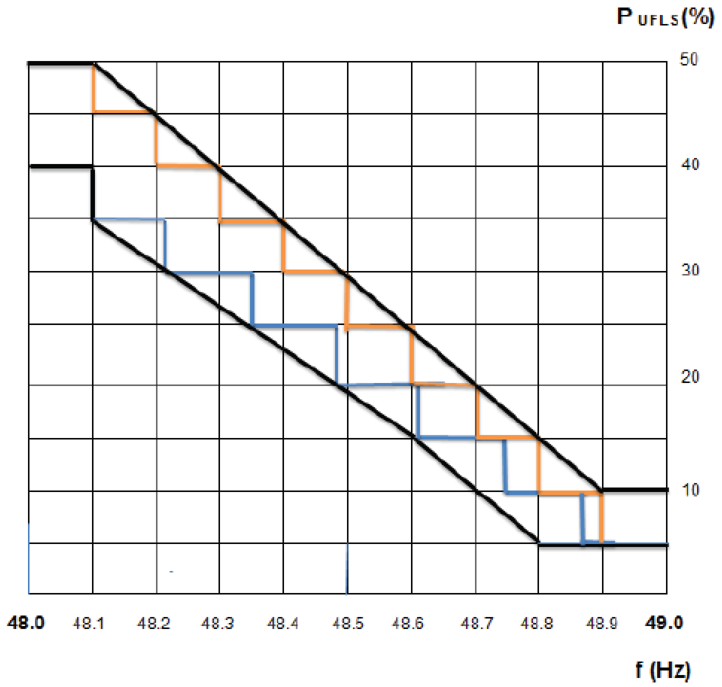
A general finding from the simulations which all parties should bear in mind is the fact that a load shedding plan is the last resort in a system that is in crisis due a sequence of severe perturbations. This means that ENTSO-E Demand Disconnection Scheme in some situations leads from a less than optimum state of the system to not optimal final state, and in few cases, cannot avoid a system black out.

This conclusion is in line with the state-of-the-art experience and it is a consequence of the behaviour under extreme circumstances. Many local problems such as voltage stability, loss of units due to false tripping by protection, grid splitting, can produce unexpected situations within the system. These particular effects can be studied with more detailed models, but experience shows that uncertain information about parameters and real grid configuration at moment of the transient studied can lead to results which are even more inconsistent.

So starting from these considerations, the study was based on a normative model that guarantees an adequate degree of conservative approach without deviating to far from the real system behaviour.

The maximum value of total load that shall be shed per single TSO is 50% of the reference load for the whole system; the minimum value that shall be shed per single TSO is 40% of the reference load; Figure 9 illustrates the “permitted area” where the expected general system behaviour of load shedding plan is shown. Two load shedding plans, as an example, are shown. The black curve delimits the boundary of maximum load that can be shed (clearly in whole frequency range must be considered the constraint about maximum step amplitude, equal to 10 %).

ENTSO-E AISBL • Avenue Cortenbergh 100 • 1000 Brussels • Belgium • Tel +32 2 741 09 50 • Fax +32 2 741 09 51 • info@entsoe.eu • www.entsoe.eu



The number of steps and the value of the total shed load is chosen in order to avoid overcompensation or frequency stagnation at low values. The appropriate ideal frequency to the system after load shedding intervention could be in the band of ± 200 mHz around 50 Hz; but this is not possible or feasible in all studied cases.
The amplitude of each step shall be in the range of 5-10%. The minimum mandatory number of steps for single TSO is 6; this value is a compromise between the equal linear theoretical setting and the optimal practical solution. If the maximum permitted amplitude of single step is exceeded, the TSO must increase the number of steps in order to comply with it.

Selected operating frequency range of the automatic Demand Disconnection Scheme is 49.0 - 48.0 Hz. The highest value is determined by the minimal frequency value of the automatic disconnection of pump-storage generating units from pumping mode (e.g. 49.3 Hz) taking into consideration a necessary security margin. The lowest value is determined by the minimal required operating frequency value (47.5 Hz) of the generating units taking into consideration a small frequency band also with necessary security margin for an individual additional load shedding of TSOs if it is needed. This additional load shedding can be important after a network split in case of island operation.

- **<u>LFDD requirements in the NC ER</u>**

Based on the study, the NC ER develops requirements for implementation of Automatic Low Frequency Demand Disconnection Scheme in all European TSO, with dedicated parameters for each Synchronous Area.

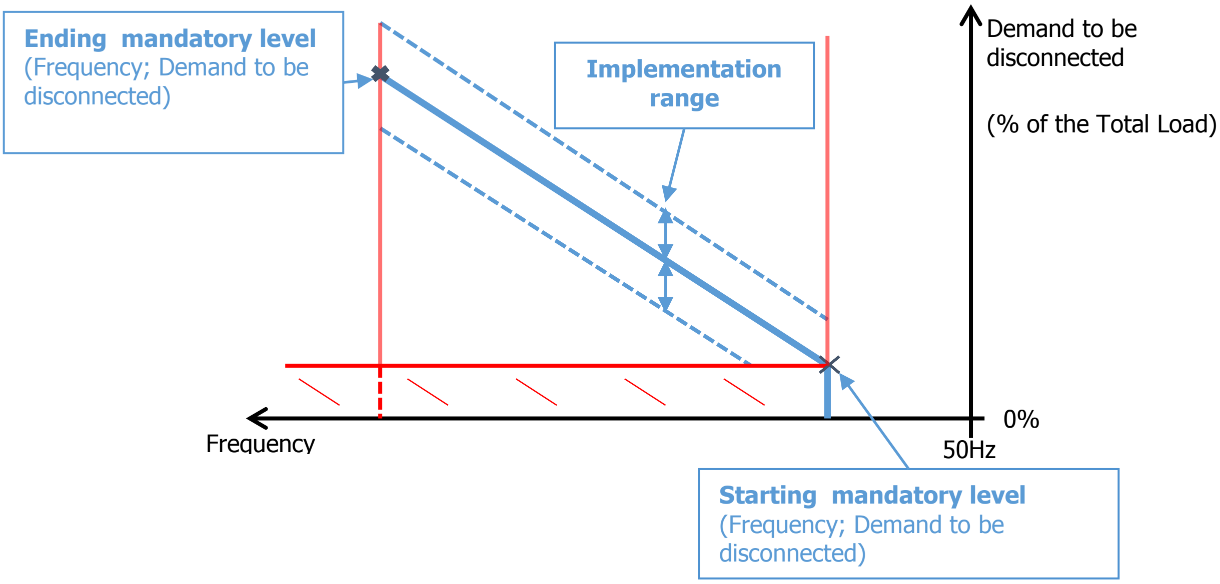
All the characteristics of the scheme are synthetized in a table. One of this characteristic is the implementation range. This range around the ideal target is necessary for different reasons including the following:

- Demand disconnection relays are installed on the network (mainly at distribution level) so that their activation corresponds to the disconnection of a given percentage of the Total

Load at a given time of the year (or in average during the year…). Depending on the type of generation/consumption behind the relays (industry, domestic with more or less thermo sensitivity, renewable energy sources infeed…), the demand disconnected by a relay changes, even if expressed as a percentage of the Total Load.

- After an incident (loss of an important amount of generation, grid split…) the frequency drops in the whole synchronous region but it will not be exactly the same in every substations of the region at the same precise moment. It will lead to the activation of some relays before others even if supposed to work at the same frequency thresholds.
- The disconnection of demand by some relays will lead to a disruption of the frequency signal and could lead to a start over of the frequency measurement by relays around, meaning an additional delay to their activation.

The implementation range correspond to the tunnel in dotted line in the drawing:



It is important to note that article 8(2).c of NC ER and the definition of Demand in NC ER ensure that for each specified frequency step defined in this article, disconnected Demand will correspond to a specific netted value (load – generation) covering both following situations:

- Generation (mainly embedded generation) connected behind DSOs disconnection relays; and
- Generation that would disconnect due to the frequency deviation before the frequency reach admissible disconnection thresholds defined in NC RFG.

The percentage of Demand to be disconnected applies to Total Load, which is defined in the regulation 543/2013:

- Total Load, 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.
- Notes: Generation should include all types of generation connected, including auto-generation (e.g. solar panels for own use) whether estimated or measured.

ENTSO-E AISBL • Avenue Cortenbergh 100 • 1000 Brussels • Belgium • Tel +32 2 741 09 50 • Fax +32 2 741 09 51 • info@entsoe.eu • www.entsoe.eu

5. 4 Market Interactions

0. General

This chapter provides a general scope related to market activities and TSO in the unlikely event of an Emergency State or an even more unlikely event of a Black-out State. As ENTSO-E values the liberalisation of the Energy market very high, market activities and its accompanying processes will be suspended with the utmost care and always as a last resort: indeed the action of conduction business is free, also during an Emergency State or a Black-Out State.

1. Market Activities Suspension Triggers

This article described the conditions under which a TSO can or must stop market activities: Market Activities Suspension Triggers. These triggers shall be related to the physical conditions of the Transmission Grid (paragraph 2). Also more market related conditions like the percentage of Demand or Generation Disconnection in the LFC area of a TSO must be taken dully into account (paragraph 3). As the field of market activities is not the sole expertise of a TSO, an NRA approval process is foreseen (paragraph 4).

2. Procedure for market activities suspension

This article clarifies which market activities can be suspended by a TSO. Because of the fact that each TSO is fully responsible for the functioning of its LFC Area and Transmission System, each TSO must be able to decide whether or not he wants to suspend market activities also when this affects market coupling processes where many more parties are involved. If any market activity is suspended, communication with BRPs is foreseen in paragraph 2 and communication between NEMOs and its Market Participants in paragraph 3. During an Emergency or Black-Out situation, it might be necessary to freeze the physical system state in which situation production and demand units can't effectuate the freedom of dispatch anymore. Most likely TSOs will request an individual unit to produce a certain amount of MW (paragraph 4).

3. Procedure for TSO processes suspension

This article allows the TSO to suspend TSO processes, under the condition that the relevant Market Activities Suspension Triggers are met. This ensures that market processes will run as long as possible.

4. Procedure for market activities and TSO processes restoration

This article gives a procedure to be used during restoration of market and TSO processes. Paragraph 1 describes conditions which must be fulfilled before a TSO can restore a market activity. Condition in art 4(1)(d) should be considered in reference to typical values in normal system state. Paragraph 2 describes conditions which must be fulfilled before a TSO can restore a TSO process. TSOs do have a bit more flexibility when restoring TSO processes because sometimes the processes are a precondition for a market activity to run.

GL CACM and NC FCA gives TSOs the right to curtail cross zonal allocated capacities in case of an emergency or force majeure situation. In addition to these options TSOs can use three strategies to find the correct amount of Cross Zonal Capacities: use the already existing calculated Cross Zonal Capacities, launch a regional capacity calculation process applicable in Normal and Alert States in accordance with GL CACM and use values TSO defines based on the actual physical network conditions (paragraph 3).

The latter possibility means using the Cross Zonal values that have been used by TSOs during the restoration process to help re-energise each other systems. It is quite common for Market activities

ENTSO-E AISBL • Avenue Cortenbergh 100 • 1000 Brussels • Belgium • Tel +32 2 741 09 50 • Fax +32 2 741 09 51 • info@entsoe.eu • www.entsoe.eu

to be performed crossing borders of Member States as is reflected in, for example, the day ahead and intraday market coupling mechanisms. When only a part of a region must be suspended it might be necessary for the TSOs of this region to launch a partial market decoupling, whilst taking into account the procedures that have been established by the participants of the market coupling projects (paragraph 4).

It is necessary that the Cross Zonal Schedules must be used as input for the Load Frequency Controller of each TSO in order to allow for a coordinated frequency management. This will be done in coordination with the Frequency Leader (paragraph 5).

5. Communication procedure

Paragraph 1 demands a communication procedure to be set up with market parties, including the NRA, to be used during the restoration of market and TSO activities. This procedure must be based on the roles that are in place to run a liberalised energy market: e.g. BRP, BSP, NEMO, DSO, TSO, and must focus strongly on interactions between these roles. The ultimate aim of this communication procedure is ensuring that all parties in its role know exactly which activities it can still perform and which not during a restoration process. This procedure can only be done on a national level because the roles and tasks of TSOs differ from one Member States to another. Paragraph 2 and 3 lay claim to the importance of regular updates of current status to NRAs and NEMOs. The intention is that this communication will be performed by different people than the operational people we refer to in paragraph 1.

6. Settlement principles

This article lay claim to the importance of continuation, during each Emergency State of the settlement processes described in NC EB (paragraph 1). It is acknowledged however, that it can be necessary for certain specified circumstances during Black-Out State, Emergency State with suspension of market activities or during Restoration State, to deviate from the settlement principles in NC EB (paragraph 2). Because of the potential financial impact on market parties, the deviating settlement principles and the national arrangements must be approved by the NRA. The latter also ensures market consultations are in place (paragraph 3). These deviations could be necessary because of the necessity during an Emergency State or Black-Out State that TSOs need to instruct, or commandeer generation and/or demand units apart or in portfolio. And as each TSO could have different tasks appointed towards herself, these deviating settlement rules and principles can only be done on a national level. It is important the national arrangements make sure that all variants of settlements are properly addressed: TSO with BRP, TSO with BSP, and TSO with TSO, of which the latter of course have to be agreed upon with the relevant TSO (paragraph 4). For example, it can be reasonable in some cases during the restoration phase that the generators receive a compensation for costs they have reasonably incurred: e.g. start costs, fuel costs and operational costs. The last paragraph, 5, ensures that the financial neutrality of TSOs is ensured.