European Network of
Transmission System Operators
for Electricity

Explanatory note for Additional Properties of Frequency Containment Reserves

20.02.2019

Explanatory note

Regarding Article 3.1:

In case of system imbalances and resulting deviations of system frequency, FCR are activated to stabilize the system. For an effective stabilization, FCR needs to be quick enough to avoid unacceptable (dynamic) deviations of system frequency. Thus, activation has to start as soon as possible after occurrence of the deviation. Nevertheless, depending on the used technology of FCR providing units, some delay of physical activation is unavoidable. To ensure that this time delay remains within acceptable limits, a maximum delay shall not be exceeded. Exemptions can be granted by the TSO in case the delay is only insignificantly exceeded because of the used technology. Nevertheless, if quicker response is possible based on the applied technology, it should not be artificially delayed in order to contribute as effectively as possible to stabilize the system.

Regarding Article 3.2:

Since FCR is the fundamental component for stabilizing system frequency, it is of utmost importance that FCR providers ensure the capability of connection of their FCR providing units and groups over the whole permitted range of system frequency in which the system can be operated. Nevertheless, TSOs can require disconnection of FCR providing units or groups if they are part of the automatic over-frequency control scheme in the respective LFC area in accordance with Commission Regulation (EU) 2017/2196 Article 16 (3). Due to the different technologies of FCR providing units and different possible voltage levels of connection of these units, it is very important to, on one hand, require respective parameter settings of the FCR providing units and, on the other hand, consider possible shedding concepts of DSOs. Even if these DSO shedding concepts usually strive for shedding only load branches in case of low frequency, FCR providing units might also be affected, resulting in a loss of FCR capacity. Thus, close cooperation with respective DSOs will be needed.

Regarding Article 3.3:

Categorization into LER or non-LER:

The SO GL introduces the categorization of FCR providing groups or units in “LER” (for Limited Energy Reservoir) and “Non-LER”;

For LER providing units or groups **only**, when the reservoir is exhausted, it is admitted by SO GL to stop FCR provision after entering into alert state but not before a certain period of time between 15 minutes and 30 minutes has passed. The minimum period of time will be determined according to the CBA methodology pursuant to article 156(6) of the SO GL.

On the contrary, the “non-LER” FCR providing units or groups shall always be capable of providing FCR continuously (meaning for an indefinite period of time), regardless of the system state in respect to article 156(7) of the SO GL.

From a technical point of view, even e.g. big hydro storage power plants have a “limited” energy reservoir and, although they could continuously provide FCR for days or months, they might not necessarily be treated as LER.

TSOs, therefore, decided to differentiate between “LER” and “non-LER”, based on the definition of a minimum period of full continuous FCR provision to be applied for the categorization between “LER” and “non-LER” FCR providing groups or units. This minimum period is called “LER prequalification period”.

As illustrated in the following figure, depending on the LER prequalification period definition, it is well understood that the amount of FCR providing groups or units categorized as LER units will differ:

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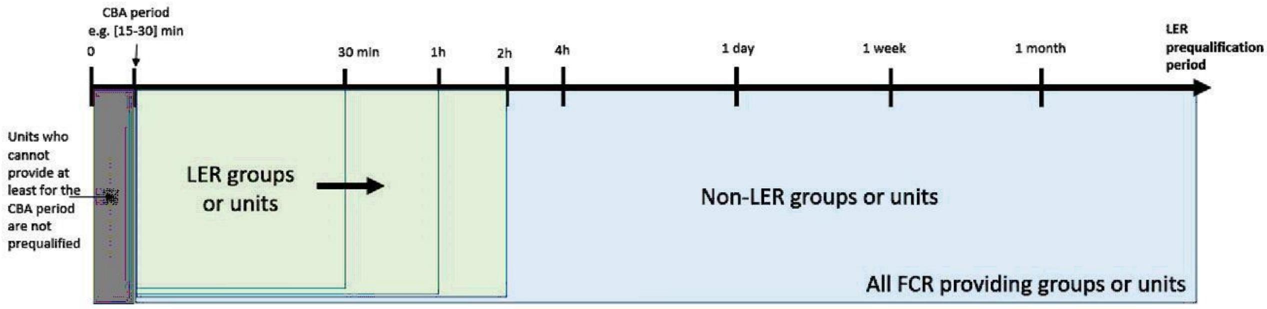

The longer the LER prequalification period, the higher the share of LER groups or units TSOs will have to satisfy the FCR dimensioning volume.

Since the obligation for LER groups or units to provide full FCR in alert state is weaker compared to non-LER groups or units, there is a risk for the system of providing a LER definition which would imply a higher share of LER groups or units. To cover this risk, TSOs consider that the LER prequalification period should be defined as the shortest period possible.

On the other hand, it is acknowledged by the TSOs that, in order to guarantee full activation of FCR regardless to the system state, the LER prequalification period shall be long enough to cover the lead time needed for the BSP to perform an energy reservoir management according to its local terms and conditions. By local terms and conditions, TSOs refer to any local process which might play a role in the energy reservoir management strategy of the BSP, such as local market rules, local scheduling rules, local FCR obligations transfer rules and/or local compensation and back-up rules. Indeed, the LER prequalification period shall be long enough to cover the time period (including any lead time) for which a BSP no longer has the capability to perform any energy reservoir management action (e.g. time period for which a loss of FCR provision cannot be compensated by the BSP).

Considering all local conditions in the Synchronous Area of Continental Europe, the maximum time period for which a BSP cannot compensate its FCR exhaustion by means of the energy market or shift FCR in accordance to article 156(6) of SO GL is **2 hours** (e.g. in case of 1-hour market period with 1-hour lead time).

This **2-hour period** is based on the same considerations as the **2-hour period** in article 156(13) of SO GL as the maximum admitted time period (for Synchronous Area Continental Europe) for reservoir recovery in case of exhaustion after an alert state for an LER FCR providing group or unit.

By setting a LER prequalification period, TSOs consider all BSPs in Synchronous Area Continental Europe, based on their local terms and conditions, shall always be capable of guaranteeing continuous FCR provision for **non-LER** FCR providing groups or units, regardless of the system state.

This definition is fully in line with the CBA methodology assessment pursuant to article 156(11) of the SO GL for which the risk of FCR exhaustion for the Synchronous Area is assessed, considering non-LER FCR providing groups and units are always available, regardless of the system state.

<u>For the sake of clarity</u>, a conventional unit without any specific constraint of reservoir such as a thermal unit shall never fail the 2 hours of full FCR provision prequalification criteria (because of depletion of reservoir). Therefore, such conventional units shall never be categorized as LER under this definition.

The fulfilment of the time period of 2 hours is considered as a common prequalification requirement. It shall be proven by the FCR providing unit or group that the capacity of its energy reservoir is sufficient to allow the full activation of FCR in both positive and negative direction. The capability is only achieved if there is at least one energy reservoir storage level where a full activation for the LER prequalification period is

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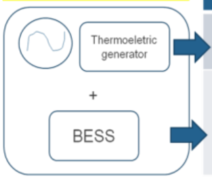
possible in either positive or negative direction. The positive effect of an energy reservoir management shall not be considered during the classification of LER or non-LER.

The following figure illustrates two examples of the requirements applicable in case of a FCR providing unit or group composed of both limited and unlimited energy reservoir technical entities, alternatively deemed as non-LER or LER in accordance with Articles 156(7) and (8) of SO GL. Common assumptions for both configurations are (top vs. bottom of the figure): same overall FCR provision volumes, rated power/technology of each technical entity and the state of charge of a limited energy reservoir technical entity at the beginning of the timeframe. The FCR provision splitting between technical entities and, subsequently, the minimum reserved FCR margin on the unlimited energy reservoir technical entity alter the classification of the FCR providing unit or group.

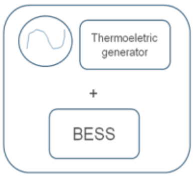
Examples of FCR provision splitting between technical entities

LER FCR dynamic support to conventional units



Total FCR provision	FCR provision distribution at steady state (e.g. >30seconds)	Technical entities duty	SOGL classification	Additional prescriptions to LER as a whole
≥100%	100%	Full activation at steady state	Art.156(7) "unlimited"	
	0%	Compensating non LER dynamics only (no activation at steady state)		•No normal state obligations •No time period

Full FCR provision by LER



Total FCR provision	FCR provision distribution at steady state (e.g. >30seconds)	Technical entities duty	SOGL classification	Additional prescriptions to LER as a whole
≥25%	0%	Continuous activation in normal state only	Art.156(8) "limited"	
	100%	Full FCR activation at steady state		• shifting provision in normal state + "1,25:1,00" or equivalent solution •Time period

Examples: FCR provision distribution supposed against a 200 mHz frequency deviation 5

On the basis of the configuration shown at the top of the figure, the limited energy reservoir technical entity (Battery Energy Storage System, BESS) is in charge of compensating, fully or partially, the FCR dynamic activation of its coupled thermoelectric generator. This activation is generally performed during frequency transients and it is completely substituted by the conventional generator full activation at regime. Since, e.g. for prolonged a frequency deviation, the entire FCR provision is reserved on the latter, the FCR providing unit or group is not classified as LER in accordance with Article 156(7) of SO GL. The BESS system shall only ensure its availability in order to uphold the dynamics of the provision, and not "the energy content" of the FCR provision.

According to the configuration shown at the bottom of the figure instead, the limited energy reservoir technical entity (BESS) supplies the entire FCR provision of the FCR providing unit. Since the conventional group reserves an FCR margin smaller than the total FCR provision (<100%), this configuration limits the FCR providing unit capability in case of a full activation for the adopted timeframe (under the assumption of a given state of charge).

The FCR providing unit is then classified as LER in accordance with Article 156(8) of SO GL.

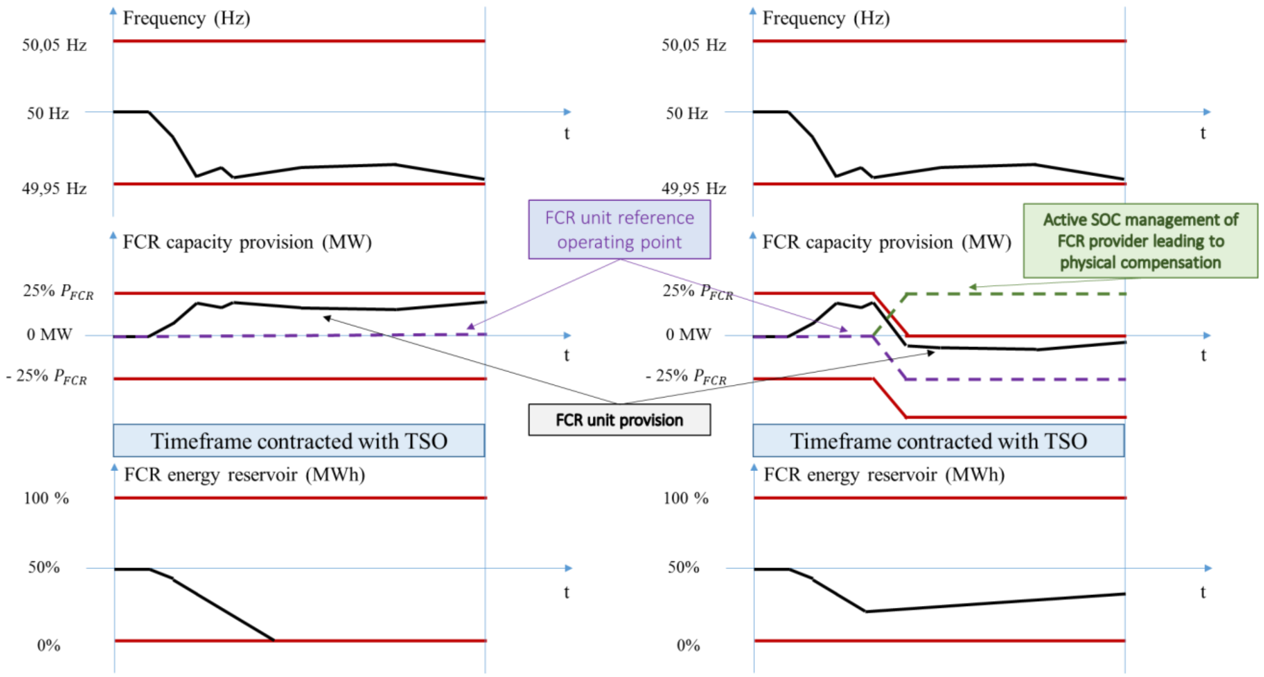
Article 156 (9), (10) and (11) of SO GL apply to FCR providing units or groups and, in accordance with Article 156(8), the limited energy reservoir technical entity (BESS) shall activate its FCR for as long as the frequency deviation persists, unless its energy reservoir is exhausted in either the positive or negative direction. In this example, an FCR margin, equal to or greater than 25% of the provision, shall be reserved on the conventional group so as to guarantee a continuous FCR providing unit activation in normal state and, in accordance with Article 156(8), as long as available.

Further Prequalification Requirements for LER units:

FCR providing units with limited energy reservoir bear in general the risk of losing effective FCR capacity in case of longer lasting deviations of system frequency due to empty reservoirs. Thus, a charging concept based on a defined energy exchange with the grid (energy reservoir management) for such units is essential to guarantee an appropriate activation, particularly in stressed system states. In exceptional cases where a FCR providing unit or group is not technically able to implement energy reservoir management (e.g. hydro power plants), or a FCR provider chooses not to implement energy reservoir management, the respective FCR provider shall be able to compensate a possible lack of energy and, hence, a lack of FCR provision, by shifting FCR activation to available providing groups or units.

Normal state with frequency deviations larger than +/-50 mHz implies an energy depletion with a possible impact on the energy availability for the alert state. FCR providers shall consider these frequency deviations before entering into alert state to comply with the minimum activation period in accordance with Article 156(9).

Since normal state includes a constant frequency deviation of a maximum of 49.99 mHz, the energy reservoir may be depleted. The energy reservoir management for FCR providing units or groups with limited energy reservoir takes into account this scenario in order to guarantee continuous activation of FCR. Hence, an additional power dimensioning of 25% (50 mHz divided by 200 mHz) is required to allow continuous FCR provision while applying energy reservoir management. Nevertheless, this requirement is determined only for standalone operation of FCR providing units with limited energy reservoir, which means that operation is completely separated from other units that may provide energy reservoir management for this unit. The following figure illustrates the requirement for additional power dimensioning of 25%:



The figure illustrates the relationship between frequency deviation, FCR power provision and energy reservoir usage.

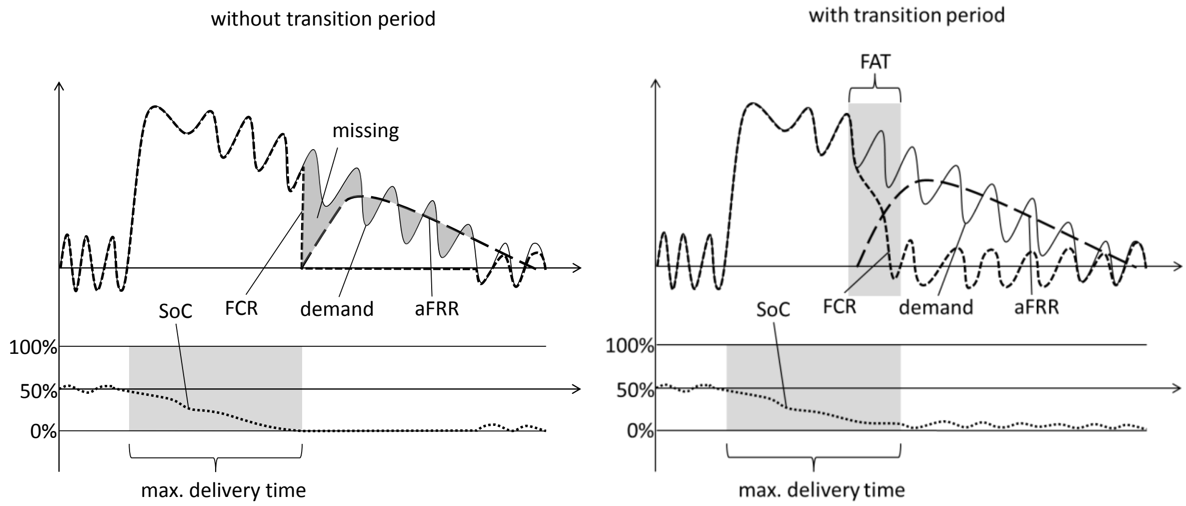
On the left side of the figure, a theoretical case of reservoir exhaustion without active energy reservoir management is presented during the timeframe contracted with TSO. The FCR unit reference operating point is used to represent the energy reservoir management strategy.

On the right side of the figure, the same case is presented applying a theoretical energy reservoir management strategy with physical compensation. It is shown that a shift of the reference operating point enables charging of the reservoir. After shifting the operating point to continue providing FCR up to 200mHz frequency deviation, it can be understood that 125% (so additional 25%) of the FCR unit prequalified power might be reached.

If the energy reservoir management made use of over fulfilment of activation (e.g. when system frequency exceeds 50 Hz, energy intake is higher than required), possible negative impacts on system stability like power swings could occur. Thus, such an energy reservoir management is not allowed.

An energy reservoir management cannot prevent a full exhaustion of the energy reservoir in case of very long-lasting deviations in alert state. Therefore, the concept of the so called "Reserve Mode" has to be additionally adopted to achieve a deterministic and controllable behaviour of FCR providing groups and units, and to prevent them from provoking an arbitrary behaviour (e.g. sudden complete stop of activation) in such critical situations. Intention of the reserve mode is, therefore, the maximum possible prolongation of the stabilizing effect for the system, considering the existing limitations.

The idea of the Reserve Mode is to relieve FCR providing units with limited energy reservoir from the "mean deviation" of system frequency. By applying this approach, the availability of FCR providing units with limited energy reservoir can be prolonged (see also graph below) depending on the mean value of system frequency.



Regarding Article 3.4:

With respect to the particular importance of FCR for the system security, the appropriate activation of FCR, especially in extraordinary situations, (e.g. system split or outage of FCR components) are of utmost importance.

In the light of encouraged FCR market development, the needs of the respective market participants are taken into account as far as possible. One of the requests of the market participants is the centralized control of FCR, as well as centralized frequency measurement, in order to increase cost efficiency. Nevertheless, compared to the current approach of on-site frequency measurement and fully autonomous activation of FCR, central frequency measurement and central control bears the inherent risk of malfunction (in case of system split) or loss of FCR capacity (outage of SCADA or communication). In general, a significant degradation of system security compared to the current level of security is not acceptable.

Therefore, the respective requirements in this proposal take into account:

- The possibility of applying centralized frequency measurement and centralized operation of FCR, in case the BSP can demonstrate that a complete decentralized solution or a decentralized fallback procedure cannot be implemented with adequate efforts;
- The respective application of Article 154(4) of the SO GL, which includes requirements concerning limitation of concentration of FCR with respect to single incidents.

In consequence, the total FCR operated by a single independent FCR controller is limited to 30 MW, in particular with respect to incidents affecting e.g. the SCADA of the BSP. The BSP is allowed to operate more than one independent FCR controller. In addition, and in order to prevent the effect of technical malfunction of FCR provision by central control, the total FCR operated with central control and central frequency measurement in a LFC block of a TSO is limited to 75 MW, so as to consider outages of a telecommunication provider in the region of a TSO, which might offer its service to a number of BSPs.

FCR providing units and groups shall be based on local frequency measurement at least per connection point, where the connection point is defined as the point of physical connection to the public grid. In special cases where the FCR units or groups are connected in an industrial grid, the FCR units' local frequency measurement shall be used. The justification for this requirement is the fact that FCR activation should be based on the measurement of the local frequency to ensure proper activation, also in extraordinary scenarios. From the technical side of the FCR providing unit, local frequency measurement is a natural feature in most manufacturing technologies, both for synchronous units and for units with a non-synchronous connection (through power electronics) to the system. This requirement has been already applied in the past.

Derogation and Development:
Experiences with central frequency control will be shared during a period of 4 years after entry into force of this Article by the reserve connecting TSO and evaluated by all TSOs. If the outcome proves that centralized control of FCR providing groups can be as reliable and robust as a decentralized solution, the joint TSOs may reconsider the preferred (decentralized) solution, either by extending the derogation period or by allowing centralized control of FCR as an alternative solution under specific conditions. The evolution and development of appliances controlled by BSPs on centralized principle might allow more robust solutions during this derogation period.

Regarding Article 3.5:

In emergency state, when the deviation of system frequency exceeds 200 mHz, the procured FCR are exhausted by principle. To prevent a system collapse and a respective disconnection of all generating units and demand facilities, the FCR providing units have to continue activation of the procured volume. This concept has also been applied in the past.

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