Testing and reporting of measurements for units and groups participating in pilot study for variable resources

Draft Pilot Study

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 kilometres 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.

Content

Introduction

Svenska kraftnät procures ancillary services and remedial actions to ensure a balanced and stable electric power system. This category includes FFR, FCR-D upward, FCR-D downward, FCR-N, aFRR upward and/or downward as well as mFRR upward and/or downward.

The purpose of this pilot study is to allow actors with variable resources to practically test principles for the delivery of ancillary services in practice, i.e. during normal operation. After an approved initial prequalification, the actors are given the opportunity to participate on the ancillary service markets during the pilot. For FFR, however, an annual procurement takes place, which is why market participation through this pilot might be commenced first in 2023. During the pilot Svenska kraftnät will evaluate the resources and discuss difficulties/improvements regarding variable resources together with the actors. This way, the threshold for entering the ancillary service markets becomes lower, and both actors and Svenska kraftnät will be given the opportunity to test new principles and build competence in this area.

In the pilot study for variable resources, real-time communication with Svenska kraftnät is not required, with the exception of aFRR where real-time communication is required for activation of the ancillary service. The provider of the ancillary service shall instead continuously log the measurements and submit the logged data to Svenska kraftnät monthly for review. This document describes the requirements on the format and sampling time of the submitted data, as well as the tests the actors shall perform to participate in the pilot. The supplier may choose in which format the data is logged during operation, but when it is submitted to Svenska kraftnät, it must be in the units and format specified in this document.

Wordlist

Common abbreviations and concepts are explained.

Abbreviation/concept	Explanation
FCR-N	Frequency Containment Reserve Normal. Ancillary service.
FCR-D up	Frequency Containment Reserve Disturbance Upwards. Ancillary service. Refers to upward regulation only.
FCR-D down	Frequency Containment Reserve Disturbance Downwards. Ancillary service. Refers to downward regulation only.
FFR	Fast Frequency Reserve. Remedial action.
aFRR	Automatic Frequency Restoration Reserve. Ancillary service.
mFRR	Manual Frequency Restoration Reserve. Ancillary service.
Hz	Hertz. Unit of measure for electrical frequency. Indicates how many times per second the voltage changes direction.
LER	Limited Energy Reservoir, i.e. units and groups with limited energy reserves. Resources with limited energy reserve may, for example, constitute of energy storage and/or corresponding technology.
Max power	A unit's or group's maximum power. Denoted in MW (MegaWatt).
Min power	A unit's or group's minimum power. Denoted in MW (MegaWatt).
ms	Millisecond. Unit of measure for time. An ms is one thousandth of a second.
MW	Megawatt. Watt is a unit of measurement for resistive electrical power. One MW is 1 000 000 watts.
MWh	Megawatt hours. Unit of measure for electrical power over time. 1 MWh corresponds to 1 megawatt during one hour.
s	Seconds.
UTC	Coordinated Universal Time. Zero point is GMT (Greenwich Mean Time). Sweden has a time zone of UTC + 1.
Max test	Capacity test on the maximum capacity of the unit or group. Demonstrated capacity during max test determines the maximum volume that may be sold.
Min test	Capacity test on the minimum capacity of the unit or group. Demonstrated capacity during min test determines the minimum volume that may be sold.
Max capacity	Maximum capacity of the unit or group (the capacity obtained during the max test).
Min capacity	Minimum capacity of the unit or group (the capacity obtained during the min test).

Measurements to be logged

The supplier shall, for each unit or group participating in the pilot, log and save the data listed below with the specified resolution or better for the whole month. The data most be logged for the whole time period regardless of whether the unit or the group has been procured or not. The file that contains the data must be compressed (zipped) before uploading. The data is divided into two main areas: operational data and forecasted data. Operational data is data that is measured/calculated in real time and corresponds to the actual operating hour as it is measured/calculated, while forecasted data is forecasted values before future operating hours. Forecasted data for an operating hour must be calculated in advance, latest at the corresponding time of bidding.

The actor might choose whether these two categories of data should be logged in the same file or divided into two separate files. Below is a list of the data to be logged for each category.

Operational data

> Date and time (preferably UTC, otherwise clearly marked)

> Measured active power [MW]

> Reference value (baseline) active power [MW], excluding regulation
  For each unit and/or group, the actor must provide a baseline. The baseline shall correspond to the power that would have been delivered if no ancillary service had been activated. The baseline can be equal to the plan for production/consumption if the instantaneous deviations from the plan during normal operation are insignificant.

> Max power [MW]
  Maximum power refers to the unit's or group's maximum power, above which regulation should not or cannot take place. This could possibly be used to calculate the current control space.

> Min power [MW]
  Minimum power refers to the unit's or group's minimum power, below which regulation should not or cannot take place. This could possibly be used to calculate the current control space.

> Regarding LER: Available energy for upward regulation [MWh]
  Current available amount of energy in the unit or group that can be used for upward regulation.

> Regarding LER: Available energy for downward regulation [MWh]
> Current available amount of energy in the unit or group that can be used for downward regulation.

Forecasted data

> Date and time (preferably UTC, otherwise clearly marked)
> Time indicates the moment for which the forecast tries to predict. If forecasted data is entered in the same file as operational data, only one column is used for date and time that refers to both operational data and forecasted data.

> Forecasted bid capacity [MW]
> Forecasted bid capacity refers to the minimum capacity that the actor has calculated and guaranteed to be available for delivery during the entire actual operating hour. This constitutes the ceiling for how much the actor estimates might be sold, based on the forecast and uncertainty margin. This corresponds to procured capacity if all the bid capacity is procured. Forecasted bid capacity must be calculated in advance, latest at the time of bidding.

> Procured capacity [MW]
> Procured capacity refers to the capacity the actor has been called on during the actual operating hour. It can be all or parts of the forecasted bid capacity.

> Forecasted power [MW]
> Forecasted power refers to relevant data linked to the actor's expected power (produced or consumed) during the operating hour. Forecasted power can consist of several values and should, in addition to the expected power, also include uncertainty intervals, such as percentiles. Forecasted power must be calculated in advance, latest at the time of bidding.

In addition to the general signals specified above, ancillary service specific signals must be logged in accordance with following sections.

Other information

In the event of deviating or unexpected behavior of the resource, Svenska kraftnät may need to ask control questions about the response. In addition to the mandatory values stated above, it may therefore be appropriate to log other measured values, in order to facilitate the assessment and enable a less restrictive interpretation of the exhibited behavior. This type of information can for example include:

> Wind speed [m/s]

> Pitch angle [°]

> Solar irradiance [W/m²]

> State-of-charge [%]

> Guide vane opening [%]

> Hydraulic head [m]

> Description of the operating condition

In case of uncertainty about which data is to be logged, this can suitably be discussed together with Svenska kraftnät in the pilot study.

Ancillary service specific information

This section specifies information that applies specifically to each respective ancillary service. This includes data to be logged (in addition to the general data specified above), sampling time and tests that are required for participation in the pilot. The tests roughly correspond to the ordinary pre-qualification tests but can be somewhat simplified, as well as contain additions for variable resources, such as one hour of logging of baseline and active power.

FFR

Data

Additional measurements to be logged for FFR, supplementary to the general ones:

> Measured grid frequency [Hz] (resolution ≤ 10 mHz)

> Available capacity FFR [MW] (resolution ≤ 0.01 MW)
This refers to the actual delivery of FFR that will take place in the event of an activation.

> Status regulator on/off [1/0]
This value indicates whether the FFR regulator is on or off. The value is 0 or 1, where 1 indicates the regulator is switched on.

> Activated FFR-capacity on/off [1/0]
This value indicates whether FFR is activated or not. The value is 0 or 1, where 1 indicates ongoing FFR activation.

Sampling time

Registration intervals of logged data for FFR are described under point 1 below. If this is not possible for the actor to fulfill, the actor can log data according to point 2, after agreement with Svenska kraftnät.

1. Keep the sampling time constant at maximum 100 ms throughout the measurement series.

2. Use a sampling time of 1 s during normal operation and 100 ms in the event of a disturbance. The time interval to be logged and saved in the event of a disturbance is from 10 seconds before the activation of FFR up until 15 minutes from the time of activation. Since this results in two different sampling times, the measurement data must be separated into two files before they are sent to Svenska kraftnät. One file must contain logged data for normal operation (sampling time 1 s), while the other file contains logged data during disturbance (sampling time 100 ms).

Test for participation in the pilot study

Ordinary tests according to the test program for maximum test (minimum test is optional).

FCR

Data

Additional measurements to be logged for FCR, supplementary to the general ones:

> Measured grid frequency [Hz] (resolution ≤ 10 mHz)

> Available capacity FCR-N [MW] (resolution ≤ 0.01 MW)
  This refers to the actual delivery of FCR-N that will take place in the event of a full activation. Should FCR-N capacity for upward and downward regulation differ, the reported value shall consist of the capacity in the limited direction. Available capacity FCR-N is always stated as a positive value.

> Available capacity FCR-D upward [MW] (resolution ≤ 0.01 MW)
  This refers to the actual delivery of FCR-D upward regulation that will take place in the event of a full activation.

> Available capacity FCR-D downward [MW] (resolution ≤ 0.01 MW)
  This refers to the actual delivery of FCR-D downward regulation that will

take place in the event of a full activation. Available capacity for FCR-D downward regulation is stated as a positive value.

> Status regulator FCR-N on/off [1/0]
  This value indicates whether the FCR-N regulator is on or off. The value is 0 or 1, where 1 indicates the regulator is switched on.

> Status regulator FCR-D upward on/off [1/0]
  This value indicates whether the FCR-D upward regulator is on or off. The value is 0 or 1, where 1 indicates the regulator is switched on.

> Status regulator FCR-D downward on/off [1/0]
  This value indicates whether the FCR-D downward regulator is on or off. The value is 0 or 1, where 1 indicates the regulator is switched on.

Sampling time

Registration interval of logged data for FCR is described under point 1 below. If this is not possible for the actor to fulfill, the actor can log data according to point 2, after agreement with Svenska kraftnät.

1. Keep the sampling time constant at maximum of 1 s throughout the measurement series.

2. Logging with 1 s sampling time applies when a change in the measured value has taken place in excess of a threshold value[1], otherwise logging must take place at least once per minute when the change in the measured value does not exceed the threshold value.

Tests for participation in the pilot study

> FCR-D (upward and downward): Capacity test for maximum capacity (capacity test for minimum capacity is optional), as well as one hour logging of baseline, active power and measured frequency.

> FCR-N: Capacity test for maximum capacity (capacity test for minimum capacity is optional). Endurance test only needs to be 20 minutes (i.e. 20 minutes of full activation in each direction instead of one hour), as well as one hour of active regulation with logging of baseline, active power and measured frequency. Specify the capacity of the test for active regulation.

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[1] According to agreement with Svenska kraftnät.

aFRR

Data

Additional measurements to be logged for aFRR, supplementary to the general ones:

> aFRR-Setpoint per unit or group [MW] (resolution ≤ 1 MW)

> Activated aFRR per unit or group [MW] (resolution ≤ 0.1 MW)

> Available capacity aFRR upward regulation [MW] (resolution ≤ 0.1 MW)
  This refers to the actual delivery of the aFRR upward regulation that will take place in the event of a full activation.

> Available capacity aFRR downward regulation [MW] (resolution ≤ 0.1 MW)
  This refers to the actual delivery of the aFRR downward regulation that will take place in the event of a full activation. Available capacity for aFRR downward regulation is stated with a positive value.

> Status aFRR control on/off [1/0]
  This value indicates whether the unit or group is available for delivery of aFRR (responsive to aFRR control signal). The value is 0 or 1, where 1 indicates that the unit or group is responsive to the aFRR control signal.

Sampling time

Registration interval of logged data for aFRR is described under point 1 below. If this is not possible for the actor to fulfill, the actor can log data according to point 2, after agreement with Svenska kraftnät.

1. Keep the sampling time constant at maximum of 5 s throughout the measurement series.

2. Logging with 5 s sampling time applies when a change in the measured value has taken place in excess of a threshold value, otherwise logging must take place at least once per minute when the change in the measured value does not exceed the threshold value. The threshold value for the change is 0.1 MW, alternatively X %[2] of the unit's/group's maximum capacity. The measurements must be logged in a common data file where it is clearly shown with which time intervals logging has been done.

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[2] According to agreement with Svenska kraftnät.

It is recommended to log with 1 second sampling time if possible, especially during response test at prequalification.

Tests for participation in the pilot study

Ordinary tests according to test program for aFRR, as well as one hour logging of baseline and active power during normal operation (no activation of aFRR during the hour).

mFRR

Data

> mFRR-Setpoint per unit or group [MW] (resolution ≤ 1 MW)

> Activated mFRR per unit or group [MW] (resolution≤ 0.1 MW)

> Available capacity mFRR upward regulation [MW] (resolution ≤ 0.1 MW)
  This refers to the actual delivery of mFRR upward regulation that will take place in the event of a full activation.

> Available capacity mFRR downward regulation [MW] (resolution≤ 0.1 MW)
  This refers to the actual delivery of mFRR downward regulation that will take place in the event of a full activation. Available capacity for mFRR downward regulation is stated as a positive value.

> Status mFRR control on/off [1/0]
  This value indicates whether the unit or group is available for delivery of mFRR. The value is 0 or 1, where 1 indicates available mFRR capacity.

Sampling time

Registration interval of logged data for mFRR is described under point 1 below. If this is not possible for the actor to fulfill, the actor can log data according to point 2, after agreement with Svenska kraftnät.

1. Keep the sampling time constant at maximum of 10 s throughout the measurement series.

2. Logging with 10 s sampling time applies when a change in the measured value has taken place in excess of a threshold value, otherwise logging must take place at least once per minute when the change in the measured value does not exceed the threshold value. The threshold value for the change is

0.1 MW, alternatively X %[3] of the unit's/group's maximum capacity. The measurements must be logged in a common data file where it is clearly shown with which time intervals logging has been done.

Tests for participation in the pilot study

Ordinary tests according to test program, as well as one hour logging of baseline and active power during normal operation (no activation of mFRR during the hour).

Format

In order for Svenska kraftnät to be able to review submitted data as smoothly and objectively as possible, the process for this is partially automated. Formatting and file names should therefore follow the specifications below.

Data must be delivered in csv-format (character encoding UTF-8), values separated by commas (,) and decimals specified with decimal point (.).

Rows are separated by line breaks (↵ ASCII/CRLF=0x0D 0x0A).

File names must be specified on the format [Resource]_[Service]_[Area]_[Interval]_[Sampling_rate]_[Date].csv, where the sub-elements are specified as follows:

> Resource = Identifier for the resource in accordance with an agreement with Svenska kraftnät.

> Service = Ancillary service that the log file includes. One of FFR, FCR-D Upward, FCR-D Downward, FCR-N, aFRR or mFRR.

> Area = Bid area for the unit/group. The bidding area can be either SE1, SE2, SE3 or SE4.

> Interval = Time intervals that the log file includes, are specified on the format YYYYMMDDThhmm-YYYYMMDDThhmm.

> Sampling rate = Nominal time difference between samples specified in milliseconds.

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[3] According to agreement with Svenska kraftnät.

> Date = The date when the log file was compiled to be sent to Svenska kraftnät, on the format YYYYMMDD.

Example of file name:

```
UnitG1_FFR_SE3_20200515T0000-20200601T2359_100ms_20200602.csv
```

Data points in the csv-file are formatted as follows:

```
DateTime,Cap,InsAcPow, …
[DateTime1],[record1_1],[record1_2], … ,[record1_X]
[DateTime2],[record2_1],[record2_2], … ,[record2_X]
etc.
```

Data columns to be included in general

Columns to be included are specified below, including title row and data type. Columns that are not applicable must be left blank.

> DateTime = Date and time on the format YYYYMMDDThhmmss.nnn, where n is decimals of a second
> Example: 20200601T093702.012

> InsAcPow = Instantaneous measured active power in [MW], specified as a double with at least two decimals (for aFRR and mFRR with at least one decimal)
> Example: 120.53

> RefAcPow = Reference value (baseline) active power in [MW], specified as a double with at least one decimal
> Example: 120.5

> ForecAcPow = Forecasted power in [MW], specified as a double with at least one decimal
> Example: 120.5

> Pmax = Maximum active power in [MW], specified as a double with at least two decimals
> Example: 100.52

> Pmin = Minimum active power in [MW], specified as a double with at least two decimals
> Example: 100.52

> LERUp = Available energy for upward regulation in [MWh], specified as a double with at least two decimals
> Example: 10.57

> LERDown = Available energy for downward regulation in [MWh], specified as a double with at least two decimals
> Example: 10.57

Data columns to be included for respective ancillary service and for FFR

Below is a list of data columns that are to be included specifically for each respective ancillary service and for FFR (in addition to the general ones above).

FFR

> GridFreq = Measured grid frequency in [Hz], specified as a double with at least two decimals
> Example: 49.32

> ContStatusFfr = Control signal if the FFR regulator is set to allow delivery, Boolean indicator [1/0] with activated (= 1) or not activated (= 0)
> Example: 1

> FfrCap = Available capacity FFR in [MW], specified as a double with at least two decimals
> Example: 20.10

> ForecCapFfr = Forecasted capacity FFR for the hour in [MW], specified as a double with at least one decimal
> Example: 120.5

> ProcuCapFfr = Procured capacity FFR for the hour in [MW], specified as a double with at least one decimal
> Exempel:120.5

> ContOutSig = Control signal for activation (i.e. trigger conditions met and delivery profile in progress), Boolean indicator [1/0] with activated (= 1) or not activated (= 0)
> Example: 1

FCR

> GridFreq = Measured grid frequency in [Hz], specified as a double with at least two decimals
> Example: 49.32

> ContStatusFcrn= Control signal for if the FCR-N regulator is set to allow delivery, Boolean indicator [1/0] with activated (= 1) or not activated (= 0)
Example: 1

> ContStatusFcrdUp = Control signal for if the FCR-D upward regulator is set to allow delivery, Boolean indicator [1/0] with activated (= 1) or not activated (= 0)
Example: 1

> ContStatusFcrdDown = Control signal for if the FCR-D down regulator is set to allow delivery, Boolean indicator [1/0] with activated (= 1) or not activated (= 0)
Example: 1

> FcrnCap = Available capacity FCR-N in [MW], specified as a double with at least two decimals
Example: 20.10

> FcrdUpCap = Available capacity FCR-D upward regulation in [MW], specified as a double with at least two decimals
Example: 20.10

> FcrdDownCap = Available capacity FCR-D downward regulation in [MW], specified as a double with at least two decimals
Example: 20.10

> ForecCapFcrn = Forecasted capacity FCR-N for the hour in [MW], specified as a double with at least one decimal
Example: 120.5

> ProcuCapFcrn = Procured capacity FCR-N for the hour in [MW], specified as a double with at least one decimal
Exempel:120.5

> ForecCapFcrdUp = Forecasted capacity FCR-D upward regulation for the hour in [MW], specified as a double with at least one decimal
Example: 120.5

> ProcuCapFcrdUp = Procured capacity FCR-D upward regulation for the hour in [MW], specified as a double with at least one decimal
Exempel:120.5

> ForecCapFcrdDown = Forecasted capacity FCR-D downward regulation for the hour in [MW], specified as a double with at least one decimal
Example: 120.5

> ProcuCapFcrdDown = Procured capacity FCR-D downward regulation for the hour in [MW], specified as a double with at least one decimal
Exempel:120.5

aFRR

> AfrrSetP = aFRR-setpoint in [MW], specified as a double
Exempel: 20

> AfrrAct = Activated aFRR in [MW], specified as a double with at least one decimal
Example: 20.1

> AfrrUpCap = Available capacity for aFRR upward regulation in [MW], specified as a double with at least one decimal
Example: 20.1

> AfrrDownCap = Available capacity for aFRR downward regulation in [MW], specified as a double with at least one decimal
Example: 20.1

> ForecCapAfrrUp = Forecasted bid capacity aFRR upward regulation for the hour in [MW], specified as a double
Example: 120

> ProcuCapAfrrUp = Procured capacity aFRR upward regulation for the hour in [MW], specified as a double
Example: 120

> ForecCapAfrrDown = Forecasted bid capacity FRR downward regulation for the hour in [MW], specified as a double
Example: 120

> ProcuCapAfrrDown = Procured capacity FRR downward regulation for the hour in [MW], specified as a double
Example: 120

> ContStatusAfrr = Control signal for whether the unit or group is available for control of aFRR, Boolean indicator [1/0] with available (= 1) or not available (= 0)
Example: 1

mFRR

> MfrrSetP = mFRR-setpoint per unit in [MW], specified as a double

> MfrrAct = Activated mFRR in [MW], specified as a double with at least one decimal
> Example: 20.1

> MfrrUpCap = Available capacity for mFRR upward regulation in [MW], specified as a double with at least one decimal
> Example: 20.1

> MfrrDownCap = Available capacity for mFRR downward regulation in [MW], specified as a double with at least one decimal
> Example: 20.1

> ForecCapMfrrUp = Forecasted bid capacity mFRR upward regulation for the hour in [MW], specified as a double with at least one decimal
> Example: 120.5

> ProcuCapMfrrUp = Procured capacity mFRR upward regulation for the hour in [MW], specified as a double with at least one decimal
> Example: 120.5

> ForecCapMfrrDown = Forecasted bid capacity mFRR downward regulation for the hour in [MW], specified as a double with at least one decimal
> Example: 120.5

> ProcuCapMfrrDown = Procured capacity mFRR downward regulation for the hour in [MW], specified as a double with at least one decimal
> Example: 120.5

> ContStatusMfrr = Control signal for whether the unit or group is available for control of mFRR, Boolean indicator [1/0] with available (= 1) or not available (= 0)
> Example: 1

Other data that is relevant to the specific resource and thus must be logged, may be freely named by the actor. Svenska kraftnät shall be informed of what each abbreviation stands for and in which unit they are specified.

An example of how a csv-file should be structured (without forecast data or resource-specific data) is shown in Figure 1. If the forecast data is logged in a separate file, it should be structured according to the same principle as in Figure 1 below, but with different column names and data.

```
DateTime, InsAcPow, RefAcPow, Pmax, Pmin, GridFreq,
ContStatusFcrdDown, FcrdDownCap

20200601T093702.000, 120.53, 120.2, 180.00, 20.00, 50.00, 1, 30.33
20200601T093703.000, 120.53, 120.2, 180.00, 20.00, 50.10, 1, 30.33
20200601T093704.000, 112.67, 120.3, 180.00, 20.00, 50.20, 1, 30.53
20200601T093705.000, 105.28, 120.5, 180.00, 20.00, 50.30, 1, 30.44
```

Figure 1: Example of how the logged operational data is to be reported, in this case for a unit that delivers FCR-D downward. This example does not include forecast data or resource-specific data.