Statnett

Appendix 1:

Technical Product and Interface Specification for Delivery of Automatic Frequency Restoration Reserves (aFRR) to Statnett

Version October 2021

1. Definitions

BSP	Balancing Service Provider is the market participant that provides the balancing services to its connecting TSO.
aFRR Unit	An aFRR unit is one single unit that is controlled with a single set-point which is realised in **one single station**. How this set-point is distributed among the physical generating units within the station is solely decided by the BSP's control system (see Figure 1). The BSP's bids for supply are given per aFRR unit. The bids must comply with the product parameters described in the aFRR product definition in Chapter 3, Product Specification. Because of the filtering in the main controller the total power demand will change gradually, one step at a time.
Station	A station is a single generator or set of generators that are co-located and connected to the transmission network via a substation. A station is defined as having one aFRR unit.
Station Group	A set of stations that are co-located and connected to the Transmission network via several substations. If the TSO approves it, a station group can be treated as a station and thus an aFRR unit. This approval will be part of the pre-qualification process.
BSP's Control System	The BSP's Control System, i.e. automatic generator control, is a control function running in the BSP's SCADA system. It needs to have an automatic transmission of set-points to the generating unit and must be able to take control orders sent by the TSO and execute them. The control system should not have any closed loop frequency functions other than that of primary reserve. The TSO orders are combined with the BSPs' predefined generation schedule. It is assumed that the system has a control function for executing the schedules. The control system does not have to be a closed loop system, but it is preferable. The details of how the control orders from the TSO are implemented is up to the BSP. Some requirements are mandatory to ensure that the aFRR functions correctly.

Station/ generation mix	An aFRR Unit can be made up of one or more generators. The TSO provides the set-points which the BSP distributes as they see fit while staying mindful of the performance requirements. It could, for example, be possible to combine a large and slow production unit with a fast, smaller unit. This would provide the capability to provide secondary reserves from the slow unit without compromising with the performance requirements. To approve this set up, the mix of generators is must be documented and used for subsequent deliveries. This is to ensure that the uniform product is delivered.

2. Introduction

Brief introduction to aFRR

The automatic Frequency Restoration Reserves (aFRR), also known as Load Frequency Control (LFC) is a control function running in the TSO's (Statnett's) SCADA system which can control frequency and interchange (flow in or out of the control area) in the system. This is a secondary control scheme that operates in parallel with the primary regulation but on a slower bandwidth. Primary regulation, which is locally implemented in the generator, will match the generation with the load quantum but will not recover system frequency to the nominal level. This task is performed by aFRR using a PI regulator.

The main aim of aFRR is to reverse the deterioration in frequency quality in the Nordic synchronous system. aFRR is the automatic regulation of the system based on frequency. Decay in frequency is recognized and an additional appropriate quantum of reserve is indicated electronically. This automatic regulation is the key to achieve a faster response time. The risk of a major incident or outage occurring whilst the system frequency is outside the 49.9 to 50.1 frequency band is increasing and improvements are necessary.

The automatic Frequency Restoration regulation should not affect the overall stability of the Power Control system. To ensure this it is important that the aFRR control loop does not interfere with the Frequency Containment Reserves' (FCR) control system. Therefore, the aFRR must react slower to changes in the frequency than the FCR (primary). This is achieved by applying a low-pass filter to the frequency measurement in FCR with a sufficiently high time constant.

An aFRR unit can be fulfilled by one or more assets, however all the assets in the aFRR unit must be in a single station. The contribution of each individual generator can vary if the total quantum of aFRR reserves is unchanged. In the example in Figure 1, the BSP obligation is to deliver up to 65 MW in a defined time period (a 6-hour block). The BSP could plan to deliver from their wind power generators e.g. 2 hours and from their hydro power for the remaining 4 hours. This example shows only positive aFRR. A BSP's control system can be used to deliver both positive and/or negative aFRR.

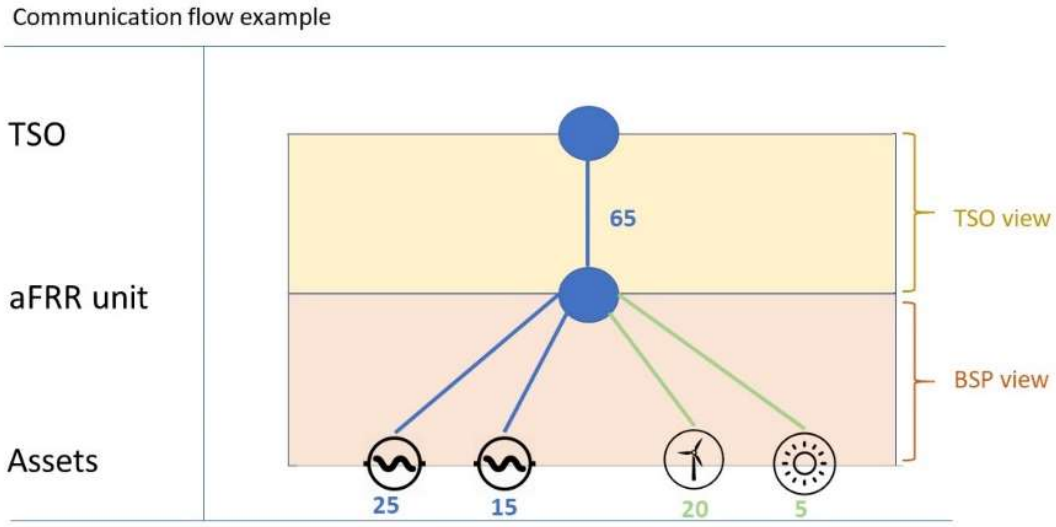

Figure 1: The diagram illustrates the communication flow between the TSO, aFRR unit and the power producing assets

3. Product Specification

BSP schedules

Each BSP has a schedule which is either executed automatically using a control system or is manually implemented. However, the units participating in the secondary control are required to be automatically controlled by the TSO request known as Set Point (SP) or aFRR signal. This alters the resultant production to match the current needs as shown in Figure 2.

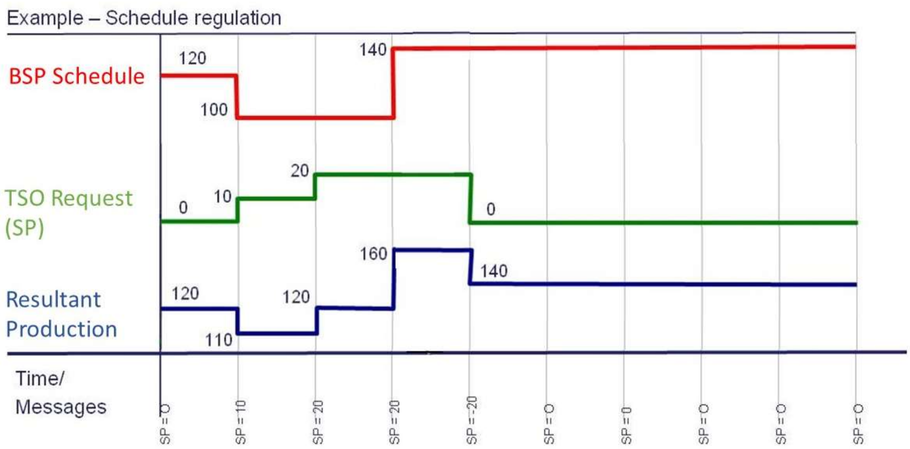

Figure 2 shows an example of when a BSP schedule (red) is modified by a TSO request (green). The BSP's resultant production is then the sum of the original schedule and the TSO request (blue).

Changes in schedules are executed by the BSP independently of the TSO control.

Parameters and Values

The response required from the BSPs is illustrated in Figure 3 and the utilized parameters are defined in Table 1.

Table 1 Definition of parameters that form the aFRR unit response

Parameter	Value	Comment
Step Size	1 MW	Minimum value: every set-point is a multiple of this. *NB. Statnett have changed this from 10MW according to Nordic harmonisation.*
Delivery time	120 s*	Maximum value. *NB. Statnett may request a longer time period up to 300 s should Nordic harmonisation require it.*
Delay	30 s	Maximum value

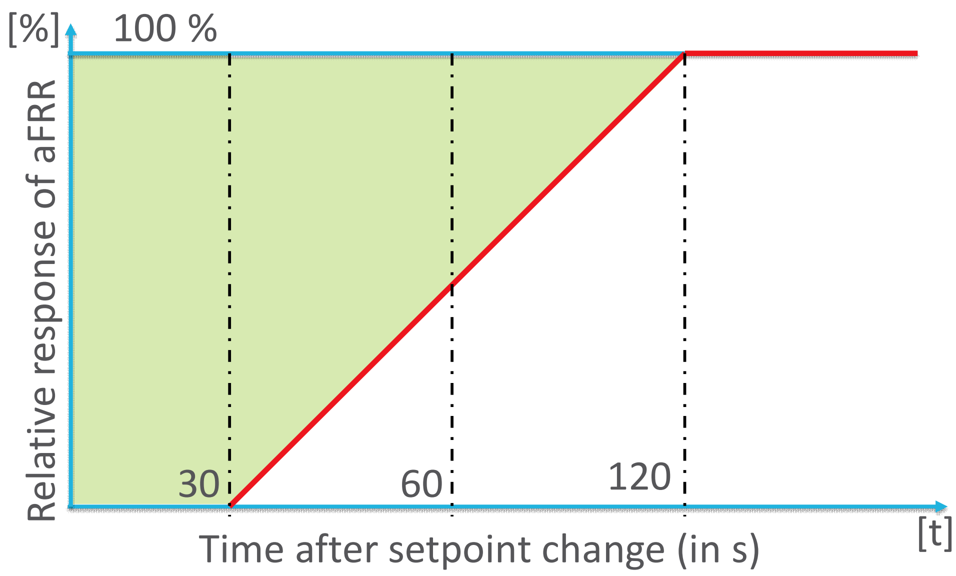

Figure 3: Shows the relative response of aFRR as a function of time after set point change.

Full Activation Time (FAT)

FAT is the time it takes from an aFRR activation signal is sent from the TSO's SCADA system until the generators reach their new production level according to the new set point.

The minimum FAT should be met for individual changes.

The delay time denotes the time from the signal is sent from the TSO until the generators start to change their production level. This delay time should be as short as possible, maximum equal to the time set in table 1 above.

The delay time shall be the same when responding to changes in both directions.

Set-point Definition

The signal from Statnett's SCADA system is a delta set point and tells how much the BSP should differ from the planned production, or the production without aFRR.

Planned changes in production due to tertiary regulation or spot trade shall go ahead and shall not affect the contribution to aFRR.

Frequency Containment Reserves can still be delivered.

Capacity/Regulating Volume

The regulating volume defines the maximum and minimum change that Statnett can request from an aFRR Unit.

The available regulating volume for each aFRR Unit is the result of the Secondary Reserves Market. Statnett can only regulate within the purchased regulating margins, unless Statnett's control centre agrees an increase to regulation limits in operation, i.e. if another BSP fails to deliver.

aFRR ACE calculation mode

aFRR ACE calculation mode can be set in three different modes by the TSO:

- Constant frequency (CF) when only frequency is considered,
- Constant net interchange (CNI) where only interchange in and out of the control block is considered
- TLB tie-line bias where both frequency and interchange are used.

Regulation mode in the aFRR control function in Statnett SCADA -system is set to Constant frequency (CF)

Actual aFRR contribution

The actual aFRR contribution from an aFRR unit is a calculated measurement. Under normal circumstances this should coincide with the control set-point. This signal is sent from the BSP to Statnett.

This signal should be a continuous measurement, reflecting how much the aFRR unit is contributing to the aFRR. If the contribution is spread over multiple generators their individual contribution should be summed in this measurement.

$$ActualFRR = SP_{FRR} + e = P_{gen} - P_{plan} - FB \times \Delta f$$

where SP_{FRR} is the set point from Statnett, e is errors due to oscillations, inaccuracy in the turbine regulator etc. P_{GEN} is the MW measurement from the generator(s), P_{PLAN} is planned production before aFRR and $FB * \Delta f$ is an adjustment for primary regulation.

Interplay between FCR and aFRR

The BSP may deliver both aFRR and FCR from the same station/generator at the same time.

When the BSP defines the capacity of aFRR to which it will be obligated through a bidding process it must calculate the FCR maximum capacity based on a frequency deviation of 0.5 Hz [49.5 – 50.5 Hz], taking into account the current droop settings.

Bidding Limitations

The BSPs control system must check that an asset does not belong to more than one active aFRR unit.

The BSP aFRR unit should normally only include a single station, however inclusion of co-located stations can be accepted following acceptance by the TSO.

With the definition of different products different aFRR units may be defined with unique identifiers and different parameters requirements defined by the system modelling set-up.

4. Interface Specification

Using aFRR Set Point

The BSP's control systems must be able to read the aFRR set point and divide this correction among the generating units currently at disposal. The actual division is up to the local BSP. One suggestion is to use participation factors which are dynamically normalised. This correction is added to the scheduled generation level (base point) for the individual units. The BSP's control systems will send out set-points to the individual units according to the system's implementation. The set-point is transferred via ICCP from Statnett to the BSP.

Setting the Remote Control Permitted Status

The TSO will only regulate an aFRR Unit if the signal *Remote Control Permitted* is set. This should be set when the unit is ready to receive and execute set-points.

The BSP's control systems must have a monitoring function that checks the conditions for setting this signal, sets it and transmits this signal to the TSO.

Monitoring Validity of aFRR Set points

The BSP's control system must have a monitoring function that checks that the aFRR set-point orders transferred from Statnett are within the bids and in compliance with other parameters. If not, this function should set the Unit in limitation signal (Up or/and Down).

Other Information

The BSP's control system should provide Statnett with the currently available reserves (up and down) and how much they are currently contributing to the aFRR.

Communication Time Out

In case of a communication breakdown, the BSP's control system should maintain its current contribution level to the aFRR for some time. This time-out should be for a pre-defined period from the last change of the aFRR set point. The time out period is set by the TSO and should be possible to configurable.

This function is added to allow for smooth recovery after a short communication breakdown. With a loss of communication between the aFRR and the control system e.g. the aFRR set-point becomes invalid the current contribution to aFRR will be maintained for E.G. 900 seconds from the last received change from the aFRR as shown in Figure 4

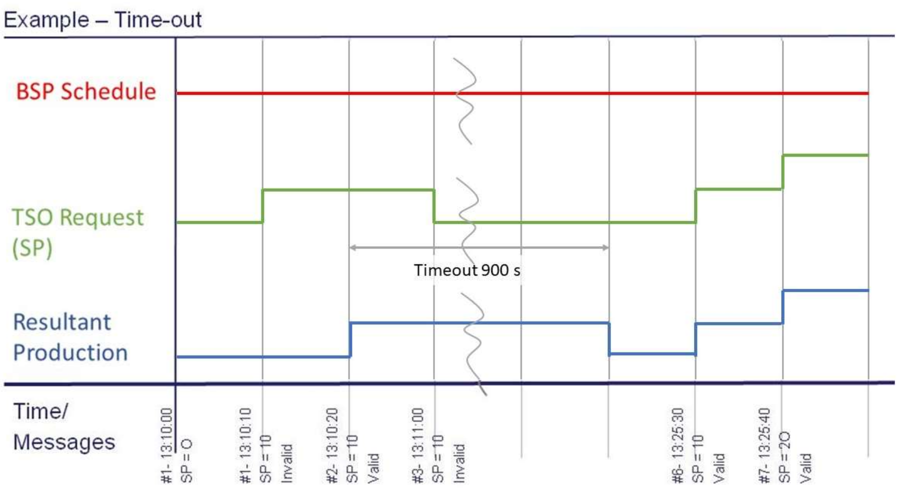

Figure 4: Description of the timeout functionality. The resultant production does not change in the timeout period.

Should the TSO communication be lost this regime ensures that the different BSPs will not set their contribution to zero at the same time but last received change.

Communication Failure

The BSP should monitor of the communication band and ensure that an alarm will be generated with loss of the connection. This alarm will then be used to initiate the time-out condition above.

Availability

A dedicated ICCP/ connection will be established between Statnett's National Control Centre (NCC) and the BSP SCADA. The availability requirement for this connection and subsequent connection from the BSP SCADA to the Station will be 99 %. Availability is measured on a weekly basis starting Monday 00:00 and approximates to 10 min/week. ICCP server restarts should not be included in this metric.

When calculating the availability of the system down-time caused by the TSO is subtracted.

5. System Design

This section describes requirements regarding system design, protocol, and availability for the connection between the TSO SCADA servers and BSP SCADA servers, as illustrated in Figure 5.

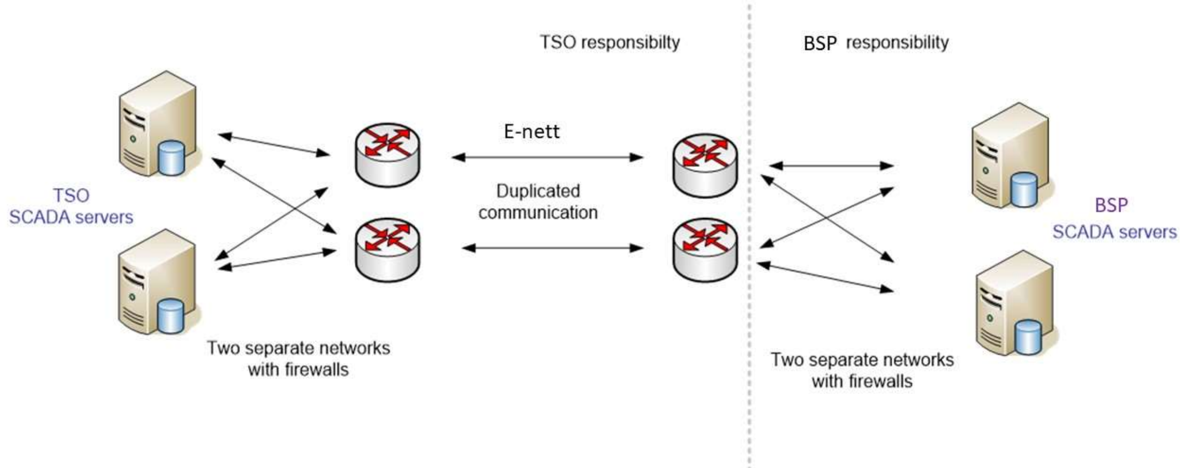

Figure 5: System design

The following requirements are needed to be accepted as a supplier of Secondary reserves for the TSO:

- The BSP must have two separate physical connections to the network called E-NETT.
- The BSP must have a Control Centre with two separate redundant SCADA servers.
- The BSP should have two separate networks with two firewalls connecting their SCADA servers to the E-NETT network.

aFRR should have a dedicated ICCP connection. Other SCADA signals should go on another ICCP connection.

To ensure lowest possible down-time, the TSO will install duplicate routers at the BSP site, each of them connected to a separate BSP firewall. This configuration will ensure redundancy in the complete chain from the TSO SCADA servers to the BSP SCADA servers. BSP will be responsible for the duplication of firewalls and network at the BSP site.

All signals between the TSO and the BSP shall be based on ICCP protocol. The communication will be encrypted using ICCP.

All indications and set point values are transferred spontaneously, while all measurements are sent cyclically.

6. Signal descriptions

Remote control permitted status signal BSP → TSO	When set this signal means that the aFRR is permitted to control the unit. This does not imply that the aFRR has taken control of the unit but it is a pre-requirement for the TSO to use it in regulation.
Limitation status signals BSP → TSO	When this signal is sent, it means that the unit has reached its limits either up or down. There is one upper and one lower limitation signal. This signal is used by the BSP to no longer increase or alternatively no longer decrease regulation as long as the corresponding signal is sent. This signal is sent by the BSP when the first signal equal to the max or min reserve is received If the commanded set point violates the control system's ramp rate, or turn time limitations, both limitation signals shall be sent.
Available reserves BSP → TSO	Available reserves up and down. This is a confirmation that there is available sufficient regulation with reference to the contractual obligations of the BSP. Example: sold capacity =100, activated = 10 -> available reserves =100)

Control Set-point TSO → BSP	The set-point is sent as a set point value over ICCP. Whenever the TSO is controlling the aFRR unit this value will be updated; it will not be updated if aFRR is not controlling it. If this value is not valid the BSP control system should not use this signal. A time out should be applied before considering this signal invalid in order to handle temporary loss of communication. The control signal will be increments of the step size 1 MW, and its signal rate will be not more often than every 4 seconds. A configurable delay after set-point transmission can be added. To verify that the BSP control system has received the set point value, a measurement containing the last received set point value is returned to the TSO. For each aFRR unit there will be defined a control set-point that is updated through ICCP. This set-point shall be interpreted as a deviation from the current scheduled generation level. The control set-point signal is an accumulated value and therefore a new signal replaces the old one. The value is defined in MW.
Regulation Validation	Regulation validation aims to ensure that regulation activation by the TSO is in-line with the Bids submitted by the BSP and is within the product specification set for the reserves. TSO validation is in two steps. First bids are validated, and a bid step curve is made available to the aFRR for selection of reserves based on geographic location. Second the aFRR has functionality which limits the set-point regulation signal to blocks of 1 MW and a signal rate of 10 seconds. Furthermore, it controls that set-point regulation does not exceed contractual agreed limits for regulation bid by the generating unit. The BSP can have its own validation of performance in addition to the TSO, but this is not a requirement from the TSO.

7. Appendix:

Activation Profiles Examples

Signal list

*Table 2 shows the mapping between SCADA and the correct telemetry. * STATION_NAME in ICCP GLOBAL ID should be exchanged with the station name in question.*

Discrete Name	Telemetry Template	GEN description	ICCP GLOBAL ID
LFGD -AGC in limit down	CZMBR_INPUT CZMBR_ATMN_P_I	AT LIMIT DOWN STATUS	***STATION_NAME**** _AGC_LIM_DOWN
LFGD -AGC in limit UP	CZMBR_INPUT CZMBR_ATMX_P_I	AT LIMIT UP STATUS	***STATION_NAME**** _AGC_LIM_UP
LFSE-enabled	CZMBR_OUTPUT CZMBR_LFC_P_O	LFC ENABLED	***STATION_NAME**** _FRR_ENABLED
LFSF – Remote Control Permit	CZMBR_INPUT CZMBR_AUT_P_I	REMOTE CONTROL PERMITTED	***STATION_NAME**** _AGC_RCP
LFAC – Actual LFC Contributi	CZMBR_INPUT CZMBR_AREG_A_I	ACTUAL LFC CONTRIBUTION	***STATION_NAME**** _AGC_ACTUAL_MW
RDOW – Current LFC res. down	CZMBR_INPUT CZMBR_RVDN_A_I	CURRENT LFC RESERVE DOWN	***STATION_NAME**** _AGC_RES_DOWN
RUP – Current LFC res. up	CZMBR_INPUT CZMBR_RVUP_A_I	CURRENT LFC RESERVE UP	***STATION_NAME**** _AGC_RES_UP