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Guidance for variable resources for the provision of ancillary services and remedial actions

SVENSKA KRAFTNÄT

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Note that this is a translation of the Swedish document “*Vägledning för variabla resurser för att leverera stödtjänster och avhjälpande åtgärder”* in case of any inconsistency between the Swedish and English version, the Swedish version shall prevail.

1 Background and purpose

Historically, ancillary services have been provided by resources whose active power has been more or less fully controllable, which means that the initial value before regulation and the final value after regulation have been well-defined. Thus the provision of ancillary services has been clear and well defined. A pilot study was conducted between 2022 and 2023 to enable variable resources such as wind, solar or variable consumption to provide ancillary services. The pilot study culminated in a final report presenting a number of prequalification requirements and adapted evaluation methods that deal with natural power variations [1]. This enables variable resources to provide ancillary services while also allowing Svenska kraftnät to evaluate the capacity sold from variable resources.

This document introduces the baseline concept, as well as methods for improving baseline, suggestions on collecting data for prequalification and guidance for bidding. Please see the final report of the pilot study for more detailed information on these elements [1].

This document aims to support providers with variable resources so that they can undergo the prequalification process and guide the provider through topics linked specifically to the provision of ancillary services from variable resources.

Note that this document is a technical support document that does not replace regular test programmes and requirements, but serves as a complement to them.

2 Baseline

Providing ancillary services from resources with underlying power variations requires calculation of a baseline[1] indicating what production/consumption would have been if the ancillary service had not been activated. This section provides a definition of the baseline to be calculated by the provider and various suggested methods that can be used to improve baseline.

2.1 Definition of baseline

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

[1] In this context, “baseline” refers to a technical reference curve, also known as “reference power” or “reference value” (not financial).

Equation 1

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

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

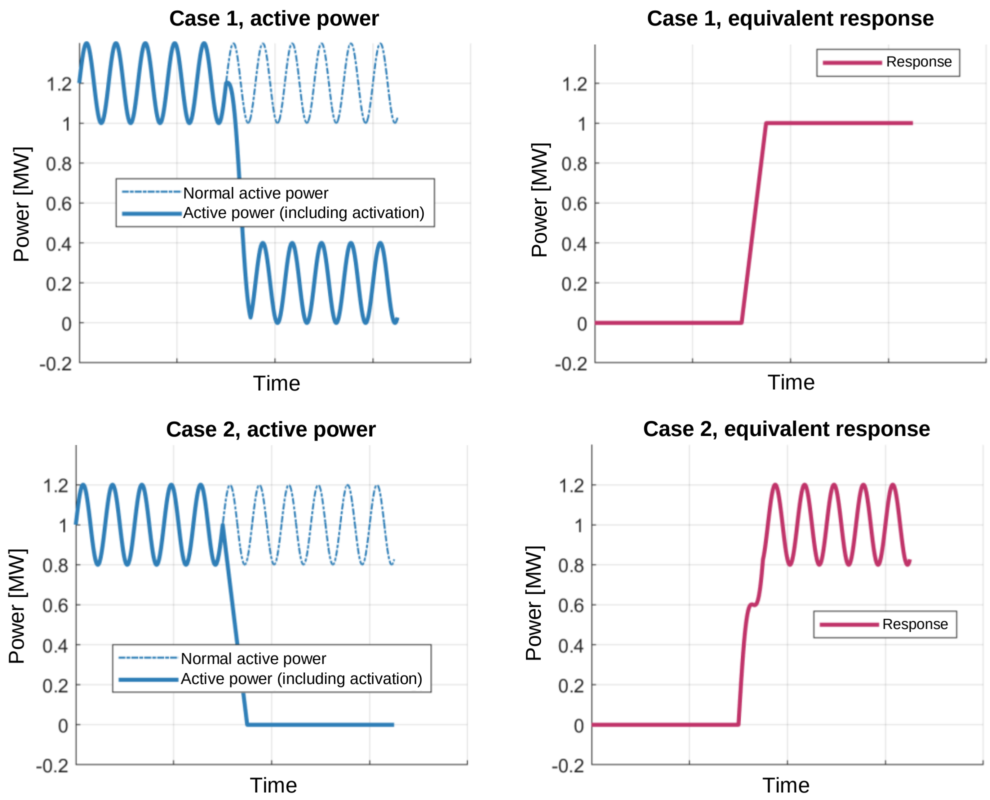

Figure 1. Illustration of the equivalent response among resources with variable production/consumption. **Top row:** In Case 1, the variations are unaffected by the activation and the response is constant. **Bottom row**: In Case 2, the power variations cease during activation. This results in a variable response, which is undesirable.

Case 1, which can be seen in the top row of Figure 1, shows a situation in which the power varies in a manner that is independent of whether or not the resource has been activated. Hence provision is not affected by the variations and the response is constant. Case 2 illustrates a situation in which the variations are dependent on provision. In this case, the variations are transferred to the response, in accordance with the equivalent response graph for Case 2, because the power variations cease during activation. Thus it is not possible in Case 2 to ensure clear provision of the ancillary service.

During activation, “Normal active power” is typically not available for direct measurement. Instead, a reference method is used to calculate the baseline, which should correspond to the normal active power that would have been produced/consumed if the ancillary service had not been activated. The baseline is used to calculate the active power set point during activation.

Equation 2

$$'Set\ point\ during\ activation' = 'Baseline' + 'Set\ point\ provision'$$

For provision to be correct, the baseline has to be reliable and corresponds to "Normal active power". In cases where the active power of a resource is fully controllable, the baseline is well-defined and equal to the active power (excluding ancillary service activations). Other resources, such as wind power and solar power, are variable by nature. There are two different principles for reference methods that these variable resources can use in order to set a baseline and provide ancillary services:

Method 1 – Regulation with respect to a dynamic baseline that follows the natural power variations of the resources. During an activation, the power of the resource is regulated downward or upward relative to the dynamic baseline. The regulation should correspond to the expected provision. The dynamic baseline may be based on, e.g., the theoretically available power calculated from appropriate measurements. A certain margin has to be added to the baseline to allow for upward regulation.

Method 2 – Limit the set point to a static baseline to obtain a well-defined base power. For example, a production plant may output a constant (limited) power instead of delivering at the theoretical maximum power. The baseline is clearly defined and regulation is performed based on this static level. The same principles applies to consumption resources.

These two principles are illustrated in Figure 2 and Figure 3 below, with examples of up- and downward regulation, respectively. Both methods result in identical provision, in accordance with Equation 1.

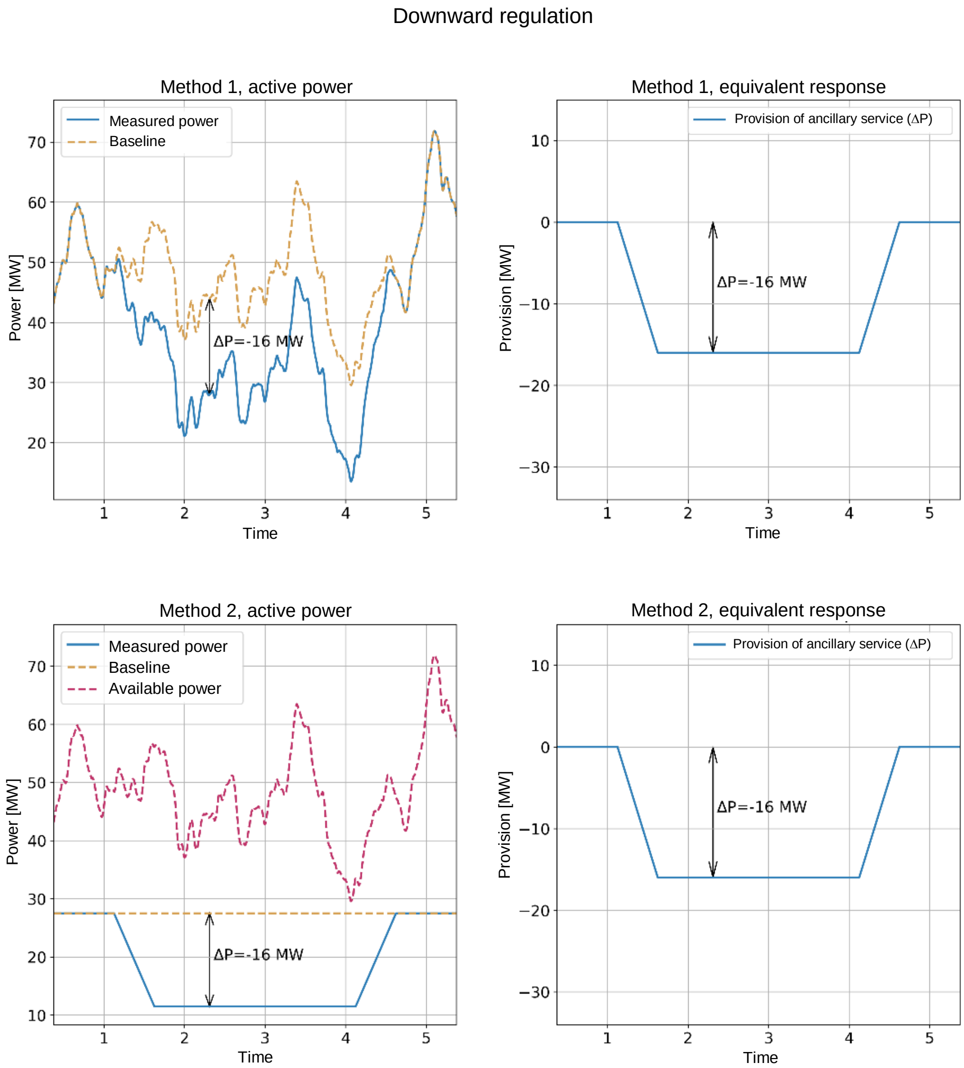

Figure 2. Illustration of Method 1 and Method 2 in the provision of downward regulation. **Top row:** example where Method 1 is applied. On the left is a dynamic baseline that follows the measured normal power of the resource before and after activation. During activation, the power is downward regulated relative to the dynamic baseline. The regulation corresponds to the provision, which is illustrated in the figure on the right. **Bottom row:** example where Method 2 with a static baseline is applied. On the left, the setpoint has been limited and no longer follows the theoretically available power, but instead maintains a stable and well-defined level that constitutes the baseline. During activation, the power is downward regulated with respect to the static baseline.

For both Method 1 and Method 2 as illustrated in Figure 2, it is observed that the ancillary service provision is the same as a result of the fact that the difference between the baseline and the measured power is identical for both methods.

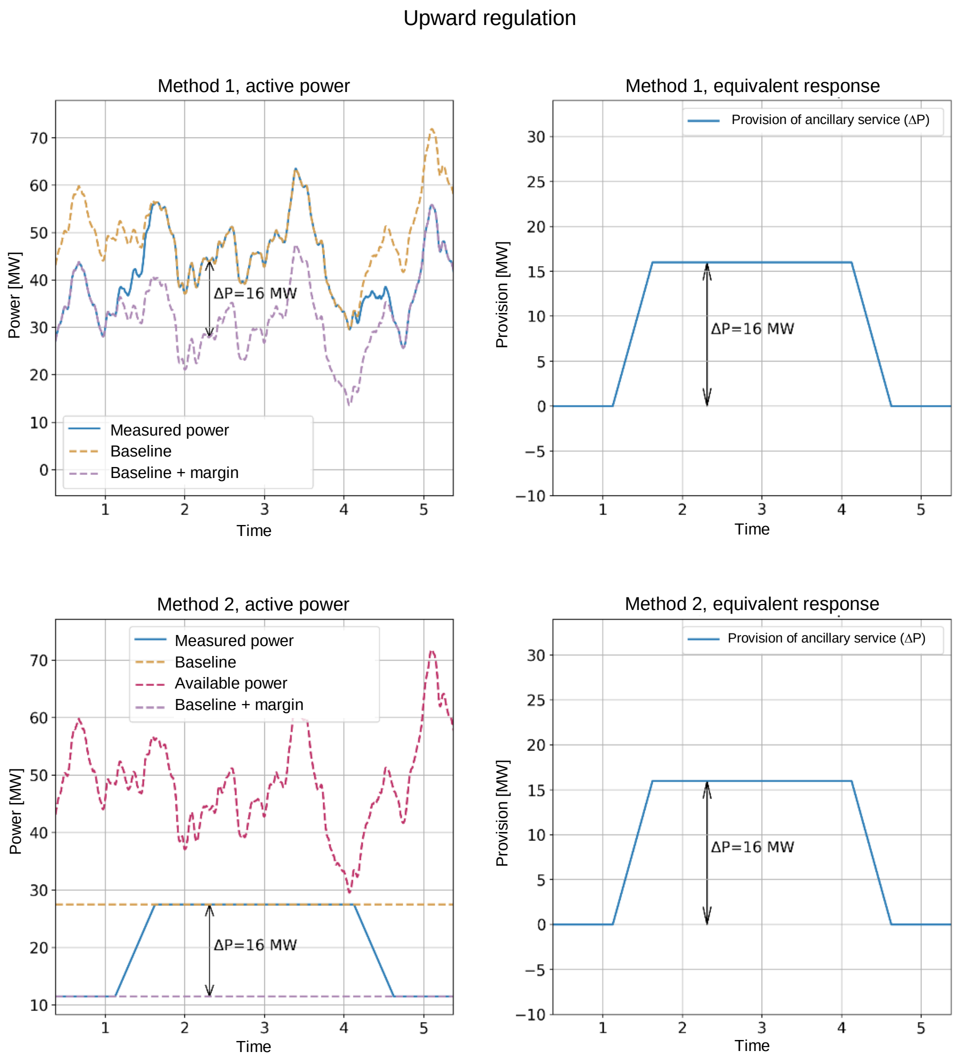

Figure 3. Illustration of Method 1 and Method 2 in the provision of upward regulation. **Top row:** example where Method 1 is applied. On the left is a dynamic baseline that follows the theoretical available power and a dynamic baseline with an added margin to allow for upregulation. During activation, the power is upward regulated towards the dynamic baseline from the dynamic baseline with addad margin. This regulation corresponds to the provision, which is illustrated in the figure on the right. **Bottom row:** example where Method 2 with a static baseline is applied. On the left, the setpoint has been limited and no longer follows the theoretically available power, but instead maintains a stable and well-defined level that constitutes the baseline with a margin to allow for upward regulation. On activation, the power is upregulated with respect to this static baseline.

For both Method 1 and Method 2 as illustrated in Figure 3, it is observed that the ancillary service provision is the same as a result of the fact that the difference between the baseline with a margin and the measured power is identical for both methods.

Activation based on a dynamic baseline curve require these values to instantaneously follow the natural power variations of the resource. A deviation between the baseline and the active power (which is not due to activation of any ancillary services), will result in a corresponding deviation in the provision of the ancillary service. Regulation based on a static baseline requires a sufficient margin to be applied to the static baseline in order to guarantee the provision of an ancillary service on the basis of the natural power variations. Examples of how the ancillary service provision may be affected when neither Method 1 nor Method 2 is met are illustrated in Figure 4 below for downward regulation and in Figure 5 below for upward regulation. These deviations will give an absolute difference in active power (MW), which is then converted into a relative deviation in relation to the intended provision. The relative deviations must be minimised, measured as a percentage of capacity sold.

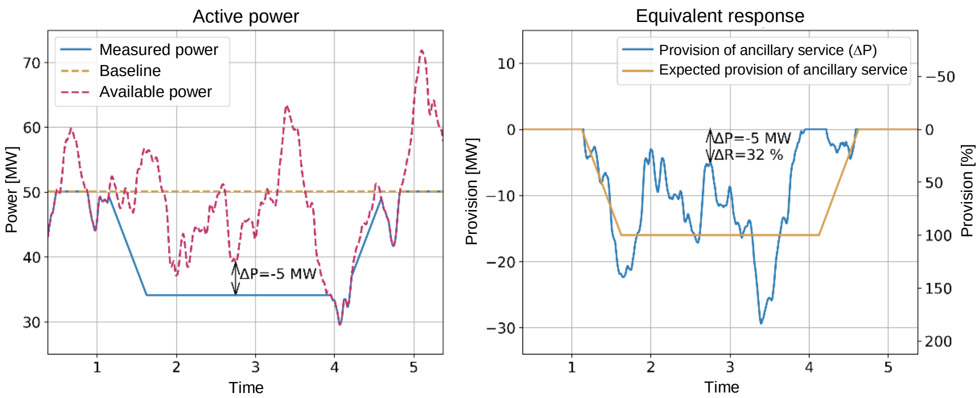

Figure 4. Illustration of the provision when the basline neither corresponds to the theoretically available power (according to Method 1) nor has been calculated below that (according to Method 2). The graph on the left shows the measured power, baseline and available power during a hypothetical downward regulation of 16 MW. The difference between normal active power without activation and the basline propagates and gives rise to a corresponding difference between the expected and actual provision of the ancillary service. This difference in provision is illustrated in the right-hand figure in absolute terms on the y-axis on the left, and as a relative proportion of expected provision on the y-axis on the right. The relative error must be minimised.

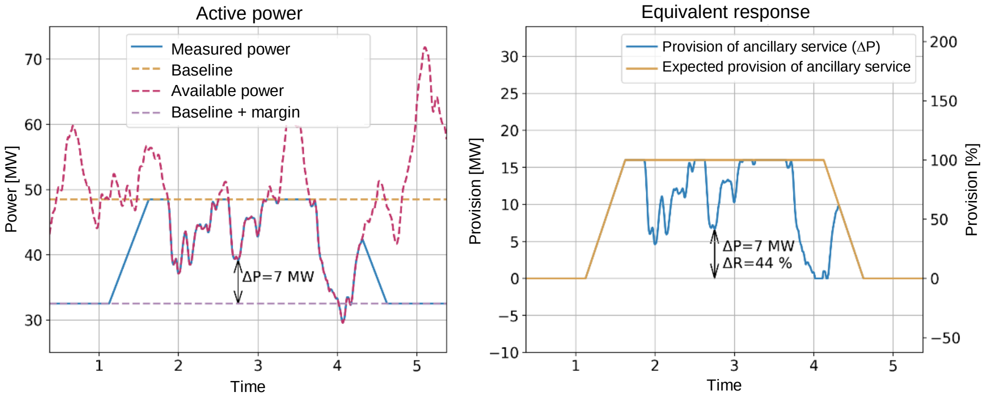

Figure 5. Illustration of the provision when the basline neither corresponds to the theoretically available power (according to Method 1) nor has been calculated to be below that (according to Method 2). The graph on the left shows the measured power, basline and available power during a hypothetical upward regulation activation of 16 MW. The difference between normal active power without activation and the basline propagates and gives rise to a corresponding difference between the expected and actual provision of the ancillary service. This difference in provision is illustrated in the right-hand figure in absolute terms on the y-axis on the left, and as a relative proportion of expected provision on the y-axis on the right. The relative error must be minimised.

2.2 Suggested methods to improve baseline

The baseline should provide the best possible representation of the production/consumption for a unit/group when no ancillary service activation takes place. The baseline must meet defined requirements for the deviation between the baseline and the measured power, as well as deviations for percentile values. A low-quality baseline leads to an increase in the minimum permitted bidding capacity, which means that the capacity range for the bidding will be reduced. With a very low baseline quality, the minimum permitted bidding capacity will be equal to or higher than the rated power of the resource, which means that a prequalification cannot be approved. There are methods for improving the baseline in order to avoid this. This section presents a few suggestions for methods that can be used. Note that these are merely suggestions, so there is no obligation to use any of these methods. The suggestions are written at a general level and, if used, must be adapted to each resource.

The methods presented below are primarily aimed at producing a dynamic baseline, but variants of these can also be used for a static or semi-static/semi-dynamic baseline. It is up to the ancillary service provider to decide whether or not a solution is suitable for their resources. Combinations of different solutions may also be considered in order to achieve the best results. Note that methods for improving the baseline are not limited to the methods referred to below, but providers have the opportunity to use their own methods to improve the baseline. How the baseline has been derived must be described clearly in the prequalification application.

2.2.1 Adjustment of production towards a baseline

Suitable for the provision of ancillary services such as: FFR, FCR, aFRR and mFRR.

To be able to use this method, a margin is added to the dynamic baseline as production/consumption is adjusted towards the corrected reference value. This margin involves some production curtailment or consumption reduction, and it is up to the provider to find a suitable margin level adapted to its resources. The advantage of this method is that the deviations in the baseline can be reduced almost completely.

2.2.2 Calibration

Suitable for the provision of ancillary services such as: FFR, FCR, aFRR and mFRR.

Calibration is a suitable method if there is a clear mean deviation between the baseline and the measured active power when the ancillary service is not activated. The aim of calibration is to be able to adjust so that the mean deviation between the baseline and the measured active power becomes zero.

One way of applying calibration is based on analysis of deviations of historical data for production or consumption. A calibration table can be developed on the basis of these data – for different production/consumption ranges and/or seasonal variations, for example – showing how the reference value should be calibrated on the basis of the factors that are most crucial for the resource in question.

Measurement data should always be monitored and the calibration table should be updated regularly in order to stay current.

2.2.3 Freezing method

Suitable for the provision of ancillary services such as: FFR and FCR-D[2].

The freezing method adjusts the baseline at the time of activation, which minimises initial deviations and thus ensures correct initial provision. The adjustment is based on the deviation between the reference value and the measured power at the time of activation. The adjustment value used is frozen during the activation of the ancillary service, and upon deactivation the adjustment value is reset until the next activation. This principle is best suited to ancillary services that are normally activated for shorter periods, such as FFR and FCR-D.

2.3 Reduction factor

Any deviations between the baseline and the measured power affect the minimum bidding capacity that a resource is permitted to provide. A reduction factor can be used to compensate for deviations that leads to a minimum capacity. The reduction factor does not improve the baseline but instead enables bidding with a lower capacity and works by adding extra capacity to the cleared capacity, i.e. if the bid capacity is $K_{red}\,\Delta P$, the capacity to be provided is ΔP. The compensation is given for the reduced capacity, $K_{red}\,\Delta P$. A reduction factor can be used for FCR-D, FCR-N and aFRR with different reduction factors for the various ancillary services.

[2] The freezing method does not work for FCR-D up for wind power, solar power or other resources that need to limit their production in order to provide FCR-D up.

3 Collection of data for prequalification

To be able to prequalify a variable resource, the provider needs to have collected at least two consecutive months of data, including measured power, baseline and fictitious or notional bids[3]. More information on how to report data can be found in *Reporting of measurements for units and groups participating with variable production and consumption* [2]. These data are used to evaluate the accuracy of the baseline and the strategy that will be used for bidding.

Data collected must include at least 300 hours of fictitious bids for FFR and FCR and 150 hours of fictitious bids for aFRR and mFRR. If the number of hours of fictitious bids is not reached in two months, the data collection period may be extended until the minimum number of hours of fictitious bids is reached.

For units/groups that are already providing ancillary services or remedial actions, a pause in bidding is needed for the provision of these ancillary services during the data collection period. Exceptions can be made for FCR-D down as activations are rare and for relatively short periods. The reason for pausing the bidding of other ancillary services is that activation of an ancillary service affects the measured power and hence the evaluation of the baseline. Variable resources that are not already participating in any ancillary service market are not affected by this.

The reference value must not be affected by ancillary service activation or measured power and must be as used during activations. This is necessary for the reference value to be useful and the provision to be definable.

3.1 Choice of period for data collection

The appropriate period for data collection is dependent on the type of resource to be prequalified.

For weather-dependent resources such as solar and wind power, there may be a risk of snow and icing during the winter months that can affect production, e.g. icing on wind turbine blades or snow cover over all or part of a solar farm. Therefore, the general recommendation for wind and solar power is to plan data collection for spring, summer or autumn if the baseline calculation is not adapted to take into account the impact of snow and/or icing.

[3] Fictitious or notional bids are the bidding capacity that would be bid if resources participated in the market.

Regardless of when data collection for prequalification takes place, the provider is expected to guarantee that the quality of the baseline and bid availability demonstrated during prequalification can be maintained during the hours that bids will be placed from the entity/group after approved prequalification.

4 Bidding from variable resources

Some types of variable resources are weather-dependent and can be adversely affected in certain weather situations, resulting in non-provision. Therefore, available bidding capacity will be evaluated in prequalification [1]. After approved prequalification, it is very important for the provider to minimise the risk of non-provision when bidding.

4.1 Bidding in winter

Predicting the impact on resources and provision of ancillary services in weather forecasts can be a major challenge, e.g. wind and solar power production can be very affected by icing on wind turbine blades or snow covering all or part of a solar farm. To provide ancillary services from wind or solar power under such weather conditions, the reference value should be adapted to provide an accurate representation of the power under these conditions.

It has proven difficult to predict exactly when icing or snowfall will occur, and so this risk needs to be considered before bidding.

If the bid capacity cannot be provided during the operating hour, this needs to be reported to Svenska kraftnät as soon as possible and bidding should not take place again until it is possible to ensure that the function of the unit/group has returned to normal.

5 References

[1] "Final report from the pilot study: Provision of ancillary services from resources with variable production or consumption," Svenska kraftnät, 2023.

[2] "Reporting of measurements for units and groups participating with variable production and consumption," Svenska kraftnät, 2023.