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Provision of ancillary services and remedial actions from units with variable production or consumption

Valid during Svenska kraftnät's pilot study during 2022

SVENSKA KRAFTNÄT

Svenska kraftnät

Svenska kraftnät is a state owned enterprise with the task of maintaining Sweden's electricity transmission grid, which consists of about 16,000 kilometers of 400 kV and 220 kV transmission lines with substations and interconnectors. Svenska kraftnät is also the system operator for electricity in Sweden. Svenska kraftnät is developing the transmission grid and the electricity market to meet society's need for a secure, sustainable and cost-effective supply of electricity. In this, Svenska kraftnät plays an important role in implementing national climate policies.

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Content

Background and purpose

Svenska kraftnät procures ancillary services and remedial actions to ensure a balanced and stable electric power system. This category includes FFR, FCR-D upwards, FCR-D downwards, FCR-N, aFRR and mFRR. During activation of these services, the active power – production or consumption – is adjusted in accordance to the sold capacity. This means that the difference between active power before and after the activation should be equal to the sold volume. Moreover, the adjustment of active power should also satisfy the technical requirements for each respective service. It is the instantaneous change between the ordinary active power and the new level of active power (after regulation) of the resource that constitutes the delivery of the ancillary service.

Historically ancillary services have been provided by resources whose active power has to a large extent been fully controllable both before, during and after the regulation of power. This has meant that both the initial value before regulation and the final value after regulation have been well defined. Hence, the difference between the two values has been clearly defined, and thus the delivery of the ancillary service.

For some types of resources, the active power is variable and dependent on external factors that are not controllable. To ensure a correct delivery of an ancillary service despite underlying natural fluctuations in power, a baseline (SW: "referensvärde") needs to be established. The baseline constitutes the level from which the unit regulates. It is used during operation by the controller to set active power, as well as in retrospect by Svenska kraftnät to validate and verify delivery, for example to assess volume and compliance during prequalification or auditing. The method for producing a baseline – the reference method – is a prerequisite to deliver ancillary services from resources with natural fluctuations in active power.

This document introduces the concept of a baseline, and describes how the reference method is used for calculating a baseline during provision of ancillary services.

Please note that this document is a supporting document of technical nature. The document does not replace, but is meant to be a complement to, the ordinary test programs and technical requirements of the respective ancillary service. Baselines and reference values to handle economical aspects concerning for example settlement and adjustments of imbalances, or other market related network codes, are not addressed in this document.

Definition of baseline

The delivery of an ancillary service is defined as the difference between measured active power and the power that would have been produced/consumed without activation, the normal active power.

Equation 1

$$'Delivery' = |'Measured\ active\ power - 'Normal\ active\ power'|$$

The principle of equation (1) is illustrated in Figure 1.

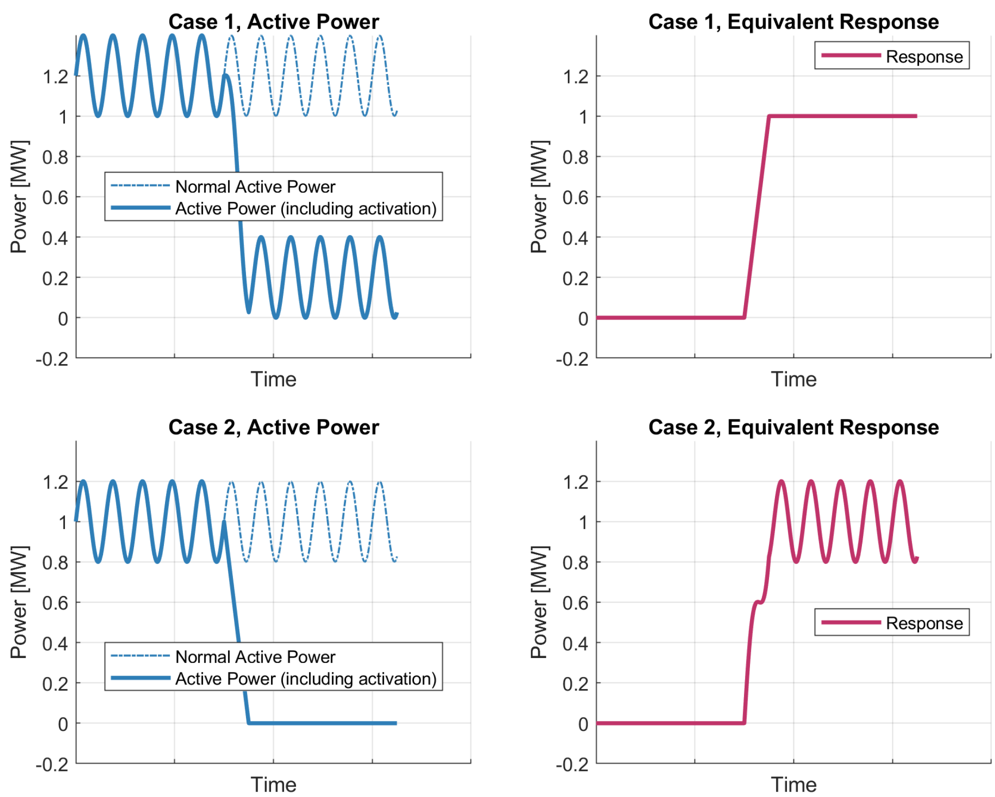

Figure 1. Ilustration of equivalent response from units with varying production/consumption.

Case 1, shown in the top row of Figure 1, illustrates a situation where the active power varies independently of whether the unit is activated or not. Thus, the delivery is not affected by the variations.

Case 2, shown in the bottom row of Figure 1, illustrates a situation where the variations are dependent of the delivery. In this case the variations are transferred to the response, in accordance to the equivalent response shown in the right graph.

During an ongoing activation 'normal active power' is usually not available for direct measurement. Instead, a reference method is used for calculating a baseline, which should match the normal active power that had been produced/consumed without activation. The baseline is used for calculating the set point for active power after regulation, and is not supposed to deviate from normal active power without activation of the ancillary service.

Equation 2

$$'Set\ point\ after\ regulation = 'Baseline' + 'Set\ point, delivery'$$

To get an accurate delivery the baseline needs to be reliable and match the normal active power. In case the active power is fully controllable, the baseline is well-defined and equals the active power (without activation). Other resources, like e.g. wind power, are variable by nature. Two different types of reference methods can be used by this type of units/groups, in order to obtain a baseline and deliver ancillary services:

> **Method 1 – Regulation with respect to a dynamic baseline that follows the natural variations of the unit.** During activation, the active power of the unit is adjusted downwards or upwards in relation to the dynamic baseline. The adjustment should equal the expected delivery. The dynamic baseline can be based on e.g. theoretical available power, calculated continuously from appropriate measurements.

> **Method 2 – Limit the set point to obtain a stable and well-defined baseline.** For example, a production unit can produce a stable (limited) power, instead of delivering full available power. The baseline thus becomes clearly defined and the regulation is performed based on this level. The same principles can also be applied to consumption resources.

These two principles are illustrated in Figure 2 and Figure 3, with examples of up- and downregulation, respectively. Both methods gives an identical response, in accordance with Equation 1.

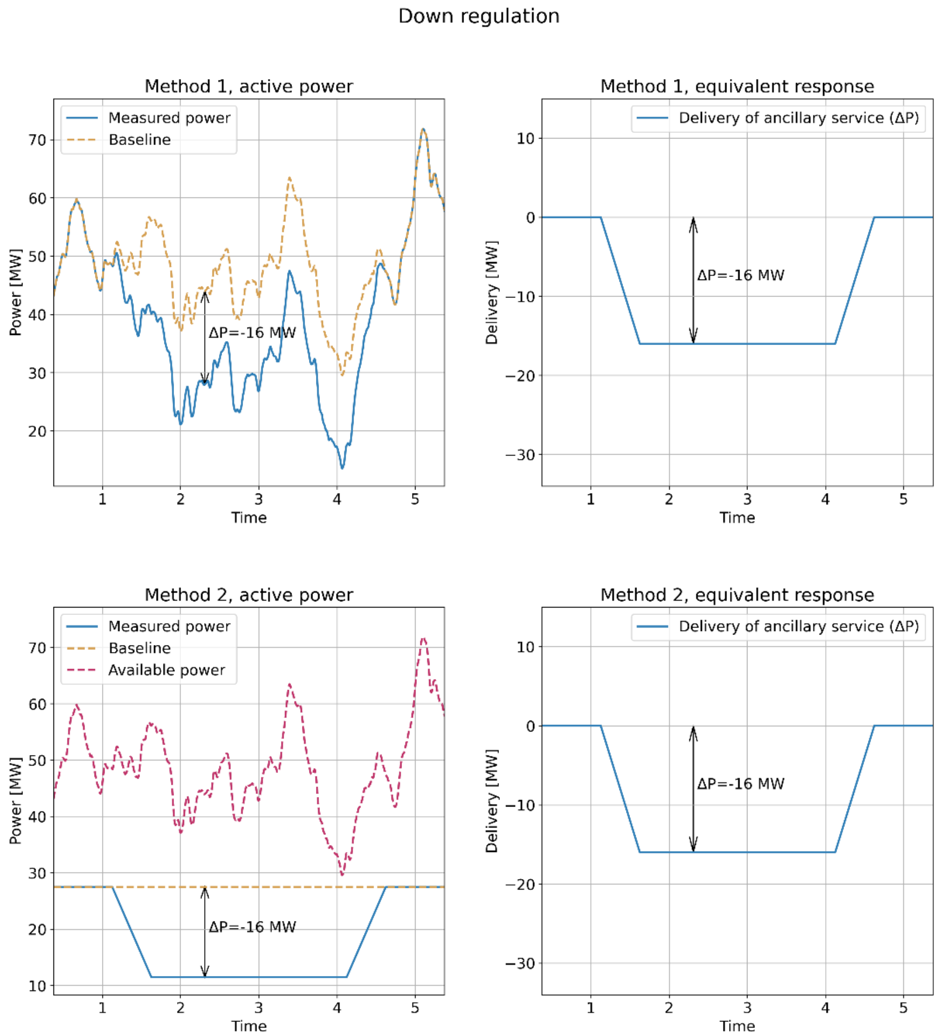

Figure 2. Example illustrating Method 1 and Method 2 to obtain a baseline for delivery of downregulation.

The top row of Figure 2 exemplifies application of Method 1. In the left graph, a dynamic baseline is shown, which matches measured active power before and after activation. During activation, there is an adjustment in power relative to this baseline. The adjustment corresponds to the delivery of the ancillary service shown in the right graph.

The top row of Figure 1 exemplifies application of Method 2. In the left graph, the set point has been limited and the active power is no longer following the fluctuating available power. Instead, it keeps a stable well-defined level, which constitutes the baseline. During activation, the power is downregulated with respect to this static level.

In Figure 2, Method 1 and method 2 results in the same delivery, as the difference between baseline and measured power are identical.

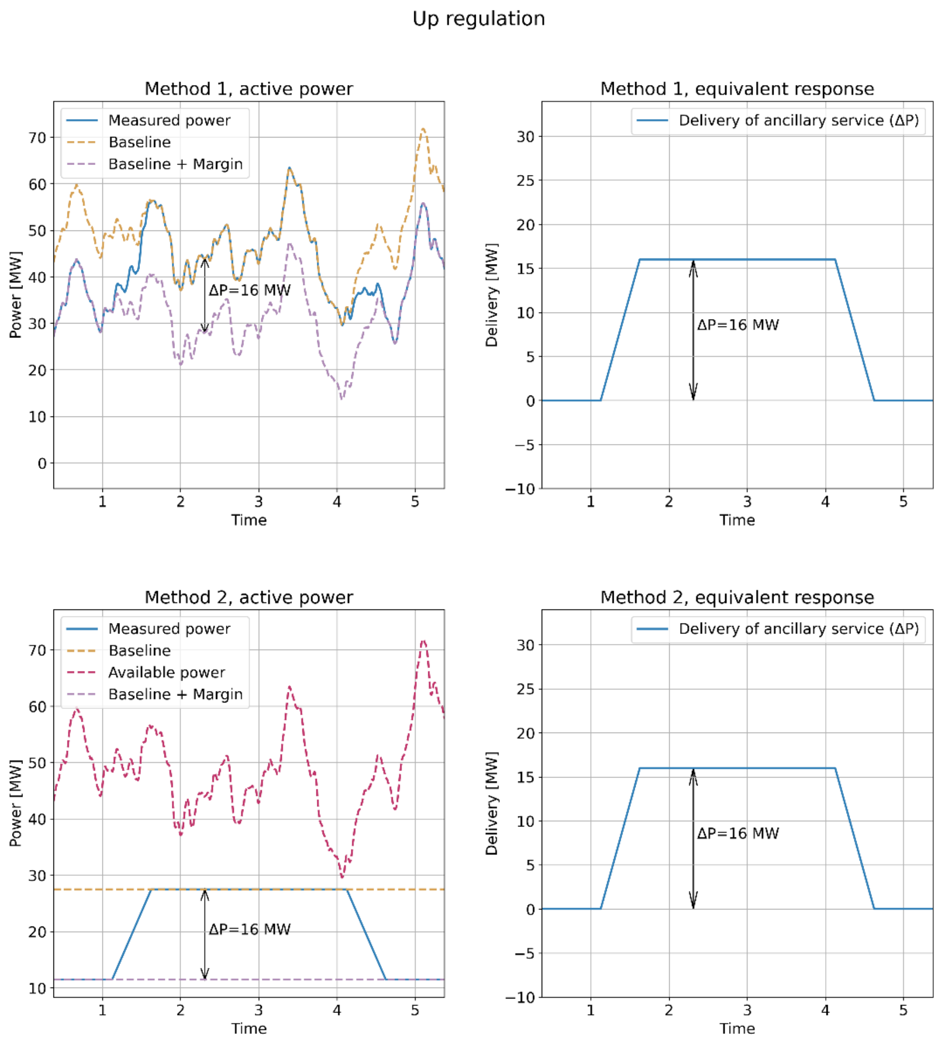

Figure 3. Example illustrating Method 1 and Method 2 to obtain a baseline for delivery of upregulation.

The top row of figure 3 exemplifies the application of Method 1. In the left graph, a dynamic baseline is shown, which follows measured active power before and after activation. During activation, there is an adjustment in power towards the baseline, as a margin has been added to allow for upregulation. The adjustment corresponds to the delivery of the ancillary service shown in the right graph.

The bottom row of Figure 3 exemplifies application of Method 2. In the left graph, the set point has been limited and the active power is no longer following the fluctuating available power. Instead, it keeps a stable well-defined level, which constitutes the baseline. During activation, the power is upregulated with respect to this static level.

In Figure 3, Method 1 and Method 2 results in the same delivery, as the difference between baseline and measured power are identical.

Usage of a dynamic baseline requires that the baseline follows the natural power variations of the unit instantaneously. A deviation between baseline and active power (that is not caused by an activation of the service), will result in a corresponding deviation in delivery of the ancillary service. This is illustrated in Figure 4 regarding downregulation and in Figure 5 regarding upregulation. Deviations between baseline and active power will result in a difference in active power (MW), which is then recalculated and specified as a relative number in relation to the intended delivery. These relative deviations should be minimized, counted as a percentage of sold capacity.

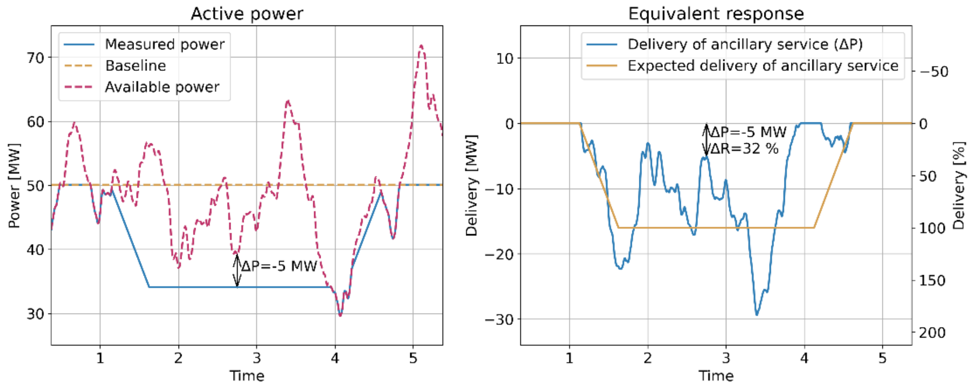

Figure 4. Illustration of delivery from down regulation when the baseline is neither corresponding to the normal active power (Method 1) nor has been computed to fall short of the same value (Method 2).

The left graph of Figure 4 shows measured active power, available power (normal active power) and the baseline during a downregulation of 16 MW. The difference between baseline and ’normal active power’ (without regulation) is transferred to the delivery, and results in an equivalent difference between actual and expected delivery. This difference is illustrated in the right graph, with absolute numbers on the left y-axis (MW), and relative proportion of expected delivery on the right y-axis (percentage of delivery). The relative error should be minimized

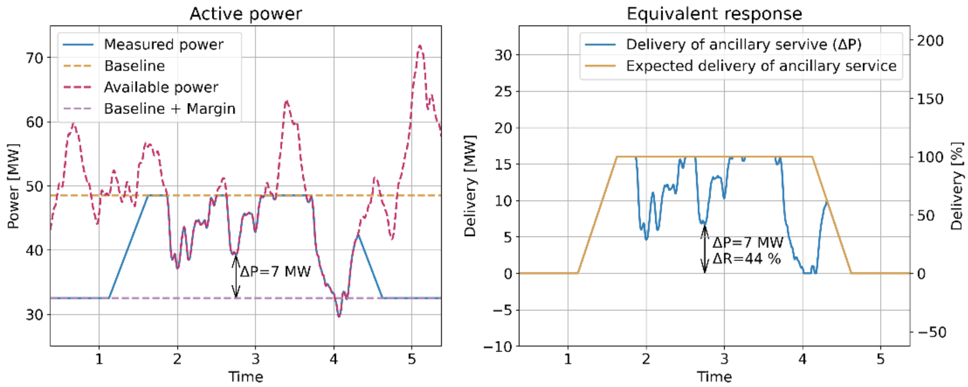

Figure 5. lustration of delivery from up regulation when the baseline is neither corresponding to the normal active power (Method 1) nor has been computed to fall short of the same value (Method 2).

The left graph of Figure 5 shows measured active power, available power (normal active power) and baseline during an upregulation of 16 MW. The difference between baseline and 'normal active power' (without regulation) is transferred to the delivery, and results in an equivalent difference between actual and expected delivery. This difference is illustrated in the right graph, with absolute numbers on the left y-axis (MW), and relative proportion of expected delivery on the right y-axis (percentage of delivery). The relative error should be minimized.

Principles for evaluation and validation of the reference method

The reference method described in this document shall be developed by the provider performing the application, and is assessed during the prequalification process. The reference method should be carefully described in the prequalification application: how is sold capacity guaranteed, how is regulation during operation performed, how can the delivery be validated, etc.

The accuracy of the baseline is evaluated by analyzing operational data for a longer period. The potential provider should log data during normal operation. During the logging period, there shall be no regulation or delivery of ancillary services. The logged data is provided to Svenska kraftnät along with data of ordinary test results, during prequalification.

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