

aFRR Manual for EMS Providers

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Terms and abbreviations

ACC A Consultancy Company.

active power is the momentary measure of the actual consumption or production of a device or portfolio.

aFRR automatic Frequency Restoration Reserve.

available active power is the maximum total power the device or portfolio could consume or produce under the current circumstances if it were set to consume or produce maximally. This value is provided separately for both directions..

BSP Balancing Service Provider.

delta setpoint is a relative power value *relative* to the reference signal.

EMS Energy Management System.

ISP imbalance settlement period. Often used interchangeably with Program Time Unit (PTU).

reference signal is the power the device or portfolio would have produced or consumed in the absence of an automatic Frequency Restoration Reserve (aFRR) activation.

TSO Transmission System Operator.

1 Introduction

A Consultancy Company (ACC) offers IT services to help Balancing Service Providers (BSPs) manage their asset portfolio on aFRR. In order to be active on aFRR, the BSP should be able to dispatch their asset portfolio in real time in response to activations it receives from the Transmission System Operator (TSO). This requires a direct connection with those assets, but ACC does not integrate with physical hardware. Instead, ACC aims to partner with players in the EMS space to facilitate this integration.

The purpose of this document is to clarify the expectations ACC has of EMS providers regarding their capabilities and responsibilities when partnering with ACC to deliver aFRR on behalf of BSPs.

2 Portfolio

The BSP offers power and is activated on its entire portfolio at once. The BSP's portfolio consists of multiple locations, each of which may contain one or more devices. An example of how a BSP's portfolio may be structured is given in Figure 1. A location corresponds to a grid connection identified with a unique EAN18 code, while a device corresponds to a uniquely controllable group of flex power and is identified with a unique identifier determined by the EMS provider. Devices may be physically controlled by multiple EMS providers.

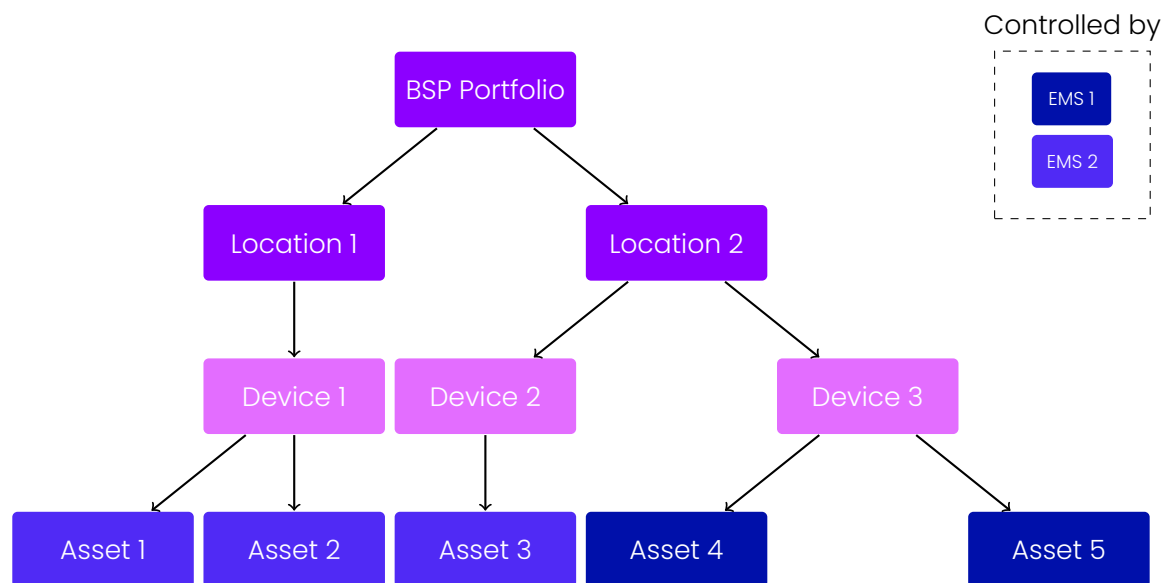


Figure 1: Typical data flow between the different parties involved in aFRR

Devices and locations are registered with ACC by the BSP. ACC registers all locations with the TSO. The devices are not passed on to the TSO and are only used by ACC to aggregate measurements (Section 4 and disaggregate aFRR activations).

From the perspective of ACC, a device is a single unit that can report a single reference signal and adjust its active power relative to a single delta setpoint. This is visualized as the third row in Figure 1. In principle, a device may consist of multiple assets (and even mix multiple asset types such as wind, Photovoltaic (PV), batteries, etc.), as long as all assets in the device

can be controlled through a single delta setpoint. These are visualized as the fourth row in Figure 1. These are relevant for the BSP, but not for ACC.

Contrary to the delta setpoint, ACC can accept the required measurements both on the level of each individual asset behind the device, or only aggregated to the level of the device. Measurements may not be aggregated to levels higher than the device, and regardless the level of aggregation, measurements should contain all required values as described in Section 4.

If, e.g. for the purpose of subsidies or contracts, the BSP requires different groups of assets to be steered with different priorities in response to an aFRR activation, all groups should be registered with ACC as a separate device with a unique device identifier. This is also the case if both groups of identifiers are present at the same location.

3 Responsibilities

In this section, we describe a typical day on which the BSP delivers aFRR, and where the responsibilities of the BSP, EMS provider and ACC lie. The relevant portions of this process are visualized in Figure 2, and the full process for aFRR is described by the Dutch TSO TenneT in the *Manual aFRR for BSPs* [1].

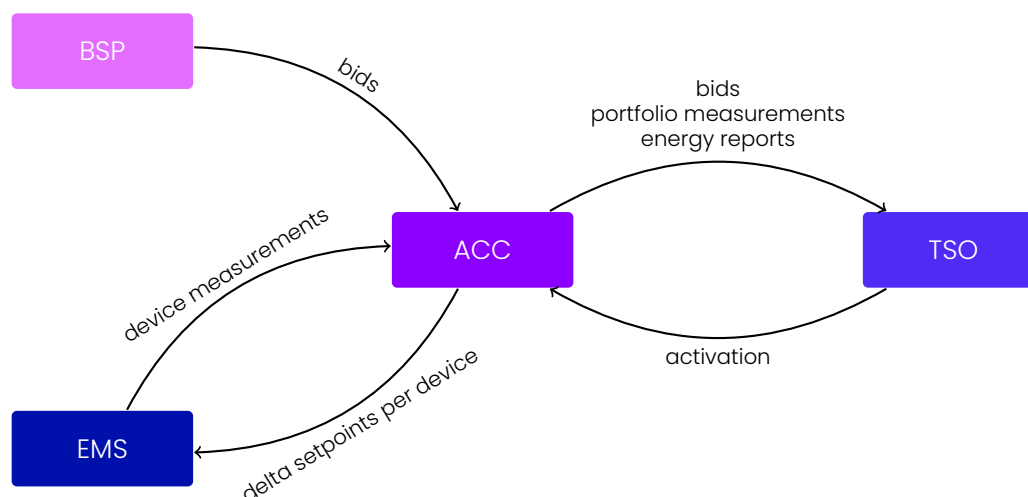


Figure 2: Typical data flow between the different parties involved in aFRR

Before aFRR delivery starts, the BSP bids in aFRR capacity to the TSO. The bids specify, per imbalance settlement period (ISP) and for the entire portfolio as a whole, the amount of available power (in the upward or downward direction) and the minimum required compensation the BSP expects to receive for delivering that amount of power. The BSP submits these bids to ACC, who in turn forwards these to the TSO.

When there is sufficient imbalance, the TSO *activates* the BSP by sending an *activation* to ACC. ACC disaggregates this activation across all devices in the portfolio in real time, and sends one delta setpoint for each device to the EMS provider managing that device, such that all activated devices in aggregate meet the activation requested by the TSO.

The EMS provider provides real-time measurements (Section 4) to ACC, which ACC uses to determine which devices in the portfolio are eligible for participating in the aFRR activation,

and to send real-time aggregated active power and reference signal measurements to the TSO.

After the day of delivery has concluded, ACC compiles an activated energy report and shares this report with the TSO. The TSO uses this report to correct the imbalance position of the BSP with the relevant Balance Responsible Partys (BRPs), and to determine the compensation the BSP is eligible for.

4 Measurements

During and around aFRR activations by the TSO, the BSP is required to report measurements of the portfolio with high frequency. These measurements consist of the active power – which is the total power the portfolio is producing or consuming at that time – and the reference signal – which is the total power the portfolio *would have* produced or consumed in the absence of an activation. When the BSP is not activated, the active power and reference signal should be the same; when the BSP *is* activated, the difference between these two values should be equal to the activation.

At the time of writing, these measurements should be sent in to the TSO every four seconds. In the future, this frequency will likely be increased to every (one) second.

ACC requires the EMS providers to report the following data for each device in the portfolio that they manage at least every four seconds:

1. Measurement time stamp
2. active power
3. reference signal
4. available active power (in both directions)

ACC aggregates the active power and reference signal to the portfolio level (potentially across multiple EMS providers) and communicates these with the TSO on behalf of the BSP.

The available active power, on the other hand, is used when ACC receives an activation order from the TSO on behalf of the BSP to understand how the activation can be disaggregated across the portfolio. This disaggregation results in a delta setpoint for each device in the portfolio. ACC sends this delta setpoint to the EMS provider that manages the device, who is then responsible for delivering that amount of power *relative to* the reference signal. The EMS provider should constantly adjust the active power to ensure that the difference between active power and the reference signal remains equal to the received delta setpoint.

To illustrate these concepts, two detailed examples of how these measurements are constructed in various conditions are given in Appendix A.

4.1 Active Power

The active power is the total power that a device is actively producing or consuming at the time of measurement. ACC maintains the *generator sign convention*, which means that a positive value corresponds to power production by the device and a negative value corresponds to power consumption by the device.

In the case of an aFRR activation, the active power increased by the amount specified in the delta setpoint for that device. In the case of downward activation, this value will be negative.

As a consequence, in that case the active power will in fact decrease.

4.2 Reference Signal

The reference signal represents the total active power that the device *would* be producing in the counterfactual case where the device was not activated. This value takes into account all activity of the device, *except* any potential active delta setpoint.

The TSO dictates the way this value is determined may not be affected by any potential aFRR activation [1, p.21]. Maintaining the last measured active power from before an activation, for example, is explicitly not allowed. Outside of aFRR activations, this value should be equal to active power.

In the case of solar, the reference signal is usually equal to what the device would be producing if no aFRR was activated. If the device is being controlled with additional strategies other than aFRR, the reference signal is adjusted to take production following those strategies into account. For example, in the case of curtailment to 0%, the reference signal is adjusted to 0MW to reflect the curtailment taking place.

For most other assets, the reference signal usually corresponds to the day-ahead schedule, backed by power trades on established markets.

The formal requirements for the reference signal are described in Chapter 6.4 of the *Manual aFRR for BSPs* [1, pp. 20–22]. Part of this chapter describe the requirements for the aggregated reference signal. Meeting these requirements are the responsibility of ACC and may be ignored by the EMS provider. The EMS provider is encouraged, however, to study the specifications for establishing the reference signal in general, as these apply also to individual assets.

4.3 Available Active Power

The available active power represents the total power that is available to the device, i.e. that the device can consume or produce at the time of measurement. This value is independent from the active power. This power is typically split into *upward* and *downward* available power. ACC expects both values to be absolute.

ACC uses these values during disaggregation of activations received from the TSO to determine how much each device in the portfolio could potentially contribute to the aFRR activation.

In the case of batteries, for example, this is usually the total charge (for downward) and discharge (for upward) power available to the specific battery. That is assuming that the battery is not used for any activity other than aFRR and that outside of aFRR activations, the battery is sitting idle. Examples for how the available active power would change for devices that have a non-zero active power outside aFRR activations are given in Appendix A.

In the case of solar, the downward available active power is usually 0MW, as that is the most a typical solar installation can consume. Upward available active power is typically equal to the reference signal, as that is the most a typical solar installation can produce. These values may change if the solar installation is used for other purposes than aFRR. Examples of how that activity might affect the available active power are given in Figure 4 in Appendix A.

5 Communication Protocols

ACC will send delta setpoint to the EMS provider per device using HTTP requests. The delta setpoint ACC will always be relative to the reference signal calculated and reported by the EMS provider for that device. The EMS provider should be able to accept such HTTP requests, e.g., through a REST API. The exact schema may be dictated by the EMS provider.

Measurements (as defined in Section 4 need to be communicated in real-time. At the time of writing, the TSO expects updated measurements exactly every four seconds, but this may change to every (one) second in the future. As such, measurements the EMS provider collects from devices need to be propagated to ACC with minimal delay.

ACC currently accepts these measurements through two different channels: directly through MySQL or through Advanced Message Queuing Protocol (AMQP). In both cases, ACC is flexible on the exact schema to support, as long as, at minimum, the measurements as described in Section 4 are available through this channel in near-real-time.

Facilitating other channels of communication may be possible after consultation.

A Measurement examples

In this appendix, we illustrate the interplay between the various measurements during aFRR activation. To keep this examples as simple as possible, we ignore, for now, that a portfolio can consist of many devices. We focus instead on a single fictitious solar asset. That asset type has been chosen because solar usually exhibits fickle active power throughout the day, which helps illustrate how the various measurements are affected by external circumstances.

A.1 Simple measurement example

Figure 3 demonstrates a fictitious day with downward activation. The available active power is shown as a curve displaying a typical solar profile for an asset with a peak power of 2MW.

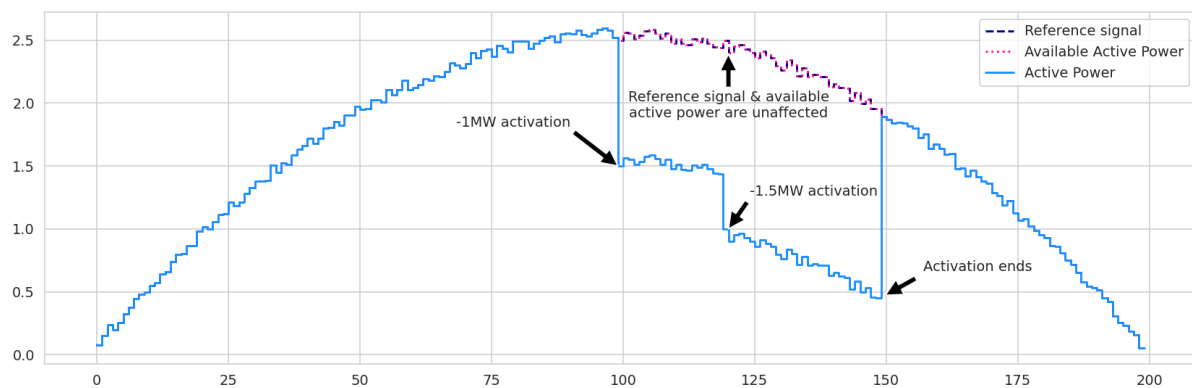


Figure 3: An example of active power, reference signal and available power during an aFRR activation

At the start of the day, the reference signal, active power and available active power are all equal. All three values gradually increase in line with the increasing solar irradiance.

At the 100 interval, an activation is received from the TSO. ACC performs a disaggregation, which results in a 1MW downward delta setpoint for this device. From that moment onward, the active power is lowered by 1MW relative to the reference signal, while the reference signal and available active power continue to follow the nominal solar profile unchanged. As the solar irradiance – and with it the reference signal – continues to increase, the active power is continuously adjusted, so that it remains 1MW less than the reference signal.

At the 120 interval, the downward activation is increased to 1.5MW. This coincides with a gradual decrease in solar intensity. From that moment onward, the active power of the device is adjusted to be 1.5MW less than the reference signal.

Finally at the 150 interval, the aFRR activation ends. This is indicated by a delta setpoint of 0MW. From this moment onward, the active power is adjusted such that it becomes equal to the reference signal.

For the entire day, the available active power in the upward direction is equal to the reference signal, because both correspond to the maximum available power at any point during the day.

Since solar installations cannot consume power, the available active power in the downward direction is equal to 0W.

A.2 Measurement example combining aFRR with curtailment

A slightly more complex example is given by including curtailment. During moments where the device is being curtailed, upward activation is available for solar installations. This is illustrated in Figure 4.

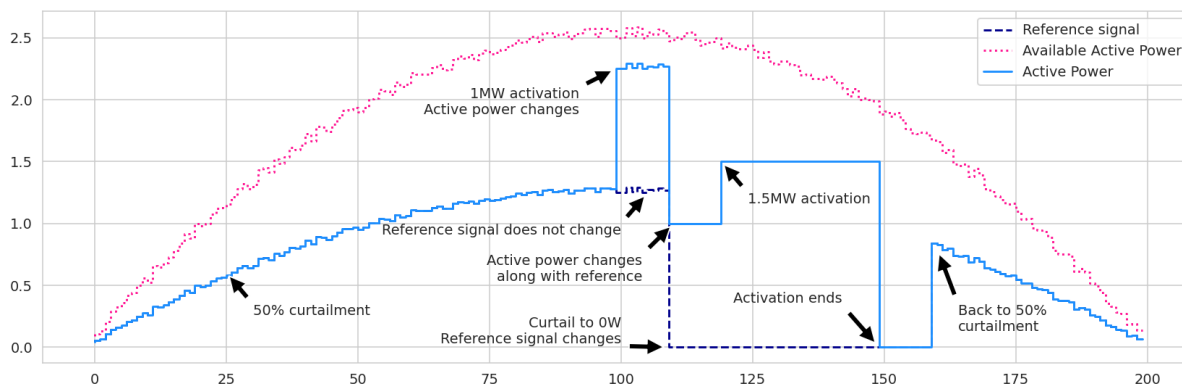


Figure 4: An example of active power, reference signal and available power during an aFRR activation in conjunction with curtailment

In this example, the device is curtailed to 50% from the start of the day. The available active power is unchanged compared to Figure 3, because what could potentially be produced is the same as in that scenario. The reference signal, however, is half the available active power, as this is meant to represent the activity of the device in the absence of any aFRR activation.

At the 100 interval, the device receives a 1MW upward delta setpoint. The reference signal remains unchanged, as it is not allowed to be affected by aFRR activations. The active power, on the other hand, rises to 1MW above the reference signal to realize the delta setpoint as the device increases its solar production.

At the 110 interval, the device is fully curtailed to 0MW. As this is not an action related to aFRR, this affects the reference signal, which follows the curtailment signal and drops to 0MW. The active power follows this drop to stay 1MW above the now changed reference signal to 1MW.

At the 120 interval, the aFRR delta setpoint is increased by 0.5MW to 1.5MW. As such, the active power also rises to 1.5MW, which is 1.5MW above the reference signal. The reference signal itself and the available active power are unaffected by this change in delta setpoint.

At the 150 interval, the aFRR activation ends, signaled by a 0MW delta setpoint that is sent to this device. This does not affect the reference signal or available active power but, since the device is still being curtailed with 100%, the active power is decreased to 0MW. Now that the aFRR activation is over, the reference signal and active power are equal again.

Finally, at the 160 interval, curtailment is reset from 0% to 50%. Both the reference signal and the active power (which follows the reference signal) increase to 50% of the available active power to reflect this change.

References

- [1] TenneT TSO B.V. *Manual aFRR for BSPs*, 09 April, 2026. Reference: SOP-SYS aFRR EN V2.7, <https://tennet-drupal.s3.eu-central-1.amazonaws.com/default/2026-04/aFRR%20Manual%20for%20BSPs%20en%20v2.7.pdf>.